I. MAMUZIĆ

CROATIAN METALLURGICAL SOCIETY (CMS)
HRVATSKO METALURŠKO DRUŠTVO (HMD)

15th INTERNATIONAL / 15. MEĐUNARODNI

SYMPOSIUM OF CROATIAN METALLURGICAL SOCIETY
SIMPOZIJ HRVATSKOG METALURŠKOG DRUŠTVA

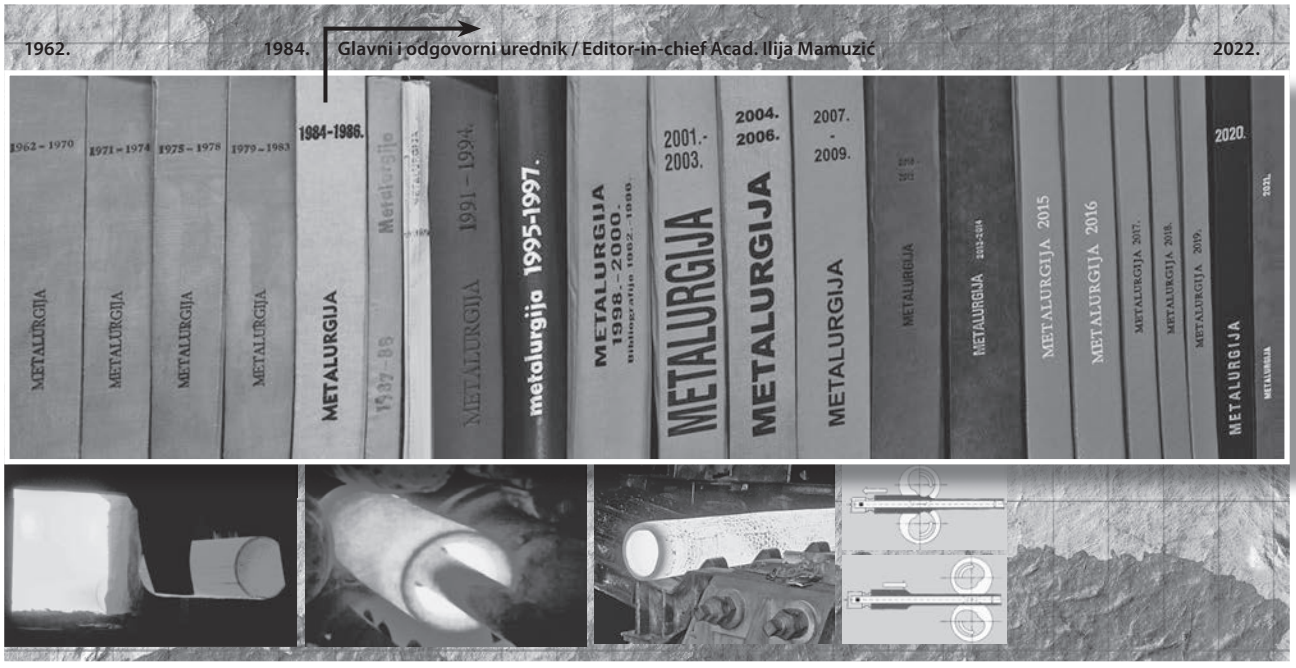
S H M D ´2022

MATERIALS AND METALLURGY / MATERIJALI I METALURGIJA

BOOK OF ABSTRACTS / ZBORNIK SAŽETAKA

Obljetnice Hrvatske metalurgije
Anniversaries of Croatian Metallurgy

1952.–2022.	HRVATSKO METALURŠKO DRUŠTVO / CROATIAN METALLURGICAL SOCIETY	/ 70 god./y
6 000. god./y	METALURGIJA NA TLU HRVATSKE / METALLURGY ON THE TERRITORY OF CROATIA	/ 6 000 god./y
1960.–2020.	SVEUČILIŠNI STUDIJ METALURGIJE / UNIVERSITY STUDIES OF METALLURGY	/ 60 god./y
1962.–2022.	ČASOPIS METALURGIJA – Bibliografija / METALURGIJA JOURNAL – Bibliograph	/ 60 god./y



Željezara Sisak, 60 godina proizvodnje bešavnih cijevi (1952.-2012.)
Steelworks Sisak, 60 years of the production of seamless tubes (1952-2012)

ZAGREB, CROATIA, March 22 – 23, 2022
ZAGREB, HRVATSKA, 22. – 23. ožujak 2022.

http://ilija-mamuzic.from.hr

THE AIM OF SYMPOSIUM

The aim of this Symposium is to point out all the possibilities of the materials and achievements in metallurgy.

15th International Symposium of Croatian Metallurgical Society „Materials and Metallurgy“ was held as a part of: Please see Metalurgija 60 (2021) 1,3

„Countries Participating at the 15th International Symposium of Croatian Metallurgical Society“ – total 50 „Organizer“, „Co-organizer“, „Co-operation with organizations“, same as 14th symposium, Please see Metalurgija 59 (2020) 3, 420-421

ACCEPTED ABSTRACTS

Symposium have been held :

1st: Zagreb – 1994 – February, 16 – 18 (88 lectures)
2nd: Split – 1996 – June, 20 – 22 (150 lectures)
3rd: Šibenik – 1998 – June, 25 – 27 (192 lectures)
4th: Opatija – 2000 – June, 25 – 29 (333 lectures)
5th: Šibenik – 2002 – June, 23 – 27 (375 lectures)
6th: Šibenik – 2004 – June, 20 – 24 (368 lectures)
7th: Šibenik – 2006 – June, 18 – 22 (475 lectures)
8th: Šibenik – 2008 – June, 22 – 26 (615 lectures)
9th Šibenik – 2010 – June 20 – 24 (541 lectures)
10th Šibenik: 2012 – June, 17- 21 (641 lectures)
11th Šibenik: 2014 – June, 22- 26 (689 lectures)
12th Šibenik: 2016 – June, 19- 23 (546 lectures)
13th Šibenik: 2018 – June, 24- 29 (561 lectures)
14th Šibenik: 2020 – June, 21- 26 (435 lectures)
15th Zagreb: 2022 – March, 22- 23 (456 lectures)

NAPOMENA:

- Mnogi autori / koautori nisu se pridržavali zadanog oblika i dužine sažetaka referata. Znanstveni odbor je izveo usaglašavanje, te isprika ako postoje nedostaci. Moguće je i možebitni izostanak nekog sažetka. Sve Reklamacije se usvajaju do 30. svibnja 2022. god., posebice tisak, Metalurgija 61 (2022).
- **Održavanje 15. Simpozija, ZAMOLBA, vidi 1. god. staro UPOZORENJE, naša WEB stranica.**

NOTE:

- Many authors / co-authors have not observed the given form and length of abstracts of their reports. Scientific board has made adjustments, so we apologize if there are any faults.An abstract might be failing.
All Protests will be accept till May 30, 2022, and after separately publish, Metalurgija 61 (2022).
- **The holding of 15th Symposium, PLEASE, see one year old WARNING, our WEBsite**

1. J. Kozák, L. Krejčí, I. Hlavatý, R. Čep, I. Samardžić

Utilization of diffraction analysis in the study of martensitic weld deposits using tungsten carbide particles on S235JR+N steel. The durability of classic structural steels against various types of wear is generally low. Therefore, various types and combinations of resilient materials are constantly evolving, which are designed to reduce the cost of components replacement or repairs. This paper deals with the structures that are formed in a weld after addition of tungsten carbide particles to protect the surface of the components from wear. The resistance of the weld surface layer containing tungsten carbides is also evaluated in comparison with a layer without these particles.

2. K. Milewski, M. Madej

Structure and mechanical properties of diamond-like carbon (DLC) coatings doped with silicon. This paper reports the study of silicon-doped diamond-like carbon coatings a-C:H:Si prepared by Plasma-Assisted Chemical Vapour Deposition (PACVD) on 100Cr6 steel. Surface morphology and elemental composition were determined with the use of Scanning Electron Microscopy (SEM) / Energy Dispersive Spectroscopy (EDS). Surface topography measurements were performed using Atomic Force Microscopy (AFM). The scratch test assessment of the influence of a-C:H:Si coatings on mechanical properties was based on the measurements of nanohardness and adhesion to the substrate. The results show that silicon-doped diamond-like carbon coatings a-C:H:Si are characterized by a uniform surface structure, high hardness and good adhesion to the substrate.

3. Kusmono, C. Bora, U. A. Salim

Effects of cold rolling (CR) and annealing time on microstructure and mechanical properties of AA 5052 aluminum alloy. In this paper, the influences of cold rolling and annealing time on the microstructure and mechanical behaviors of AA 5052 aluminum alloy were investigated. An aluminum sheet was cold-rolled at room temperature at 15, 30, and 45 % rolling reduction. The 45 % cold-rolled sample was subsequently annealed at 370 °C for 2, 4, and 6 h. The microstructure was observed using optical microscopy whereas the mechanical behaviors were evaluated through hardness and tensile tests. It was found that the equiaxed grains are severely elongated along the rolling direction with increased rolling reduction. The hardness and strength increase significantly with an increase of rolling reduction but the ductility decreases. The annealing treatment reduces hardness and strength but improves the ductility.

4. Withdrawn from the conference

5. M. S. Xu, J. L. Shi

Fracture analysis of nodular cast iron crankshaft. Based on the analysis of the fracture of a certain type of QT800-2 nodular cast iron crankshaft, the cause analysis of the fracture crankshaft is discussed based on macroscopic inspection, metallographic analysis and mechanical properties test. The results show that the shrinkage and surface cracks in the casting process are the main factors leading to the fracture of the crankshaft, and the process improvement measures for the manufacturing process of QT800-2 nodular cast iron crankshaft are put forward.

6. A. R. Toleuova, A. M. Dostayeva, O. M. Zharkevich, S. A. Abdulina, M. A. Adilkanovva, D. Serikbayev

Calculating and experimental studying phase transformations in the Al-Zr-Fe-Si system alloys. The paper presents the results of calculating phase transformations in Al–Zr–Fe–Si alloys. It is urgent to develop a fundamentally new class of aluminum alloys in which the required level of hardening would be ensured by means of alloying them with transition elements and dispersion hardening during heterogeneous annealing, eliminating the hardening operation during their heat treatment. In this case, it becomes possible to maintain the obtained structure stability and high heat resistance at elevated temperatures.

7. P. V. Kovalev, S. V. Ryaboshuk, A. Z. Issagulov, M. K. Ibatov, Sv. S. Kvon, V. Yu. Kulikov

Studying nanopowder modifiers (NPM) effect on structure and properties steels. The article investigated the macrostructure and microstructure of cast metal. Studies have shown that the introduction of nanopowder modifiers leads to a significant modifying effect, which has a positive effect on the structure of cast metal and is manifested in the grinding of both cast grain and dendritic structure. It was found that when the concentration of NPM in the metal in the form of particles of titanium nitride is 0,035 %, the nitride particles are distributed fairly uniformly in the metal volume, the cast metal structure is highly dispersed, and the mechanical properties of the steel significantly increase after thermomechanical processing.

8. Withdrawn from the conference

9. Y. R. Li, W. L. Zang

Prediction and analysis of slab quality based on neural network combined with particle swarm optimization (PSO). Based on the study of the mechanism of bloom crack, the main factors affecting the quality of bloom are determined. The intelligent optimization algorithm combining PSO and Back Propagation(BP) neural network is introduced to establish the prediction model based on typical defects. Collect on-site sample data, normalize it, and PSO is used to recalculate the weights and thresholds to accelerate the convergence and improve the accuracy and stability of the results. The experimental results show that the prediction accuracy of the optimized neural network model is high, and it is closer to the actual production of continuous casting.

10. M. Spilka, W. Łoński, R. Babilas

Corrosion properties of electrodeposited Cu/Co multilayers. The paper presents the results of corrosion resistance of Cu/Co multilayer systems fabricated by using the electrolytic method. The systems obtained were composed of layers differing in number and thickness, which was determined by observing the cross-sections of the samples using scanning electron microscopy (SEM). The measurements of multilayer system corrosion properties carried out in 3,5 % NaCl solution showed different corrosion resistance depending on system thickness. The microscopic observations revealed the effect of the aggressive environment on the Cu/Co multilayer systems manufactured, adopting various forms of corrosion degradation.

11. E. U. K. Maliwemu, V. Malau, P. T. Iswanto, I. Kambali, T. Sujitno, Suprapto

Corrosion fatigue crack propagation of AISI 316L by nitrogen ion implantation in simulated body fluid. A thin layer was formed on the surface of the AISI 316L substrate by the process of nitrogen ion implantation at a vacuum pressure of 10^{-6} torr, a current of 50 mA for 90 minutes with the implantation energy of 20, 40 and 60 keV. The purpose of this study was to investigate the effect of nitrogen ion implantation on corrosion fatigue resistance in Simulated Body Fluid solution as a corrosion medium. The results show that the nitrogen ion implantation could increase corrosion resistance by reducing the corrosion rate and increasing the number of fatigue cycles.

12. Yurianto, S. H. Suryo, Syaiful, Y. Umardani, P. Yanuar

The role of residual stress to hardening and cracking on quenched and tempered armor steel welded joints. The material used in this study is Hot Rolled Plate Steel 10 mm thick. The material cut into two parts. Both are heated at 900 °C, held for 30 minutes, and cooled in water. The first and second

specimens tempered at 125 °C and 175°C, respectively, and produces Q_{900}&T_{125} Steel and Q_{900}&T_{175} Steel. Measure d and do, and the axial, normal and transverse residual stresses using neutron ray diffraction. The method used is to measure free stress and stress, and the axial, normal, and transverse residual stresses using neutron diffraction. The shrinkage always leads to the weld center which causes the weld joint curved by the solidifying weld metal surface. The pattern and direction of the three residual stresses concentrated at the weld center.

13. E. Spišák, J. Majerníková, Ľ. Kaščák, J. Slota

Influence of plastic deformation inhomogeneity on corrosion resistance of tin plates. Thin steel sheets are used in the production of food packaging, especially for long-term storage. Reducing the thickness of steel sheets and increasing the speed of the drawing process in the manufacture of packaging often decrements its plastic deformation stability. These changes bring about the need to use evaluation methods able to determine mechanical and plastic properties of steel sheets quickly and at a low cost. Two types of tin-plated steel sheets were used for experimental research into the influence of plastic deformation on their corrosion resistance. The paper compares the results of the uniaxial tension test and the biaxial tension test of tin-plated sheet properties.

14. F. Vodopivec

Copper wire, model and equation of electrical resistance. Electrical resistance is modeled as conversion of electricity to heat with scattering of axial flux of EE quanta to heat with copper and oxygen electrons. In the derived resistance equation, parameters related to wire substructure, current density and wire temperature are considered. Wire interatoms EE travelling paths are proposed, as well. With 0,00037 wt. % O in copper wire, ASTM quoted resistance is calculated. In absence of electric current, R_c=0, then, copper atoms, J* and oxygen atoms affect the resistance by axial current, rsp quanta flux.

15. S. Gabdullin, S. Baisanov, S. Kim A. Mukhtar

Melting of ferrosilicon manganese with the use of high ash rock coal as a reducing agent. A study of the process of smelting ferrosilicon manganese with the use of high ash rock coals as a reducer instead of traditional coke was carried out. The physicochemical properties of coke from high-ash coals of the Kuu-chek deposit have been studied. The fundamental possibility of its application for the production of standard ferrosilicon manganese in large-scale laboratory conditions has been shown.

16. S. Yeşiltepe, M. K. Şeşen

Hot shortness in steels and a novel aprroach. Hot shortness in steel is a result of tramp element accumulation in recycled steels, mainly Copper (Cu). Cu refinement in conventional steel production method is not achievable. Studies are concentrated on slag chemistry, magnetic separation and chlorination of steel scrap. We report a novel and simple approach in elimination of surface Cu segregation from steel. Cu is found to be accumulating on the steel surface in oxidation process. Oxidation of thin steel slabs concentrates Cu on the steel surface in short time. Machining of the steel surface eliminates Cu segregation and macro surface cracks. Results showed that satisfying mechanical properties can be obtained from machined steel samples.

17. D. F. Liu

Crack analysis of crankshaft for diesel engine. The cause of crankshaft fracture crack of a certain vehicle has been analyzed through macroscopic inspection, chemical composition analysis, microstructure analysis, hardness test, mechanical properties test and dimension inspection. The analysis results show that: All of its chemical composition, microstructure, hardness, mechanical properties and dimensions accord with the technical specifications. However, due to the bearing score of the seventh main journal and the wear of fillet, the crankshaft cracked at multi-points from the fillet. The reason is that the fracture of crankshaft is finally caused by large cyclic external force.

18. B. Oleksiak, K. Kołtało, R. Poloczek

Application methods and selected properties of zinc flake coatings. The lamellar technology, also known as flake galvanising, is gaining an increasing share of the zinc coating market. This share mainly covers the area of fasteners, such as nuts, screws, bolts, buckles and springs. The unquestionable advantages of flake coatings include, among others, high corrosion resistance, total absence of chromium (VI) and hydrogenation of the parts, as well as good resistance to chemicals or UV resistance. This paper presents application methods and selected properties of zinc flake coatings.

19. Iqbal, N. Ali, H. Husin, Akhyar, Khairil, A. Farhan

Effect of pouring temperature on impact toughness on brass (Cu-Zn) through metal casting. The purpose of this study is to investigate the impact toughness of brass (CuZn) with five variations of pouring temperature during the production of cast-samples through a metal casting process. Five variations of the pouring temperature are 1 060, 1 110, 1 160, 1 210, and 1 260 oC, respectively. Meanwhile, the mold is produced from medium carbon steel and does not preheat (room temperature). The results show the maximum impact toughness is 20,67 Joule at 1 110 oC of pouring temperature, then the minimum impact toughness is 17,67 Joule at 1 260 oC of pouring temperature. In general, it can be concluded that the impact toughness decreases with increasing pouring temperature.

20. M. Radoń, Z. A. Opiekun, A. Dec

Structural analysis of sheet nickel welded joints. The paper presents an analysis of structure nickel sheet welded joints made by applying Gas Tungsten Arc Welding (GTAW) method. Based on results of metallographic examination, HV5 hardness measurements, Energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD) analysis of the welds it was found that the joints were characterized with a three-zone structure with large columnar dendrites in the welds. Columnar dendrites show a mosaic sub-structure with uniformly distributed carbides of M3C type rich in nickel.

21. W. Liu, X. D. Shu, G. X. Zhou, X. Z. Du, Y. J. Lang, Y. X. Xia

Effect of solid solution treatment on microstructure and mechanical properties of extruded MgY12Zn2,5 magnesium alloys. The microstructural evolution of MgY12Zn2,5 magnesium alloys was observed, and the strengthening and toughening mechanism of the alloys were studied. The results showed that the MgY12Zn2,5 alloy after solution treatment with higher content of 14H - LPSO (long - period stacking - ordered structures) could more effectively inhibit the recrystallization and growth of recrystallized grains, and the microstructure was more fine and uniform. And its tensile strength (R_m), yield strength (R_v) were 395 MPa, 308 MPa and elongation (A) 17,5 %, respectively. In contrast, the MgY12Zn2,5 alloy treated at 470 °C for 24 h, whose Rm, Rv, were only 376 MPa, 282 MPa and A 15,5 %, respectively.

22. J. F. Jin, G. Song, H.C. Ji, W.C. Pei

Constitutive model of AISI 1035 at high temperature. Use Gleeble-1500D thermal simulation test machine to conduct thermal tensile test on AISI 1035 in the deformation temperature range of 1 173,15~1 373,15 K and strain rate range of 0,2 ~ 20 s^{-1}. Using the obtained true stress-strain curves, an intrinsic model of the material was constructed using a model considering strain compensation. The results showed that the correlation coefficient of the Arrhenius model of AISI 1035 considering strain compensation was 0,984 with an average absolute error of 3,550 %, which can accurately predict the flow profitability. The experimental data matched well with the prediction curves obtained from the model calculation, which verified the feasibility of the model.

23. H. Q. Zhang, H. C. Ji, W. C. Pei, Y. G. Li

Research on model of 6005A aluminum alloy. The deformation behavior of 6005A aluminum alloy at a strain rate of 0,01-10s^{-1}, a deformation temperature of 673-773K and a total strain of 0,8 was studied. Using the stress-strain data of 6005A aluminum alloy with a strain of 0,05-0,8, an Arrhenius-type constitutive model was established. And verified the accuracy of the model. The results show that: the flow stress of 6005A aluminum alloy increases with the increase of strain rate, and decreases with the increase of deformation temperature; Under different strains, the correlation coefficient (R) between the experimental value and the predicted value is as high as 98 %, and the average relative error ($AARE$) is less than 10 %, indicating that the established model has high predictability.

24. R. Yao, H. C. Ji, J. F. Jin, X. Y. Shao, H. Y. Long

High temperature constitutive model of 6005A aluminum alloy. Use Gleeble-3800 thermal simulation test machine to conduct thermal tensile test on 6005A aluminum alloy at 623~723 K and 0,01~1 s^{-1} strain rate. Using the obtained true stress-strain curve, the modified Zerilli-Armstrong (m-Z-A) model considering strain compensation was used to construct the constitutive model of the alloy. The results show that the correlation coefficient and average absolute error of the m-Z-A model are 0,97311 and 4,1779 %, respectively. The experimental data is in good agreement with the predicted curve obtained by calculating the model, which verifies the feasibility of the model.

25. Z. Zimniak

Telctroplastic effect in magnesium alloy AZ31 using supercapacitors. In this work, a pulsed electric current is applied to a specimen simultaneously with a quasi-static uniaxial tensile load. To do so a short-time current pulse generator, inducing supercapacitors was designed and manufactured. The experiments with low operating voltage were performed at different electric current pulse period and frequency. The electroplasticity of AZ31 magnesium alloy under a pulsed electric current is investigated experimentally. Appropriate control of current parameters makes it possible to change not only the stress levels in the process, but also achieved plastic strain values. The result of the present study with low operating voltage is expected to provide a basis to develop advanced metal forming processes using electroplasticity.

26. A. Volokitin, I. Volokitina, E. Panin, A. Naizabekov, S. Lezhnev

Strain state and microstructure evolution of AISI-316 austenitic stainless steel during high-pressure torsion (HPT) process in the new stamp design. The investigation of strain state and microstructure evolution of AISI-316 austenitic stainless steel during high-pressure torsion process in the new stamp design was performed. The study using Deform-3D program was conducted. The deformation was carried out at ambient temperature. The results of strain state study showed that after 4 passes the processed workpiece is obtained the level of equivalent strain more than 5. But the distribution of strain has a gradient view in the cross section. The simulation results of the microstructure evolution showed that after 4 passes of deformation the initial grain size of 12 μm can be reduced up to 0,8 μm. But the distribution of grain size in the cross section also has a non - uniform gradient view.

27. F. B. Chang, Y. Gao, L. Gao, L. Y. Huang

Study on laser welding of dual phase steel. In this paper, Neodymium-doped Yttrium Aluminum Garnet crystal laser welding machine is used to study the laser welding process of dual phase steel. The electric current, pulse width and frequency are selected as variables for welding, and the maximum force of weldment under different parameters is detected by tensile testing machine. Through the analysis of the experimental results, find out the influence of different parameters on the welding quality, select the best welding parameters. The analysis shows that the current has the most significant effect on the welding quality, followed by the frequency, and the pulse width has almost no effect.

28. J. Boryca, C. Kolmasiak, T. Wyleciał, D. Urbaniak, H. Otwinowski

Experimental measurements of scale adhesion for a pre-oxidized steel charge. In industrial practice, the charge is heated before the forming process and often reaches the furnace "cold". This means that after leaving the continuous casting of steel, for various reasons it is not heated immediately, but stored instead. This causes not only the cooling of the charge but also its oxidation in the atmosphere of the surrounding air. The paper presents the research methodology and discusses the results of adhesion measurements for a pre-oxidized steel charge.

29. A. Płachta, B. Oleksiak, G. Siwiec, G. Junak

Mechanical properties of brass sheets. Brass is widely used in the machine industry, automotive, shipbuilding, construction, metalworking industries, as well as in the production of fittings. Certain types of brass, despite the almost identical chemical composition and the same form resulting from the standards, e.g. sheets of a certain thickness, often differ in performance, e.g. mechanical properties. The presented work compares selected mechanical properties of CuZn39Pb2 brass sheets from different manufacturers.

30. B. Oleksiak, M. Kuczyńska-Chałada, R. Poloczek

Application methods and selected properties of zinc flake coatings. This article presents examples of properties of nickel and silver coatings applied by galvanic method. For quality tests, profilometric and thermal expansion methods were used.

31. A. E. Burdonov, P. K. Fedotov, Y. V. Novikov, A. A. Garashchenko, M.P. Kuzmin, A. V. Rasskazova

Influence of temperature on the strength of alumina-containing raw materials. The work is devoted to the study of the effect of temperatures on the physical and mechanical properties of an alumina-containing product in order to select crushing and grinding equipment for subsequent enrichment operations. In the course of the study, three series of experiments were carried out: at room temperature 23 °C, with heating the material in a drying chamber to 200 °C, and also under cryogenic exposure – 195,75 °C using liquid nitrogen. As a result, the substantiation of the change in the physical and mechanical properties of raw materials when changing is presented. Recommendations for the selection of crushing equipment have been developed.

32. A. A. Akberdin, A. S. Kim, A. S. Orlov, R. B. Sultangaziyev

Mathematical model of the diagram of the Fe-Si-B composition system. A diagram of the phase composition of the Fe – Si – B system is constructed in the form of elementary triangles of coexisting phases and its mathematical model was created. Its isothermal sections are given in the temperature range of 300 - 2 000 K. The diagram is composed of one-component phases Fe, Si, B, binary compounds Fe_3Si, Fe_2Si, Fe_5Si_3, FeSi, $FeSi_2$, FeB, Fe_2B, SiB_4, SiB_6, SiB_{14}, as well as ternary phases Fe_5SiB_2 and Fe_5Si_2B. To estimate the sizes of crystallization fields, the areas of elementary triangles were calculated, the probability of existence (prevalence) of each compound in the phase space of the diagram was established.

33. A. A. Akberdin, A. Z. Issagulov, S. S. Kvon, Ye. P. Chsherbakova, D. R. Aubakirov, G. H. Adamova

Modifier effect on mechanical properties of low-chromium cast iron. The results of studying the properties of prototypes obtained at the production site of the QazCarbon LLP (Karaganda, Republic of Kazakhstan) are presented. Grinding balls were smelted of low-chromium cast iron treated with modifiers of various nature. Boron-barium-containing materials were used as modifiers. It was found that the use of boron-barium-containing additives as modifiers qualitatively and quantitatively changes the structure of the alloy under study. After modification, the structure becomes more dispersed, the quantitative ratio between the main structural components:ledeburite, pearlite and carbide phase, changes. Such changing the structure has a positive effect on the impact resistance of the samples.

34. M. Krbaťa, J. Majerík, I. Barényi, M. Eckert, R. Čep, J. Sedlák, I. Samardžić

Dilatometric analysis of cooling curves for high strength steel X155CrMoV12. The article deals with phase transformations and austenitizing behavior of the X155CrMoV12 tool steel. Dilatation analyses of a series of samples were performed at various cooling rates, chosen in the range from 10 °C/s to 0,1° C/s. Acquired experimental data were used for evaluation of dilatometric curves in order to map the temperature ranges of phase transformations of the austenite to pearlite, bainite or martensite. All experimental samples from dilatometric analyses were then subjected to microstructural analyses and hardness measurements to characterize the microstructure and hardness for each tested heat treatment regime.

35. M. Krbaťa, J. Majerík, I. Barényi, M. Eckert, R. Čep, J. Sedlák, I. Samardžić

Experimental determination of continuous cooling transforma-tion diagram for high strength steel X155CrMoV12. The article is a result of investigations which deals with the phase transformations of tool steel X155CrMoV12. The experimental data obtained was used to evaluate the resulting Continuous Cooling Transform (CCT) diagram, which consists of seven dilation curves. All experimental samples from dilatometric analyzes were then subjected to microstructural analyzes and hardness measurements to characterize the microstructure and hardness for each heat treatment mode tested. Atomic Force Microscopy (AFM) microscopy was also used to study the carbides present in steels and their size and shape for all selected cooling modes.

36. G. Shvachych, I. Mamuzić, V. Tsvykh, M. Khylko, H. Sashchuk, O. Timchenko, O. Ivaschenko, D. Moroz
Some complex intensification features of spheroidizing annealing of low carbon steel. The paper considers complex intensification features of spheroidizing annealing of low-carbon steels and possible technological realizations of intensive annealing modes in current lines. The research aims to reveal the intensification nature of the steel's spheroidizing due to the non-isothermal holding and an internal coolant for the metal heating. That allows a significant reduction of the spheroidizing annealing process while improving the steel product's technological properties – providing a high dispersion and homogeneity of the structure across the entire plane of its section. The multiprocessor computing system with its mathematical and IT software for modeling the heat treatment modes of metal billets effectively controls the processes.

37. A. A. Akberdin, A. Z. Issagulov, D. R. Aubakirov, R. B. Sultangaziyev, S. K. Arinova
Thermodynamic simulation of phase formation in chrome cast iron. The analysis of phase formation in gray and chromium – alloyed cast iron has been carried out.The method of complete thermodynamic simulation with the TERRA software package has been used.The calculations have been carried out inthe temperature range of 500 – 2 000 K at the system pressure 0,1 Mpa.The conditions for the formation of chromium carbide needed for the production od wer – resistant materials have been found.

38. S. Gubenko, I. Mamuzić
Interphase boundaries inclusion-matrix in steels. The features of the structure of interphase boundaries of the inclusion-matrix and their influence on the behavior of nonmetallic inclusions under deformation and thermal effects are investigated. The influence of high-energy treatments and active media on the formation of microcracks in steels along the inclusion-matrix boundaries is shown. The transformation of nonmetallic inclusions and interphase boundaries of the inclusion-matrix under various thermal and deformation effects and its influence on the properties of steels is studied. The active role of the interphase boundaries of inclusion-matrix in the formation of mechanical, technological and operational properties of steels is shown.

39. S. Gubenko, E. Parusov
Plasticity of the alloys with different structures. The manual describes modern concepts of the physical nature of plasticity and strain strengthening of metals and alloys having different crystal structure and microstructure. The basic mechanisms and features of plastic deformation under different loading conditions are considered. The interrelation between phase and structural transformations in metals and alloys with processes of strain strengthening and dynamic softening is shown.

40. S. Gubenko, I. Mamuzić
Phase and structural changes in the eutectic inclusions in steels under laser action. In the result of the system eutectic inclusion-matrix transits to the state of unstable equilibrium which determines structure and properties of laser-quenched interphase boundary. Processes of melting, fusion and dissolution of eutectic non-metallic inclusions and also of the melting of steel matrix play the great role in transformation of inclusion-matrix boundaries under laser action. In the result of high-speed melting of inclusions "eutectics" heavy oversaturated liquid solution or two liquid solutions on the base of inclusion and steel matrix differing by concentration heterogeneity are formed. In such liquid systems nonbalanced mass transfer is happened that suppresses of cooperative growth of phases and formation of cooperative structures of non-metallic inclusion.

41. O. V. Movchan, K. O. Chornoivanenko, I. Mamuzić
In-situ composite based on alloys of the Fe-V-Cr-C system. The regularities of structure formation during carburizing of the Fe-V-Cr system alloys have been investigated. It is shown that the growth of three-phase austenite-carbide colonies $\gamma + VC + Cr_{23}C_6$ is possible in this system. The temperature-concentration conditions for the growth of ternary austenite-carbide colonies in the Fe-V-Cr alloys have been established. They grow in the Fe + 3.3% V + 14.5% Cr alloy during carburizing at 1100 °C. The wear resistance of the Fe + 3.3% V + 14.5% Cr alloy with triple clones in a carburized layer has been investigated. It is shown that the wear resistance of a colonial structure of a carburized layer significantly exceeds the wear resistance of layer with globular carbides.

42. D. B. Hlushkova, I. Mamuzić
Corrosion resistance of reinforced layers of 15Х11МФ steel steam turbine blades. Corrosion tests of blade samples were carried out, the leading edges of which are reinforced in three ways: by reinforcing with high-frequency currents, electrospark alloying with T15K6 alloy, and electrospark alloying with 15Х1МФ-ІІІ steel. According to the results of the tests, the layer reinforced by quenching with high-frequency currents has the lowest rate of corrosion, and the layer reinforced by electrospark alloying with T15K6 hard alloy has the highest rate. The corrosion rate of a layer reinforced with electrospark alloying with 15Х11МФ steel is 2.1 less than that of a layer reinforced with T15K6 alloy.

43. O. I. Derevianko, I. Mamuzić
Fractal criterion for assessing the corrosion of metals. Physicochemical processes that form the phenomenon of metal corrosion are nonlinear and have areas of chaotic behavior, which causes the formation of corrosion microstructures on the metal with fractal properties. As a result of the research, it has been shown that the metal corrosion process has a pronounced crossover of fractal dimension values. The emergence of which is associated with the beginning of the formation of a loose border of corrosion seat. This effect causes an avalanche-like process of metal corrosion. The proposed method for determining the appearance of a crossover makes it possible to record the moment of a change in the type of corrosion.

44. T. V. Kimstach, S. I. Repiakh, K. I. Uzlov, I. Mamuzić
Cu-Al -Sn system low-alloyed alloys properties investigation. The best of investigated alloys within Sn and Al variation indicated ranges has ultimate tensile strength R_m = 220 ... 300 MPa, tensile yield strength $R_{v0,2}$ = 115 ... 130 MPa, specific elongation A_5 = 20 ... 30 %, impact toughness KCU = 50 ... 120 J/cm^2 and hardness *HB* = 770 ... 830 MPa. Cast alloy free linear shrinkage value is 1,31 ... 1,49 %, absolutely difficult linear shrinkage is 0,39 ... 0,43 %. Alloy transition temperature from ductile to elastic state during cooling in casting mold is 255 ... 305 °C. It has been found that for developed alloy with aluminum and tin content increasing, E_5, KCU and UTS values decrease. $R_{v0,2}$ value increases with content of both Al and Sn in bronze increasing.

45. N. E. Kalinina, T.V. Nosova, I. Mamuzić
Increase of structural stability and properties of heat-resistant nickel alloys by nanomaterial treatment. An analytical review of the existing views on the problem of the high-temperature strength of high-temperature nickel alloys of the of gas turbine engine blades has been carried out.. For the treatment of nickel melts, a complex powder modifier based on titanium carbonitride Ti (CN) with a particle size of 50...100 nm was proposed. An increase of the alloys mechanical properties of alloys was also achieved: $R_{v0,2}$ – by 10… 13 %; R_m – by20% ; KCU - by 40%. The tests for high-temperature corrosion showed decrease of the corrosion depth in modified samples by 25%, which is confirmed by the effect of modifying with nanodispersed modifiers.

46. Yu. Proydak, L. Isaeva, I. Mamuzić
Rational amounts of titanium and aluminum in carbon steels to obtain dispersed nitrides under hot rolling conditions. Heat treatment is optimally carried out in two modes: normalization or quenching at 900 °C and subsequent tempering at 650 °C. With this heat treatment, there are two temperature maxima for the release of aluminum nitrides in austenite (900 °C) and ferrite (650 °C). Aluminum nitrides with a cubic lattice released from ferrite are more dispersed and have a better effect on the properties of steel than hexagonal AlN formed from austenite. For the complete binding of nitrogen to AlN nitrides, the amount of aluminum in carbon steel must be ≥40 • 10-3 wt. %. To obtain fine nitrides and maintain a sufficiently high fluidity of carbon steel, the optimal aluminum content should be (40 - 60) • 10-3 wt. %.

47. V. A. Gladkykh, Yu. S. Proidak, A. V. Ruban, I. Mamuzić
DSC analysis of the MnO-Al_2O_3 system. According to one version, the diagram shows two eutectics (E_1 - 24 % Al_2O_3, 76 % MnO) and (E_2 - 72 % Al_2O_3, 28 % MnO) and manganese spinel $MnAl_2O_4$, which melts congruently at 1 850 °C. According to another version, the E_2 eutectic is absent, and

the spinel melts incongruently. The nature and melting point of the compounds of this system play an important role in the smelting of ferrosilicon manganese with high silicon content. The experimental data obtained are close to the phase diagram with incongruent spinel melting and the absence of the E_2 eutectic. The data obtained make it possible to predict the earlier appearance of the liquid phase and to consider the carbon reduction process of MnO and Al_2O_3 from the liquid phase.

48. A. Yu. Proidak, I. Mamuzić, M. Poreba

Quality of a Copper-Phosphorus Alloy. Experimental melting was carried out in a Tamman furnace to obtain a ligature (10,06 % P; 73,14 % Cu; 15 % Fe; the residue is represented by impurities). The alloy was subjected to the electron microscopic study using an X-ray microanalyzer, thus revealing the alloy structure represented by copper phosphide $Cu_3P_{(1+x)}$, iron phosphide Fe_2P, solid solution of Si and P in copper, and eutectic. Copper-phosphorus alloy, smelted using crude phosphorite, can be recommended for complex alloying of cast irons and steels for various functional purposes. When using phosphorite concentrates that have been enriched according to the developed magnetic flotation scheme, the iron content in the alloy is minimal.

49. G. N. Tregubenko, G. A. Polyakov, S. N. Podgorny, I. Mamuzić

Production of construction steel with carbonitride hardening on basis of the complex microalloying of N – Ti – Al. The analysis of literary data and authors long-term researches is in-process executed in area of theory and practice of production of steels with carbonitride hardening is shown. The influence of nitrid elements on a microstructure and properties of a steel on all stages of metallurgical redistribution (cast and deformed metal before and after heat treatment). At is determined the examples of industrial application of the offered system of wide spectrum microalloying of economical steel for build constructions and special engineer (railway transport, pipeline armature and other) are given.

50. Yu. S. Projdak, G. N. Tregubenko

Development of production technology sparingly steel with carbon nitride hardening for power engineering. The technology of production of cast economic steels with high quality indicators for mechanical and operational properties at elevated temperatures is developed. The developed technology can be used to manufacture the castes of parts of responsible purpose and high strength operating in the temperature range of 250-450 °C. For example, for the production of parts of hydro-, steam and gas turbines, the parts of the nuclear power plants, heat supply stations, thermal power plants, nuclear reactors and installations, as well as parts of welded structures with a large volume of welding.

51. V. Selivorstov, Yu. Dotsenko, D. Nasonov, I. Mamuzić

The effect of modification with silicon carbide on the mechanical properties of the secondary aluminum alloy of the Al-Si system. The effect of modification on the mechanical properties of the secondary aluminum casting alloy (wt.%: 0,528 Mg, 1,124 Cu, 11,539 Si, 84,969 Al, 0,905 Fe, 0,692 Zn, 0,242 Mn) without heat treatment was determined by the introduction of silicon carbide with a particle size of 1-3 μm in the amount of 0,1, 0,2, 0,3 wt. %. When the content of SiC in the alloy from 0,1 % to 0, 2%, the indicators of R_m increase from 130-145 MPa to 155-166 MPa, respectively. Increasing the SiC content to 0,3% leads to a decrease in R_n values in the range of 117 - 127 MPa. Hardness indices (HD): unmodified alloy - 42 - 43, alloy with a content of 0,1% SiC - 43 - 44, with a content of 0,2% SiC - 46 - 47, with a content of 0,3% SiC - 43 – 44.

52. I. O. Serzhenko, V. T. Kalinin, I. Mamuzić

Specific features of the physico-chemical processes during the hardening of the nanodispersed surface layer of the casting in the form. The mechanism of interaction of the cast iron melt with the layer of nanodispersed compound includes the following processes: heating of the layer of powder (possibly paste) due to the physical heat of the melt; filtration of the melt into the pores of the powder and its further heating; distribution of nanopowder particles in the liquid phase at the time of melt filtration; further distribution of nanopowder particles in the liquid phase after filling the intergranular space; diffusion processes during cooling of the impregnated metal in the solid state. The technology of using nanopowders as hardening agents to obtain a wear-resistant cast composite layer is a promising direction in the foundry industry .

53. V. Selivorstov, Yu. Dotsenko, N. Nasonov, I. Mamuzić

The effect of modification with silicon carbide on the density of the secondary aluminum alloy of the Al-Si system. The effect of modification on the density of the secondary aluminum casting alloy (wt.%: 0,528 Mg, 1,124 Cu, 11,539 Si, 84,969 Al, 0,905 Fe, 0,692 Zn, 0,242 Mn) was determined with the introduction of silicon carbide powder with a particle size of 1-3 μm in an amount of 0,1, 0,2, 0,3 wt. %. It has been established that the density of the alloy of castings with a silicon carbide content of 0,1 % is 2 761 kg/m^3, and that of the unmodified alloy is 2 715 kg/m^3. With an increase in the silicon carbide content to 0,2%, the density of the metal is 2 735 kg/m^3. With a SiC content of 0,3 wt.%, the density of the alloy is 2 752 kg/m^3. The density of the metal of the castings obtained in the sandy-clay form with the modification of 0,1% SiC is 2 673 kg/m^3, with 0,3% SiC - 2 676 kg/m^3.

54. A. Hrubiak, L. Kieush, A. Koveria, S. Fedorov, I. Mamuzić

Investigation of the Nickel-Cobalt Manganese cathode material from spent lithium-ion batteries via Infrared spectroscopy. In this research, it present a way through which to identify the structure of Nickel-Cobalt Manganese (NCM) cathode material by means of Infrared spectroscopy (IR spectroscopy). Based on the IR spectra of the initial cathode material, there are intense adsorption peaks that stretch the C=C bonds in the graphite structure. In addition, the peaks of 3000-3700 cm^{-1} are not observed, which proves the absence of O-H functional groups. After annealing, it was noticed that the surface structure of NCM has been changed. The appeared peaks indicate the recovery of NCM cathode material. The peak intensities of stretching vibration at 3410 cm^{-1} correspond to N-H groups, vibrational peak at 1650 cm^{-1} is related to C-C and C=O groups and vibrational peak at 1080 cm^{-1} characterizes the presence of C-N or C-O groups.

55. K. I. Uzlov, S. I. Repiakh, A. V. Dziubina

Aluminum bronze BrA9Zh3L per GOST 493 solid state transformations and properties processing. According to aluminum-ferrous bronze BrA9Zh3L microstructure and reticular characteristics studies results, it has been found that under significant undercooling (cooling rate> 1°C /min) below eutectoid temperature (at ~ 500 °C), martensitic transformation occurs with high-temperature β-phase stabilization and/or its martensitic derivatives: β_1, β_1', β', etc. formation. These phases, due to their origin diffusion-less mechanism, atoms in cubic crystal lattice ordered arrangement preserve. Technological or natural impurity Zn – 0,2…0,3% content leads to impact properties catastrophic decreasing. This is due to in alloy, as eutectoid structure $\alpha+\gamma_2$ component, rhombohedral chemical compound γ_2-Cu_9Al_4 of trigonal system formation.

56. M. A. Kovzel, T. V. Kotova, I. Mamuzić

Structure and properties of deformed ultra-low carbon steels. It investigated the effect of rolling deformation modes in the ferritic temperature range on the formation of the structure and properties of ultra-low-carbon steels. It was found that as a result of processing, which includes rolling the studied steels in two passes and cooling with a furnace, an uneven structure and the following set of properties were formed: R_m = 225–260 MPa; R_v = 165–195 MPa; R_m/R_v ~ 0,72–0,73; A = 25-32 %; HRF 73–75. The results of the work make it possible to determine the optimal composition of ultra-low-carbon steels, make the choice of rational technological modes of obtaining thin-sheet rolled products and so on.

57. M. A. Kovzel, T. V. Kotova, I. Mamuzić

Optimization of the composition of steels 01ЮТ, 01ЮТА by the method of physical and chemical modeling. Concentration ranges of elements to optimize the composition of ultra low carbon steels and to ensure the required set of rolled products properties were obtained using the method of physico-chemical modeling. The choice of the concentration of elements for 01ЮТА, 01ЮТ steels implemented in the range: C (0,002…0,003 %), Mn (0,12-0,13 %), Si (0,01-0,02 %), P (0,006-0,008 %), S (0,011-0,012%), Al (0,04-0,05 %), Ti (0,05-0,06%), N (0,004-0,005 %), Ca (0,0002-0,0003 %). The concentration interval of the elements, established according to the calculated data, will provide a uniform structure and the necessary set of properties of steels capable of deep drawing.

58. F. Vodopivec, S. Rešković, I. Mamuzić

The influence of Nb content on the crystal latice distortion of a final thermomechanical treatment microalloyed steel. Studies have been performed on microalloyed steel with three different niobium content: 0,036%, 0,048% and 0,066%. All steels had the same basic chemical composition.

Samples for research were taken from different phases of final thermomechanical treatment. The samples were analyzed by transmission electron analysis and X-ray diffraction profile analysis. Precipitation of niobium carbonitrides was observed in all tested samples. In steels with 0,048% nobium, densely complex carbonitride arrays were observed in the grain and along the boundaries of the crystal grain. The highest degree of interaction between deformation of induced nobium precipitates and dislocations was found in steels with o, o48% Nb. The largest distortion of the crystal lattice was determined on the same samples. In steel with 0,036% niobium is less pronounced and the crystal lattice distortion is less.

59. L. Zheng, D. Xu, Y. C. Ren, B. Zheng
Cause analysis and improvement measures of steel-heaping in wire rods production. Based on the composition detection results of steel inclusions, it is found that the steel-heaping reason of cold heading wire is caused by the slag entrapment in steelmaking process. In view of the above reasons, by controlling the fluctuation of liquid level of tundish, controlling the fluctuation of continuous casting speed, optimizing the thickness of covering slag and tundish cover powder, the phenomenon of steel-heaping in the rolling process can be effectively reduced when producing Q195 and other cold heading steel. It is of great significance to guide process improvement.

60. I. Vidaković, G. Heffer, K. Grilec, I. Samardžić
Resistance of modified material surfaces for agricultural tillage tools to wear by soil particles. Agricultural tillage tools are exposed to various forms of wear during operation. Abrasive wear by soil particles is the most important wear form, and the most exposed to it are representatives of tools whose working parts are in direct contact with the soil during work - plows, subsoilers, disc harrows, harrows, cultivators, etc. The factors of wear process can be divided into three categories - abrasive soil conditions, tillage tool properties and operational factors. The paper presents a research of the abrasive wear of modified material surfaces (quenched, cladded and boronized) during motion in the mass of soil particles at different speeds and a comparison of their abrasion resistance.

61. S. K. Arinova, T. V. Kovaleva, D. A. Issagulova
Niobium effect on heat resistant properties of Cr18Ni10Ti steel
The niobium effect on long-term strength of Cr18Ni10Ti steel is considered. There is substantiated selecting this steel for obtaining cast parts for metallurgical furnaces. It is shown that introduction of Nb in amount of 1% into steel of a given composition increases tensile strength by 15%. Improving the properties is associated with the formation of NbC carbides.

62. B. Kelamanov , O. Sariev, A. Akuov, Ye. Samuratov, Z. Sultamuratova, R. Orynbassar
Study of nickel briquettes by thermographic method. The results of thermogravimetric studies of nickel concentrate (briquettes) with the establishment of its characteristic features are presented. The study of nickel concentrate with different reducing agents showed the thermographic possibility of involving them in metallurgical processing. The values of the activation energy in the process of thermal studies are determined.

63. B. Kosec, M. Bizjak
Thermal properties of cu-Al-Ni-Mn shape memory alloy. The mechanical properties and microstructure of copper base shape memory alloys are relatively well known, while data on thermal properties (thermal conductivity, specific heat, temperature conductivity) are not available. In the frame of our investigation work thermal properties of rapidly solidified Cu-Al-Ni-Mn alloy were determined. As the first part of the work, a study and evaluation of the device for determining the thermal properties Hot Disk TPS 2200 has been carried out. In the second part of the work, the measurements and analysis of thermal properties of rapidly solidified Cu-Al-Ni-Mn in accordance with the standard ISO 22007-2 at ambient and elevated temperatures has been done.

64. V. V. Yugay, A. D. Mekhtiyev, S. G. Ozhigin, R. Zh. Aimagambetova, Y. G. Neshina, Y. Zh. Sarsikeyev
Using optical fibers to control the stress-strain state of steel structures subject to fatigue failure. The article presents the results related to developing and practical testing the method of monitoring the stress-strain state of steel structures of mine hoisting machines. Certain positive properties of optical fibers make it possible to use them for measuring the stress-strain state of steel structures. An optical fiber of the ITU-T G.652.D standard is used as a sensor. The analysis and review of the current state of development of fiber-optic conductors is performed. The proposed method of non-destructive testing the stress-strain state of metal structures is capable of providing continuous measurements in real time. The proposed method is universal and suitable for monitoring the stress-strain state of any metal structures subject to fatigue failure.

65. A. Marek
Hot dip Zn-5Al coatings with improved corrosion resistance of reinforcement steel. The article presents the results of tests of Zn-5Al coatings obtained on reinforcement bars made of B500SP steel. The microstructure using Scanning electron microscopy (SEM) and chemical composition in microregions using Energy dispersive spectroscopy (EDS) are shown. The electrochemical parameters of the corrosion process of the coatings were determined and the mechanical properties of the reinforcement bars after the coating were tested. It was found that the coating consists of the outer layer consisting of hypoeutectic regions of Al solution in Zn (α) and the ZnAl eutectic (α+β), and a diffusion layer composed of $FeAl_3$ phase. Potentiodynamic tests have shown that the Zn-Al5 coating provides sacrificial protection for the reinforcement steel and has a much lower corrosion current density compared to the traditional zinc coating.

66. A. S. Kim, A. A. Akberdin, N. Yu. Lu, R. B. Sultangaziyev, A. S. Orlov
Diagram of the equilibrium phase composition of the Fe – Cr – Si – B system. Isothermal sections of the phase composition diagram of the Fe – Si – Cr – B system in the temperature range of 300 – 3 000 K with a step of 200 K are constructed. The diagram is shown at a temperature of 1 900 K, which is typical for silicochromium at the outlet from the furnace. A mathematical model of the diagram has been created in the form of a system of linear equations connecting the chemical composition of the metal with its phase. A computer program has been developed for the numerical calculation of the number of formed phases. Silicochromium with 0,3 – 0,5 % boron is located in the crystallization field $CrSi_2$ – Si – SiB_4 – FeSi.

67. S. K. Arinova, Sv. S. Kvon, V. YU. Kulikov, M. M. Abdildina, A. E. Omarova
Thermodynamic modeling and analysis of the structure of a heat-resistant alloy of the Fe-Cr-Ni system. There has been carried out thermodynamic modeling of phase transformations of the Fe-Cr Ni alloy alloyed with titanium and niobium in order to predict the phase composition and to substantiate the concentration of alloying elements of the experimental alloy for parts of metallurgical equipment. The results of microstructural analysis and phase composition of an experimental heat-resistant alloy are presented.

68. A. D. Mekhtiyev, P. A. Kropachev, Y. G. Klyuyeva, S. Zh. Aizhambayeva, A. V. Yurchenko, A. D. Alkina
Strengthening elements to increase fatigue strength of mine hoisting machine steel structures. The article deals with the issues of reliable operation of metal structures of mine hoisting machines. A method has been developed that makes it possible to increase the brake device steel beam structures strength, which will further prevent the formation and growth of cracks in the body of the metal structure. It is proposed to strengthen the «weak points» in the structure to increase strength and resistance to fatigue failure with the complete rejection of using expensive high-strength alloys. To study the stress-strain state and fatigue failure of steel structures, the method of computer simulation was used. The article presents the results of studying metal structures of mine hoisting machines by non-destructive testing methods; the percentage of various damages is determined. The article discusses a method for combating fatigue failure of steel structures through the use of elements that strengthen the structure in the places of its fatigue failure.

69. L. V. Semushkina, N. K. Tussupbayev, D. K. Turysbekov, S. M. Narbekova, M. M. Musina
Processing of mature copper tailings from concentration plant using a composite reagent. The research presents the results of laboratory studies on the flotation processing of mature copper tailings using KF2 composite reagent. KF2 flotation agent is a mixture of sodium butyl xanthate, thionocarbamate, and composite aerofloat at a ratio of 1:1:3. In the base regime, a rough copper concentrate obtained had a copper content of 10,9 % with a recovery of 74,91 %. The use of KF2 composite flotation reagent increases the extraction of copper into rough copper concentrate by 5,31 %. This made it possible to obtain a rough

copper concentrate with a copper content of 13,0 % and a recovery of 80,22 %. Consumption of KF2 flotation reagent is halved compared to the basic sodium butyl xanthate collector.

70. J. Dolenc, A. Nagode, P. Fajfar
Characterization of the ancient horseshoe. The history of hoof protection for horses dates back to 400 BC, when hooves were protected with plants and leather straps. Metal horseshoes as we know them today were developed in the 9th century. An archaeometallurgical characterization of an iron horseshoe found in Slovenia was carried out. Based on its shape, we estimate that it dates from the 15th century. The metallographic properties and hardness of the examined horseshoe were compared with the results of new modern horseshoes.

71. T. Šolić, D. Marić, S. Suhi, I. Samardžić
Analysis of the vehicle exhaust system corrosion and its effect on the eco-test result. This paper deals with analysis of the vehicle exhaust system quality and its influence on the results of measuring exhaust emissions of the Otto and Diesel motor vehicles. Results of eco-tests obtained from correct and faulty vehicle exhaust systems were compared to conclude that damages caused by corrosion had significant influence on the pass rate of vehicles at eco-test. Referring to vehicles with the Otto engine, damages in the exhaust system increase the oxygen level, which results in the increased λ factor and in failure at the eco-test. On the contrary, vehicles with the damaged Diesel engine exhaust system allow the gas to leak through the damage, so the measurement of blackening is lower, i.e. the eco-test result is better than that of the exhaust system without damage.

72. W. Ścieżor, R. Kowal, K. Franczak, G. Kiesiewicz, P. Kwaśniewski, S. Kordaszewski, M. Sadzikowski
Determination of the properties of AlCu4,5Mg3 alloy obtained in the continuous casting line. The presented research work covered both metallurgical synthesis of the AlCu4,5Mg3 and the continuous casting process of casts rods with a diameter of 14mm. The obtained cast rods were further subjected to the chemical composition tests in order to determine the homogeneity and distribution of the alloy additives. Additionally the materials were tested not only in terms of their mechanical properties in the Vickers hardness test but also in terms of their structure using light microscopy and scanning electron microscopy.

73. B. Smyrak, M. Zasadzińska, T. Knych, A. Mamala, A. Kawecki, M. Walkowicz, P. Strzępek
Susceptibility to deep processing in the wire drawing process of etp and of grade copper. The susceptibility to deep processing in the industrial wire drawing process has been investigated in the research paper regarding the copper grade influence on the process. The conducted research included the identification of the mechanical and electrical properties of wires manufactured from Cu-ETP wire rod and Cu-OF cast rod in terms of the applied deformation. In particular, as main contribution of this research to the scientific and industrial community a mathematical model describing the wire strengthening and softening characteristics was determined.

74. A. Kawecki, E. Sieja-Smaga, P. Kwaśniewski, G. Kiesiewicz, P. Kretowicz
The influence of heat treatment and plastic deformation on the electrical and mechanical properties of Cu-Ag alloys for the construction of high-field bitter type electromagnets. Cu-Ag alloys may be used in the form of sheets for the construction of Bitter type magnets. The paper presents results of laboratory studies on obtaining of ingots from Cu-(1÷7wt.%)Ag alloys, solution treatment and aging and rolling proces. Has been shown influence of different heat treatment and plastic deformation on the mechanical and electrical properties. The microstructural analysis of castings and sheets with the use of SEM microscopy is also presented.

75. A. Kawecki, E. Sieja-Smaga, A. Brudny, A. Morawski, T. Cetner, R. Kowal
Research on properties of multi-core superconducting wires made from materials based on magnesium and boron. The article presents the results of laboratory research on the production of multi-core superconducting wires. Multicore wires containing boron and magnesium powders in a copper matrix were obtained in the drawing process combined with intermediate heat treatment. The wires contains powder cores were sintered under high isostatic pressure to produce the MgB_2 superconducting phase. The critical temperature for the composite's superconducting state was determined. The microstructure (SEM) and chemical composition analysis of multi-core wires was also presented.

76. S. Cai, F.Y. Zhu, H.C. Ji, Z.L. Zhao, W.C. Pei, J.Y. Zhang
Pipeline offline trough cleaning technology. In the process of contemporary industrial pipeline installation, most pipelines must be cleaned before being put into use due to production and operation process requirements. This paper takes the offline trough cleaning of pipelines as the research object, and explores the evolution process of the metal microstructure under this cleaning method and the best cleaning conditions under the influence of the three factors of concentration, temperature and time.

77. A. Nowak, R.Kowal, E. Sieja-Smaga, P. Strzępek
Influence of heat treatment on fatigue properties of 6101 series aluminium alloy wires. AAAC conductor fatigue resistance in overhead power lines is critical for electrical safety and stability of power transmission system. The article discusses the influence of the artificial aging of 6101 series aluminium alloy wires on their operational properties. Moreover, the influence of the proposed heat treatment on the fatigue strength and the nature of breakthroughs of the tested wires was compared.

78. G. Kiesiewicz, A. Mamala, W. Ścieżor, P. Kwaśniewski, A. Kawecki, M. Sadzikowski, K. Franczak
Metallurgical synthesis of modified EN-AW 6080 alloy with different Mg and Si content ratio and research on basic mechanical and electrical properties of obtained materials. Research works presented in the article aim to determine optimal ratio of Mg and Si content in chemical composition of commercial EN-AW 6080 aluminium alloy in order to maximize mechanical properties of this material. Various amounts of Si (in the rage of 0,6-1,2 wt. %) and Mg (0,6-1,1 wt. %) along with 0,4 wt. % of Fe, 0,4 wt. % of Mn and 0,05 wt. % of Ti were metallurgically synthesised with the use of gravity die casting process which allowed to obtain 5 different castings. In the next phase of research works all alloys were subjected to mechanical and electrical properties testing in as cast temper and after performed heat treatment.

79. M. Maleta, J. Kulasa
Influence of the variable content of Al, Ni and Fe on the mechanical properties and susceptibility to cold working of aluminium bronze. In this study, the influence of the variable content of Al, Ni, Fe on the grain refining and the change of mechanical properties of aluminium bronze cast into iron ingot mould was investigated. The ingots were tested for susceptibility to cold plastic working in the rolling process. It was shown that a small amount of iron (0.8 wt. %) influenced a significant level of grain refining and improvement of mechanical properties. For alloys with an increased content of Al, Fe and Ni, the maximum value of the true strain of 0.36 was achieved in the cold rolling process. The possibility of achieving similar mechanical properties for alloy with reduced content of alloying elements was demonstrated after applying the true strain of 0.61.

80. J. Kasińska, P. Matusiewicz, P. Malinowski, L. Barwicki
Matrix replica-based assessment of the microstructure of primary steam piping elbows after long-term operation. The degree of degradation of ferritic-pearlitic steels is assessed by describing the size, dispersion and distribution of carbides along the grain boundaries, grain growth and the occurrence of microcracks. The article reports the results od the microstructural assessment of primary steam pipeline elbows made of 13HMF steel. Digital image analysis of matrix replicas was performed. It included the classification of microstructures in terms of pearlite/bainite change classes (fragmentation of cementite plates, spheroidization, coagulation) and the evaluation of carbide precipitation processes and damage processes. The perlite/bainite areas were found to disappear completely after long-term operation.

81. K. Milewski, M. Madej
DLC coatings on the roller bearing elements of belt conveyors. The aim of the study was to analyze the anti-wear diamond-like carbon coatings produced by Plasma-Enhanced Chemical Vapour Deposition. The DLC coatings were deposited on the rings of rolling bearings operating in the belt conveyors. The service life of the bearings was 1.5 years. The bearings were exposed to harsh environmental conditions. After disassembly of the bear-

ings, the influence of the coatings on the improvement of the tribological properties of friction nodes was assessed. Characterization of the geometric structure of bearings was carried out on an optical profilometer. The use of diamond-like coatings on rolling bearings has extended the service life of friction nodes in industrial conditions three times.

82. J. Kowalczyk, M. Madej, D. Ozimina

Influence of coating application parameters on selected properties. In order to improve the functional properties, e.g. tribological, strength, anti-corrosion, coatings are applied. The coatings can be applied by the physical PVD and chemical CVD vapor deposition. In addition, the process chemical vapor deposition can be supported with plasma PACVD in order to obtain lower temperatures of the deposition process. In this paper, titanium coatings were deposited on steel using the PACVD process. These coatings were deposited at the same gas flow and power parameters, but at different times. This resulted in the creation of coatings with different properties. Increasing the time by half increased the thickness of the coating by about 78%.

83. K. Piotrowska, M. Madej

Influence of TiO_2 coating deposited with the ALD technique on the properties of Ti13Nb13Zr titanium alloy. Research conducted in many centers around the world shows that despite advances in the use of biomaterials for medical applications, tribological and corrosive wear remains a significant problem. The paper presents the geometric structure of the surface, hardness and the results of tribological tests for TiO2 layers obtained by the ALD technique. The geometrical structure of the surface before and after the tribological tests was assessed using a confocal microscope with interferometry mode. An instrumental indentation was used to measure nanohardness. Model tribo tests were carried out for reciprocating motion under conditions of dry friction and friction lubricated with artificial saliva and saline. The tests showed that the TiO2 samples showed lower wear and higher hardness.

84. M. Madej

The properties of diamond - like carbon (DLC) coatings on titanium alloys for biomedical applications. The paper presents the results of DLC coating of produced by the method of physical vapor deposition (PVD) on the titanium alloy for biomedical applications. Surface morphology and elemental composition were determined with the use of scanning electron microscopy / energy dispersive spectroscopy. Hardness was determined by instrumental indentation. Tribological tests were carried out under technically dry friction and friction with lubrication of Ringer's solution. The DLC"s are characterized by high hardness (increased by an 7-fold) and anti-wear properties. In the case of technically dry friction, the coefficient of friction decreased by 80%, and in the case of Ringer's solution by almost 90% compared to the results obtained for substrate.

85. K. Radoń-Kobus, M. Madej

Properties of TiO_2 coatings applied by atomic layer deposition on 100Cr6 steel. The paper presents the method of forming TiO_2 coatings on 100Cr6 steel using the ALD method and assessing the properties of the obtained coatings. The coatings were assessed in terms of surface morphology, chemical composition, contact angle and tribological properties. The performed tribological tests show that TiO_2 coatings are characterized by lower resistance to motion. During measuring the geometric structure of surfaces on samples with TiO_2 coating, smaller wear traces were recorded than for 100Cr6 steel. The obtained values of the contact angles prove that the 100Cr6 steel coated with TiO_2 is more hydrophobic than the uncoated 100Cr6 steel. TiO_2 coatings can be used in low-loaded tribological systems and as barrier coatings.

86. M. Poręba, M. Pytel, M. Drajewicz, W. Ziaja, M. Góral

Modification of the Cu-ETP copper surface layer with chromium by pvd and diffusion annealing. In the study the attempt was made to increase the durability of copper by creating a surface layer saturated or supersaturated with chromium only in the area of the highest thermo-mechanical loads during the welding process. A two-stage technological process was developed, consisting of: application of chrome coating of the thickness about 1 μm on the Cu-ETP copper surface using PVD method, and then performing the process of its diffusion annealing at a temperature of 950 °C in the vacuum. As a result a diffusion CuCr layer with a thickness of approx. 20 μm was obtained having hardness of about 120 HV0.01.

87. M. Spilka, W. Łoński, A. Radoń, R. Babilas

Preparation and selected properties of $Al_{88}Y_{8-x}Fe_{4+x}$ (x = 0, 1, 2 at.%) alloys in bulk form. The paper presents selected properties of Al-Y-Fe rapidly solidified alloys. Samples in the form of plates, obtained by pressure casting method, were subjected to structural tests in order to determine the mechanical properties of the alloys, as well as their corrosion resistance. The corrosion resistance of samples was examined using polarization tests in 3,5 % NaCl solution at 25 °C. The influence of this corrosive medium on the sample's surface was analyzed with microscopic observations and energy-dispersive spectroscopy. The mechanical properties of alloys were determined by Vickers hardness tests. The results showed that the properties of $Al_{88}Y_{8-x}Fe_{4+x}$ (x = 0, 1, 2 at. %) alloys are related to changes in the content of alloying elements.

88. R. Zapała, B. Kalandyk, P. Pałka

Effect of temperature on the mechanical properties of X5CrNi18-9 steel. The results of static tensile tests conducted on a selected steel grade with austenitic matrix are discussed in this paper. The tensile tests were carried out at the following temperatures: 200, 400 and 700°C. Under the conditions of the static tensile test, all the samples failed with a characteristic "necking" forming a cup-conical shape. It has been found that with increasing temperature the strength properties decrease and the elongation increases. The microscopic examinations of the fractures showed that they were mostly plastic, and numerous "dimples" were filled with non-metallic inclusions characterized by a globular shape and a size of up to 8μm.

89. B. Kalandyk, R. Zapała, I. Sulima, J. Kasińska

Effect of freezing on the abrasion resistance of cast steel containing 1.1% C, 16% Cr and 0.9% Mo. The results of abrasion resistance tests carried out on 440C cast steel containing 1.1% C, 16% Cr and 0.89% Mo after several variants of heat treatment, including freeze hardening at -70°C immediately before tempering at 200 and 550°C, are presented in this paper. The wear resistance tests were carried out by the ball-on-disc dry friction method. In the samples (with and without freezing) tempered at 200°C, lower mass losses were obtained than in the samples tempered at 550°C. Additionally, it was found that the applied freezing procedure significantly contributed to the reduction of mass losses in samples tempered at both temperatures.

90. J. Lachowski, J. Borowiecka-Jamrozek

Analysis of the fracture mechanism of cast steel under hydrostatic pressure. Plastic deformation and demage evolution in low-carbon steel containing non-metalic inclusion are analysed experimentally and numerically.The cast steel was subjected to the heat treatment : normalizing,oil quenching and tempering.Test were carried out of hydrostatic pressure of 500 Mpa and 1 000 Mpa.In the tensile test the tensile strength,elongation and reduction of area were examined.Fractography of the speciments was carried out of observe fracture mechanism.The Finite Elements Method has been used for modelling of deformation of speciments.The computer simulation was perfomed using ABAQUS system.The computed output was compared with experimental results.

91. M. Góral, M. Poręba, T. Kubaszek, K. Ochał, M. Drajewicz

The influence of process parameters on structure and thickness of Y_2O_3 coatings deposited by PS-PVD method on graphite for metallurgical applications. Graphite is one of materials used in metallurgical applications, however, it is characterized by low oxidation resistance. In the article, an yttria oxide coating was deposited using Plasma Spray Physical Vapour deposition method (PS-PVD) on graphite. Next, the influence of selected process parameters (power current, powder feed rate, or plasma gasses composition) on coating thickness and structure were discussed. The obtained coatings were characterized by hybrid structure with partially formed columns. The linear relationship between power current and coating thickness was observed. There was no significant influence of other analyses' process parameters on coating thickness or microstructure.

1. C. N. Zhang, Y. R. Li

Markov hot blast stove prediction based on hybrid intelligent algorithm. Hot blast stove air supply is a continuous process, and the working conditions are very complex. The improper data processing of the traditional Markov prediction will easily lead to the deviation of the results. In this paper, a hybrid intelligent optimization algorithm is used to pre-process the data sources and obtain reasonable data. The experimental results show that the algorithm has good convergence and stability. The improved Markov predicted value is close to the actual value and accords with the target.

2. B. Dai, H. Long,Y. Wen, Y. Ji

Effect of ludwigite(B_2O_3) on high Al_2O_3 slag and its mechanism used as a new blast furnace welding flux. Based on the measurement of viscosities and critical temperatures of CaO-MgO-SiO_2-Al_2O_3-B_2O_3 slag system with various B_2O_3 contents, the slag with higher than 15 mas. % Al_2O_3 content has the lowest critical temperature and the widest solid-liquid coexisting region at about 2,0 mas. % B_2O_3. Furthermore, the X-ray diffractometer (XRD) result verified that bechilites whose melting point are low forms. Raman spectra revealed that the effect of network forming on viscosity is smaller than the effect of bechilites, which leads to the slag viscosity decrease with B_2O_3 addition. Base on the above research, so ludwigite can meet the requirements of a BF welding flux to decrease the critical temperature and improve the fluidity of the high Al_2O_3 slag.

3. J. Kasińska, D. Myszka

Influence of rare earths metals (REM) on the structure and selected properties of grey cast iron. The paper presents the results of tests carried out on grey cast iron obtained in laboratory conditions. Cast iron EN-GJL-200 was enriched with REM at 0,3 % wt. in relation to the weight of the charge metal. The presence of REM was found only in some elements of the structure, i.e. in ferrite and in precipitations. An 18 % decrease in the coefficient of friction was observed for REM-modified cast iron as compared to the base cast iron.

4. Z. S. Zhang, X. L. Zhu, M. G. Shen, G. W. Ao

Simulation study on effect of chassis water cooling on solidification of eleven tons flat steel ingot. In this paper, the solidification process of eleven tons flat steel ingot is simulated by the finite element analysis software PROCAST, and the solidification state of the ingot with and without chassis is analyzed and compared. The results show that the forced cooling chassis makes low temperature area of the bottom ingot enlarged. And it has little influence on the temperature field and the solidification speed of the upper ingot. For the small flat steel ingot, the forced cooling chassis will deteriorate the shrinkage.

5. K. Kostúr

Optimal control of heating in a reheating furnace. In this paper a new method is proposed for solving an optimal control problem using the complex model of a reheating furnace that was used to get reference values for the optimal zone temperatures. Validation before using a complex simulation model in optimal control procedure showed that the model worked well for the prediction of thermal behavior. The aim of optimal furnace temperature control is the minimisation of fuel consumption and the minimum deviation between desired and final steel block temperature profiles. The optimisation procedure and some results are described.

6. Ye. P. Shcherbakova, Sv. S. Kvon, D. A. Issagulova, S. K. Arinova

Heat treatment effect on the properties of vibration treated steel during crystalization. The effect of heat treatment on the structure and properties of 30HGSNMA steel that has been subjected to vibration treatment at the stage of primary crystallization is considered in the work. It is proposed to use normalization with accelerated cooling with a water-air mixture among possible treatment methods. The properties of steel after this heat treatment are investigated. It has been found that there is a significant increasing of hardness, tensile strength and impact strength, and the level of these properties is comparable with the level of properties after hardening and tempering. The introduction of one-stage heat treatment that consists in normalization with accelerated cooling, allows reducing the heat treatment cycle and increasing the equipment productivity.

7. M. Warzecha

Non-metallic inclusions controling at the ladle furnace (LF) station. The article contains the results of research performed on the determination of the quantity and morphology of non-metallic inclusions identified at the secondary metallurgy process during the cold-swelling steel production. Continuous improvement of steel quality standards, which today is primarily associated with the amount of inclusions contained in the steel product, enforces actions taken to remove the largest possible number of inclusions from steel and/or by their modification at the final stage of secondary metallurgy processing. Therefore, research was undertaken at the ladle furnace industrial stand, and the steel samples were subjected to metallographic testing. It was shown that the number and/or the size of inclusions identified in the samples taken at the beginning and end of the process decreased, and in addition they were modified.

8. V. Yu. Kulikov, A. Z. Issagulov, M. K. Ibatov, D. A. Issagulova, T. V. Kovaleva, Ye. P. Chsherbakova

Studying the properties of sand-resin molds made using a variable load. The article investigated both shell mold samples and casting samples. The castings were made of 35L steel. A scheme of the formation of a sand-tar shell form using variable pressure was presented. As can be seen from the graphs, the application of the load during the formation of the shell form significantly affects the size of the burn in the direction of its decrease. The pressure of 0,18 ... 0,25 MPa, which is defined as optimal for obtaining the forms of castings «Link», can be considered very satisfactory for the value of the burnout. As pressure increases, the rate of decline of the burn on the castings decreases. Obtained in semi-industrial conditions, the samples were investigated in the laboratory of KSTU. The strength, hardness and gas permeability of the forms were determined.

9. Ye. Shabanov, S. Baisanov, K. Grigorovich, A. Baisanova, R. Toleukadyr, Zh. Saulebek

Recovery of low-carbon ferrochrome with multi-component aluminum-silicon-chrome (Al - Si - Cr) alloy. The paper describes pilot smelting of low-carbon ferrochrome (LCFC) with new type of reductant – multi-component aluminum-silicon-chrome alloy (FASCh). Provisional calculations confirmed by results of pilot smelting show that use of FASCh alloy helps to stabilize LCFC slag and prevent its decomposition. Due to high Al content in FASCh the phase area of slag shifts from dicalcium silicate (larnite- Ca_2SiO_4) area into the helenite area ($2\ CaO \cdot Al_2O_3 \cdot SiO_2$).

10. O. Sariev, S. Kim, Ye. Zhumagaliev, B. Kelamanov, M. Sultanov, N. Nurgali

Viscosity and crystallization temperature of ferroalloy slags from Kazakhstan ore. Experimental research with synthetic mixtures imitating typical ferroalloy slags is described in the paper. Samples imitating slags of high-carbon ferrochrome, ferrotitanium and high-carbon ferromanganese were made of analytical grade reagents by mixing and melting in a resistance furnace. Slag viscosity was measured with electric vibratory viscometer in the temperature range of 0 – 1 800 °C. Based on research results it is recommended to use higher basicity slags together with specific additions (fluxes) reducing slag's viscosity and melting point.

11. A. Akuov, Ye. Samuratov, B. Kelamanov, Ye. Zhumagaliyev, M. Taizhigitova

Development of an alternative technology for the production of refined ferrochrome. In the article presented the refined ferrochrome smelting technologies by furnace, converter and out-of-furnace methods. The main attention is paid to the new aluminum-silicothermal process for obtaining refined ferrochrome by the furnace method using a multicomponent alloy - aluminosilicochrome. The results of laboratory experiments on the smelting of ferrochrome using the multicomponent alloy are presented. As a result, melting products were obtained: ferrochrome with 63 – 68 % chromium and 1 – 3 % carbon and slag with 2 – 6 % chromium oxide.

12. O. Sariev, B. Kelamanov, Ye. Zhumagaliyev, S. Kim, A. Abdirashit, M. Almagambetov

Remelting the high-carbon ferrochrome dust in a direct current arc furnace (DCF). The paper describes the results of pilot remelting of high-carbon ferrochrome dust in a 1.8 MVA DC arc furnace. Standard grades of high-carbon ferrochrome, such as FeCh800, FeCh850 and FeCh900, were obtained with the following furnace performance: chrome extraction - 89,5 %; slag ratio - 0,5; specific power consumption - 2 272 kW·h/ton.

13. X. Y. Wang, Y. Zeng
Analysis and study test materials coke in a high temperature furnace. The test material of a high temperature furnace is coke. in order to study the influence of temperature on the reactivity of coke, the reactivity index and weight loss rate of coke were measured under different reaction temperature conditions, and the dynamic observation of coke reaction process was made under the microscope. The reaction mechanism of coke was analyzed, and the influence of temperature on metallurgical properties was evaluated.

14. K. Sh. Akhmetova, B. K. Kenzhaliev, S. A. Trebukhov, A. V. Nitsenko, N. M. Burabaeva
Achievements in the titanium production development. This paper presents the results of material flows balance studies and quality analysis of the technological products. It is shown that stillage bottoms pulp feed on the melt mirror of potassium chloride electrolyte with a speed less than 2,5 t/h excludes the temperature overshoot within 570 - 620 °C of titanium tetrachloride vapors sublimation. Chlorinator melt bubbling in the process initial period with dried air (nitrogen) can significantly improve the quality of titanium products.

15. B. Dai, Y. Ma, H. Long, Y. Ji, J. Rao
Properties of MnO on high Al_2O_3 slag and its mechanism used for flushing blast furnace (BF). In this work, the properties and mechanism of the slag with different MnO content were researched, including the viscosity and critical temperature measured by rotating cylinder method, the mineral phase and microstructure confirmed by X-ray diffraction (XRD), scanning electronic microscopy (SEM) and fourier transform infrared spectrometer (FTIR). The experiment results showed that during the process of flushing blast furnace, the appropriate and optimal MnO in the slag was 1,5 to 2,0 mas .%, the mechanism of flushing by MnO was that the tephroite whose melting point is low forms, the depolymerization of [SiO_4]-tetrahedral structure caused by MnO addition also plays an important role in reducing the viscosity of the slag.

16. D. Han, X. Zhu, S. Li, X. Liao, X. Ai
Study on cleanliness of interstitial-free (IF) steel continuous casting slab. By means of metallographic observation, scanning electron microscopy and electron probe micro analysis, the quantity, particle size, distribution, morphology and composition of inclusions in the slab were discussed in detail. Which can provide a reference for the process optimization of IF steel and the production of pure steel slabs. The results show that the content of C, N and O in the IF steel continuous casting slab produced by this plant is controlled at about 20 ppm, and the content of P and S is lower and the steel is relatively pure. Most of the inclusions are below 2 μm. Most of the inclusions are pure Al_2O_3, a small part contains a small amount of microscopic MnS.

17. T. Merder, J. Pieprzyca
Emergency condition of the operation of a non-symmetric tundish. The aim of the research was to analyze the influence of the flow behavior of liquid steel in a three-strand, asymmetric tundish when not all outlet openings are working. This problem was solved through physical modeling. The tests were carried out with the use of the water model of the continuous casting (CC) machine equipped with an asymmetrical, three-strand tundish model, made on a reducing scale. Modelling research concerned casting 110 x 110 mm square ingots. The obtained results of visualization tests and resistance time distribution (RTD) characteristics (F type) allowed to determine the method of mixing the steel (changes in mixing intensity were estimated) for the analyzed experimental variants.

18. R. Shi, Y. Cui, J. Zhao, X. Li, C. Zou, Y. Yu
Direct reduction and extraction of iron from nickel smelting slag coupling of preparation of cementing materials using gangue composition. Aiming at the properties of Fe and SiO_2 in nickel slag, the process of preparing DRI by direct reduction nickel slag from coal base was proposed, and the component of gangue is used as raw material to prepare C_2S(belite) and C_3S (alite), which is a comprehensive utilization of nickel slag. The reduction reaction of iron coupling of the reaction of cementitious materials was realized through thermodynamic calculation and experiment. The reduction roasting products of nickel slag with iron, C_3S and C_2S as the main phase were obtained by reasonable batching and temperature control technology of reduction roasting reaction.

19. L. F. Zhang, E. Y. Sun, H. Xu, S. R. Jin, Z. Lv, G. D. Li
Application of metallurgical steel slag in foamed concrete. In this paper, in order to improve the utilization of metallurgical steel slag, the strength and water resistance of magnesium sulfide cement foam concrete with metallurgical steel slag as admixture were studied. The hydration products were characterized by scanning electron microscope (SEM). The results show that the structure of magnesium sulfide cement foamed concrete is more compact, the strength is not lost, the water resistance is improved to a certain extent, and the cracking of foamed concrete is inhibited to a certain extent by the appropriate amount of metallurgical steel slag.

20. D. Han, X. Zhu, S. Li, X. Liao, X. Ai
Study on flow and temperature drop behavior of six-stream tundish with less-flow casting. In this paper, numerical simulation method was used to study the influence of closing different nozzles on the flow state and temperature distribution of molten steel in the six-stream tundish, which provides a theoretical basis for ensuring the temperature uniformity of molten steel in the tundish and the subsequent stable continuous casting production during the less-flow casting. The results show that: (a) In the case of closing one nozzle, when the No. 3 nozzle is closed, the overall temperature is relatively uniform. (b) In the case of closing two nozzles, when the No. 2 and No. 3 nozzles are closed, the overall temperature is more uniform.

21. P. K. Fedotov, A. E. Senchenko, K. V. Fedotov, A. E. Burdonov
Hydrometallurgical processing of gold-containing ore and its washed products. This article presents the results of hydrometallurgical studies of gold-bearing ore. The experiments were carried out on 2 parallel weighed portions with the analysis of products by assay (cake) and atomic absorption (solution) analyzes of gold. To determine the technological properties, tests were carried out on the direct and sorption cyanidation of ore samples using different material sizes, the concentration of the complexing agent in the solution and the preliminary treatment of the pulp with lime. The study of the sorption activity of the ore, as well as the dynamics of gold dissolution was carried out.

22. A. Baisanov, Zh. Maishina, A. Isagulov, N. Smagulova, V. Yudakova
Experimental melting of high-silicon ferromanganese with the use of ferromanganesian ore and manganese slag. This work presents the results of smelting ferromanganese from high-silica iron-manganese ores with 36 % manganese content by the flux method. The Shubarkol deposit coal and metallurgical coke as reducing agents were used.The fluxing material was solid slag from the smelting of medium-carbon ferromanganese. The technological modes of the smelting process are established. The optimal composition of the charge was determined. As a result of the theoretical and experimental studies, the tasks have been solved completely - the smelting technology of high-silicon ferromanganese was developed and tested using a substandard raw materials, such as iron-manganese ores and flux.

23. J. Dobránsky, M. Pollák, M. Kočiško
Proposal of a new solution for mold temperature monitoring. The paper deals with the proposal of a new solution for monitoring the mold temperature. The mold is used for the production of thermosetting products by pressing technology. At present, the mold temperature is measured separately at sixteen locations of the mold. This measurement is lengthy and laborious, causing production downtime. At the same time, measurement is physically problematic since the mold has a temperature in the range of 130 to 150 °C. The controller must manually record all measured data in the record and re-write the record to the computer. The new solution is to measure four control points at once. The controller will measure these points and the measured data will be sent online to the system. This method will clearly speed up the measurement process.

24. A. Z. Issagulov, T. V. Kovaleva, Ye. P. Chsherbakova
Lost pattern complex composition effect on steel casting structure and properties. One of the ways to produce high-quality castings at relatively inexpensive costs is lost foam casting. However, the existing problem of surface carburization due to the burnout of the polystyrene pattern and general contamination of the near-surface layer is one of the factors that hinder the widespread use of this casting method. In order to minimize carburization, it is proposed to use a complex pattern composition. The results of studying the effect of the pattern complex composition and the technological parameters of manufacturing the "Through Cover" casting for the ingot purity and structure are presented.

25. R. A. Ramazanova, V. I. Samoilov, N. V. Seraya, G. K. Daumova, E. M. Azbanbaev, R. A. Aubakirova
Investigation of the kinetics of sulphuric acid leaching of zinc from calamine. This article aims at the research of kinetics of the sulphuric acid leaching of zinc from calamine (hemimorphite) of Shaimerden deposits. The ratio of zinc extraction from calamine to water-soluble zinc sulphate was determined at various leaching durations and its temperatures. The concentration of the sulfuric acid solution, the flow rate of this solution and the size of the calamine particles, selected in the course of this work for leaching zinc from this mineral with the specified solution, made it possible to establish the value of the "apparent" activation energy of the reaction of calamine with sulfuric acid, amounting to 3,075 kJ / mol.

26. B. Gajdzik
Steel production in Poland with pessimistic forecasts in COVID-19 crisis. The publication consists on the situation in Polish steel industry after the start of COVID-19 pandemic. The aim of the publication is to present the impact of the COVID-19 crisis on steel production in Poland. The analysis of the volume of steel production in Poland was carried out between January 2020 and June 2020 and compared to the production in the same period in 2019. In order to deepen the analysis of the situation in the Polish steel industry data about apparent steel use and situation in steel consuming sectors were presented. The paper ends pessimistic forecasts for steel production in Poland.

27. B. Gajdzik
Steel production, consumption and foreign trade in Poland in crises: the financial crisis 2008-2009 and the COVID-19 crisis – first half of 2020. The publication consists on the situation in Polish steel industry in crises. The aim of the publication is to compare the volume of steel production in Poland in the periods of two crises that is the financial crisis from US in 2007-2009 and the COVID-19 crisis. In the quantitative analysis such data are compared: manufacture of crude steel and finished steel products, consumption of steel products, foreign trade in steel products. The changes in the steel production, consumption and foreign trade in two analyzed crises are helping to assess the depth of the crisis in steel industry.

28. E. Kardas, R. Prusak
The quality of coke and its consumption blast furnace process. The assessment of quality of coke and its consumption in blast furnace process is presented in the paper. The statistical analysis of three basic parameters of coke was made. As a main quality parameters: moisture content, ash content in the dry state, volatile matter content in dry state and calorific value were selected. Then influence of two selected parameters of coke on fuel consumption was calculated. The study was carried out in cooperation with a Blast-Furnace Department of a Polish steelworks and was based on the results coming from this Department. The analysis covers the period of three calendar years.

29. W. Deng, L. Zhang, D. Cang
Study on distribution of sulfur element in blast furnace (BF) process with different pellet proportions. In this study, a series of BF smelting industrial tests were conducted with different proportions of pellet in iron-bearing materials in a 450 m^3 BF in Hebei, China. The results showed that with increasing proportion of pellet, total sulfur(S) input amount of the raw materials in BF iron-making process decreased after a slight increase. The result revealed that increasing the pellet proportion will not affect the quality of pig iron (PI), but also can reduce the sulfur load of BF.

30. K. Janiszewski
The influence of ferrous scrap's grade on the yield of steel smelted in an electric-arc furnace (EAF). In the paper there is presented a statistical analysis of the influence of various quality classes and the amount of scrap in steel charges on the rate of liquid steel yield from the electric arc furnace (EAF). The research methodology involved the analytical simulation of changes in the liquid mass of steel acquired from melts with different scrap content and statistical analysis of data obtained from the correlating process documentation (so-called melting sheets) under industrial conditions. The attained results may be employed in any steel mill that uses electrical steelmaking processes, to design the composition of a metal charge while bearing in mind the qualitative and economic aspects.

31. J. H. Zhang, Y. X. Chen, D. Z. Yang
Process design and life anylysis of tundish lining. The working lining of continuous casting tundish is made of magnesia dry material with short service life. It is found that the refractory lining cast steel zone is the key to influence the service life of tundish. Therefore, the material formula of tundish casting steel area is developed, and the construction is carried out in different parts, so that the balanced corrosion can improve the working life of tundish lining, reduce the turnover of tundish, improve the yield of steel, and reduce the consumption of steel resistant material per ton, which has good economic and social benefits.

32. S. M. Jia, L. Miao, C. J. Wu, D. Xu
Simulation study on the effect of riser heating mode on solidification of flat ingot head. According to the production practice of 14 tons flat ingot, the influence of heat preservation measures on solidification state of ingot head is analyzed by the software ProCAST. The results show that the heating riser and electromagnetic heating riser delay the cooling of molten steel in the ingot head, but these heating risers have little effect on the temperature of the middle and lower parts of the ingot. Due to the different influence of corner heat transfer, the solidification time of molten steel in wide side is longer than that in narrow side. In comparison, the solidification time of the ingot head with electromagnetic heating riser is the longest.

33. H. H. Yu, X. Li, S. M. Wang, Q. Z. Liu, H. Liu
Effect of Cr_2O_3 on crystallization of CaO-MgO-Al_2O_3-SiO_2(CMAS) slag glass-ceramics. Using stainless steel slag and iron tailings as main raw materials, the CaO-MgO-Al_2O_3-SiO_2 (CMAS) glass-ceramics with a solid waste utilization rate exceeding 70 % was prepared, and the effects of Cr_2O_3 content on the nucleation and crystallization of glass-ceramics were investigated by X-Ray diffraction (XRD). Research indicates that the main crystalline phases of CMAS are all pyroxene, and the content of Cr_2O_3 increases in a certain range, which promote the crystallization ability of crystals in glass. Besides, the increase of Cr_2O_3 content within a certain rangepromotes the crystal crystallization in glass.

34. J. Pieprzyca, T. Merder
The process of dissolving solid lump carbonaceous fuel (SLCF) in the oxygen converter - physical modeling. The article presents the results of modeling research of hydrodynamic phenomena occurring in the oxygen converter during the addition of SLCF while blowing the liquid bath. The water physical model of the oxygen converter was used for the research. The oxygen lance of the model was equipped with a head with five nozzles at an angle to the lance axis. The research was aimed at determining the most favorable process parameters for the use of lump fuel in the oxygen converter.

35. Y. J. Zhang, L. B. Wu
Adaptive neural event-triggered design for the molten steel level in a strip casting process. This paper considers an adaptive neural event-triggered control problem of the molten steel level for twin roll strip casting systems with the inclined angle. Firstly, the model is improved and simplified into an affine nonlinear system by exploiting input compensation technique. Then, an adaptive observer is established based on radial basis function neural network (RBFNN). Furthermore, an adaptive event-triggered control scheme and corresponding adaptive updated laws are designed. It is proved that the proposed control method can guarantee the system output can follow reference signal and all closed-loop signals are bounded. Finally, the validity of the control scheme is verified through semi-experimental system dynamic model.

36. A. Bobrowski, D. Drożyński, K. Kaczmarska, B. Grabowska, S. Cukrowicz
Kinetics of gas emission from aluminosilicates used as a relaxing additive for moulding and core sands. The article presents the results of gas emissions generated during heating of mineral additives – aluminosilicates (perlite ore and vermiculite). The test on a laboratory stand for a 1 g sample at 1 000 °C was carried out. It has been shown, that there is a correlation between the degree of fragmentation and the amount of gas generated. The finest fraction of perlite ore caused a similar quantitative gas emission as ground vermiculite. The presence of additives in molding sands, regardless of the size of fraction, should not affect the formation of casting defects. The addition of perlite ore and vermiculite does not effect the ecological properties of moulding sand.

37. L. Bernat

The influence of cooling rate and heat treatment on microstructure and mechanical properties of Al-Si-Cu alloy castings made in gypsum molds. The influence of cooling rate and heat treatment on the mechanical properties of Al-Si-Cu alloy castings made in gypsum molds were presented in the article. A series of identical T6 heat treated strength samples were made for three variants of mold temperature: 30 °C, 200 °C, 300 °C. The cooling rate in the thermal axis of the sample, the Dendrite Arm Spacing microstructure parameter were measured. Analyzed parameters were correlated with the obtained values of mechanical properties.

38. A. Z. Issagulov, V. Yu. Kulikov, Sv. S. Kvon, M. K. Ibatov, S. K. Arinova, A. M. Dostayeva

Comparative analysis of graphite inclusions in chrome cast iron structure. The paper presents the results of a quantitative metallographic analysis of graphite inclusions in the structure of chrome cast irons including cast iron of the Nihard class, as well as after treatment with titanium carbide. The ThixometPro software was used for the analysis. The shape, size, perimeter, distribution density of graphite inclusions, as well as the area occupied by the structural components and their dispersion were evaluated. It is shown that the introduction of titanium carbide has a favorable effect on the pattern of graphite inclusions and some parameters of the structure in general.

39. M. Mukhametkhan, Y. Mukhametkhan, S. Tleugabulov, G. Zhabalova, V. Shevko

Thermodynamic interaction of concentrate, sludge and mill scale from carbon. Of particular interest are currently man-made deposits formed or being formed on the territory of the objects of placement of man-made waste of the metallurgical complex, including the preparation of raw materials (mining, processing, agglomeration, etc.), directly metallurgical processing and related production. The downward trend in iron ore reserves makes it particularly relevant to process man-made waste from ferrous metallurgy in order to obtain man-made iron ore raw materials.

40. V. Tolokonnikova, S. Baisanov, G. Narikbayeva, I. Korsukova, Ye. Mukhambetgaliyev

Modeling method of phase equilibrium in metal-slag system. This paper demonstrates a new modeling method of the complex heterogeneous processes between a metal and slag based on a pattern of formation of the crystallization fields of phases. The theoretical justification was provided for the using of the osmotic coefficients of Bjerrum-Guggenheim with the reduction reactions of elements from the liquid oxide melts into metal. As an example, the equilibrium procedure of a carbon-saturated Fe-Si melt with liquid $CaO\text{-}SiO_2\text{-}Al_2O_3$ slag was presented and a mathematical model of the complex phase equilibrium in a metal-slag system was provided.

41. W. Bialik, S. Gil, S. Kozłowski

Technical and technological solutions in development of FeSiAl alloys production from industrial wastes in submerged arc furnace (SAF). This article presents a description of the carbothermic process concerning production of iron-silicon-aluminum alloys with 55 to 75 wt. % of silicon and 4 to 20 wt. % of aluminum in industrial conditions. For the process, mining waste resulted from mechanical processing of coal being the source of silicon and aluminum compounds as well as high-ash fine coal as a reducer was used. A modern technological line for FeSiAl smelting was described, consisting of a SAF (fitted with two 7,75 MVA three-phase transformers and six self-baking electrodes) to ensure optimum power distribution in the furnace. In addition, technical and technological parameters of the process were presented with a particular emphasis placed on Al and Si yields.

42. A. Z. Issagulov, V. Yu. Kulikov, Sv. S. Kvon, M. K. Ibatov, Ye. P. Shcherbakova

Studying properties of chrome cast irons modified with titanium carbide. The paper presents the results of studying hardness and wear resistance of chrome cast irons. In the study there were considered samples of cast iron of the ChN2H, ChN4H2 grades and ChN2H after treatment with titanium carbide. Titanium carbide in the amount of 1 % by weight with dispersity of 500 microns was introduced during casting into ChN2H cast iron. As a result of this treatment, the cast iron hardness and wear resistance become comparable to those of Nihard grade cast iron. Studies have shown the promise of using refractory compounds as modifiers for cast irons.

43. V. Tolokonnikova, S. Baisanov, G. Narikbayeva, I. Korsukova

Assessment of dissociation rate of $FeCr_2O_4$ using the Bjerrum-Guggenheim coefficient. A calculation procedure of line positions of the monovariant phase equilibrium for the crystallization regions of a congruent compound using the osmotic coefficient of Bjerrum-Guggenheim $\left(\Phi'_{A_m B_n}\right)$ was developed. The relevant mathematical apparatus for an analytical description of lines and surfaces of the phase crystallization was recommended. As an example of $FeO\text{-}Cr_2O_3$ oxide system, the assessment of dissociation rate of congruent compound of $FeCr_2O_4$ was performed. The demonstration material of behavior of the osmotic coefficient of Bjerrum-Guggenheim under boundary conditions as assessment criterion of melt structurewas presented.

44. B. Kelamanov, Ye. Samuratov, A. Akuov, A. Abdirashit, A. Burumbayev, R. Orynbassar

Research possibility of involvement Kazakhstani nickel ore in the metallurgical treatment. The work results of laboratory tests on the involvement of Kazakhstan oxidized (silicate) nickel ores with a 0,5 – 1 % nickel content into metallurgical proccessing to obtain nickel-containing cast iron with a 3 – 5 % nickel content. The tests include the study of nickel ores by nonisothermal kinetics, the study of the structure of the phase structure of nickel ores by petrography, the process of agglomeration of nickel ores and smelting of nickel-containing cast iron from the obtaining sinter using 2 types of reducing agents (coke and coal).

45. A. D. Mekhtiyev, Ye. Zh. Sarsikeyev, A. V. Atyaksheva, A. D. Atyaksheva, T. S. Gerassimenko, A. D. Alkina

Method of preventing deposits on the inner surface of circulating water pipelines of ferroalloy electric furnace cooling systems. The article provides an overview of a promising method of preventing deposits on the inner surface of circulating water pipelines of cooling systems of ferroalloy electric furnaces. There is considered the approach to practical implementation of magnetic treatment of circulating water in the cooling systems for the purpose of eliminating scale of hardness salts in pipelines. There is presented the design of an electromagnetic hydrodynamic water activator, as well as its main parameters. The results of practical testing and processing experimental data are presented. It has been established that the effect of a magnetic field on water is of a complex multifactor nature.

46. A. Zhakupov, A. Bogomolov, A. Zhakupova, S. Abdulina, V. Salina

Determination of technological parameters for continiuous casting of a hollow pipe billet. This article presents a method for calculating the speed of a hollow steel billet continuous casting for the seamless hot-rolled pipes production. The recalculation of the modeling results into the actual volumes of industrial production was carried out according to the condition of the similarity criterion of Fourier numbers. The casting speed of a steel hollow billet are determined, the increase of which, compared with a solid billet, amounted to 16 %.

47. S. Mashekov, B. Bazarbay, A. Zhankeldi, A. Mashekova

Development of technological basis of 3D printing with highly filled metal-poly-dimensional compositions for manufacture of metal products of complex shape. This article discusses the possibilities of obtaining "green" parts by the FDM (Fused deposition modeling) method from ready-made polymer-metal compositions used in the MIM (Metal Injection Molding) technology and the technology of obtaining functional metal products of complex shape and structure. The influence of technological parameters of 3D printing on the quality of parts (presence of defects) obtained by highly filled polymers has been established. Thermogravimetric analysis was carried out to determine the melting point without changing the composition of the material. A filament was fabricated from granular feedstock material catamold 316L using the FDM technique.

48. L. Semushkina, G. Abdykirova, D. Turysbekov, S. Narbekova, Zh. Kaldybaeva, A. Mukhamedilova

About the possibility of copper-bearing ore flotation processing of with the use of a combined flotation reagent. The paper includes the results of laboratory studies for the copper-bearing ore flotation with the use of a combined reagent. The combined flotation reagent was preliminarily passed through a UZDN-A1200T ultrasonic disperser before flotation to obtain a reagent microemulsion. The copper content in the concentrate was 21,5 % with extraction of 83,3 % in a closed cycle in the base mode. It was 21,8 % with an extraction of 88,3 % when a combined flotation reagent was used. There is an increase in copper extraction by 5 %. The combined reagent consumption is reduced by 15 % compared to the main technology.

49. D. Turysbekov, N. Tussupbayev, L. Semushkina, S. Narbekova, Zh. Kaldybaeva, A. Mambetaliyeva
Effect of the water-air emulsion size of the foaming agent solution on the non-ferrous metal minerals flotation ability. The research objective is to study the effect of the water-air emulsion size of the foaming agent solution on the flotation ability of non-ferrous metal minerals. An air-water emulsion of a foaming agent solution was obtained in a water-air microemulsion generator. It has been established that the supply of microbubbles to the monomineral flotation process makes it possible to increase the yield of minerals with different dispersion ability and accelerate the flotation process by 10 - 15 %.

50. C. Kolmasiak, M. Łągiewka
Solidification of the Al alloy composite reinforced with graphite particles. The aim of the work was to analyse the solidification of the Al matrix composite reinforced with graphite particles and to determine the influence of these particles on the solidification kinetics of metal composites. The AlMg10 alloy was used as the matrix of the tested composites. The tests covered composites containing 10 %, 20 %, 30 % graphite particles, produced in a two-stage process with the method of mechanical mixing. Solidification tests were performed by the thermal derivative analysis method (ATD). The introduction of ceramic particles into the matrix changed the solidification kinetics of the alloy.

51. A. M. Dostayeva, I. I. Erahtina, N. R. Zholmagambetov, N. A. Medeubayev, S. R. Zholmagambetov
Investigation of aluminum-titanium alloys production and labor safety in metal smelting process. The labor protection requirements for the smelting process of aluminum alloys and the human safety condition are provided in this work. Also it includes the metallographic analysis results of aluminum-titanium alloys. ThixometPro software was used for analysis' performance and Thermo-Calc program used for the phase diagrams drawing of triple systems.

52. R. A. Ramazanova, S. V. Mamyachenkov, N. V. Seraya, G. K. Daumova, R. A. Aubakirova, Zh. T. Bagasharova
Research of kinetics of zinc leaching with sulfuric acid from smithsonite. The study investigates the kinetics of zinc leaching from smithsonite with sulfuric acid in order to expand the zinc production feedstocks. The recovery rate of zinc from smithsonite into water-soluble zinc sulfate was found at different leaching time and temperature. Sulfuric acid concentration, its consumption and smithsonite particles size selected in this work for leaching of zinc from this mineral using the indicated solution allowed to determine the magnitude of "apparent" activation energy of the smithsonite reaction with the indicated acid, equal to 2,633 kJ / mol. The calculated value of E, shows that the process investigated is accompanied by diffusion phenomena.

53. M. Łągiewka, C. Kolmasiak
Composite centrifugal castings after remelting. The presented work presents the results of research on the content and distribution of SiC particles in metal composites after remelting. The research covered the AlMg10 alloy matrix composites produced by mechanical stirring. The castings were made using the centrifugal casting technology, on a machine with a vertical axis of rotation. The abrasive wear tests of the produced composites before and after the re-remelting were also carried out.

54. K. Akishev, P. Bykov, Zh. Shoshay, A. Tulegulov, D. Yergaliyev
MAthematical formulation and the problem solution of clustering recipes of concrete mixtures using technogenic waste and slags of metallurgical enterprises. The relevance of the use of man-made waste and slags of metallurgical enterprises as a replacement for traditional fillers in concrete mixes has good potential due to producing high strength characteristics and reducing the cost of manufactured building products. The aim of the research is a mathematical formulation of the problem solution of clustering concrete mix recipes using man-made waste and slags of metallurgical enterprises, the criteria are the composition and strength of concrete mix recipes made experimentally. The statistical methods usage of analysis made it possible to determine the measures of the proximity of clusters, to produce clusters with optimal formulations of concrete mixtures.

55. D. Grigorova, R. Paunova
Thermodynamic and kinetic investigation of carbothermic reduction of electric arc furnace dust. The thermodynamics and kinetics of electric arc furnace dust (EAFD) reduction were studied experimentally. The oxygen potential in the systems was determined by the electromotive force (EMF) method. Experimental equations for $\Delta G = f(T)$ were derived. The CO content at different temperatures was determined. The highest degree of reduction was observed at the ratio EAFD/reducing agent - 1:2 at a temperature of 1 173 K. The changes in the mass during heating, the rate of the processes, and the reduction degree were mathematically modeled. The activation energy is 74,7 kJ/mol for EAFD: reducing agent 1:1 and increased to 95,2 kJ/mol for the ratio EAFD: reducing agent 1:2,5. Analysis of the reaction kinetics showed that the reduction process was mostly chemical кinetics controlled.

56. J. Y. Hu, X. W. Liao, L. H. Feng, W. Kang, Y. Liu
Composition design and physical properties prediction of mold flux for continuous casting of high Mn–high Al steel. The deterioration of CaO-SiO_2 based mold flux caused by the reaction of steel -slag interface is a bottleneck restricting the high Mn-Al steel continuous casting production efficiently. Drawing binary phase diagram of mold flux based on the CaO–Al_2O_3 composition, the influence of different solvents on the melting characteristics of the mold flux were investigated and the reasonable mass ratio of CaO/Al_2O_3 and the content of SiO_2, SrO, MgO, Na_2O and B_2O_3 were determined. According to the viscosity and the melting temperature model calculation, the physical property is beneficial for the composition design of low-reactivity mold flux.

57. A. Z. Issagulov, Sv. S. Kvon, V. Yu. Kulikov, M. K. Ibatov, S. K. Arinova
Chromium-nickel cast iron composition effect on properties and graphitization process. The paper considers the cast iron based on nihard-2 composition effect on the properties and process of graphitization. It is shown that changing the Cr:Si ratio equal to 2:1 leads to the development of the graphitization process, as a result of which lamellar graphite appears in the structure. Subsequent modification leads to changing the shape of the graphite into the nodular one, which leads to some decrease in hardness but increases resistance to abrasive wear by about 20-25 %.

58. R. T. Li, H. Yi, D. Xu
Simulation study on influence of adjoint flow to core flow. In the process of steel production, jet stirring is very important, and the core velocity of jet determines the stirring ability of jet. In jet flow, due to the influence of the gas viscosity, the kinetic energy of the jet will be dissipated, which makes the length of the velocity core region unable to reach a large length. In this paper, the adjoint nozzle is set around the main nozzle, which can protect the core jet by adjoint flow, slow down the energy consumption of the core flow and extend the length of the core area of the jet. The results show that the velocity attenuation of the jet with and without adjoint flow is not obvious compared with that of the non accompanying flow. When the temperature of the accompanying flow reaches a certain level, the protection effect of the wake on the core jet is more obvious.

59. T. Merder, J. Pieprzyca
Influence of casting rate on the mixing process of steel in non-symmetric tundish. The article presents the results of research aimed at determining the nature of changes in the mixing of liquid steel in asymmetrical tundish due to the increase in casting speed and the possibility of limiting the use of Flow Control Devices (FCD). The tests were carried out on the water model of the Continuous Steel Casting (CSC) device equipped with the tundish model. Four variants of casting speed were analyzed. The analysis of the obtained results was divided into two stages: qualitative analysis of flow and mixing (visualization process) and quantitative analysis of flow and mixing (by analysis of mixing curves - Residence Time Distribution (RTD) type F).

60. A. K. Narembekova, B. B. Katrenov, K. Zh. Zhumashev
Coverter sludge dezincification by hydrometallurgical method. The article presents the results of studying the process of sludge dezincification by hydrometallurgical method: leaching of zinc from sludge with hydrochloric acid solutions. The object of the study was converter sludge with the zinc content of 1,24 %. On the basis of experimental data, the optimal conditions of sludge leaching were established: the concentration of hydrochloric acid in the solution was 15 %, the leaching time was 90 min, the liquid : solid phase L:S ratio was 6:1. The separated iron cake contained 0,43 % zinc and could be returned to the production cycle at the stage of agglomeration of iron ore raw materials.

61. M. Niesler, J. Stecko, J. Łabaj, A. Smagór, L. Blacha
Application of waste anthracite dust in the process of copper matte smelting. This study presents the results of research on the process of smelting of copper matte with the use of anthracite waste dust as fuel. A method of introducing this carbon-bearing waste into the technological process carried out in a shaft furnace in the form of an additive to briquettes with copper concentrate was developed. These briquettes were tested for the required strength properties.

62. J. Pieprzyca, T. Merder
Modified froude criterion in modeling two-phase flows in a steel ladle. The dominant dynamic similarity criterion in the modelling of two-phase flows in steel metallurgy is the modified Froude (Fr) criterion. Modifications of this criterion, depending on the purpose of the research, may take various forms. The article presents the results of experiments carried out with the application of the steel ladle water model, with the use of various modifications of Froude criterion. The results obtained allow for the classification of the tested modifications from the perspective of the research objectives.

63. S. H. Wang, S. Tong, C. X. LI, Y. K. Xue, K. X. Zhang, H. K. Sun
Phosphorus (P) migration behavior in the process of converter slag gasification dephosphorization. The high P content in steel slag limits its recycling during the smelting process, and the P can be effectively removed from the steel slag by gasification dephosphorization. In this experiments, the effects of temperature, basicity, and FeO for gasification dephosphorization rate are studied through thermodynamic calculations. The Scanning Electron Eicroscope (SEM) and Energy Dispersive Spectrometer (EDS) analysis that microscopic morphology of slag before and after reduction. In addition, a model is established to describe the phosphorus migration behavior of gasification dephosphorization process.

64. J. S. Wu, Y. J. Zhang
Effect of inclination angle on flow field and temperature field in molten pool during twin-roll inclined strip casting. For the twin-roll inclined strip casting, simulate the fluid-thermal coupling in molten pool by mathematical model, and analyze the effect of tilt angle on flow field and temperature field in molten pool. The increase of inclination angle would enhance the asymmetry of temperature field and flow field, which provided a basis for adjustment of control strategy.

65. R. K. Zhaslan, B. A. Zhautikov, V. I. Romanov, A. A. Aikeyeva, A. S. Yerzhanov
Improvement of methods for semi-finished carbon product tapping from the basic oxygen furnace (BOF). The article considers the experience of optimizing the slag adjustment mode in the Basic Oxygen Furnace (BOF) and reducing the proportion of oxide non-metallic impurities in steel. The article presents the results of a research on the separation of slag from metal during the starting period of carbon semi-product tapping, on the elimination of an emergency situation when the hole is shut up at any degree of slag viscosity, the use of the device at any tap hole diameter after the heat, the simplicity of the design. The use of the device makes it possible to increase the durability of the taphole lining, reduce repair costs, and improve the quality of steel by reducing non-metallic impurities. The innovative devices proposed by the author can be useful for metallurgical enterprises.

66. A. K. Tarakanov, N. V. Pushkarenko, I. Mamuzić
The improved technology of iron preparation for the oxygen-converter melting. The new energy-saving technology for iron refining in a casting ladle with simultaneous removal of silicon and sulfur in the combined reaction zone is proposed. It ensures the formation of floating drops of synthetic slag, which is close to the CaO - SiO_2 - Al_2O_3 - MgO system with a reduced oxidation potential. The desulfurization of iron is proceeded in the bubbling zone through the interaction of sulfur with floating drops of synthetic slag, which have a high absorbtion capacity for sulfides. The formation of the main cover slag is also ensured in order to intensify the desulfurization process and to increase the temperature of iron during its processing.

67. A. K. Tarakanov, I. Mamuzić
Possibilities of the smelting reduction processes (SRP) optimization. With the appearance now of the first real commercial aggregates, SRP will pay an ever-increasing role as the world's hot metal supplier. Having the corresponding mathematical models and computer programs, it is possible with sufficient trustworthiness to forecast technical and economic parameters of diverse versions of SRP. The mathematical models, which have been worked up, make the opportunity to choose in particular conditions the most effective technology, proceeding from the definite criteria of optimization and assigned limitations. The created dynamical imitator of the SRP may be used for perfection of the process control methods.

68. M. V. Yaholnyk, A. S. Koveria, L. Kieush, M. O. Fursov, V. A. Tkach
The use of biocoke in the iron ore sintering. Nowadays the use of lignocellulosic biomass as a metallurgical fuel is important, which allows reducing the impact on the environment and contributes to the decarbonization of metallurgy. In this study, we propose to use biocoke obtained from a blend of coal and wood pellets at different final coking temperatures (950 or 1 100 °C) as fuel for iron ore sintering. To compare the results obtained using biocoke, industrial coke was used. It can be concluded that the sintering parameters met the requirements in the case of using biocoke obtained at a pyrolysis temperature of 1 100 °C.

69. O. V. Gupalo, O. O. Yeromin, I. Mamuzić
The study of heat transfer in a rotary hearth furnace. A mathematical model of heat transfer by radiation and convection in the furnace has been developed. The furnace operation has been researched for fuel combustion with enriched air containing 21-100 % of oxygen. It has been determined that the contribution of convection to heat transfer in the heating zones of the furnace is 5-6 %, and it increases to 14-18 % at the beginning of preheating zone. Carrying out the calculations of metal heating neglecting convection leads to the emergence of relative errors in calculating the temperature fields of metal and flue gases.

70. O. V. Gupalo, O. O. Yeromin, I. Mamuzić
Rational use of process oxygen in rolling-mill shops. The usage of this excess for enriching the combustion air in heating furnaces avoids oxygen loss and reduces fuel consumption. A method of rational distribution of excess oxygen between the heating furnaces of rolling-mill shops has been developed. The application of the methods has been considered in the example of oxygen distribution between four heating furnaces characterized by different energy efficiency indicators. It has been shown that the application of the method allows increasing in fuel economy up to 78% compared to using oxygen in one or more randomly selected furnaces.

71. O.O. Yeromin, O.V. Gupalo, I. Mamuzić
Reducing carbon dioxide emission of a metallurgical plant. Most of the blast-furnace gas produced by the plant is used for heating of blast air as well as steam and electricity production. However, a significant part of it remains unused and burned outside the technological units, and the combustion products are released into the atmosphere. The analysis and optimization of the fuel balance of the metallurgical plant have been carried out. The gross emission of carbon dioxide has been chosen as the optimality criterion. Minimization of the criterion has been achieved by the full use of blast-furnace gas and reducing natural gas consumption of the plant. It has been determined that the reduction of carbon dioxide emissions is 10 300 t/year.

72. L. Kamkina, V. Efimov, R. Ankudinov, I. Filippov
The use of shungite for sintering manganese agglomerate. The paper presents the results of experiments on the study of physicochemical processes involving shungite rock during sintering of manganese agglomerate. The replacement of sinter fuel carbon with shungite carbon was varied - 20, 40 and 60 %. It has been established that the rational value of carbon replacement for sinter fuel is 35-40 %, at which sufficient mechanical strength of the finished sinter remains. The results of the composition of the products of heat treatment of shungite rock at different temperatures and initial size are presented.

73. V. Kirichok, Y. Myanovska, I. Mamuzić
The use of fine enrichment products of manganese ore in sintering processes. The mineral formations provided by the calculation when varying the composition of the initial charge with a certain amount of fine manganese concentrate of the 2nd grade fraction 0-1 mm were found in the structure of

the experimental agglomerate. It was found that at a content of 9… 11 % of carbon in the initial charge manganese is mainly in the form of monoxide and there is no significant amount of manganese silicates, which has a positive effect on reducing energy costs for the destruction of the silicate phase. The obtained data develop an idea of the processes of formation of the rational composition of manganese agglomerate with the use of man-made materials.

74. Yu. Proydak, Y. Mianovska, I. Mamuzić
Reduction of oxidized iron ores with hydrogen in aqueous solutions of electrolytes. The process of magnetizing reduction of hematite occurs with the simultaneous occurrence of several processes: direct reduction of Fe3 + ions to Fe2 + by atomic hydrogen on an iron cathode, electroreduction and catalytic action of Fe2 + ions, which appear in the electrolyte upon dissolution of the steel anode material. The study of the electrochemical properties of suspensions showed that the reduction during electrolysis of suspension particles proceeds through the stage of adsorption on the electrode and depends on the potential. It was found that the structural features of the experimental reactors influence the results of the reduction of hematite to magnetite, the anode and cathode materials, the current strength and the composition of the electrolyte on the magnetization process.

75. K. Velichko, L. Kamkina, A. Meshalkin, I. Mamuzić
Rational parameters of technology for producing steel with different carbon content in the converter. The obtained results of an experimental study of the features of the melting of two grades of steel, containing, respectively, 0,015 and 0,025 % carbon confirm: the rationality of the composition of cast iron for silicon and sulfur, which ensured a reduction in the amount of lump lime in the melting of low-carbon steel by 19,7 %, medium-carbon - by 12.5%; the possibility of obtaining high degrees of desulfurization of steel in the converter 62 % when smelting low-carbon and 58,2 medium-carbon steel; the prospects of using experimental slag-forming mixtures based on technogenic waste of various origins with the given: basicity, CaO: SiO2: Al2O3 ratio, redox potential and purpose.

76. Yu. Proydak, V. Kamkin
Modeling the process of carbon oxidation during evacuation in the production of low-carbon steel. For modeling, it used the mathematical model of liquid steel decarburization, developed earlier by Y. Yakovlev, taking into account micro- and macro-transfer. As the results of calculations have shown, in the process of carbon oxidation during the evacuation of liquid steel, an essential role is played by the growth of CO bubbles, on the surface of which the oxidation reaction occurs. The initial radius of the CO bubble when it is detached from the lining has practically no effect on its development when it floats up. The sharp increase in the rate of oxidation in the upper layers of the metal is directly related to the increase in the size of the bubbles.

77. A. M. Grishin, A. A. Nadtochy, I. Mamuzić
Role of metal iron in solid phase reduction of oxides. The intensifying effect of metallic iron on the gasification process is realized through two possible mechanisms. According to one of them, iron accelerates the last stage of the carbon gasification process - the release of CO due to the destruction of keto complexes.According to another mechanism, the oxidation of iron with carbon dioxide leads to the formation of iron-oxygen complexes on the surface of the metal phase, the concentration of which is not the same. The presence of a concentration gradient leads to the migration of oxygen atoms along the iron surface to carbon grains, and partially penetrate into the interbasis spaces of its lattice. Probably, the influence of metallic iron is realized along both paths simultaneously.

78. O. Dvorkovoj, Y. Sinitsin, I. Mamuzić
Use of hydrolysis lignin in the composition of slag forming mixtures for treatment of steel and alloys. The best indicators of their impact on the processes of preparation (mixing, pelletizing) and heat treatment of a mixture of initial components in an inclined rotary kiln with a controlled oxidation potential in the working space of the kiln were obtained using hydrolysis lignin of current moisture. It is most effective to use lignin as a binder at the stage of mixing the initial dispersed components of the mineral part of the initial mixture, with the removal of moisture, the release of resins and bitumen.

79. V. Kamkin, Ju. Khrutskaya, I. Mamuzić
Estimation of the parameters of preliminary deoxidation of an intermediate product from electro arc furnace (EAF) in the production of extra-low-carbon steel. When smelting such grades of steels in EAF, aluminum is used to remove the over-oxidation of the metal, the amount of which must be consistent with the level of over-oxidation of metal. A thermodynamic assessment of the process of preliminary deoxidation of the intermediate product from EAF was carried out and a comparison was made with production data, the results of which showed the inconsistency of the flow rate required and given in the flow chart. In case of overconsumption of aluminum, the potential for removing carbon during vacuumisation decreases and the formation of alumina nonmetallic inclusions increases, and in case of a shortage of it, excessive loss of silicomanganese occurs.

80. Ju. Khrutskaya, L. Kamkina, I. Mamuzić
Thermodynamic assessment of the influence of the order of adding of deoxidizers on the composition of the formed non-metallic phase in high-carbon steel. Thermodynamic modeling of the process of deoxidation of steel with a different order of adding of deoxidizers has been carried out. For C82D steel grade, MnC17, FeV, SiC, FeCa were used as deoxidizers. It was found that the use of MnC17 for preliminary deoxidation, followed by the addition of FeV and SiC and the final modification of FeCa, makes it possible to provide a more favorable composition of non-metallic inclusions, which is represented by low-melting calcium aluminate CaO $6Al_2O_3$ and a relatively low (~ 1 %) content of Al_2O_3, and also contributes to less silicon loss.

81. A. P. Gorobets, Yu. S. Proydak, I. Mamuzić
Analysis of the stability of oxide-fluoride melts in refining steel processing electrometallurgical processes. Mass transfer processes were studied in partial systems CaF2-Al2O3, CaF2-SiO2 and CaF2-H2O leading to temperature dependence of Gibbs energy of reactions. Equilibrium constants were calculated for ladle and ESR conditions for reactions forming volatile components AlF3, SiF4 and HF (at 1 873K KAlF3 = 1,03 10-8 mm Hg, KSiF4 = 5,93 10-4 mm Hg и P2HF/H2O = 5.649·10-4). Some CaF2 losses observed during steel refining are not eventually regulated by mass-transfer reactions but rather processes between metal, oxide-fluoride melt and gas environment.

82. Yu. S. Proydak, A. P. Gorobets, I. Mamuzić
Substantiation of an innovative concept of refining steel with out-of-burn treatment with the use of alkaline alumosilicate – pegmatite. Innovative technology ladle treatment steel processing with the use of a part of slag-forming mixtures of alkali aluminosilicates-pegmatite theoretically proved. The results of the Industrial development technology with the replacement of 50-80 % fluorspar by pegmatite were summarized and analyzed. The results of evaluation of the quality of the metal on non-metallic inclusions in accordance with GOST 1778-70 scales and ASTM E-45 (method A) confirm the effectiveness of the technology with partial or complete replacement of fluorspar by pegmatite.

83. O. V. Zhadanos, I. V. Derevyanko, V. V. Portnyi, I. Mamuzić
Researching of thermophysical processes in Acheson furnace for the production of silicon carbide to develop automatic process control system. Thermo-physical model of silicon carbide production process in Acheson furnace is developed. Dynamics of thermal condition of furnace reaction zone is computed by finite difference method. Temperature front of reducing reactions is indicated. It is reasonable to estimate effect of input power dynamics on sizes of zones of reduction products by means of developed model in order to obtain analytical dependences of change of thermal condition of furnace reaction zone which will enable to work out technological recommendations on conduct of silicon carbide production process and to develop Automatic Process Control System of furnace.

84. G. V. Tregubenko, V. T. Kalinin, I. Mamuzić
The redistribution of hydrogen between the phases during the crystallization of aluminum and its alloys. A research result is: development of theoretical bases of process of gas release of hydrogen during crystallization of aluminium and its alloys and forming of foundings with optimum gas porosity. Simple and comfortable for practical application expressions are first got for determination of influence of different factors on the process of gas release of hydrogen during crystallization of foundings from an aluminium and its alloys. Application of the set dependences is given by possibility actively to manage the process of gas release of hydrogen at thermosetting of aluminium and its alloys, to optimize a technological process and so on.

85. A. A Nadtochiy, V. S. Kyrychok

Thermodynamic modeling of equilibrium in complex oxide systems based on manganese. The activation characteristics for slag with a basicity of 0,3 indicate an increased tendency to crystallization. The addition of Al_2O_3 to the ternary system leads to the appearance of a complex compound $3CaO \cdot Al_2O_3 \cdot 3SiO_2$, and above 6% Al_2O_3, an increase in $2MnO \cdot SiO_2$ is observed with a simultaneous decrease in $CaO \cdot SiO_2$. An increase in Al_2O_3 from 2 to 9 % leads to an increase in the viscosity of the slag at 1350 °C. An increase in MgO to 9 % leads to a significant increase in the viscosity of the slag. An increase in the MgO content in the slag above 7 % leads to the decomposition of MgO compounds with SiO_2, which in turn leads to an increase in free SiO_2 oxide.

86. T. Selivorstova, V. Selivorstov, I. Mamuzić

Using gas-dynamic pressure to improve the efficiency of cluster adsorption in carbon steel. It has been experimentally established that when gas-dynamic pressure is used during the crystallization of a cylindrical carbon steel casting, the amount of sulfide inclusions increases with increasing pressure, and the average size of the inclusion decreases by 1.2 - 20.6 times. By increasing the stresses in the solidifying metal layer in contact with the surface of anisomorphic particles, the pressure promotes the formation of an active transition layer of clusters in the zone of their contact, due to which these particles acquire the ability to subsequently act as active centers during heterogeneous crystallization.

87. V. O. Ruban, O. M. Stoianov, K. H. Niziaiev, Y. V. Synehin

Simulation of steel blowing processes in LF through hollow electrodes. The formation of the bubbling zone and the exposure of the metal mirror when blowing through the bottom blowing devices in the ladle have been studied. It is defined that for the conditions of refining blowing (gas flow rate 100 l/min.) The thickness of the slag layer practically does not affect the process of exposing the metal mirror. In the homogenization blowing mode 400 l/min and "intensive" 800 l/min, the relative "open-eye" area on the metal mirror is 20-22% and 73-80%, respectively, and is determined primarily by the thickness of the slag. Using the method of mathematical analysis, an equation is obtained that describes the effect of the flow of gas supplied to the bottom blowing devices and the thickness of the slag layer on the relative "open-eye" area of the metal mirror in the steel ladle.

88. R. P. Andryukhin, L. S. Molchanov, Y. V. Synehin

Water modelling of steel homogenization in finish alloying of steel in top casting. The technology of finishing alloying of steel in a mold during top and bottom casting is considered. To find the optimal place for introducing alloying agents into the melt as the mold was filled, three series of experiments were carried out: 1) top casting with the introduction of dye into the mold; 2) bottom casting with the introduction of dye into the mold; 3) bottom casting with the introduction of dye in the trumpet, the results of which were used to determine the time of complete homogenization of the dye in the liquid. It has been established that the introduction of alloying additives on the metal mirror in the mold is expedient to carry out after filling the mold by one third, regardless of the casting method.

89. H. V. Meniailo, V. E. Khrychikov

The volumetric shrinkage of rolling rolls made of ductile cast iron weighing 8860 kg was experimentally investigated. The kinetics of volumetric shrinkage was recorded by the movement of graphite electrodes of the electroslag heating installation, recording a decrease in the level of cast iron in the riser. The bath level in the riser was flat, without a solidified metal layer on the walls of the mold, which also made it possible to determine the total volumetric shrinkage. The temperature of the slag bath at the bottom of 1555 ... 1520 ^{0}C provided the movement of the melt and the supply of the shrinkage of the casting. The metal consumption from the profit was 363 kg or 4.1% of the roll weight. The optimal duration of electroslag heating was established, which made it possible to reduce the consumption of electricity, graphite electrodes and fluxes.

90. A. D. Semenov

Removal of shrinkage depression in art castings with different wall thickness. Occurrence of a shrinkage depression is caused by formation in massive parts of a casting of thermal knots from which center the melt is filtered for food of shrinkage of the hardened layer on all nearest surfaces of a casting. Therefore, it was believed that when moving the melt from the thermal unit, in its center, a void and under pressure is formed, which leads to the retraction and curvature of the hardened layer of metal on the surface of the casting with less strength. The vacuum in the center of the artistic casting thermal unit was eliminated by moving atmospheric air along a thin tubular needle made of austenitic stainless steel, which is used for medical injections.

91. G. Siwiec

Research of zinc concentrate oxidative roasting process. In this work, the tests on the oxidative roasting process of zinc sulphide and zinc sulphide concentrate were carried. When zinc sulphide ores are used in the proces of obtaining the metalic zinc, then oxidative roasting operation is always a preliminary stage of the basic zinc production process. Both by the hydrometallurgical and by the pyrometallurgical method.

92. J. G. He, W. J. Tao, Y. Li, G. Z. Dong, X. X. Cui

Impact of cathode slot on current distribution in cathode carbon of an aluminum electrolyticl cell. The current distribution in a fresh aluminum electrolytic cell with slotted carbons is investigated by the Finite Element Method (FEM). The effects of the length of slots, l_a and l_c on current distribution were also determined. The maximum local current density and its position do not change with an increase in l_c ($0 \leq l_c \leq 200$ mm) for a 400 mm slot located 150 mm from the upper surface of the cathode carbon. However, the maximum current density shifts towards the cell center with increasing slot lengths. Current distribution control thus plays a role in optimizing the cathode slot length.

93. S. Temirova, G. Abdykirova, E. Kuldeyev, E. Tastanov, I. Bondarenko, I. Motovilov

On the possibility to obtain manganese concentrate from manganese-containing tailings. The paper presents the results of studies intended to separate minerals by density in a heavy liquid. Chemical analysis found that the manganese content amounts to 16,32 % in the studied sludge sample. Manganese sludge was separated by specific gravity in M-45 heavy liquid (the aqueous solution of a complex salt of barium iodides and cadmium with a density of 3 000 kg/m^3). The tailings sample was fractioned by specific gravity in the material with a particle size of -2,5 + 1,0 mm; -1,0 + 0,5 mm and -0,5 + 0 mm. The manganese content in the heavy fraction of 3 000 kg/m^3 was 32,5 %. The manganese content in the light fraction varied from 1,7 to 2,5 %. Light fractions were represented by aggregates of quartz and calcite with manganese minerals. According to X-ray phase analysis, heavy fractions were mainly represented by minerals braunite, bixbyite, barite and hematite.

94. S. H. Wang, S. Tong, C. X. LI, Y. K. Xue, K. X. Zhang, H. K. Sun

Phosphorus(p) migration behavior in the process of converter slag gasification dephosphorization. The high P content in steel slag limits its recycling during the smelting process, and the P can be effectively removed from the steel slag by gasification dephosphorization. In this experiments, the effects of temperature, basicity, and FeO for gasification dephosphorization rate are studied through thermodynamic calculations. The Scanning Electron Microscope (SEM) and Energy Dispersive Spectrometer (EDS) analysis that microscopic morphology of slag before and after reduction. In addition, a model is established to describe the phosphorus migration behavior of gasification dephosphorization process.

95. M. Niesler, J. Stecko, J. Łabaj, A.Smagór, L. Blacha, A. Smalcerz

Application of anthracite dust in the processing of steel dusts. Scrap processed in the electric arc furnace (EAF) process in the form of car bodies or housings of household appliances generates dust containing a large amount of zinc. Coke or anthracite is currently used as a reducer in pyrometallurgical technologies used for the processing of waste zinc-bearing materials. The article presents the results of research on a large-laboratory scale, in which anthracite dust was used as a waste reducer. The presented research confirmed the high efficiency of the reducer used. The degree of zinc removal in the process of steel dust processing in the kiln was at the level of 80 %. Such values indicate that waste anthracite dust can be an alternative carbon-bearing material in the process of steel dust processing.

96. D. Turysbekov, N. Tussupbayev, L. Semushkina, S. Narbekova, Zh. Kaldybaeva, A. Mukhamedilova
Study of the properties of water-air microdispersion of a floatation agent solution. The objective of the study is to investigate the properties of water-air microdispersion of floatation agent solution. The air-water emulsion of flotation agent solution is obtained in the air-water microemulsion generator. Butyl airfloat, foaming agent C-7 and cationic collector butyltriethylenetetramine B-TETA have been studied as reagents. The factors influencing emulsion stability have been determined. It was found that the temperature increase worsens the stability of microdispersion, the optimal speed of the generator is 6 000 rpm and higher. Floatation agent solutions give stable microdispersions at different solution concentrations. The optimum microdispersion is obtained at a generator speed of 6 000 rpm from 0,5 g/l solution of butyl airfloat, from 50 g/l solution of C-7 and B-TETA. The particle size of the dispersion ranges from 41-59 μm.

97. A. A. Ultarakova, Z. B. Karshigina, N. G. Lokhova, A. M. Yessengaziyev, K. K. Kassymzhanov, S. S. Tolegenova
Extraction of amorphous silica from waste dust of electrowinning of ilmenite concentrate. The paper presents research on the processing of waste dust from the electrical smelting of ilmenite concentrates with the removal of silicon from them by the fluoride method. The optimum conditions for fluorination of electric smelting dust were determined, at which the degree of silicon fluoride sublimation was 84,2 %. The silicon-containing sublime obtained in the presence of an ammonia agent has been studied. Based on the results of thermal analysis and studies on the effect of process duration the optimum pyrolysis modes that provide the separation of fluoride and silicon oxide: temperature 530 - 560 °C and duration of 60 - 80 min have been determined. The content of silicon oxide in the obtained product was 96,3 %.

98. D. Xu, B. Zheng, L. X. Guo, H. X. Pang
A mathematical model of critical jet heights causing droplets splashing in bof steelmaking. It is important to understand the physical interaction between top-blown oxygen jet and liquid bath in basic oxygen steelmaking furnaces (BOF). In this study, cold model experiments were carried out to investigate the cavity depth, diameter and the instability at the gas-liquid interface. Images of the cavities were captured by a high-speed video camera to study cavity performances. A modified judging equation of the gas-liquid interface instability was developed by the critical jet flow and the critical jet height at a determined jet diameter. The critical parameters were in good agreement with experimental measurements.

99. D. Xu, B. Zheng, L. X. Guo, L. Zheng
A mathematical model of cavity depth in converter steelmaking. In this study, cold model experiments were carried out to investigate the cavity depth. It was found that the existing model prediction deviated from the experimental results at higher gas flow rate. The normalized linear relationship was obtained between the dimensionless characteristic cavity depth (n_0/H) and a combined dimensionless parameter of the Froude number (Fr) and the ratio of nozzle diameter to jet height (d_e/H). Further, the linear law of the slope and the intercept of normalized fitting line with the nozzle diameter were obtained.

100. Ch. Hu, K. Yang
Prediction of silicon content in hot metal based on golden sine particle swarm optimization and random forest. Particle Swarm Optimization (PSO) algorithm quickly falls into local optimum, low precision. In this paper, add the golden sine operation to the particle position update. The results show that the improved PSO algorithm has better optimization ability. The main parameters affecting the silicon content in hot metal are selected. Then, calculate the correlation coefficient and significance level between parameters and silicon content in hot metal. Finally, the prediction model of silicon content in hot metal is established based on the Random Forest (RF) optimized by improved PSO. The results show that the hit rate is 87,17 %.

101. Akhyar, I. Hasanuddin, M. Ibrahim, A. Farhan, Z. Jalil
Evaluation of cast defects in ship propeller of recycled aluminum alloy. The material used is recycled aluminum alloy. The ship's propeller is cast through a steel mold. The macroporosity, misrun, and cold shut defects formed in the cast products of the ship's propellers were observed for their location, geometric shape, and size. Defects are generally formed at the tip of the blade with various geometries and sizes, and shrinkage cavity defects are observed at the butt of the blade. No defects were found in the product when die mold was preheated.

102. I. Bondarenko, Ye. Kuldeyev, N. Serzhanova, N. Sadykov, A. Tastanova
The process of beneficiation of fine chrome sludges on concentration tables. Processing industrial products and technogenic waste is an urgent task in mining and metallurgical industry. In Kazakhstan, processing of chrome ores of the Kempirsay group of deposits creates more than 15 million tons of sludge tailings with a chromium oxide content of up to 30 wt. %. The best results of processing fine chrome raw materials are demonstrated by Turkish enterprises that use sludge separation by size classes and enrichment on concentration tables. The authors performed a research on Dubersay tailing dump chromium sludge enrichment (Kazakhstan) using similar technological approaches, which allowed to obtain concentrates containing 51 wt.% Chromium oxide and increase the yield of rich fine chromium concentrates by 14 % compared to the existing enrichment scheme.

103. I. Bondarenko, E. Kuldeyev, S. Temirova, A. Tastanova, N. Sadykov
Obtaining of strong chromium pellets with the use of a ferrosilicon-calcium binder. The article presents the results of research on the synthesis of strong chrome pellets based on concentrates obtained by enrichment of chrome sludge. To obtain strong fired pellets from the concentrates, it is proposed to use a ferro-silico-calcium reagent as a binder, which makes it possible to increase the strength of the pellets by 2-3 times in comparison with the technology operating at "Donskoy Ore Mining and Processing Plant". This excludes the supply of fluxing reagents during electric arc smelting of raw materials to high-carbon ferrochrome. Pellets from concentrates obtained during the processing of tailings from the Dubersay sludge storage have increased strength up to 5 330 N/pellet at a roasting temperature of 1 200 °C.

104. L. Semushkina, G. Abdykirova, D. Turysbekov, S. Narbekova, Zh. Kaldybaeva, A. Mukhamedilova
Flotation processing of copper-molybdenum ore using a combined flotation reagent. The paper presents the results of laboratory studies on the flotation of copper-molybdenum ore from the Kazakhstani deposit using a combined reagent. A combination of butyl xanthate, a noninogenic collecting agent with a thioamide group – TC-100 thionocarbamate and higher aerofloat (Reafloat series) was used as a combined flotation reagent. The ratio of the components of the combined reagent was, in %: 85:15:5. The combined flotation reagent was preliminarily passed through a T18 digital ULTRA-TURRAX disperser before flotation to obtain a reagent microemulsion. The use of a microemulsion of a combined reagent increases the extraction of copper into the copper-molybdenum concentrate by 3,69 %, the extraction of molybdenum by 6,05 %.

105. W. Bialik, S. Gil, S. Kozłowski
Ecological effect of modernization of a metallurgical furnace. In the paper, a feasible ecological effect of modernization of a conventional metallurgical furnace intended for charge material preheating before plastic working processes is described. The modernization activities involved replacement of the previous recuperator, the negative pressure control system of the furnace and a proposal for application of modern low emission burners. The suggested design of a recuperator with a higher energy recovery level due to a decreased flue gas temperature will contribute to reduced consumption of electrical energy that is necessary for the extraction ventilator drive. The modernization activities led to decreased total process-induced CO_2 emissions resulting from lower consumption of gas and electrical energy (nearly 11 % in relation to the state before the modernization).

106. D. Yessengaliyev, T. Kainenova, A. Angsapov, G. Zhexenbaeva, G. Zhaumitova, Z. Sultamuratova
Feasibility study of using with high basicity manganese ore for smelting refined ferromanganese. Modern production of the refined ferromanganese based on the use rich manganese concentrate. But reserve the rich manganese concentrate deficit every year. Therefore, it is necessary to involve the base manganese ores for smelting manganese alloys. The article presents the results of X-ray phase, microstructural, thermal analyses of studies of the high basicity manganese ore "Ushkatyn III" and smelting of refined ferromanganese from it. Reached high extraction of manganese from the charge blend (78 %) from ore (56 %) and lime consumption was reduced by 30 %.

107. Ye. Kuatbay, A. Nurumgaliyev, Ye. Shabanov, O. Zayakin, S. Gabdullin, T. Zhuniskaliyev
Melting of high-carbon ferrochrome using coal of the saryadyr deposit. The article presents the results of large-scale laboratory tests on the smelting of high-carbon ferrochrome with the replacement of parts metallurgical coke with high-ash coal from the Saryadyr deposits. According to the test results,

it can be stated that the optimal percentage of replacing metallurgical coke with high-ash Saradyr coal is 30 – 40 %. During a large-scale laboratory test, it was also established that the cost of the alloy was reduced due to the partial replacement of expensive coke and removes the fluxing component of quartzite from the charge composition, and improves the TPE of the high-carbon ferrochrome smelting process.

108. T. Merder, J. Pieprzyca, M. Saternus, M. Tkadlečková
The interaction of the argon curtain at the interface: metal-slag in a tundish. Due to the need to improve the quality of the produced steel, especially its metallurgical purity, attempts are made to use inert gas bubbling curtain in the tundish. The article presents the results of the research of metal-slag interaction carried out with the use of the trough-type two-strand tundish water model, made on a reducing scale – 1 : 2,5. The tundish model is built with two gas bubbling curtain. The aim of the research was to determine the optimal value of the flow rate of the blown gas, ensuring the safe course of the process taking into account the secondary contamination of liquid steel with atmospheric gases and endogenous inclusions originating from the slag.

109. G. Abdykirova, S. Temirova, E. Kuldeyev, A. Tastanova, I. Bondarenko, L. Semushkina
A study on the beneficiation ability of manganese-containing technogenic raw materials. The work presents the results of studies on obtaining ferromanganese concentrate from technogenic manganese-containing raw materials with grain size less than 10 mm. It is found that the main valuable minerals of the feedstock are psilomelane, pyrolusite, bementite; among the rock-forming minerals, quartz and kaolinite, often saturated with finely dispersed iron compounds, prevail. Sieving and concentration of raw materials of - 10 + 5 mm and - 2 + 0,2 mm in two-chamber jigging machine with separation of two concentrates and tailingns allowed to obtain a joint manganese concentrate with 35,1 % manganese content, 11,5 % iron content with 78,23 % manganese recovery. The obtained manganese concentrate is suitable for further metallurgical processing.

110. I. Mamuzić, G. Shvachych, B. Moroz, V. Chorna, N. Voroshylova, S. Shvachych
Modeling of hazardous impurities transport. The considers solutions to the ecology problems, which set is formulated from cause-effect relationships. According to the adopted model, the equation's coefficients for the harmful impurities transfer are attributed to the causal features of the process. Along with direct methods of mathematical modeling of harmful impurities transfer in the atmosphere from pollution sources, considers the formulation and methods of solving inverse problems, which essence is to estimate the input parameters based on actual information about the modeled system, known from the experiment. Based on the research results, a software package was developed to implement the solution of the coefficient inverse problems of ecology using the mathematical modeling method.

111. W. Zhang, Z. X. Yin
Seismic performance analysis of blast furnace shell structure. In this paper, the finite element software ANSYS is used to establish a three-dimensional space model of the blast furnace shell, and the static analysis of the space steel structure system of the blast furnace is carried out. The seismic response of the outer shell system of the blast furnace is analyzed by response spectrum method and linear time history analysis method, so as to explore the seismic response of the blast furnace shell.

112. H. Zhang, B Wang, J. Zhang
Parametric of dimensional analysis on iron bath gasifier. In this paper, an iron bath gasifier is designed to handle organic solid waste. A 1:8 water model is constructed to study the effects of the various parameters on the mixing time. The empirical formula between the mixing time and dimensionless groups was determined by multiple linear regression. The study results show that the flow rate of bottom nozzle, flow rate of side nozzle, top lance position, and tracer height have a great impact on the mixing time. By substituting previous experimental data into the empirical formula, the calculated and experimental values of the dimensionless group of mixing time are found to be highly relevant.

113. K. Franczak, P. Kwaśniewski, G. Kiesiewicz, M. Sadzikowski, W. Ściężor, S. Kordaszewski, D. Kuca
Research on the continuous casting process of cucrzr alloys with the addition of scandium dedicated for resistance welding electrodes. The article presents the results of research on the metallurgical synthesis of CuCrZr copper alloys with the addition of scandium as a new material for spot welding electrodes for the resistance spot welding of Zn-coated steel sheets. The tested material was manufactured in a continuous casting process in a horizontal arrangement in the form of rod. The alloys were heat treated to determine their hardness and electrical conductivity properties. Zinc diffusion tests into the material structure were carried out on the produced castings, reflecting the conditions accelerating the wear of electrodes during resistance welding of Zn-coated steel sheets.

114. S. Kordaszewski, P. Kwaśniewski, P. Strzępek, G. Kiesiewicz, W. Ściężor, M. Sadzikowski, K. Franczak
Graphite crystallizer and its surface quality as a factor affecting the copper continuous casting process. Pure copper is one of the best conducting metals among known materials, making it the first choice for wires and microwires. However, before subjecting to metal working, the material is being manufactured in the continuous casting lines. The experimental study conducted in laboratory conditions proved that the external surface quality, and thus the contact quality with the cooling system is being responsible for the worsening or improving of the heat transfer and therefore the temperature of the crystallizer itself. The conducted study might function as sort of a guideline for the industrial process.

115. S. Kordaszewski, P. Kwaśniewski, G. Kiesiewicz, K. Franczak, W. Ściężor, R. Kowal, P. Strzępek.
Optimalization of the metallurgical synthesis parameters of CuZn37 brass with nickel and silicon alloy additives. The modifying possibility of the commercial CuZn37 brass (M63) with nickel and silicon is being discussed throughout the article. The proposed alloy additives made it possible to improve the commercial brass properties by precipitation hardening, thus making it extremely competitive in comparison to base material. The study also discussed the conditions (temperature and time) of the metallurgical synthesis and its influence on the weight percentage of not only proposed alloy additives but also the amount of zinc loss from the commercial brass due to the evaporation during the metallurgical processes.

116. R. Kowal, A. Mamala, W. Ściężor, P. Kwaśniewski, A. Nowak, S. Kordaszewski, K. Franczak
Correlation between the Mg and Si macrosegregation phenomenon and mechanical properties in EN AW-6060 aluminium alloy billets obtained by horizontal continuous casting. Modern non-ferrous metal applications are faced to high requirements in terms of even distribution of the alloying elements. In general, the homogeneity of the chemical composition of the materials affect to their mechanical properties. As part of this paper the relationship between the local concentration of Mg and Si in 90 mm diameter billets from EN AW-6060 aluminium alloy and local variability of yield stress in experimental conditions which simulates technological conditions for hot metal forming processes. The phenomenon of macrosegregation remained specified for billets obtained in the technology of horizontal continuous casting, dedicated to extrusion or forging.

117. P. Strzępek, M. Zasadzińska, S. Kordaszewski, W. Ściężor
Geometry and surface quality of the crystallization system and their influence on the temperatures throughout continuous casting processes of copper-magnesium alloys. Copper-based materials for electrical purposes usually find their origin in continuous casting lines where the effectiveness of the process and the quality of the final product depends among others on the crystallization system. The paper investigates the influence of the surface quality of the crystallizer and the geometry of the cooling system on the temperature distribution throughout the copper-magnesium alloys casting process. The obtained results prove that as the contact between the crystallizer and the cooling system is worsening the temperature of the crystallizer and the cast rod increase significantly, therefore affecting the efficiency of the process.

118. A. Brudny, J. Kulasa, B. Cwolek, W. Malec, B. Juszczyk
Influence of the continuous casting process of tin-zinc-lead bronze on the wear of the graphite crystallizer. The research conducted in this paper concerns the influence of the continuous casting process of tin-zinc-lead bronze on the wear of the graphite crystallizer. Observations and testing of the external surface of the cast rods indicate their good quality, without casting defects. No excessive surface degradation was observed on the inner surface of the crystallizers after casting. It was assessed that the surface quality of the crystallizer would be acceptable for further use, despite stuck residue, mainly in the crystallization zone.

1. S. A. Mashekov, U. D. Angarbekov, A. E. Uderbayeva, N. Sarsenbayev

New-design radial-shear rolling mill (RSRM) automation. The article deals with a new-design radial-shear rolling mill combined with pressing function. Finite element methods and MSC.SuperForge SW were used to generate quantitative data and establish basic patterns of strain-stress state (SSS) and temperature distribution during workpieces rolling-pressing in helical rollers. Formulas were derived by theoretical data approximation to allow a highly accurate determination of the SSS and temperature distribution pattern in the deformed workpiece. An equation-based mathematical model for the RSRM operation is proposed. The RSRM operation mathematical model is implemented in WinCC 7.0 and Step 7 SW using FBD and SCL PL. Sensor-derived data allow to automatically adjust the process modes of manufacture of bars and wires while avoiding any production defects.

2. P. Szota, S. Mróz, A. Stefanik, K. Laber, R. Mola

Theoretical and experimental analysis of the backward extrusion process with a rotational die of AZ31 alloy. In this work theoretical and experimental analysis of the backward extrusion with a rotary die of the AZ31 alloy has been performed. The modification of the classical extrusion was based on the use of a rotary die. The results of theoretical research have confirmed that the use of the modified backward extrusion causes the appearance of shear stress in deformed material, which could affects the activation of additional mechanisms of deformation. The numerical modelling of the rotating extrusion of AZ31 alloy has been conducted by using the computer program Forge®. The experimental tests were carried out in the conditions of the STD 810 torsion plastometer using newly designed tools.

3. S. Barannikova, Yu. Li

Kinetics of deformation bands in a low-carbon steel — stainless steel bimetal. The regularities of non-uniform plastic deformation evolving on the Lüders bands are studied in a low carbon steel – austenite stainless steel bimetal via a digital image speckle method. The local strain distributions in the bimetal low-carbon steel base layer at the yield point stage are presented by the two strain localization bands that are similar to the Lüders bands. Analogous distributions arise at the yield point from the bimetal austenite stainless steel clad layer in the form of two strain localization fronts that are identical to the Portevin-Le Chatelier bands. Finally, the generation of strain localization bands is described in the context of a solid-state wedging model.

4. Y. F. Jiang, X. Zhou, W. Y. Zhang

A surface defect detection method for rolling magnesium alloy sheet based on computer vision. In the rolling process of magnesium alloy sheet, defects such as edge crack, fold and ripple are easy to appear on the surface of the sheet. These defects will affect the product yield and quality, and cause waste of resources. In this paper, computer vision technology is used to analyze the image of rolling magnesium alloy sheet in real-time, extract its defect features, and Bayesian classifier and Random Forest (RF) classifier are used to identify defects. The experimental results show that the comprehensive defect recognition rate of the RF algorithm is up to 92,4 %, which is much higher than the accuracy of Bayesian classifier, and it is more suitable for the recognition of surface defects of magnesium sheet.

5. P. Skubisz

Results of thermomechanical treatment implementation in hammer drop forging industrial process. The study concerns cost-effective realization of Thermomechanical controlled processing (TMCP) in a forging process. The goal of the study was to produce mechanical properties of the steel in as-forged direct-cooled condition equivalent to those of quenched-tempered structural steel with simultaneous energy-savings benefits. The results of satisfactory implementation into hammer forging of a complex-geometry made of microalloyed medium-carbon steel 38MnVS6 in industrial conditions are presented. The use of finite element analysis for estimation of proper run of cooling curves and full-scale simulation for reproducible hot deformation and cooling conditions resulted in producing R_m over 1 120 MPa with elongation reaching 20 %.

6. S. A. Mashekov, G. A. Smailova, Zh. S. Abdimuratov, B. A. Nurlybayev, S. A. Orynbayev, A. Zhauyt

Phase and structural transformations in foil billet during rolling of helical rollers and longitudinal wedge mill (LWM). In the article, by changing the technological modes of strip rolling in helical rolls and a longitudinal wedge mill, the phase and structural transformations in the foil blank are studied. It was found that rolling in helical rolls with twelve passes of the initial alloy billet 2017 provides its nanostructuring with the formation of a mixed structure. It is shown that rolling alloy 2017 in helical rolls leads to an increase in the density of dislocations. It has been proved that with an increase in the number of passes, the excess phases, mainly of coarse particles of the (CuFeMn) 3Si2Al15 phase, are significantly crushed. The volume fraction of these particles does not change.

7. S. A. Mashekov, E. A. Tussupkaliyeva, S. A. Akparova, L. R. Kiyanbekova, K. K. Nurakhmetova, B. N. Absadykov

Influence of rolling modes on the anisotropy of sheet metals from carbon steel rolled on the longitudinal wedge mill (LWM) of a new design. The longitudinal wedge mill (LWM) of a new design is proposed in this article. By using the MSC.SuperForge software product which designed for the stress-strained state of the billet when rolling strips from steel S235JR on the LWM. The rational modes of hot and cold rolling and their effect on the anisotropy of sheet metals from steel S235JR have been defined. It was proved in our work that compared with cold rolling, during hot rolling of sheet billets in the sheet plane it does not appear the significant anisotropy of mechanical properties.

8. S. A. Mashekov, E. A. Tussupkaliyeva, Zh. K. Aimurzaeva, B. N. Absadykov, A. Alimbetov

Development of rational technology of rods production on a radial-shift mill (RSM). The radial- shift mill (RSM) of a new design, which makes it possible to obtain high quality rods by the combined rolling-pressing process is proposed in this article. Special attention is paid to the influence analysis of rolling in smooth and helical rolls and to the rolling-pressing on the formation of structures in rods from M1copper alloy. It has been established that processing by the combined process makes it possible to form a fine-grained structure along the cross-section of the bars without disrupting the continuity of the billet material. By using physical modeling the effect of temperature-deformation processing modes on the kinetics of dynamic recrystallization of copper alloy M1has been studied. The dependence of the size of the recrystallized grain from temperature and degree of deformation has been established.

9. Y. B. Kaliyev, K. D. Baizhumanov, Z. Zh. Tursymbekova, M. A. Zhumanov, G. A. Smailova, M. M. Azilkiyasheva, A. Zhauyt

Study of stress-strain state billets when rolling in a continuous mill of hot-rolled thin stripes using MSC super forge. The article proposes a new design of a continuous mill. To study the stress-strain state during rolling of thin slabs on the proposed mill, a three-dimensional geometric and simulation model of the rolling process was developed using MSC SUPER FORGE. Based on the obtained results of numerical modeling, the distributions of equivalent strains in a thin slab when rolling in 1 mill stand, the distribution of equivalent stresses in a thin slab when rolling in 1 mill stand, the distribution of the temperature field in a thin slab when rolling in 1 mill stand.

10. Y. Gao, L. Y. Huang, C. Chen

Analysis on temperature field after angle steel's controlled cooling. According to the theory of thermal analysis, the angle steel as the research object, was established as one finite element model in section steel and was taken the thermal analysis with the software ANSYS. Contrasting the natural cooling and controlled cooling, could get angle steel's each parts about the temperature changes and the angle section's temperature field in all directions. Analysis results show that: the control cooling could increase the cooling rate, making the temperature distribution of steel more uniform, improve the temperature field distribution, and even increase mechanical property and general performance, which have a good reference value for the study to angle steel's controlled cooling on temperature field.

11. Y. J. Lu, X. D. Shu

Effect of aluminum alloy wheel forging and spinning process parameters on forming force. In order to study the influence of process parameters on the forming force during the forging and spinning process of the wheel hub, five parameters were selected: die preheating temperature, blank temperature, upper die down speed, friction coefficient and feed rate.Use Deform and Simufact software to simulate and obtain the influence law of each process parameter on forming force.The results provide a certain reference for reasonable selection of process parameters in the forming process.

12. J. N. Shi, X. D. Shu, S. Zhang, J. T. Wang, Y. X. Xia, C. Q. Ye

Effect of process parameters on the surface forming accuracy of step of hollow step shaft formed by three-roll skew rolling. This paper adopts a three-roll skew rolling technology with rolls that can either converge or move apart to form shafts with variable cross-section dimensions. Based on the rolling pitch, the effect of rollers' rotation speed, radial speed, axial speed of chuck on the forming accuracy of the hollow shaft surface is analyzed. Increasing the rotation speed of rollers, reducing the radial speed of rollers and the axial speed of chuck can obtain higher surface forming accuracy. The finite element simulation results verified the correctness of the conclusion.

13. Sh. Xu, S. H. Zheng, Sh. Z. Yang, Q. H. Yang

Optimization of deep drawing process parameters of 304 stainless steel. The one-step drawing process of double-box flume was simulated by finite element method(FEM). It was found that major defects in the forming process were vertical surface fractures in the box and material accumulation near rounded corners. The optimal forming parameters were obtained by optimizing and improving workpiece, single factor analysis and orthogonal experiment optimization. Guiding grooves with an included angle of 140° and a depth of 1 mm was designed in the blank holder to guide materials from accumulation area to insufficient area, thus reducing material fractures and improving deep drawing. The ultimate depth of one-step drawing without defects was increased to 190 mm by optimizing process parameters and improving structure.

14. Z. Ma, H.C. Ji, W. C. Pei, S. F. Wang, Y. G. Li

Constitutive relationship of 7075 aluminum alloy based on modified Zerilli-Armstrong (M - ZA) model. The Gleeble – 3500 thermal simulation testing machine was used to perform isothermal tensile test on 7075 aluminum alloy at a deformation temperature of 300 – 450 °C and a strain rate of 0,01 – 1 s^{-1}, and the true stress-strain curve of the alloy was obtained. Based on the true stress-strain data, the modified Zerilli-Armstrong (M-ZA) model was used to construct the constitutive model of the alloy, and the fitting accuracy of the model was analyzed.

15. Z. S. Peng, H. C. Ji, W. C. Pei, B. Y. Liu, G. Song

Constitutive relationship of TC4 titanium alloy based on back propagating (BP) neural network (NN). Using Gleeble-3800 thermal simulation testing machine, the TC4 titanium alloy was subjected to hot compression experiments under the conditions of deformation temperature of 810 – 950 °C, strain rate of 0.001 - 1s^{-1}. The research shows that the flow stress of TC4 titanium alloy is more sensitive to the deformation temperature and strain rate during thermal deformation, and it increases with the decrease of the deformation temperature and the increase of the strain rate. Based on BP neural network, a constitutive model of TC4 titanium alloy α+β two-phase region is established. The correlation coefficient reaches 0,996, which proves that the model can predict the high temperature flow stress of TC4 titanium alloy.

16. J. S. Wu, Y. J. Zhang

Research on calculation model of rolling force in twin roll inclined strip casting process. For the twin roll inclined strip casting process, the tilt angle function is introduced to describe the casting process, and the mathematical model of the calculation of the rolling force coupled with the tilt angle function is proposed, and the relationship between the influence of the tilt angle on the rolling force is derived, thus enriching the casting and rolling theory.

17. Zh. A. Ashkeyev, M. Zh. Abishkenov, S. A. Mashekov, A. Kawalek, K. A. Nogaev

Study of the deformation state during the pulling of the workpiece in a special die. The article presents the results of a study of the deformation state when pulling a metal workpiece in a special die, preventing unidirectional metal flow in the longitudinal direction. The results of the studies on variational methods and mathematical modeling showed that the values of shear deformations in the central zone of deformation focus are respectively within 0,081 – 0,1226 and 0,085 – 0,175, which in turn proves the possibility of obtaining long-term metal workpieces with increased physical and mechanical properties in the die.

18. S. Lezhnev, A. Naizabekov, E. Panin, I. Volokitina, D. Kuis

Recycling of stainless steel bar scrap by radial-shear rolling to obtain a gradient ultrafine-grained structure. The paper presents the results of the conducted experiments confirmed not only the possibility of processing bar scrap from stainless metals to produce a marketable product, but also confirmed the possibility of obtaining high-quality bars with a gradient fine-grained structure and an increased level of mechanical properties. This discrepancy in the structure of the peripheral and axial zones, together with the results of microhardness measuring across the cross section of samples with a total degree of deformation of 44,4 %, indicates the gradient nature of the formed microstructure.

19. L. Y. Huang, Y. Gao, C. Chen

Study on the best method of controlled cooling for rolled angle steel. In this paper, the large-scale finite element analysis software ANSYS is used to establish the three-dimensional finite element model of angle steel and analyze the temperature field during the cooling process. Taking the spray density and spray speed as the design variables, the temperature gradient as the state variables, and the maximum temperature difference as the objective function, the optimization design of angle steel controlled cooling method is carried out. The results show that the maximum temperature difference of angle steel is reduced and the temperature distribution is more uniform after optimization, which has a very important guiding significance for the reasonable customization of angle steel controlled cooling process.

20. M. M. Azilkiyasheva, S. B. Shayakhmetov, G. B. Bakyt, B. T. Kopenov, G. A. Smailova, Y. Y. Baubekov, A. Zhauyt

Development of a method for calculating the degree of use of the plasticity resource (DUPR) when rolling on a new continuous mill. A new design of a continuous mill is proposed in the article. A method has been developed for calculating the degree of use of the plasticity resource when rolling thin slabs on a new continuous mill using the data obtained in the MSC Super Forge environment. To determine the stress-strain state, it used measurement data in 5 stands. When rolling in the proposed mill steel D16 there is no violation of the continuity of the strip material. This is proved by calculation in the MSC Super Forge environment using the distribution of DUPR over the cross section of strips when rolling in a mill of a new design.

21. A. Zhauyt, A. Bukayeva, Z. Tursymbekova, G.Bulekbayeva, Zh. Begendikova, G.Mambetaliyeva, M. Chazhabayeva

Development of hot rolling technology using the method of physical modeling. These days, ensuring the high quality of thin products (0,6 – 2,0 mm) is the most promising direction for the development of hot-rolled strip production. Hot-rolled strips can be used in place of a more expensive cold-rolled strip. The effect of cooling modes on quality of hot-rolled metal was observed heating at different temperature, the degree of deformation was observed after cooling by water-air mixture. It was observed that the micro hardness of the samples decreases and the amount of structurally free ferrite increases by decreasing the cooling time and increasing the temperature.

22. Q. J. Lian, X. D. Shu, T. Z. Chen

Research on temperature field and microstructure distribution of cross wedge rolling based on square billet. The emergence of the square billet is a breakthrough in the selection of raw materials, but related research is relatively scarce. Therefore, this paper conducts a finite element simulation for the rolling process of the square billet. Four characteristic points are taken on the longitudinal section of the billet to track the temperature change. Research on the law of field changes. At the same time, the change of the grain size and dynamic recrystallization percentage of the rolled piece during the rolling process is studied. Simulation and experiment are combined to obtain the change rule of the average grain size of the characteristic points of the longitudinal section of the billet with time.

23. G. Song, H. C. Ji, W. C. Pei, J. S. Li, S. Cai, B. X. Liu

Hot forging for producing railway wagon bogie adapter. Hot forging forming of railway wagon bogie adapter is a new railway wagon bogie adapter processing technology. In this paper, a hot forging die for railway wagon bogie adapter was designed, and the forming quality were analyzed by using DEFORM-3D software. Then, the feasibility of the process was verified by experiments. It was found that using this mold can eliminate the defects such as loose as-cast in metal smelting process, optimize the microstructure, forging products with good density, product quality and other characteristics of stability.

24. D. Strycharska, Z. Skuza
Improving the efficiency of the rolling process of 16 mm ribbed bars in the three-strand technology. The paper presents a modification of the slitting pass system for the three-strand rolling of 16 mm-diameter ribbed bars, which will reduce the wear of rolls, and thus increase the economic efficiency of the analysed process. The results of theoretical research were verified on the basis of the performed measurements of force and energy parameters during the rolling of ribbed bars according to the multi-strand technology in a D350 continuous rolling mill. The computer program Forge2011® was used for theoretical analysis of the rolling process with longitudinal strand separation.

25. A. Volokitin, I. Volokitina, E. Panin, A. Naizabekov, S. Aksenov, D. Kuis
Finite element method (FEM) simulation of processing of AISI-316 austenitic stainless steel by high-pressure torsion (HPT) process at the cryogenic cooling. In this work the high-pressure torsion process of AISI-316 stainless steel in cryogenic conditions is studied by means of finite element simulation. The stress and strain distributions are analyzed and compared with the ones obtained for ambient temperature. It is shown that the cooling to cryogenic temperature do not affect the equivalent strain distribution significantly. At the same time, the stress values are significantly different - with cryogenic cooling, the level of compressive stresses increases by about 20 %. The simulation of microstructure evolution in Deform-3D program showed that the use of cryogenic cooling makes it possible to further grind the original structure.

26. X. L. Xi, B. Wang
Self learning research on rolling force model of hot strip rolling based on improved adaptive difference. In order to improve the prediction accuracy of the rolling force Self-learning Model and change the phenomenon that the learning coefficient is unstable and the optimization process is not reasonable due to the experience value of the self-learning factor in the traditional self-learning, this paper proposes an improved adaptive differential evolution (IADE) algorithm based on the standard differential evolution algorithm to solve and optimize the problem quickly. The prediction accuracy of rolling force model is improved. The experimental results show that the prediction accuracy of IADE algorithm is lower than that of the traditional model, which can effectively improve the prediction accuracy.

27. C. Q. Ye, X. D. Shu, Y. X. Xia, J. T. Wang, S. Zhang
Mechanism of integrated forming of shape and inner hole of hollow axle. The paper introduces a new technology of the integrated forming of shape and inner hole of hollow axle. Firstly, the design of the process is described. Secondly, the range of feed angle of two sets of rolls and the principle to be followed are explained. Finally, the rolling process of hollow axle is simulated by Finite Element Method(FEM), and the variation law of load parameters and the distribution law of temperature and effective plastic strain in the rolling process are analyzed.The numerical results verify the feasibility of rolling hollow axle with this process.

28. X. Y. Zhang, Y. Wang, P. K. Hu
Study on rolling forming mechanism and influencing factors of blanks with arc-shaped. In this paper, the influence law was analyzed, the effective parameter range was determined. Based on the significance analysis of the orthogonal experiment with three factors and three levels, the order of the influence degree of each parameter on the forming quality of the end is obtained. According to the optimized simulation analysis in the effective scheme, the optimal forming process parameters were determined. The results show that the order of the influence of various factors on the diameter of the roll cut is as follows: roll cutting speed> friction factor> baffle gap; the best combination of process parameters is A2B1C1, the friction factor is 0,5, the roll cutting speed is $1/rad \cdot s^{-1}$and the baffle gap is 0,1/mm.

29. A. L. Syrotenko, S. L.Stasevsky, V. F. Balakin, Y. D. Ugryumov, I. Mamuzić
New metal-saving technologies of hot tube rolling on pilgrim units. Analysis of experimental and analytical data of pilgrim units type 5-12" work results of the past 20 years allowed to develop new technological schemes and methods of their implementation. Different schemes for preparation of front and back ends of the case, joint rolling of tubes with thin and thick walls, methods of withdrawal of the tube from mandrel and its calibration were evaluated. Complex application of the research results allows to significantly reduce metal consumption coefficient from 1.18 to 1.09 which allows the process to be competitive on the market.

30. I. Yu. Prikhodko, V. F. Balakin, S. A. Svyrydov
Surface quality problems in manufacturing of cold rolled strips in coils and methods for their solution. In the production of cold-rolled strips due to turn-to-turn pressure in coils in the process of bell furnace annealing, a blocking or welding-up of the turns occurs. Some defects appear on the surface of the strip, i.e. cross break lines, also called "fractures". During the skin pass rolling process, such surface defects are not eliminated, and they remain on the metal surface. This problem is complex, and many different technological methods are known, aimed at eliminating of such kind of strip surface defects. The considered ways of solving the problem can be applied partially or all-round, and allow to solve the problem of the occurrence of cold-rolled strip surface defects of the "cross break lines" type.

31. A. A. Klimenko, V. F. Balakin, I. Mamuzić
Semi-liquid stamping of metals and alloys. The presented method will make it possible to exclude additional redistribution in the manufacture of forgings and partially replace the process of shaped casting, while significantly improving the quality indicators in comparison with mold castings. The results of experiments at production facilities are presented, the analysis of the dependence of the influence on the structural parameters of the metal of the temperature of the beginning of pressing, the speed of pressing and pressure. Metallographic studies of the products obtained have been carried out.

32. D. A. Bogdan, V. F.Balakin, T. V. Balakhanova, E. V. Kuznetsov, I. Mamuzić
Increasing the corrosion resistance of oil and gas pipes by surface plastic deformation with the use of inhibitors. The results of experimental studies of corrosion resistance of pipes, 132*5 mm, treated according to various schemes of surface plastic deformation with four types of inhibitors are presented; accelerated corrosion tests have been carried out in salt mist chambers and climatic chambers with periodic moisture condensation - 120 hours. It has been established that joint plastic deformation with certain inhibitor decreases the rate of the corrosion process in the salt mist chamber 2 - 2,5 times, while ensuring total absence of corrosion in the climatic chamber.

33. Y. Proydak, G. Shlomchak, B. Moroz, A. Martynenko, I. Mamuzić
Computer simulation of heat treatment of a long-sized product. Development features and application of multiprocessor computing system with its mathematical support and software for heat treatment modes simulation of metal billets are considered. Multiprocessor system with special software is capable to set and control necessary temperature conditions along all the plane of cross-sectional of a billet at heating and self-control of metal, and with possible control of thermal mode of treatment in temperatures interval of annealing. The practical value of results obtained showed that the technological process by appropriate mathematical simulations was improved.

34. G. Shvachych, A. Sobolenko, I. Kabak, V. Khristyan, I. Mamuzić
Study of the wall thickness distribution along perimeter of hot rolled pipes. The periodic components of the wall thickness function of hot rolled pipes are investigated. Using the compiled mathematical simulation, the wall thickness of pipes is interpreted as a function of the angular coordinate that allows identifying periodic components that characterize the structure of wall thickness variation of pipes. The analysis of the corresponding harmonic components and their parameters for a real experiment is carried out. Special software has been developed for conducting practical experiments in a real process.

35. V. Ivashchenko, G. Shvachych, A. Sobolenko, A. Martynenko
Mathematical apparatus of harmonic analysis in the problem of determining the accuracy of rolled pipes. The degree of influence of the tube rolling unit mills on formation of wall thickness variation is investigated. For this purpose, a mathematical simulation of pipe wall thickness was compiled as the sum of a number of harmonic components. Using the mathematical apparatus of the Fourier transforms, the amplitudes of harmonic com-

ponents that describe various types of wall thickness variation are distinguished. The proposed computerized approach for rolling process control is focused on mathematical simulations processing of control of wall thickness variation of sleeves, of rough and finished pipes to increase their accuracy.

36. J. Y. Yuan, B. S. Sun, X. Chen, H. L. Ma, X. S. Gao, X. D. Shu

Effect of process parameters on the force parameters in warm skew rolling of copper ball. In order to better control the forming quality of copper ball by warm skew rolling process, a Finite Element Model (FEM) of copper ball warm skew rolling for the coupling of thermal and mechanical was established. The influence of process parameters on force and rolling torque was analyzed by using single factor research method. The results show that the smaller the cross angle, the lower the rolling temperature, the slower the rolling rotation speed, the greater the forming force and rolling torque, the more difficult for forming. The optimum rolling temperature is 600°C; the optimum cross angle is 2,5°; the optimum rolling rotation speed is 60 rpm.

37. X. L. Xi, B. Wang

Self learning research on rolling force model of hot strip rolling based on improved adaptive difference. In order to improve the prediction accuracy of the rolling force Self-learning Model and change the phenomenon that the learning coefficient is unstable and the optimization process is not reasonable due to the experience value of the self-learning factor in the traditional self-learning, this paper proposes an improved adaptive differential evolution (IADE) algorithm based on the standard differential evolution algorithm to solve and optimize the problem quickly. The prediction accuracy of rolling force model is improved. The experimental results show that the prediction accuracy of IADE algorithm is lower than that of the traditional model, which can effectively improve the prediction accuracy.

38. D. Strycharska, Z. Skuza

Improving the efficiency of the rolling process of 16 mm ribbed bars in the three-strand technology. The paper presents a modification of the slitting pass system for the three-strand rolling of 16 mm-diameter ribbed bars, which will reduce the wear of rolls, and thus increase the economic efficiency of the analysed process. The results of theoretical research were verified on the basis of the performed measurements of force and energy parameters during the rolling of ribbed bars according to the multi-strand technology in a D350 continuous rolling mill. The computer program Forge2011® was used for theoretical analysis of the rolling process with longitudinal strand separation.

39. S. Y. Chen, X. D. Shu, Y. J. Lu

Effect of aluminum alloy wheel forging and spinning process parameters on forming quality. This paper mainly studies the influence of process parameters on the forming quality during the spinning process of 6061 aluminum alloy wheel forging blanks. The four parameters of spinning temperature, spindle speed, wheel feed and wall thickness reduction rate are selected for research, and the quality of the surface of the hub and the influence on the size of the hub are judged. Simufact software is used to simulate the influence of various process parameters on the forming quality of the hub. The results provide a certain reference for the reasonable selection of process parameters during the spinning forming process of 6061 aluminum alloy hub.

40. B. Oleksiak, R. Poloczek

Possibilities of using the flexsim program in a manufacturing company. From the macroeconomic point of view, distribution is the process of goods relocation from producers to end customers. According to the microeconomic approach, distribution is more identified with the sales and delivery process, and the main tasks of the distribution centre include the storage of goods owned by suppliers and distributing them to recipients according to the specific instructions of the goods' owner. This article presents costs reduction and productivity improvement issues in warehouses and distribution centres. The objective of this article is to define order picking problems and to choose the best route for the operator using real simulation and optimisation.

41. I. Mamuzić, Y. Proydak, G. Shlomchak, G. Shvachych, M. Myronenko

Object oriented model for distributed database engineering in conditions of fuzzy sets. The proposed work considers object oriented model of the system that provides solution for enterprise planning and reporting task complex in conditions of fuzzy sets based on symmetric pairs of cryptographic keys. Object identifiers (cryptographic keys) describing the enterprise structure are generated automatically based on full (standardized) names of structural units. To generate the keys CRC32 one-way hash function (NIST standard) is used making possible creation of no repetitive keys. The problem solution is made by relations processor described with macrofunctions. Relations processor represents a server module providing both single and batch problem processing. From the standpoint of relations processor all tasks are concurrent.

42. P. Strzępek, A. Mamala, M. Zasadzińska, A. Nowak

Extensive analysis of the etp grade copper wire drawing force parameters in correlation with the length of the elastic deformation region. Wire drawing process is generally known as the most recognized metal forming process, however, elastic deformations present during the process before entering the drawing die are mostly omitted. That is why the extensive experimental study of the process have been conducted using drawing dies of various geometry. It allowed to define the length of elastic deformation region and its influence on the recorded drawing force parameters which are closely related to drawing stresses and thus the safety factor of the process.

43. M. Zasadzińska, B. Smyrak, T. Knych, P. Strzępek

Defects analysis of copper wires manufactured in industrial conditions. Many factors are responsible for the formation of surface and internal defects during copper wire drawing process. Generally they may be divided into defects of material or processing origin. Even input material of the highest quality with little to none defects cannot ensure the absence of breakages during the process due to inadequate process parameters. Optimally selected process parameters may reduce the risk of cracks forming during the metal forming process. The paper presents examples of wire defects and cracks occurring throughout the wire drawing process of copper in industrial conditions and a wide analysis of their source.

44. T. Knych, A. Mamala, A. Kawecki, B. Smyrak, K. Korzeń, E. Sieja-Smaga

Influence of plastic deformation on the change of electrical and mechanical properties of copper and copper alloy wires. This article is devoted to the comparison of changes in mechanical and electrical properties due to the applied deformation of copper and copper alloy rods. Bars from four different production technologies were deformed in the drawing process, including OF oxygen-free copper, electrolytic copper ETP, copper from cable granulate and silver copper with a high silver content up to 15% (by weight) obtained in laboratory technology. The article presents the chemical purity, physical and electrical properties of rods before deformation. The summary of the research on the selected materials are changes in mechanical properties and electrical conductivity as a function of deformation up to 3.5 on a logarithmic scale and the coefficient of electromechanical efficiency W_{EM}.

45. M. Łagoda, W. Głuchowski, M. Maleta, J. Domagała-Dubiel, M. Sadzikowski

Characteristics of CuCrTiAl alloy after plastic deformation. The development of the automotive industry leads to the search for newer construction materials, but also those used in the production process. Although many types of joints are used in vehicles, resistance welds remain the dominant one. The commonly used alloy for welding caps (CuCrZr) is already well known and therefore newer alloys and technologies for their production are sought to increase service life, and thus reduce production costs. Precipitation hardening CuCrTiAl alloy was analysed in this article. After casting, CuCrTiAl alloy was subjected to cold and hot deformation and then tested for its usability. The obtained results confirmed the potential of this alloy to make electrodes for resistance welding.

1. A. Z. Issagulov, M. K. Ibatov, A. M. Dostayeva, G. K. Koshebayeva, O. M. Zharkevich
Studying the properties of refractory products manufactured by two-stage pressing under industrial conditions. The article deals with studying the properties of refractory masses made by two-stage pressing under industrial conditions in order to increase strength and slag resistance of chamotte bricks due to increasing density by ensuring uniform porosity throughout the volume of the product. Changing porosity when firing is less significant than changing porosity when pressing, therefore, the structure of the product is corrected by the initial mass of components.

2. A. D. Mekhtiyev, F. N, Bulatbaev, A. V. Taranov, A. V. Bashirov, N. V. Mutovina, A. D. Alkina
Method of combating fatigue destruction of steel structures of mine hoisting machines. A method was developed to combat the fatigue failure of steel structures through the use of reinforcing elements to reduce their metal consumption and increase resistance to fatigue failure, while the use of expensive high-strength alloys is completely eliminated. To study the stress-strain state and fatigue failure of steel structures, a computer simulation method was used. Using the ANSYS computer program, the optimal forms of reinforcing elements were established and the loaded part of steel structures in continuous operation was simulated. Eleven computer models of a steel beam with various reinforcing elements were developed. The research results were used in practice in the repair of steel structures.

3. T. Małysa
Use of holt's model for forecasting until 2023 occupational accidents in the metallurgical industry in Poland. The article the issue of occupational accidents in the metallurgical industry was presented. The accident analysis included occupational accidents from 2009 to 2018. Based on compiled empirical data (2009-2018), the process of forecasting occupational accidents until 2023 was carried out. The Holt's model with an additive trend was used to carry out the forecasting process. The use of the developed forecasting model allowed to assess the tendency of changes in the number of occupational accidents in the metallurgical industry in Poland. The developed model can also be used to assess accident changes in other countries.

4. J. Piątkowski, B. Gajdzik, A. Mesjasz
Use of econometric models for predicting the lifetime of steam pipelines in the power industry. The object of the research were bends of steam pipelines 10CrMo9-10, in which the highest frequency of failures caused by material cracks occurs. The forecast of pipeline operation time was determined on the basis of results R_m. Applying the principles of statistical inference to forecast the trouble-free operation time of steam pipelines, mathematical models were selected that in a highly statistically significant way most reflect the actual reduction in R_m over time and determine the limit value of material exhaustion to avoid failure.

5. B. Gajdzik, J. Piątkowski, P. Kliś
Analysis of steel production total and by process in Poland and Romania with forecast until 2023. The publication presents changes in steel production by process: Oxygen Blown Converter (OBC) and Electric Furnace (EF) in Poland and Romania. The publication consist of the analysis of steel production by process in these countries. The analysis was realized for two countries because Poland and Romania have a similar structure of steel production (the share of particular processes in total steel production).The analysis was realized in the period last 30 years (from 1989 to 2018) with forecast until 2023. In the long period of analysis, the steel mills in these countries were radical restructured and changed from steelworks plants controlled by public institutions (government) into the capital companies on modern European market.

6. D. Malindžák, P. Kačmáry, A. Gazda, E. Mihaliková
Order logistics for discrete and continual production processes in industry 4.0 conditions. The basic goal of the article is to define changes in production logistics and its essential part of order logistics at the transformation of the production system from an automated management system with the participation of first level logistics, managers and machine operators to a fully automated, unattended production system and at the same to define and compare the differences between discrete and continuous-discrete production typical for mining, metallurgical production processes. The solution applied the methodology of comparative analysis of the comparison of current systems of order logistics [1, 2], and its operation in terms of Industry 4.0. There were applied principles of production planning and programming of numerical control (NC) machines and robots and program-controlled fully automated production processes, especially in the continuous character of processes for the design of a new algorithm of custom logistics [3].

7. A. D. Mekhtiyev, A. A. Kovtun, V. V. Yugay, E. G. Neshina, R. Zh. Aimagambetova, A. D. Alkina
Research of mechanical stress at tension of quartz optical fiber (QOF). The article presents the results of a study of the process of occurrence of mechanical stress and strain during stretching of a quartz optical fiber. The analysis and review of the current state of development of fiber-optic conductors is performed. The problems of occurrence of microcracks in the body of optical fibers during mechanical loading during operation are considered. In the process of winding optical fibers and further operation, cracks occur. The conducted research allows us to solve an important production problem related to increasing the strength of optical fibers and reducing the number of microcracks. The object of scientific research is quartz optical fiber of the G652 standard, used for the production of fiber-optic cables. For optical fibers, the greatest danger is the stretching, which is observed when rewinding the fiber, during its cabling, during the laying and operation of the optical cable. It was found that the mechanical tensile strength of G652 optical fiber was from 4 482 to 4 808 MPa, and the number of cracks and their parameters affect the tensile strength of the fiber.

8. M. Spilka
Shaping workplace safety in the metallurgical industry. Shaping workplace safety is determined by the organization of work in a way that does not endanger the employee during its performance. It consists of such aspects as occupational risk assessment and determination of the workload, as well as its impact on the employee. At workstations in the metallurgical industry, activities are performed in conditions harmful to health, hence the article presents the results of the workload assessment related to the physical load on employees at selected workplaces in the metallurgical industry. The occupational risk was also estimated and corrective actions were indicated to increase work safety.

9. T. Karkoszka
Risk management system in metallurgical production. The main aim of the paper is to characterize the proposed model of risk management system. Threats identification and risk assessment of the systemic character result in taking action directed on risk elimination, minimization or financing. Concept of the risk management system includes the following anti-risk activities concerning: knowledge, operating, experience and improvement. Those risk actions guarantee effective manner of risk management, which is of particular meaning due to the difficult situation of the European Union's steel industry facing geopolitical, economic and environmental challenges. The model in question can be treated as a guidelines for proceeding in case of prevention and response to the potential, both strategic and operational, metallurgical risk.

10. S. Tolendiuly, K. Alipbayev, S. Fomenko, A. Sovet, A. Zhauyt
Properties of high-temperature superconductors (HTS) and synthesis technology. The main results for the synthesis and study of superconducting high-temperature materials based on cuprates obtained by high-temperature synthesis are presented. The influence of the ratio of the primary components, time and exposure temperature on the output of the superconducting phase (Y123) in the composition was studied. It was found that the initial ratio of components, annealing temperature and aging time have a direct impact on the qualitative and quantitative formation of the conductive phase. The chemical, phase composition and morphology of the obtained samples were carefully studied. Optimal result (maximum conductive phase in Y-Ba-Cu-O system (Y123) size) at a temperature of 920 °C with a retention time of 6 hours.

11. A. A. Genbach, V. O. Baibekova, K. S. Olzhabayeva, A. Mergalimova, A. S. Rasmukhametova, A. A. Begimbetova, A. Zhauyt
Research and modeling of the cooling system in steam turbine bearings. A new porous cooling system in which coolant supply is produced by the combined action of capillary and gravitational forces, is proposed and studied for various technical devices and systems developed by the authors. The influence of liquid flow on heat exchange in porous materials has been studied. Calculated formulas for optimal fluid flow depending on the heat load and the type of porous structure are obtained. The design principles porous structures of evaporators are constructed. The mechanism of the vaporization process in the proposed porous cooling system using internal boiling characteristics is described.

12. B. Gajdzik
Steel industry in Poland – trends in production, employment and productivity in the period from 2004 to 2019. The publication presents the key trends in production, employment and productivity in Polish steel industry. Analysis was realized on the base of statistical data in the period from 2004 to 2019. The publication presents the results of statistical analysis and the dependences between analyzed trends. The end of analyses is 2019 year, so the actual situation in Polish steel industry is presented in the publication.

13. Ye. Mukhametkhan, M. Mukhametkhan, S. Tleugabulov, G. Zhabalova, V. Shevko
Complete thermodynamic analysis of the interaction of iron phosphate ($FePO_4$) with hydrogen (H_2) and carbon monoxide (CO). Iron phosphate in the composition of concentrate is a fairly strong chemical compound. However, with the help of gaseous substances, such complex compounds decompose when heated to the required temperature, which contributes to the reduction of not only iron, but also phosphorus. Hydrogen and carbon monoxide were used as gaseous reducing agents. This article describes in detail the thermodynamic analysis of the reduction of phosphorus from iron phosphate, its interaction with hydrogen and carbon monoxide.

14. Ye. Mukhambetgaliyev, T. Zhuniskaliyev, S. Baisanov
Research of electrical resistance and beginning softening temperature of high-ash coals for melting of complex alloy. The research results are demonstrated on the electrical resistance and beginning softening temperature of the high-ash coals of Saryadyr, Borly and Zhamantuz deposits (Republic of Kazakhstan). The research results showed that a value of the electrical resistance of the charge at the non-isothermal heating to the high temperatures depends on the chemical and mineralogical composition of the charges, and on processes of phase transformations in a sample.

15. P. A. Kropachev, A. D. Mekhtiyev, F. N. Bulatbayev, Y. Zh. Sarsikeyev, A. V. Yurchenko
Method of restoring pivot connections cast iron bushings of heat engine with external heat supply. The article presents the results of studies aimed at developing a method of restoring cast iron bushings for pivot connections of a heat engine with external heat supply. The methods of computer modeling the stress-strain state of the pivot connections are used. To carry out computer modeling, the ANSYS program has been used, which allows simulating the stress-strain state of the kinetic pair of the pivot connection of the crank mechanism of engines with external heat supply and excluding cumbersome field tests of experimental samples. The dependence of stresses on the contact surface of the bushing on the depth of the boring in relation to its total length has experimentally been established.

16. G. A. Akimbek, B. K. Aliyarov, Sh. A. Akimbekova, A. Zhauyt
Determination of the intensity of abrasive chafe by different chafeing materials. The article presents preliminary results of determining the coefficient of relative abrasiveness of various bulk materials. Comparative analysis of the early works of famous scientists devoted to the determination of the intensity of abrasive chafe by coal particles, crushed in mills to a size of 100 microns and less, or formed during their combustion by ash particles (the same or smaller size), usually moving in an air stream or smoke gases. It should be noted that in these studies, the abrasiveness of the material was determined indirectly - through the intensity of erosive chafe, without directly determining the abrasiveness of the material itself. There were practically no data on chafe by particles with sizes corresponding to crushing, interacting with the surface of elements, in the absence of carrier air or other gaseous substance.

17. O. Sariev, N. Nurgali, G. Beketova, M. Zhanabayev, T. Kainenova, A. Zhakan
Electrical characteristics of charge mixtures for melting rich titanium slag (RTS). The article deals with the selection of reducing agent and preliminary preparation of raw materials for melting rich titanium slag (RTS) from ilmenite concentrates of the Shokash deposit. In determining the electrical resistivity of ore-coal briquettes with different reducing agents the authors have found that the most specifically suitable reducing agents for melting (BTSS) are special coke and coal, as briquettes with them, have the maximum electrical resistivity in the range of temperatures of solid-phase reduction.

18. N. Nurgali, O. Sariev, A. Mukhambetkaliyev, B. Momenov, A. Kuandykova, R. Abdrashev
Phase composition of titanium-containing raw materials depending on its titanium oxide content. The article deals with the phase equilibrium in titanium-containing slag from metallurgical processing of ilmenite concentrates of Shokash deposit on the basis of five-component system TiO_2-Al_2O_3-SiO_2-MgO-CaO have been studied by thermodynamic analysis (TDA). The phase equilibria in two four-component systems CaO-MgO-Al_2O_3-SiO_2 and TiO_2-MgO-Al_2O3-SiO_2, which are part of the five-component system TiO_2-Al_2O_3-SiO_2-MgO-CaO were clarified and corrected. Thus, the data on the phase compositions of congruently (stably) melting compounds of titanium slag and slag of aluminum- and aluminosilicothermic ferrotitanium as well as slag melts from melting of titanomagnetite ores, etc. have been obtained.

19. G. K. Daumova, Yu. I. Lopukhov, E. M. Azbanbayev, N. V. Seraya, A. V. Russakova
Research of ultra-dispersed opal-quartz-carbonate bentonite clay for coating welding electrodes UONI-13/55. New single-layer and double-layer coatings of UONI-13/55 welding electrodes for welding low-carbon and low-alloy steels have been proposed. The coatings were applied with superfine ultradispersed opal-quartz-carbonate bentonite clay of the Taganskoye deposit of the East Kazakhstan region. Studies have confirmed that the use of new coatings can improve the welding and technological properties of electrodes and increase the strength and ductile characteristics, as well as the cold resistance of the deposited metal.

20. A. A. Ultarakova, A. M. Yessengaziyev, E. I. Kuldeyev, K. K. Kassymzhanov, O. Kh. Uldakhanov
Processing of titanium production sludge with the extraction of titanium dioxide. An urgent task at the present time is the disposal and processing of large-tonnage waste of titanium production of Ust-Kamenogorsk titanium-magnesium plant of the Republic of Kazakhstan. This work shows research on the development of sludge technology with the extraction of titanium dioxide and calcium nitrate, which will eliminate the formation and discharge of technological waste into the environment. Ammonium fluoride processing of cakes from sludge leaching made it possible to first isolate silicon fluorides in the form of fumes, and then sublimate titanium fluorides. Silicon and titanium fluorides were converted to silicon and titanium dioxides by alkaline hydrolysis.

21. G. Dairbekova, B. Zhautikov, N. Zobnin, D. Bekmagambetov, D. Tolubayeva
Use of Si-composite aspiration dusts production in the creation of thin-film anodes. The present time is marked by the progress of technology related to energy storage. One of the promising priority energy storage devices is lithium-ion batteries (LIB), which have a high energy density and a low self-discharge level. To increase the charging capacity and general characteristics of LIB, researchers think about replacing one of the electrodes, in particular the anode, with more promising and cheaper materials. Of all the possible materials on the market, silicon (Si) is one of the most effective, promising, cheap, and widespread materials. In contrast to pure Si, composites based on it are becoming more widespread and are actively used as a material for LIB.

22. A. K. Koizhanova, A. N. Berkinbayeva, G. V. Sedelnikova, B. K. Kenzhaliyev, M. N. Azlan, D. R. Magomedov,Y. M. Efremova (Dyo)
Research of biochemical gold recovery method using high-arsenic raw materials. This article contains the results of experiments to recover gold from complex mineral raw materials containing more than 15 % arsenic. Laboratory tests showed that standard cyanidation recovers only 26,4 % of gold into the solution. Additional oxidizing reagents used increase the leaching efficiency and enable to recover more than 40 % of gold during subsequent cyanidation. The efficiency has been established for replacement of cyanide with thiourea and thiosulfate solutions. 79,5 %, i.e. the maximum recovery rate, was found in the experiment with preliminary oxidation with T. Ferrooxidans, a bacterial culture, followed by leaching with a thiourea solution.

23. J. Furman, T. Małysa
The use of lean manufacturing (LM) tools in the field of production organization in the metallurgical industry. This article presents the possibility of using Lean Manufacturing (LM) tools for the identification of waste occurring in individual areas of the production activity of steelworks in Poland. The issue of waste reduction and improvement of the organization of production contributes substantially to cost reduction and effective implementation of production tasks. This study identifies waste, and then presents the process of its reduction based on the available methods and tools of the LM concept. Given the above, the aim of this study is to assess the possibility of adapting LM tools in the steel industry in the context of waste reduction and improvement of the organization of production.

24. T. Malysa, J. Furman

Application of selected lean manufacturing (LM) tools for the improvement of work safety in the steel industry. This article presents the possibilities of the application of Lean Manufacturing (LM) tools for the improvement of occupational safety and health. The issue of work safety in the steel industry is of particular relevance for the management of steelworks due to the number of recorded accidents at work. Given the above, the most common causes of accidents at work in the steel industry in Poland in 2009-2019 were listed. Their analysis made it possible to propose a possibility to implement solutions provided for within the Lean Manufacturing concept. This article aims to consider the possibility of adapting LM tools in order to address the causes of accidents at work and improve work safety in enterprises in the metallurgical sector.

25. T. Karkoszka

Risk – threats and opportunities in metallurgical production. The effective strategy ensuring the European metallurgical concerns a competitive position on the market must be based on the risk analysis and assessment, both connected with the influencing external and internal factors. In the study one has proposed the algorithm of systemic management with the risk of threats and opportunities, covering the risk value assessment with the application of the matrix method as well as the acceptability assessment based on the individual criteria. The comparison of the assessment results of both: risk connected with the threats and risk of possibilities, should be of systemic character and constitute the base for the decisions within the scope of risk taking actions.

26. Bm Thethwayo

The recovery of metals from electronic waste: A review. The scarcity of precious metals in the earth's crust necessitates finding secondary sources to fulfil the increasing demand for these metals. For example, a secondary source of precious metals can be made available through the metallurgical recovery of metals from electronic waste. However, conventional commercialized methods have limitations and can result in potential harm to the environment. Flotation, ionic liquids and chelating are the latest developments in this research area. This concise review entails the following: - The worth of metals in e-waste, - The current methodologies of recovering metals from the e-waste, - Current research on the efficiency of environmentally friendly reagents

27. B. K. Kasenov, Sh. B. Kasenova, Zh. I. Sagintaeva, E. E. Kuanyshbekov, A. A. Mukhtar, B. T. Ermagambet, A. Nukhuly, Zh. S. Bekturganov, A. K. Zeinidenov

Thermodynamic and electrophysical investigation of nanostructured copper-zinc manganite of lanthanum and lithium $LaLi_2CuZnMnO_6$. The paper demonstrates the results of the experimental investigation of the thermodynamic and electrophysical properties of the new nanostructured copper-zinc manganite of lanthanum and lithium ($LaLi_2CuZnMnO_6$).

28. P. Malinowski

Casting production management system. The paper presents the results of casting production management system for foundry industry. The production proces management system collects data from the entire production preparation proces, technology development using simulations, molding sand parameters, liquid metal, quality control, etc. By using the system, the foundry is able to reduce the time needed to prepare the production proces while maintaining high quality of the casting.

29. B. K. Kassenov, Sh. B. Kassenova, Zh. I. Sagintaeva, B. T. Ermagambet, E. E. Kuanyshbekov, A. A. Mukhtar

Calculation of thermodynamic properties of earth metals − copper-zinc (Cu-Zn). The approximate methods calculated the standard thermodynamic characteristics of our new obtained copper-zinc manganites of compositions of LaMeI2CuZnMnO6 and LaMeIICuZnMnO6 (MeI − Li, Na, K; MeII – Mg, Ca, Sr, Ba).

30. T. Karkoszka

Metallurgical processes safety in the context of machinery and other legal requirements. In the metallurgical processes, due to the amount and meaning of the workplace safety threats, there is a necessity of implementing the steps connected with their elimination or limitation. Undertaking the steps should be based on the identified legal requirements and the risk refraining from lack of the compliance. The most meaningful, within the mentioned scope, are the requirements concerning design, construction and use of the machines. The aim of the presented study was identification of the essential requirements stated to the machines' manufacturers, minimal requirements dedicated to the work equipment' users. One has pointed the potential risk of lack of compliance and described the ways of taking up such a risk depending on the identified legal requirements.

31. B. Gajdzik

Polish crude steel production in pandemic year of 2020 compared to previous five years. The article presents the situation in the Polish steel sector in 2020. The year 2020 was called the "pandemic year" due to the economic and social impact of the COVID-19 pandemic. The scope of the analysis included: crude steel production total and by processes in Poland in months of 2020. The data on crude steel production was compared with data from previous five years from 2015 to 2019. The analysis performed provides detailed information on increases or decreases in the amount of crude steel produced in Poland in individual months. The paper is based on data from the Polish Steel Association in Katowice.

32. B. Kelamanov, O. Sariev, A. Akuov, Ye. Samuratov, Z. Sultamuratova, R. Orynbassar

Study of nickel briquettes by thermographic method. The results of thermogravimetric studies of nickel concentrate (briquettes) with the establishment of its characteristic features are presented. The study of nickel concentrate with different reducing agents showed the thermographic possibility of involving them in metallurgical processing. The values of the activation energy in the process of thermal studies are determined.

33. B. K. Kenzhaliyev, T. Yu. Surkova, B. E. Abdikerim, A. N. Berkinbayeva, Ye. B. Abikak, D. M. Yessimova

Research on sorption properties of phosphoric production slag-waste. On the territory there are phosphorus-containing wastes - phosphorus slags, the basis of which is volostanite. The study of phosphorus slag as a uranium sorbent is of theoretical and practical interest. In the course of the research, comparable data were obtained on the sorption of the initial and activated slag by different reagents. The optimal conditions for the activation of phosphorus slag in order to increase its sorption properties have been determined.

34. S. A. Mashekov, E. A. Tussupkaliyeva, B. B. Bazarbay, M. L. Rakhmatulin, N. Sembayev

The stress-strain state (SSS) calculation of heavy loaded elements of a new-designed pressing device. The results analysis of calculating the stress-strain state (SSS) of heavily loaded elements of new powder metallurgy equipment by using an analytical method and a deformation model of metal strength is presented here. The influence of tools construction on the heavily loaded elements of the pressing device stress-strain state is determined. It is shown that the new equipment for powder metallurgy has a sufficiently high rigidity of the unit structure and satisfies the strength condition. It is noted that pressing of long length profiles on the proposed pressing device will lead to the production of finished products of high quality. As a result of the equipment SSS calculating, rational structural dimensions of main units of the pressing device were determined.

35. A. Mukhanova, N. Tussupbayev, D. Turysbekov, A. Yessengaziyev

Improvement of the selection technology of copper-molybdenum concentrate with the use of modified flotoragents. The flotation of copper-molybdenum ores Aktogay deposit of Republic Kazakhstan has been studied, with application new synthesized modified reagents. Selective flotation of copper-molybdenum collective concentrate was carried out according to standard technology with application of modified flotation agent (diesel fuel: oil = 1:1) in comparison with traditional apolar (kerosene) collector. The use of the modified reagent in the processing of copper-molybdenum ore allows increasing the molybdenum content in the molybdenum concentrate by 3,6, and extraction - by 5,7 %.

36. M. M. Mussayev, K. T. Sherov, T. M. Buzauova, A. K. Rakishev, N. Z. Karsakova, N. B. Abisheva, S. S. Ainabekova

Studying the stress-strain state of a more loaded node of a special device for turn-milling. This article presents the results of studying the stress-strain state of the intermediate shaft part, which is subjected to high dynamic loads during the operation of a special device for turn-milling. The scheme of forces acting on the intermediate shaft has been revealed. The calculation is based on the method of determining the von Mises yield criterion. It has

been established that the maximum value of the voltage and the most critical point occurs at the transition of the steps from the diameter of 25 mm to 30 mm. However, the value of these stresses does not exceed the maximum permissible ones and it can be concluded that the parametric dimensions of the intermediate shaft fully meet the requirements to ensure the quality of the device.

37. M. Niesler, J. Stecko, J. Łabaj, A.Smagór, L. Blacha, A. Smalcerz

Application of anthracite dust in the processing of steel dusts. Coke or anthracite is currently used as a reducer in pyrometallurgical technologies used for the processing of waste zinc-bearing materials. The article presents the results of research on a large-laboratory scale, in which anthracite dust was used as a waste reducer. The presented research confirmed the high efficiency of the reducer used. The degree of zinc removal in the process of steel dust processing in the kiln was at the level of 80 %. Such values indicate that waste anthracite dust can be an alternative carbon-bearing material in the process of steel dust processing.

38. Sh. Zh. Sagimbaeva, K. Sh. Shunkeyev, V. V. Tarkovsky, L. K. Tastanova, L. N. Myasnikova, G. K. Beketova

Electroplasma enrichment of natural diatomite. Method of electrohydraulic enrichment of natural diatomite from the Kazakhstan deposit as a multipurpose nanomaterial has been developed. Electrohydraulic method is based on separation of diatomite from the clay component under the influence of plasma energy arising in a short electric discharge. Complex study of enriched diatomite by spectral, X-ray diffraction (XRD), silicate (chemical) and thermal analysis methods was carried out. Independent methods of analysis applied show almost identical results for the degree of diatomite enrichment with silicon oxides (SiO_2), being in the range of 78 - 80 %.

39. L. V. Semushkina, N. K. Tussupbayev, D. K. Turysbekov, S. M. Narbekova, A. A. Mukhanova

Recycling technology for gold-containing tailings with the use of a composite reagent microemulsion. The paper contains the laboratory study results for the flotation processing of gold-containing tailings with the use of the composite reagent (CF). The CF flotation reagent is a microemulsion from a composition of sodium butyl xanthate and reaflot. A gold-containing concentrate was obtained with a gold content of 6,7 g/t with a recovery of 59,71 % in the basic mode. The use of the CF composite flotation reagent increases the gold extraction into the gold-containing concentrate by 3,77 %, as compared with the main collector - sodium butyl xanthate. The consumption of CF flotation reagent is reduced by 20 %.

40. S. Tolendiuly, K. A. Alipbayev, S. M. Fomenko, A. Sovet, A. Zhauyt

Effect graphite on magnesium diboride superconductivity synthesized by combustion method under argon pressure: Part I. Solid-state synthesis of a superconductor based on magnesium diboride doped by graphite microparticles (MgB_2@C) at argon atmosphere has been described. The superconducting characteristics of samples critical current density (Jc) and critical transition temperature (Tc) have been measured. The impact of the doping additives on superconducting characteristics of magnesium diboride has been analyzed. The results showed that the best optimal characteristics are for MgB_2@3%C that reveals a good critical transition temperature 38,8 K and the higher critical current density 2,7 x 10^6 A / cm² at 5 K.

41. Y. Kobrin, O. Hrechanyi, I. Shevchenko, I. Mamuzić

The need to balance the rotors of hammer crushers during operation in metallurgical production. An experimental analysis of the influence of different amplitudes and frequencies of vibration on the technical condition of support units and parts and drive of crushers was carried out at the laboratory installation of the hammer crusher model. The dependences of the energy of destruction of coal and coke in the hammer crusher on the balance of the rotor are established. Installation of sensors for measuring vibration parameters allows to determine in advance the critical values of the crusher and to balance the rotor according to the proposed method, which allows not to dismantle it, which significantly reduces maintenance and repa**ir time.**

42. A. Varitsev, I. Mamuzić

Resource saving in the application of carbon materials in metallurgy. Increasing the use of renewable energy sources in the country's energy balance will help solve this problem. The solution to this problem is to involve in the production of metallurgical waste to reduce the cost of non-renewable energy sources and use in energy-intensive metallurgical technologies to obtain special-purpose materials. An effective way to reduce the consumption of traditional fuels is to use carbon materials. Carbon materials can be obtained from various types of biomass that are not currently used. Such wastes may be agricultural wastes.

43. L. Kieush, A. Koveria, I. Mamuzić

Co-utilization of hydrogen and biomass in metallurgy. The quality of metallurgical products depends not only on the use of fuel for the reduction reaction but also largely on the presence of carbon in the fuel, which acts as a reducing agent of metal ores. In the case of using hydrogen, this function is performed by lignocellulosic biomass, which is a sustainable source of carbon. This technique allows completely replacing the use of non-renewable fossil fuels in metallurgy while increasing the efficiency of high-temperature metallurgical processes and mitigating harmful emissions.

44. T. Selivorstova, V. Selivorstov, I. Mamuzić

Information technology for quantitative analysis of digital images of sulfur prints. For the quantitative analysis of sulfur prints, the ASImprints software package has been developed, which allows processing grayscale and monochrome images of both whole sulfur prints and their fragments. In the "Binarization" module, a grayscale image of a sulfur print is converted into a monochrome image at a given threshold, while the proportion of the area of sulfide inclusions in a fragment is calculated. The "Analysis" module is designed to determine the areas and the number of inclusions on a monochrome image of a sulfur print or its fragment using the algorithm of recursive filling of a boundary-defined 4-connected area. The "Calibration" module is designed to determine the proportion of areas and the number of inclusions in four size ranges.

45. Y. Proydak, G. Shlomchak, B Moroz, V. Konovalenkov, I. Mamuzić

Studies of thermophysical properties of materials by inverse methods. The problem is considered to research the materials' thermal and physical properties by inverse methods. The corresponding class of mathematical simulations is derived. The main research purpose is that the simulations processing procedure as those that are controlled by input parameters reduce, on residual principle basis, to an extreme formulation. A package of applied problems had been developed for solving coefficient problems of heat-conductivity by mathematical simulation methods. The package creation had been carried out considering the requirements of object-oriented programming.

46. G. Shvachych, B. Moroz, I. Hulina, V. Khristyan, I. Mamuzić

Parallel algorithms in applied problems of metallurgical thermal physics. The problem of constructing the maximum parallel forms of difference algorithms to solve applied problems of metallurgical thermal physics is investigated. The proposed approach does not impose any restrictions on grid nodes topology of computational domain. In addition, with regard to parallel computation of arithmetic expressions, it separates the error of initial data from the rounding operations inherent in classical methods. It is shown that the constructed parallel form of the algorithm is maximum, and, therefore, has the minimum possible implementation time when using parallel computing systems.

47. V. Ivashchenko, O. Ivashchenko, l. Kabak, l. Sushko, I. Mamuzić

Research of the problem of deceleration of computations in multiprocessional computing systems when solving applied problems. The research is aimed at determining the deceleration factor associated with the increase in computing of a multiprocessor system. It should be noted that the research of these problems is important and relevant. The aim of the research is the further approach development associated with methodology definition for evaluation of the multiprocessor modular computing system effectiveness and this value impact of the computational deceleration.

48. B. Moroz, I. Udovyk, I. Hulina, V. Konovalenkov, l. Sushko

Visualization of solutions of applied problems in metallurgy based on schemes of increased order of accuracy. The problem is considered to the distributed modeling of visualization of vectors of solution for applied tasks solutions of metallurgy on the basis of schemes with increased order of accuracy. Higher acceleration of computations compared with the finite-difference approach is illustrated by the use of analytical solutions that allow

simultaneous and parallel computation for all temporary layers. It is shown that the most perspective approach to mathematical modeling of applied tasks of metallurgy should be considered the one based on numerical and analytical decisions.

49. O. Dmitrieva, T. Altukhova, I. Mamuzić

Computer modeling of diagnostic systems. The work is devoted to the solution of the actual scientific and technical problems, consisting of the substantiation, development, and study of computer models of the system for diagnosing the technical condition of electric motors. Mathematical models for diagnosing the technical condition of electric machines of mining machines based on the Bayesian statistical method, Petri nets, and cluster analysis have been developed using Kohonen neural networks, adaptive resonance, and extreme machine learning. The use of such models will increase the objectivity of diagnostics of the technical conditions of electromechanical equipment by conducting uninterrupted monitoring of energy-mechanical parameters in real-time.

50. O. Dmitrieva, I. Nazarova, V. Guskova, I. Mamuzić

Algorithmic methods for parallel modeling and visualization of dynamic processes and machine learning systems. Research is devoted to improving the efficiency of design and development of working environments for modeling and data mining. The high dimension of such models, the presence of many variables affecting the result, the choice of initial conditions require a long execution time and the use of optimization approaches to solve the problem. Providing highly efficient parallel computations in modeling and visualization of complex dynamical systems covers a new systemic organization of the use of parallel computing resources, the development of new and adaptation of existing computational methods to new parallel architectures.

51. L. Zhang, A. Semenova

The identifying software vulnerabilities process mathematical model. The software security testing features research have been carried out. The results showed the impossibility of an unambiguous the set representation of controlled parametric data characterizing the software security, and, accordingly, the input data fuzziness when assessing the software security. On its basis, the identifying software vulnerabilities process mathematical model has been developed, which differs from the known ones using the mathematical apparatus of fuzzy data to confirm software vulnerabilities. This made it possible to the simulation results increase the accuracy up to 1,5 times.

52. S. Semenov, W. Cao

Penetration testing method based on reinforcement machine learning technology. Software security testing methods research has been carried out. Manual testing disadvantages have been identified. At the same time, the algorithms synthesis complexity for the individual vulnerabilities automated detection into a single complex and revealed the using artificial intelligence systems feasibility to solve this problem. A penetration testing method was developed based on the algorithms synthesis for constructing an attack tree and reinforcement machine learning technology. The attack tree was generated using the C4.5 algorithm. The Deep QLearning Network (DQN) model was used to optimize the trajectory process for an ethical penetration attack.

53. N. Kuchuk, S. Bulba, I. Mamuzić

Mathematical simulation of topological structure self-healing network. The formulation of the problem of developing a mathematical model of Self-healing Network is proposed. The formation of the topological structure of the network was carried out in three stages. The third stage, the final one. The topological structure of the network is being formed. It is optimal according to the selected criterion. The criterion is the minimum average delivery time for a message. When solving the optimization problem, a modified K. Steiglitz method is used. The developed mathematical model makes it possible to form a regular structure of a Self-healing Network for given connectivity. The model is also used for horizontal scaling of the network.

54. H. Kuchuk, I. Petrovska

Modeling data processing programs in the self-healing network. A method for the synthesis of models for the functioning of data processing programs in the Self-healing network is proposed. The method is based on a dynamic model of behavior of asynchronous parallel processes. The initial data is trace data. Which are obtained in the process of monitoring the Self-healing network. To describe the models of the system and the external environment, a single formal-logical apparatus of temporary Petri nets is used. A high level of adequacy of the synthesized models is achieved by reasoned consideration of the identified interdependencies between events. The aggregate description of interacting parallel processes corresponds to modern design concepts.

55. V. Ivashchenko, G. Shvachych, I. Udovyk, D. Moroz, I. Mamuzić

On the problem of the efficiency of computations of multiprocessor systems when solving applied problems. The research is aimed at determining the deceleration factor associated with the increase of the computing area of a multiprocessor system when compared with the computer version with an unlimited computing area. The analytical ratios are derived for determining the calculations deceleration coefficient. A stage of simulation for calculations of the deceleration factor was carried out to determine the regularities of its change, depending on the application of a particular computing platform.

56. V. Ivashchenko, G. Shvachych, O. Ivashchenko, B. Moroz

Parallel algorithms for solving applied problems of metallurgy. A proper class of the mathematical models had been deduced for investigating the thermophysical properties of materials by means of reverse methods. A package of applied problems had been developed for solving the coefficient problems of the heat-conductiving with the methods of mathematical simulation. Creation of package had been carried out considering the requirements of the object-oriented programming. The simulation procedure had been realized on the basis of application of multiprocessor computer system. The package of applied programs is intended for treatment of thermophysical experiments with reverse methods.

57. G. Shvachych, I. Udovykd, D. Moroz, I. Mamuzić

Research of the efficiency of multiprocessor systems taking into account the influence of the network interface. Research is devoted to the development of an approach to determining the methodology for assessing the effectiveness of modular multiprocessor computing systems. At the same time, the main attention is focused on the impact peculiarities on this network interface value. The formation analysis of the multiprocessor system network interface architecture and the basic modes of its operation have been analyzed. To evaluate the processes occurring in the system during the information flows transmission, the network system bandwidth and the switch throughput were compared; which allowed determining the preconditions for optimal components selection of the multiprocessor computing system network interface.

58. G. Shvachych, D. Moroz, I. Mamuzić

Maximum parallel algorithms for solving applied problems. In this paper, using the example of solving thermal problems of mathematical physics, the possibility of creating the most parallel form of computational algorithms for solving thermal problems and their mapping to the architecture of multiprocessor systems is shown. It is shown that an effective tool for studying heat and mass transfer problems in metallurgical production can be considered the use of parallel computing technologies on distributed cluster systems, which have a relatively low cost and are fairly easily scalable both in the number of processors and in the amount of RAM.

59. D. Moroz, I. Mamuzić

Parallel numerical-analytical algorithms with continuous time. The aim of this work is to construct a numerical-analytical method of designing efficient algorithms for solution of tasks having the parabolic type. Using a priori information about the smoothness of solutions, great attention is paid to the construction of solutions of high -order accuracy. Creation of parallel computing systems required the development of mathematical concepts for constructing parallel algorithms, i.e. algorithms adapted for implementation in these systems. As the basis for constructing the parallel algorithm it can take both: a sequential algorithm and the task itself as well. It is shown, that the algorithm of numerical - analytical vectorization has the maximal parallel form and, hence, minimally possible time for realization on parallel computing devices.

60. D. Moroz, I. Mamuzić
Maximally parallel forms of mathematical models with a tridiagonal structure. Research is devoted to the development of maximum parallel forms of mathematical models with a tridiagonal structure. Parallelization of tridiagonal mathematical models by the method of straight lines and the method of sweeping allows one to create absolutely stable algorithms with the maximum parallel form and, therefore, with the minimum possible time for their implementation on parallel computing devices. It is noteworthy that, in the proposed algorithms, the input data computation errors are separated from the round-off errors inherent in PCs.

61. G. Shvachych, O. Ivashchenko, V. Busygin, I. Mamuzić
Solution of applied statistical problems based on multiprocessor systems. The paper deals with multiprocessor modeling technologies for Monte Carlo problems. Calculation schemes are presented that provide an increase in the productivity and speed of calculations. The paper proposes a modified parallel computing algorithm based on the Monte Carlo method. Here, each calculator has its own random number generator. In this case, intermediate calculations are performed independently on different, separately taken blades of the cluster, "calculators". Obviously, such a solution allows you to speed up the computation process. It is shown that parallel algorithms of the Monte Carlo method are stable to any input data and have the maximum parallel form and, therefore, the minimum possible implementation time on parallel computin

62. O. S. Maksakova, A. M. Dolzhanskiy, I. Mamuzić
Prospects for the development of standardization for means of individual protection. Analysis of data on international ISO standards adopted in Europe and Ukraine shows that CEN has adopted 63 international NDs, which is about 38 %; Ukraine has adopted 64 international NDs as national (also almost 38 %). For further development of the national regulatory framework of Ukraine and from the point of view of implementation of the provisions of the Association Agreement, it becomes expedient, first of all, to adopt international standards, which have already been adopted by the European Committee for Standardization (EN ISO).

63. O. S. Maksakova, A. M. Dolzhanskiy, I. Mamuzić
Prospects for the development of standardization for laboratory equipment. Analysis of the adoption of international standards in the EU and Ukraine for laboratory equipment showed that the European Committee for Standardization adopted 30 international ND (about 32 %) of the adopted ISO, and Ukraine as a national – 24 international ND (almost 26 %). In order to further harmonize the requirements for the procedures of mutual recognition of test results and expand opportunities for cooperative research and unquestionable access to the world level of laboratory research in Europe in general, and Ukraine in particular, standardization activities in this area should be urgently intensified.

64. O. S. Maksakova, A. M. Dolzhanskiy, I. Mamuzić
Prospects for the development of standardization for fire safety. Climate change in recent years, that is revealed by global warming, and the irresponsible environmental policies of some countries have led to catastrophic fires in many parts of the world. One of the reasons for this situation is the extremely unsatisfactory condition of regional (European) and national, in particular, Ukrainian standardization systems in comparison with the relevant ISO developments. Thus, the authors' analysis of the adoption of international ISO standards as European and national in Ukraine shows that in this area CEN has adopted only ~ 4,6 % of ISO standards, and Ukraine – about 18 %. The current situation needs to be remedied immediately, at least by harmonizing regional and / or national fire safety standards systems.

65. O. S. Maksakova, A. M. Dolzhanskiy, O. C. Mirgorodska, I. Mamuzić
Prospects for the development of nickel and nickel alloys standardization. ISO/TC 155 Technical Committee «Nickel and Nickel Alloys» operates in this field at the international level. A total of 30 standards have been adopted ISO/TC 155. In the European Committee for Standardization CEN act CEN/SS M14 «Nickel», which adopted 8 international normative documents (ND) – almost 27%, and Ukraine has not adopted any of the international standards for nickel and its alloys. Additional analysis of European NDs revealed that all EN standards for nickel and its alloys are relevant international standards adopted with varying degrees of compliance. The presented analysis indicates the need to intensify the efforts not only of Ukraine but also of the EU to develop appropriate ND.

66. T. V. Semenova
It is proposed to assess the ecological and economic efficiency of investment projects on the basis of a two-dimensional assessment system. The system provides for the use of the net modern value of the investment project, taking into account the penalties for environmental pollution and the criterion of the environmental efficiency of the investment project (environmental feasibility of investment). Integral indicators (criteria) for assessing the environmental efficiency of investment projects are developed in order to increase the objectivity of the results obtained on the environmental acceptability of the implementation of investment projects. The methodology can be used by businesses to identify investment projects consistent with an environmentally balanced investment portfolio.

67. T. Šolić, D. Marić, S. Suhi, I. Samardžić
Analysis of the vehicle exhaust system corrosion and its effect on the eco-test result. This paper deals with analysis of the vehicle exhaust system quality and its influence on the results of measuring exhaust emissions of the Otto and Diesel motor vehicles. Results of eco-tests obtained from correct and faulty vehicle exhaust systems were compared to conclude that damages caused by corrosion had significant influence on the pass rate of vehicles at eco-test. Referring to vehicles with the Otto engine, damages in the exhaust system increase the oxygen level, which results in the increased λ factor and in failure at the eco-test. On the contrary, vehicles with the damaged Diesel engine exhaust system allow the gas to leak through the damage, so the measurement of blackening is lower, i.e. the eco-test result is better than that of the exhaust system without damage.

68. M. Sadzikowski, G. Kiesiewicz, P. Kwaśniewski, K. Franczak, S. Kordaszewski, W. Ścięžor, R. Pestrak
Impurities of the surface layer of the exploited ETP grade copper railway traction scrap and its influence on the chemical composition after metallurgical synthesis. The recycling possibility of exploited ETP grade copper railway traction scrap has been evaluated in terms of reusing the materials of high Cu content for new traction equipment dedicated for modern railway and tram overhead lines based on CuNi2Si and CuZn37Ni1Si0,5 alloys. Firstly, the conducted research was focused on the qualitative and quantitative assessment of residual impurities of the scrap materials of carrying ropes and overhead contact lines. The main research part was the metallurgical synthesis and the impact of the said impurities on the chemical composition and selected properties of copper manufactured from scrap material.

69. G. Kiesiewicz, P. Kwaśniewski, T. Knych, E. Sieja-Smaga, K. Franczak, M. Zasadzińska, P. Strzępek
Characterisation of Cu-CNTs composite electrical properties in elevated temperatures. The current trend towards nanotechnology creates possibilities for its use in materials science as manufacturing material with extraordinary properties, and is one of the goals for scientists in this field. Carbon nanotubes in particular are promising due to their electrical, thermal and mechanical properties, which have been of interest for researchers around the world. This paper focuses on the manufacturing process of the Cu-CNT composite via powder metallurgy and KOBO extrusion process, its further cold drawing process, and electrical resistance test at an elevated temperature. As obtained data proved, the higher the CNT content the lower the electrical resistance.

70. K. Korzeń, S. Kordaszewski, B. Jurkiewicz, A. Kawecki, P. Strzępek, E. Bożek, B. Babiarz
New generation of cable screw connectors for electrical power engineering systems. The article presents a material analysis for a new generation of cable screw connectors with shear bolts designed for not only 1st and 2nd class of cables but also 5th class of aluminium and copper conductors that have not been previously supported. The set of properties of aluminium series 6xxx designated for screw connectors production has been determined. Finite element method simulation of the controlled shear of the bolt at the body of the screw connector has been carried out. The repeatability of the bolt shear in the actual conditions was also conducted in order to verify the prototypes of the new generation of cable screw connectors.