I. MAMUZIĆ

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

14th INTERNATIONAL
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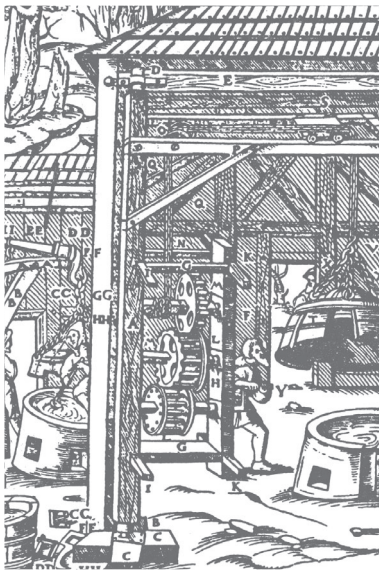
SYMPOSIUM OF CROATIAN METALLURGICAL SOCIETY
SIMPOZIJ HRVATSKOG METALURŠKOG DRUŠTVA

S H M D ´2020.

MATERIALS AND METALLURGY
MATERIJALI I METALURGIJA

BOOK OF ABSTRACTS
ZBORNIK SAŽETAKA



Metalurgija: prošlostlost XVI. st.
Metallurgy: Past - XVI. cent.

Metalurgija: sadašnjost
Metallurgy: Present

Šibenik, CROATIA, June 21 – 26, 2020
ŠIBENIK, HRVATSKA, 21. – 26. lipnja 2020.
HOTELSKO NASELJE, *SOLARIS HOLIDAY RESORT*

14th INTERNATIONAL SYMPOSIUM OF CROATIAN METALLURGICAL SOCIETY »MATERIALS AND METALLURGY«, ŠIBENIK, JUNE 21 – 26, 2020

THE AIM OD SYMPOSIUM

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

14th International Symposium of Croatian Metallurgical Society "Materials and Metallurgy" was held as a part of:

100th Anniversary of the Foundation of the Technical Faculty University of Zagreb (1919-2019), Croatia

100th Anniversary of the Foundation of Dnepropetrovsk National University (1919–2019), Ukraine

100th Anniversary of the Foundation of Metallurgy University of Ljubljana (1919-2019), Slovenia

70th Anniversity of the Establishment of Institute of Materials Research, Slovak Academie of Sciences (1950-2019)

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3. Belgium
4. Belarus
5. Benelux
6. Bosnia and Herzegovina
7. Brasil
8. Bulgaria
9. Chile
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20. India
21. Indonesia
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25. Kazakhstan
26. Korea
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28. Macedonia
29. Malaysia
30. Mexico
31. Montenegro
32. Netherlands
33. Philippine
34. Poland
35. Portugal
36. Romania
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38. Saudi Arabia
39. Serbia
40. Singapore
41. Slovakia
42. Slovenia
43. South Africa
44. Spain
45. Sweden
46. Thailand
47. Turkey
48. Ukraine
49. USA
50. Vietnam

ACCEPTED ABSTRACTS 295

Plenary Lectures	6
Materials – Section «A»	80
Process Metallurgy – Section «B»	87
Plastic Processing – Section «C»	39
Metallurgy and Related Topics – Section «D»	83
Rejected Abstracts	140
TOTAL ABSTRACTS:	**Σ 435**

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 (??? lectures)

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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. Accept our apology again.

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1. M. Knap

The steel industry has a significant impact on the European economy. In the year 2018 round 330000 people were directly employed and 2.6 million indirectly. The share of steel produced in Europe in world production is 17.2%. From the 167.4 million tons of steel, less than 60% of it was made of pig iron and the remainder was produced in an electric arc furnace. Almost 78.6% of the steel was non-alloyed carbon steel, 17.0% alloyed carbon steel and only 4.4% stainless steel. The trend of demand for steel in Europ is in the last 10 years mostly increasing, predominantly for the construction and mechanical engineering industry. The European Union is a net importer of steel, it imports almost 10 million t/year more than exports, which is ruffly one half of the annual export. A big effort was made and an even bigger task is before European steelmakers in the area of sustainability. More than 40 million tons of slag are created each year and trends of treating it as a by-product are from year to year more real. Another big topic in the European steel industry is lowering CO_2 footprint. The goal set by EUROFER till 2050 is to reduce the CO_2 release by up to 95% regarding 1990. Which of technologies will be used in the future can not be defined yet, but one of them will certainly be increased usage of hydrogen in the steel-making industry, e.a. H_2-DRI production.

2. B. Gajdzik

Steel industry 4.0 – opportunities and threats. Industry 4.0 (I 4.0) is the result of Fourth Industrial Revolution. In the new concept of development cyber-physical systems in production take important place. Production is carried out by industrial robots with intelligent computers using the internet to control and communicate and to integrate all processes inside and outside the enterprises. The pillars of I 4.0 are: Internet of Things – IoT, systems integration, simulation, augmented reality, big data, additive manufacture, autonomous system, cloud computing and cyber security. Production in industry 4.0 can be without, or with minimal, employee participation. The new concept of industry is very popular las years. Scientifics publish more and more articles about it. In the period from 2011 to 2019 in the Scopus database for «Industry 4.0» were obtained 4 554 documents, including: 1 139 with open access. The topic «Industry 4.0» were obtained 4 463, other topics" IoT – 871, «Embedded systems» – 595, «Industrial revolutions» – 446 and «Manufacture» – 421. In the WoS database for «Industry 4.0» were obtained 4 122 documents, including 2 233 proceedings papers and 1 576 articles. In new reality top managers in steelworks plants in Poland think about changes in their enterprises. In the largest steel mill in Poland (ArcelorMittal capital group), entries were made in documents about industry 4.0. The key both opportunities and barriers for the development of industry 4.0 are: on the one hand: new investment and, technological and process factor, on the other hand: cost factor of technological and process factor and human factor – reduction of employment in steel industry.

3. A. Šalej Lah, P. Fajfar, M. Bizjak, T. Rijavec

Application of NiTi alloy wire for dynamic thermal insulating. A nickel-titanium alloy with a diameter of 0.2 mm was used for preparing a smart textile system for the dynamic active thermal insulating interlining in protective clothing. Weft knitted fabrics were made from the selected cold-worked nickel titanium alloy and were than annealed at 500 °C for 30 minutes and air cooled at 20 °C to achieve a suitable transition temperature from martensite to austenite phase within the range between room temperature and 75 °C. A two-way memory shape was achieved by a cyclical shape memory training in a special constructed mould made of steel frame and an aluminium dome 30 mm high. After 15 cycles of training all knitted fabric samples achieved a two-way shape memory effect.

4. I. Samardžić, D. Marić, M. Dunđer, A. Stoić, G. Šimunović, B. Despotović

Steam boiler pipes cladding by nickel alloys. The paper describes the possibilities of using Ni-alloy as a corrosion protection layer, as well as the impact of harmful by-products of waste combustion in a thermal power plant. The paper presents the influence of the combustion waste on certain parts of the thermal power plant. In order to prolong the service life and to avoid materials degradation due to corrosion, primary protection measures are implemented (improving combustion process, improving gas temperature control, and certain modifications in plant design) and secondary protection measures (protection of boiler tubes with a protective layer, for example nickel alloys, by some of the known application techniques). One of the secendary measure technique is MAG-CMT welding process, it is possible to protect the boiler elements with Ni-alloys in order to prevent the harmful effects of corrosion. Some of the criteria of cladding layer that must be satisfy are: content of delta ferrite less than 5% on the surface of the clad Ni-alloy, slight mixing of the base and filler material while retaining the adequate bonding of the substrate (base material) and the cladding layer (filler material), achieving the uniform thickness of the cladding layer, and reducing the rough transitions between the passages.

5. I. Juraga, V. Šimunović

Properties and welding of austenitic stainless steels. Austenitic steels are classified by experts in many ways. The paper summarizes the classification of high-alloy austenitic steels into traditional Cr-Ni, Cr-Ni-Mo, Cr-Mn, low carbon and stabilized austenitic steels, superaustenitic steels and heat resistant austenitic steels. Welding technology is most widely applied joining process used in fabrication of variety of structures made of such steels. During welding, conventional welding procedures are used primarily in various versions, namely TIG and MIG welding, and Plasma, EPP procedure, REL welding, LASER welding, etc. The widespread use of austenitic steels in the fabrication of welded structures and parts has often led to unexpected and unpleasant corrosion problems in exploitation, most commonly associated with steel selection, welding, operating conditions and surface condition. Considering nature of passivity and need to retain corrosion resistance of stainless steel, selection of appropriate welding process and subsequent surface treatment of area adjacent to the welded joint are of utmost importance. Taking into consideration specific and unique requirements during the process of fabrication of structures made of Cr-Ni steels, acceptable corrosion resistance can be maintained, almost at the level equal to the used base material. If this is not a case, substantial degradation of corrosion resistance and occurrence of sudden and serious local damages are possible. Some characteristic examples of corrosion phenomena in the welded joint area on structures made of Cr-Ni steels caused during real operating conditions are presented, including primarily damages in the form of pitting corrosion, stress corrosion cracking, crevice corrosion and microbiologically influenced corrosion.

6. S. V. Dobatkin, O. V. Rybalchenko, A. A. Tokar

Simultaneous improvement of strength and in-service properties in ultrafine-grained corrosion resistant austenitic steels. The ASTM F138 and 0.08C-18Cr-10Ni-Ti austenitic stainless steels used in medicine for the manufacture of implants were investigated. The ultrafine-grained structures in both steels were obtained during severe plastic deformation (SPD) using methods of equal-channel angular pressing (ECAP), and rotary swaging (RS). The ways of the structural and phase state adjustment by varying the parameters of SPD and subsequent heat treatment were studied in detail. Primary mechanisms of austenitic steels structure formation under various deformation modes were obtained. A number of patterns of structure formation during SPD for both steels were revealed. For 0.08C-18Cr-10Ni-Ti steel, the sequence of structure formation mechanisms with increasing ECAP temperature was determined. The interrelation of the mechanisms, grain size and other microstructural characteristics (annealing twins, precipitation of alloy carbides and segregations) with the obtained structural-sensitive properties, primarily mechanical, has been established. A significant increase in strength characteristics after SPD, while maintaining satisfactory plasticity was found. The service properties, such as fatigue strength, fracture toughness, wear resistance and corrosion resistance have been studied for steels after SPD. The direct correlation of fatigue strength and tensile strength for both steels was not observed. A significant increase in fatigue strength (up to 800 MPa) in 0.08C-18Cr-10Ni-Ti steel had been determined. The processes during the cyclic deformation after ECAP were identified as the reasons of that increase. A significant increase in fatigue strength due to the creation of a recrystallized structure with a high density of annealing twins during long-term annealing of 0.08C-18Cr-10Ni-Ti steel after ECAP was found. A threefold increase in fracture toughness was revealed in UFG steels. It was noted that SPD does not degrade the corrosion properties of the investigated austenitic stainless steels. The friction coefficient and wear resistance of steels in various structural and phase states were determined. To assess the possibility of using UFG steels in medicine as a material for contacting with the blood implanted medical devices the biocompatibility tests were carried out.

1. O. V. Movchan, K. O. Chornoivanenko, I. Mamuzić

Regularities of secondary hardening of highly alloyed iron alloys. The mechanisms of secondary hardening of highly alloyed iron alloys are considered. The correlation between secondary hardening of the high-alloyed iron alloys and size of tension in a crystal lattice was established. The hardening phases are Me_2C carbide (W_2C and Mo_2C in particular) and MeC carbide (vanadium carbide VC), as well as iron and chromium carbide $Me_{23}C_6$ and, in addition, $Me_7^{I}Me_6^{II}$intermetallides based on iron and cobalt (Me^{I}), tungsten and molybdenum (Me^{II}). These particles and the fields of elastic stresses in martensite between them inhibit the dislocation movement. Dispersed precipitates block sliding planesand prevent plastic deformation.

2. S. Gubenko, V. Bespalko, I. Nikulchenko, I. Mamuzić

Formation of structure of the wheel steel near non-metallic inclusions under laser treatment. The peculiarities of fragmentation and melting of nonmetallic inclusions under laser action were established. It was established the peculiarities of transformation of the inclusion-matrix boundaries is associated with heterogenization of their structure. It was shown that laser treatment allows to transformation of the inclusion-steel matrix boundaries. 7 types of transformations were found. The effect of deformation modes and laser treatment on the initiation of cracks near inclusions during deformation at temperature range 25 900 °C was established. The effect of the structure of the microcomposite zones of saturation of the steel matrix on the spreading of cracks from inclusions, related to their inhibition, was investigated.

3. V. Y. Karpov, I. Mamuzić

Influence of iron foil thermal cycling in hydrogen. In studies of the influence of thermal cyclic exposure in hydrogen for the surface samples within the same grain formed region of undulating relief in the form of equidistant bands. After thermal cycling in argon, wavy relief was not observed. Wavy topography (equidistant lines) is the result of single acts of deformation of the metal H-layer, where this layer loses some of its energy needed to deform the metal. Describes the research allowed to clarify the mechanism of the effect of transfer pricing of iron in hydrogen.

4. V. Z. Kutsova, V. F. Balakin, G. Šimunović, T. V. Kotova, T. A. Aiupova

The ultra-low carbon steel structure after cold rolling with the displacement of one of the rolls. The analysis and statistical estimation of grain distribution in the structure of ultra-low carbon steel after cold rolling with shear is carried out.The influence of processing parameters on the formation of metal microstructure is determined. It is shown that the use of cold rolling with the displacement of one of the rolls provides the formation of a more uniform fine-grained structure of the investigated ultra-low carbon steel in comparison with the structure obtained by traditional rolling. Achieving these results will allow to further increase the physical, mechanical and operational characteristics of the metal.

5. V. Z. Kutsova, T. A. Aiupova, T. V. Kotova, I. Mamuzić

The alloying elements distribution in hypoeutectical-7%si alloys in the progress of complex physical-chemical melt treatment. The regularities of the complex physicochemical melt treatment influence on the distribution of chemical elements between phases in hypoeutectic Al-7%Si alloysare established. The data of spectral analysis correlate well with the results of microstructural, X-ray analysis and mechanical testing of alloys: AlSiSr type intermetallic compounds are formed, phases based on $FeSiAl_5$ and Fe_2SiAl_3 intermetallic phases alloyed with strontium and scandium, as well as the π phase upon strontium-scandium complexmicroalloying of Al-7%Si alloys etc. Ultimate deformation of the alloy does not lead to a significant redistribution of alloying elements.

6. K. Milewski, M. Madej

Structure and mechanical properties of diamond-like carbon coatings doped with silicon. This paper reports the study of silicon-doped diamond-like carbon coatings a-C:H:Si deposited on 100Cr6 steel by means of plasma-assisted chemical vapour deposition PACVD. The observations of surface morphology and identification of elements were carried out with the use of *Scanning Electron Microscopy* / Energy Dispersive X-Ray Spectroscopy (SEM/*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.

7. I. Petryshynets, M. Džupon, F. Kováč, L. Falat, V. Puchý

Analysis of microstructure and hardness evolution of tool steels subjected to the laser hardening. The present study deals with the effects of laser surface treatment on microstructure evolution, hardness and tribological properties of hot work tool steel in quenched and tempered (QT) condition. The most upper laser-affected zone is characterized by re-melted microstructure consisting of dendrite cells with fresh non-tempered martensite, retained austenite and inter-dendritic carbidic network. The highest microhardness values in the range from 775 to 857 HV were measured for the laser surface hardening (LSH) microstructure and the most softened microstructure exhibited the minimum hardness of 530 HV. The lowering of specific tribological wear rate in the LSH condition of studied steel compared to the QT material state resulted in the increase of surface wear resistance by 35 %.

8. E. Parusov, O. Parusov, S. Gubenko, I. Mamuzić

Influence of alloying elements on the formation of structure of wire rod from high-carbon steel. For high-carbon steel C82D alloyed with chromium ($Cr \leq 0.27$ %), hardening occurs due to the solid-solution mechanism (carbides, nitrides, or complex compounds were not detected). The most effective way to increase the initial strength class of wire rod is the simultaneous introduction of vanadium ($V \leq 0.06$ %) and chromium ($Cr \leq 0.15$ %) into the composition of the steel, which will ensure the implementation of dispersion and solid-solution hardening mechanisms.

9. M. G. Shen,Y. J. Liu, X.L. Zhu, Z. Y. Xiao, Y. C. Liu

Study on the influence of new riser structure on the quality of steel ingot. A new type of optimized riser structure was proposed, in which a low-emissivity board was inserted into the hollow interlayer of the material to increase the yield of the steel ingot. The insulation effect of different riser heights on the solidification process of steel ingot is numerical simulated. The results show that when the riser height can be reduced from 350 mm to 300 mm, the ingot yield can be increased by 1,92 %. As the number of low-emissivity boards is increases, the riser insulation performance is also increased.

10. A. Murugarajan, P. Raghunayagan

The impact of pressure die casting process parameters on mechanical properties and its defects of A413 aluminium alloy. Multi response optimization was carried out to predict and analyze the mechanical properties of A413 aluminium alloy that was produced utilizing the pressure die casting process. The injection pressure (A) Kgf/cm^2, shot velocity (B) m/s and furnace temperature (C) °C were taken in selection as the parameters that were influenced the output responses such as micro-hardness (MH) and surface roughness (Ra). The value of 0,607 was met at a high desirability in the objective of multi response optimization.

11. Y. Haranich, Y. Frolov, I. Mamuzić

Roll bonding of a composite material based on aluminum outer layers and expanded mesh inlay. However, the development of its manufacturing technology requires a complete understanding of transformation of its components during the roll bonding process. Thus, the deformation parameters of expanded mesh inlay depending on the overall reduction of three layered composite material based on austenitic steel mesh AISI 304 inner core and aluminum outer layers 1050 during the hot roll bonding process at 500 were investigated. In addition, it was conducted a study of hardening of steel mesh inlay by means of Viker's method as a result of the deformation.

12. H. C. Ji, Y. M. Li, C. J. Ma, H. Y. Long, J. P. Liu, B. Y. Wang

Modeling of austenitic grain growth of 21-4N steel. The effect of grain growth on 21-4N heat resistant steel was studied by static grain growth test. The experimental results show that the temperature inhibits carbide grain growth is between 1 000 - 1 120 °C. When heat preservation time is over 40 min, the

driving force of grain boundary is balanced with binding force of carbide nail, grain size will not grow up. There is no limit of grain size due to no pinning effect of carbides when the temperature is above 1 180 °C. Based on the theory of grain boundary migration, the grain growth model of 21-4N heat-resistant steel was established, and the relationship between the average grain size and the time of heat preservation at different temperatures was predicted.

13. F. Smaili, T. Vuherer, I. Samardžić

Resistivity during cycle loading of fine grain heat affected zone (HAZ) of 17CrNiMo7 steel prepared into laboratory furnace. Resistivity of the fine grain HAZ prepared against fatigue crack initiation will be explained in this article. Samples of material with martensitic fine grain microstructure were prepared by laboratory furnace by proper thermal treatment. Mechanical properties of fine grain heat affected zone and its microstructure were investigated. Special attention was given to behavior of fine grain during the cycle loading under stress concentration. Stress concentration was similar to the one in real welds. The S-N curve and the fatigue limit were determined. The Paris curve and the threshold for crack propagating were also determined.

14. S. Om Prakash, P. Karuppuswamy, N. Nirmal

Optimal corrosive behaviour on the weldment of AA6063 aluminum alloy by tungsten inert gas (TIG) welding process with backing plates. Pertaining on the present work on improving the corrosion resistance of AA 6063 aluminum alloy is found to weld with many backing plate materials like stainless steel, copper, marble and brass in accordance to the welding process that inherits itself with TIG. Utilizing the Orthogonal array L16, experiments were carried out. The corrosion resistance was improved by optimizing the pulsed TIG welding process parameters like current (A), gas flow rate (B), backing material (C) and backing thickness (D) using Genetic Algorithm (GA). Results proved that the GA shows a better corrosion resistance rate that was obtained to about 0,0408 mm/year with the backing material as copper.

15. F. Iob, T. Coppola, A. Di Schino

Analysis of anisotropic hardening in high strength steel (HSS) in line pipes for strain-based applications. In this paper are reported the results of an extensive and innovative mechanical characterization carried out on three large diameter line pipes for gas transportation useful to calibrate a new plasticity finite element numerical simulation (FEM) model developed at Rina Consulting – Centro Sviluppo Materiali. In particular, the anisotropic hardening for the materials has been characterized by tensile tests carried out in the base material of the pipe with tensile specimen extracted along different orientations, considering also the pipe through thickness direction.

16. T. T. Chen, S. M. Kang, Y. L. Li

Corrosion resistance of 316L stainless steel in fuel cell electrolyte. The corrosion resistance and semiconductors of passivation film on the surface of 316L stainless steel has been explored using linear polarization. Based on the Mott-Schottky analysis, the density and thickness of the passivation film are related to the potential formed by the passivation film. The passivation film is an n-type semiconductor. There is no metal ion loss or cation vacancy remaining; when the film forming potential is 0,3 / V, The chemical reaction rate at the interface is slow, and the passivation film is denser than the passivation film formed at other potentials.

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

Creep resisting steels, nanoparticles, interparticles matrix stresses, mobile dislocations motion and creep rate. Development of improved equation for better accuracy of calculation of stationary creep rate of creep resisting steels. Effect of acting stress components in particles disjunction matrix. Effect of increase of number of ferrite lattice vacancies.

18. M. L. Xu, S. M. Kang, T. T. Chen

Coating properties of electroless ni-p plating on magnesium alloy with cerium chloride. In order to improve the corrosion resistance of magnesium alloy, Ni-P coating was prepared on the surface of AZ91D magnesium alloy by chemical deposition method, and the optimum process of electroless Ni-P plating was determined. The results showed that Ni-P coatings have better corrosion resistance in 3,5 % NaCl solution under the condition: $CeCl_3$ 0,15 / g/L, $NiSO_4$ 28 / g/L, Na_2HPO_3 25 / g/L, temperature 85 / °C and pH = 7,3. The corrosion rate of the coating decreases first and then increases with increasing amount of Cerium chloride.

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

Vibration impact on properties and parameters of steel ingot porous structure. The paper deals with the vibration effect on the porous structure of alloyed steel. It is shown that the use of vibration in this mode affects positively decreasing porosity and the nature of the pores in size distribution in the ingot. Mechanical properties of the ingot, such as tensile strength and toughness, after the vibration action are also improved.

20. W. S. Wang, H. Y. Zhu, J. Sun, J. L. Lei, Y. Q. Duan, Q. Wang

Thermodynamic analysis of BN, AlN and TiN precipitation in boron-bearing steel. In this paper, the precipitation behavior of BN, AlN and TiN particles in boron-bearing steel was studied based on thermodynamic calculation. The binding capacity of boron and nitrogen is greater than that of aluminum and nitrogen, BN is preferentially precipitated as boron added to steel. BN particle reduces the free nitrogen content in steel and then prevents the formation of AlN particle. Formation of TiN particle precedes BN particle, and the precipitation amount of BN is significantly reduced by adding titanium element to boron-bearing.

21. M. X. Gao, H. Song, J. Yang , L. J. Fu

Study on residual stress and strain during rail rolling contact of straight U75V rail. Results shows that with the increase of rolling times, the straightening residual stress of rail quickly redistributed and gradually stabilized. The residual stress of rail head is mainly affected by wheel rolling, while the rail waist and bottom is mainly affected by straightening. The effect of straightening residual stress on residual shear stain is relatively small.

22. W.C. Pei, J.W. Dong, H.C. Ji, H.Y. Long, S.F. Yang

Study on crack propagation of 42CrMo. Data on the fatigue crack growth rate of the material and the crack tip factor were obtained. The crack initiation and propagation path law during fatigue crack propagation were obtained. The fatigue crack life was calculated by Paris formula, and the fatigue crack growth test and microscopic observation were compared. The propagation law and fatigue crack life of different stages of crack propagation were analyzed. The results show that the stable propagation stage of fatigue crack propagation is the key stage to determine fatigue fracture, the rate of growth is related to the stress ratio.

23. S. V. Proidak, I. Mamuzić

Prospects for the use of economically alloyed nickel-free stainless steels. Tests of mechanical properties showed that steel with 0,08 % C, 1,5 % Mn, 0,38 % Si, 13,30 % Cr is very hard and strong and at the same time is very plastic and possesses high impact elasticity both after casting and hot deformation. The increase of ferrite content from 3-5 to 50 % in the structure of cast steel XI3 with a change in its chemical composition reduces its strength at room temperature and 900 ° C. Hot deformation is likely to result in increasing strength and plasticity of the tested steel without preliminary heat treatment. Depending on the content of C, Mn and Si, the metal of the tested steels is resistant to humidity as well as artificial industrial and salt mist atmospheres. Therefore, it is possible to be employed under such conditions instead of austenite chromium-nickel steels grade 18-10.

24. B. Xu, S. Li, H. Fu, L. Yan, X. Ai

The influential factor studies on the cooling rate of roller quenching for ultra-heavy plate. In this paper, the gradient temperature rolling (GTR) method is used to establish the 12-pass rolling model by Deform-3D finite element (FE) software. The variation of temperature field and strain field of ultra-heavy plate slab under different conditions is systematically studied. The result shows that the more the number of water cooling between the passes during the rolling process, the greater the deformation of the core of slab, and the one of plate rolling with large temperature difference does not appear on near surface but gradually moves to the central part of the plate as cooling times increase.

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

An analysis of structures occurring in weld deposit of steel S235JR+N with tungsten carbide particles and martensitic matrix. Protective layers include special weld deposits, utilizing e.g. ferrous, nickel or cobalt matrices in combination with tungsten carbide particles, which according to their

properties belong among so-called composite materials, and which have slowly replaced conventional components produced from tool steels. A weld deposit with an iron-based matrix (Megafil A864M) was used, with tungsten carbide particles on steel S235JR+N. The high-level hardness of tungsten carbides together with a tough matrix allows achieving high resistance to different types of wear. This resistance significantly increases the lifetime of machine components and thus it reduces the costs of companies needed for repairs or the replacements of machine parts.

26. S. Gubenko, I. Mamuzić

Non-metallic inclusions and plasticity of steels. The problems of the influence of non-metallic inclusions in the technological plasticity and mechanical properties of steels are discussed. The results of the study of deformation and destruction of non-metallic inclusions in steel treatment pressure in various conditions were listed. Particular attention is paid to the influence of nonmetallic inclusions on the hot brittleness. of steels. We analyzed the processes that determine the influence of inclusions on the plasticity of steels under pressure treatment. The features of the local processes and phenomena occurring near the inclusions under plastic deformation, as well as various high-energy impacts were investigated.

27. M. Ogórek, T. Frączek

Ion nitriding using active screen method. Austenitic steel grade 304 according to AISI was tested after ion nitriding in the temperature range 325 - 400 °C and time range 2 - 4 h, and after two different variants. The first variant – the samples intended for nitriding were placed on the cathode, the second variant – the samples placed on the cathode were shielded with an active screen. It was found that using active screens increases the rate of diffusion of nitrogen into nitrided austenitic steel 304, thus increasing the thickness of the resulting surface layers.

28. G. Heffer, I. Samardžić, I. Vidaković, I. Opačak

Comparison of abrasion resistance of boron- and vanadium-based coatings. This research focuses on testing of abrasion resistance of boron- and vanadium-based coatings. Coating of samples with vanadium was completed by classic and duplex procedure with previous carburization. The samples were abraded by applying the ASTM G65-94 method of „dry sand/rubber wheel". The greatest wear was recorded on boron-based coating, and the least wear was exhibited by the vanadium-based coating with previous carburization. The dominant form of „zero" abrasion was determined by analyzing the sample wear traces.

29. V. U. Karpov, V. C. Zhdanov, I. Mamuzić

Bearings from gazars. Studies have shown that gazars have 2–3 higher strength compared to sintered materials of the same porosity and composition. Considering that the pores in gazars have one orientation perpendicular to the axis of rotation, their wear is further reduced due to abundant high-quality lubrication. Poredirection makes these bearings most suitable for closed lubrication systems. The use of gazars in industry will increase the savings of cast bronzes by increasing the porosity of bearings without loss of mechanical properties.

30. J. Bárta, M. Marônek, B. Šimeková, D. Marić

Analysis of weld joints made of titanium alloy grade 2 produced by electron beam welding. Selected properties of welded joints of 2 mm thick titanium alloy Grade 2 produced by different welding parameters of electron beam welding were investigated. The visual inspection, macro and micro analysis, tensile strength test and microhardness measurements were performed. Samples manufactured by appropriate welding parameters had no internal defects, heat-affected zone (HAZ) was narrow and transformation from α phase to β phase was observed in this area. The failure occurred in the base metal during tensile test, while maximum ultimate tensile strength reached 454,3 MPa.

31. K. Chinnarasu, K. Kumaresan

Influence of end milling process parameters on micro-hardness of LM25 aluminium alloy. This research focused on developing an analytical model in order to predict the changes in micro-hardness and microstructure of LM25 aluminium alloy Design of experiment (DOE) was adopted for determining the effect of end milling process parameters such as cutting speed (Cs), feed rate (f) and axial depth of cut (a_p) on arithmetic average micro-hardness (MH). The micro-hardness of the samples is tested with vicker's hardness tester. Desirability approach gives better accuracy of the result and the capability of predicting cutting process parameters.

32. T. Šolić, D. Marić, I. Putnik, I. Samardžić

Corrosion resistance of the X6CrNiTi18-10 material exposed to a salt spray test. The research was focused on testing the corrosion resistance of the X6CrNiTi18-10 material. The X6CrNiTi18-10 material is austenitic stainless steel susceptible to pitting corrosion and this can cause problems during exploitation of the construction made of this material. In order to determine the likelihood of pitting corrosion occurrence, a light microscopy was performed on test samples that were exposed to the salt spray test chamber atmosphere, i.e. sprayed with a 5% sodium chloride solution (NaCl) at different time intervals.

33. Sv. S. Kvon, V. Yu. Kulikov, Shcherbakova Ye. P., S. K. Arinova

Effect of inoculant introducing on improving ingot structure. The paper deals with the inoculant–freigrator effect on some parameters of the structure: grain size and contamination index. The "beads" extracted from steelmaking slags were used as the inoculant. The effect of the fractional composition and the number of introduced "beads" were investigated. It was established that the introduction of the "beads" of the fraction of 500 – 600 microns in the amount of 1 – 1,5 % as the inoculant contributed to the grinding of grain, reduced the tendency to segregation and dendre formation.

34. A. Z. Issagulov, M. K. Ibatov, Sv. S. Kvon, S. K. Arinova

Studying of properties and microstructure of 30 CrMnV9 steel on wear resistance. The properties and microstructure of 30 CrMoV9 steel after its treatment with ferronickel and ferromanganese with the aim of increasing the content of nickel and manganese in steel were studied. After the trial smelting, the samples were tested in four parameters: hardness, ultimate stress limit, wear resistance, and toughness. Experimental studies have shown that changing the composition of steel with increasing the nickel content up to 0,5 – 0,7 % and manganese up to 1,5 – 1,8 % leads to increasing strength, hardness and wear resistance of steel with slight decreasing its toughness.

35. B. Oleksiak, G. Siwiec, A. Wańkowicz-Lis

Nickel coatings applied with galvanic method. The presented work attempts at determining the effect of the parameters of the nickel coating process with the galvanic method i.e. current density, time and temperature, upon the quality of the coatings obtained.

36. I. A. Wahyudie, R. Soenoko, W. Suprapto, Y. S. Irawan

Enhancing hardness and wear resistance of $ZrSiO_4$-SnO_2/Cu10Sn composite produced by warm compaction and sintering. In this investigation, the SnO_2 tailing sand dominated by $ZrSiO_4$ and SnO_2 was used for the reinforcement. The results show that the highest hardness value and the lowest wear rate of the composites were achieved by adding 15 weight % of SnO_2 tailing sand. Moreover, the wear rate of Cu10Sn matrix composite exhibits a decrease significantly with an increase in the amount of SnO_2 tailing sand due to the presence of hard particles.

37. P. Sathish Kumar, A. Ramesh, R. Soundararajan

Investigation on physical and mechanical behaviour of A356 - *x* wt. % SiC/Gr hybrid composites. T6 heat treated casted samples are prepared for testing as per standard procedure to record the responses like density, porosity, hardness, ultimate tensile strength, and percentage elongation respectively. There is a gradual increment in density because of adding an optimal level of up to 9 wt. % of SiC and 3 wt. % of Gr strengthening particles available in the A356 matrix and the porosity present in the sample diminishes, which in turn increases the hardness.

38. Y. Y. Shao

Study on production of conventional grain oriented (CGO) silicon steel without normalizing process. The results indicate that, the key of CGO silicon steel hot rolled sheet canceling normalizing process is to obtain as many {111}<112> and Goss oriented grains as possible, meanwhile, it is to increase the nitrogen pressure appropriately during the temperature-rise stage of secondary recrystallization. By controlling the process parameters, the

iron loss $P_{1,7}$ of the finished product is 1,258 W/kg, and the magnetic induction B_8 is 1,840 T. Furthermore, the cubic orientation can be retained more in CGO silicon steel after annealing due to the less influence of columnar grain.

39. A. D. Mekhtiyev, F. N. Bulatbayev, A. V. Taranov, A. V. Bashirov, Ye. G. Neshina, A. D. Alkina
Use of reinforcing elements to improve fatigue strength of steel structures of mine hoisting machines (MHM). The article discusses the issues of fatigue fracture of steel structures and the method of increasing their strength through the use of reinforcing elements. The authors have proposed a method for strengthening the structure and searching for its optimal shape of the loaded part, capable with a smaller wall thickness to withstand fatigue failure of steel structures of mine hoisting machines used to transport metallurgical coke in long-term operation. The results of computer modeling the stress-strain state of a steel beam under operating loads are given.

40. C. Di Schino, C. Zitelli, G. Napoli, G. Stornelli, P. Folgarait, A. Di Schino
About some issues concerning shape memory alloys applications in neuro-rehabilitation. Shape memory alloys (SMAs) are a very promising class of metallic materials showing promising nonlinear properties. SMA have been recently applied in the field of neuromuscular rehabilitation, designing some new devices based on the above properties. The paper discusses possible uses of these materials in the treatment of movement disorders, such as dystonia or hyperkinesia, where their dynamic characteristics can be the key issue.

41. A. Strkalj, Z. Glavas, I. Mamuzic
Microstructure and properties of silicon alloyed compacted graphite irons (CGI). The microstructure, tensile properties and hardness of 25 mm thick compacted graphite iron samples alloyed with 3,01, 3,22, 3,61, 3,97 and 4,29 wt. % Si were analyzed in this paper. It was found that Si promotes and strengthens ferrite. Metallic matrix of compacted graphite iron sample alloyed fully ferritic metallic matrix was obtained in compacted graphite iron samples and nodularity. Yield strength increased, tensile strength increased, hardness increased, and elongation decreased with an increase in Si content from 3,01 to 4,29 wt. %. Analyzed Si alloyed compacted graphite iron samples have a very uniform hardness and higher ratio $R_{p0,2}/R_m$ than conventional ferritic, ferritic-pearlitic and pearlitic compacted graphite iron grades.

42. H. Fu, B. Xu, Q. Xiao, S. Li, X. Zhang, S. Bian, T. Kang
Effect of preheating temperature on post-weld residual stress of dissimilar steel plates. Based on the numerical simulation software Visual-Environment, the numerical calculation and analysis of residual stress field under different preheating temperatures for Q345/2Cr13 dissimilar plate welding were carried out in this paper. The effects of different preheating temperatures on post-weld residual stress were mainly studied. The results showed that different preheating temperatures have little effect on the lateral residual stress, while the longitudinal residual stress and the initial and end of the weld have greater impacts.

43. Yurianto, S.H. Suryo, Y. Umardani
Calculation program for steel weldability by considering the heat affected zone (HAZ) width of welded joint. Program o the welding processs includes the chemical elements content of the steel, the diameter of the electrode; electric current; electric voltage, welding speed; metal thickness will be welded and heat input. Visual Basic package program used to create the program. The study aims to create the program for determining the width of heat affected zone based on welding parameters. This research may simulate the heat-affected zone dimension based on the heat input temperature from arc welding.

44. B. Xu, H. Fu, Q. H. Xiao, S.Li, T. Kang
Numerical simulation of the influence of welding direction on residual stress after double welding of Q345 stacked-plates. Based on the welding numerical simulation software Visual-environment, this paper calculates and analyzes the residual stress field for the double pass welding of Q345 stacked plates. The paper mainly studies the influence of different welding directions on the residual stress after welding. The results show that different welding methods have little effect on the lateral residual stress, while the longitudinal residual stress and the initial and end of the weld have a greater influence, while the post-weld residual stress distribution of the anisotropic two-pass weld is more uniform.

45. X. Z. He, J. G. Li, L. Yan, X. Y. Zhang
Study on the stability of retained austenite in marine steel. The residual austenite stability in marine steel was studied by different heat treatment processes. Experimental results showed that the microstructure of the test steel consisted of martensite/bainite + ferrite + retained austenite. The retained austenite volume fractions were 20,8 % and 18,1 %, respectively, for process 1 and process 2.The retained austenite morphology, C content, distribution, and grain size all affect a steel's thermal and mechanical stability. Film-like residual austenite with high C content and fine grain size has the best stability.

46. H. Fu, B. Xu, Q. Xiao, S. Li, X. Zhang, S. Bian, T. Kang
Effect of current intensity on residual stress of Q345/2Cr13 dissimilar steel plates. The main contents in the paper were different current intensity was applied to modeling the welding process of Q345/2Cr13 dissimilar steel and the law of residual stress field were discussed. Based on the result, different current intensities have little effect on the lateral residual stress, while the longitudinal residual stress and the initial and end of the weld have a great influence. The physical properties of the dissimilar plates lead to uneven distribution of residual stress, and the current intensity should be smaller.

47. T. Frączek, M. Ogórek, Z. Skuza
The effectiveness of active screen method in ion nitriding grade 5 eli titanium alloy. A titanium alloy for biomedical applications, Grade 5 ELI, was studied, which was subjected to the ion nitriding process in the temperature range of 530 – 590 °C and during 5 – 17 h, using two variants of sample arrangement in the glow discharge chamber. The first variant – the samples intended for nitriding were placed on the cathode, the second variant – the samples placed on the cathode were shielded with an active screen. It was found that using active screens increases the rate of nitrogen diffusion deep into the nitrided Grade 5 ELI titanium alloy, and thus increases the thickness of the obtained nitrided layers.

48. P. T. Iswanto, Akhyar, A. Pambekti
Heat treatment t4 and t6 effects on mechanical properties in Al-Cu alloy after remelt with different pouring temperatures. Untreated alloy in cast-samples showed that hardness increases with increased pouring temperatures, while for samples after heat treatment (T4 and T6), the hardness value decreased with increased pouring temperatures. Tensile strength generally increases with heat treatment T4 and T6, but the influence of the temperature on the pouring tensile strength values initially presents high then decreases, then increases again. Impact energy increases after heat treatment T4 and T6. The distribution of precipitates in grain structure results in improved material properties such as hardness, tensile strength, and impact strength compared to when precipitates gathered at the grain boundary.

49. P. T. Iswanto, E. U. K. Maliwemu, V. Malau, F. Imaduddin, H. M. Sadida
Surface roughness, hardness, and fatigue-corrosion characteristic of AISI 316L by shot peening. The surface of AISI 316L was treated by shot peening at different shot durations. Shot peening variables in this work are shot durations for 0, 4, 10 and 20 minutes, with compressor pressure at 8 kgf/mm^2, steel balls with a diameter of 0,6 mm and shot gun nozzle diameter of 5 mm. The purpose of this research is to investigate the shot peening effect duration on surface roughness, hardness, and fatigue-corrosion characteristic of AISI 316L in 0,9 % NaCl solution. The results show that the duration of shot peening can affect the improvement on surface roughness, hardness, wettability and fatigue-corrosion life of AISI 316L.

50. A. Auezova, T. Buzauova, G. Abdugaliyeva, L. Kurmangalieva, N. Smagulova, A. Zhauyt
Investigation of the stress-strain state of the roller conveyor. Numerous studies have established that the damage to the lower surface of hot-rolled strips is mainly due to their friction against rollers of mill rollers. In this case, the probability of scoring, scrapes and other mechanical damage increases otherwise severe wear on the surface of the rollers, improper installation and jamming. A prerequisite for preventing damage to the surface of hot-rolled strips is also the maintenance of a high level technical condition of the mill equipment, which includes inspections of wiring armature bars, roller conveyor rollers and other units for each transshipment, timely replacement and repair of individual parts and assemblies.

51. W. Zang
A first-principle analysis of mechanical properties of carbon deficient transitional metal carbide. The lack of study in defected transition metal carbides, is partially due to the synthesis difficulty of refractory materials. The synthesis of defected carbide and their substitutional alloy will be even more difficult than single phase. First principle theory-based simulation can help to conceptualize the effects of substitutional defects on their mechanical properties. In this paper, we performed density functional theory (DFT) simulation of carbon defected α-$MoC_{(1-x)}$ phases to investigate their formation and mechanical properties for thesis sub-stoichiometric materials.

52. Ľ. Ambriško, D. Marasová, J. Šaderová, P. Maras
The effect of annealing on mechanical properties of automotive steel sheets. This paper deals with mechanical properties of galvannealed automotive steel sheet. The composition of the zinc coating modifies as a result of the annealing after galvanizing, thereby its local mechanical properties change. Presented research is therefore aimed at determination the change in tensile properties of steel due to annealing, which is an important part of galvannealing technology. Annealing of galvanized steel samples was carried out at 500 °C with different holding times at annealing temperature. Changes in both tensile strength and normal anisotropy coefficient, a decrease of yield strength and an increase of ductility were found for examined steel.

53. S. Y. Guan, W. Y. Zhang, Y. F. Jiang
A surface defect detection method of the magnesium alloy sheet based on deformable convolution neural network. In order to improve the surface quality of the magnesium alloy sheet, a surface defect detection method based on deformable convolution neural network is proposed in the paper, which presents a higher detection accuracy than those traditional methods on the convolutional neural network (CNN), support vector machine (SVM) and Bayes. The experiment result shows the final detecting accuracy is greater than 95 %.

54. P. T. Iswanto, R. I. Yaqin, Akhyar, H. M. Sadida
Influence of shot peening on surface properties and corrosion resistance of implant material AISI 316L. Shot peening is a surface treatment that improves properties on material surface. In this research, the effects of shot peening duration (0, 2, 4, 10, 20 and 30 min) on surface hardness, roughness, wettability, and corrosion in 0,9% sodium chloride were investigated and discussed. According to the experimental results, it was found that shot peening increases both surface roughness and surface hardness compared to untreated sample. Furthermore, shot peening can reduce contact angle and corrosion rate after 2 minutes.

55. Y. B. Kaliyev, B. T. Kopenov, M. N. Yessengaliyev, K. A. Zhussupov, N. R. Jakupov, A. Zhauyt
Study on physical and chemical properties of steel 60C2XA on a retractable roller conveyor. 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.

56. M. Łągiewka
Abrasive wear of composites based on CuPb30 alloy reinforced with graphite particles. The aim of the study was to assess wear rate and mechanical properties of composites based on CuPb30 copper alloy reinforced with graphite particles and the attempt to replace scarce tin in bearing bronzes with graphite particles. Composites were prepared using the method of mechanical mixing. Composite suspensions, as well as matrix alloy were gravity cast into metal and shell moulds. The effect of sample load on the amount of wear and mechanical properties of the tested materials were determined.

57. B. Oleksiak, K. Kołtało
The studies on the qualities of TIN coatings. In the paper presented the author aims at determining the effect of the parameters of tin coating process, run with galvanic method, upon the quality of the obtained coatings.

58. R. Soenoko, P. H. Setyarini, S. Hidayatullah, M. S. Ma'arif, F. Gapsari
Corrosion characterization of Cu-based alloy in different environment. Corrosion behavior of copper as alloy base material had been investigated electrochemically in three different solutions. Solution of 1 M HNO_3, 3,5% NaCl and 1M NaOH had been used as the corrosive medias for Cu alloys and Electrochemical Impedance Spectroscopy (EIS) method was used to study its corrosive characteristics. The result of the study revealed that bronze had corrosion resistance average which was higher compared to brass and copper in corrosive media of 1M HNO_3, 3,5% NaCl and 1M NaOH. The most aggressive corrosive media attacked Cu and its alloys starting from 1M NaOH, HNO_3 and 3,5% NaCl.

59. M. Trepczyńska-Łent, J. Piątkowski
Study of directionally solidified Fe – 4,25 %C eutectic alloy using electron backscatter diffraction (EBSD) technique. Electron back-scattered diffraction was used to determine the microstructure of a eutectic. Fe – 4,25 % C alloy was directionally solidified with the growth rate of 300 mm/h (83,3 μm/s) in a vacuum Bridgman-type furnace with liquid metal cooling. Eutectic phases have been observed using optical microscopy and scanning electron microscopy. The morphology of the eutectic phases was described. EBSD analysis reveals pronounced direction <100> of cementite in the microstructure produced by directional solidification.

60. E. Spišák, J. Majerníková, Ľ. Kaščák, J Slota
Influence of plastic deformation inhomogeneity on corrosion resistance of tin plates. Thin tin-coated steel sheets are still the predominate material to produce packaging. Reducing the thickness of thin steel sheets and increasing the desired drawing speed in the manufacture of metal packaging leads to a loss of plastic deformation stability. This leads to significant slip lines, or even to material failure. Two lots of tinned steel sheets produced by different processes were used for experimental research of plastic deformation influence on corrosion resistance. The properties of the steel sheets used were evaluated by the uniaxial tensile test and the Bulge test. The influence of deformation and deformation localization on their corrosion resistance was evaluated on the examined samples.

61. M. Spilka, R. Babilas, W. Łoński
Corrosion properties of electrodeposited Cu/Co multilayers. The paper presents corrosion resistance investigation results of Cu/Co multilayer systems fabricated by the electrolysis method. The obtained systems were composed of layers about different number and thickness, which was determined by observing the cross sections of the samples using scanning electron microscopy (SEM). The surface morphology of samples was observed using stereoscopic microscope (SM). The surface topography was tested using atomic force microscope (AFM). Corrosion properties measurements of multilayer systems carried out in 3.5% NaCl solution showed different corrosion resistance depending on thickness of the systems. The corrosion resistance was evaluated by recording of the open-circuit potential (E_{OCP}). The corrosion potential (E_{corr}) and corrosion current density (j_{corr}) was determined by the Tafel extrapolation method.

62. Kasińska J., Myszka D.
Influence of rare earths metals 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 (Rare Earth Metals) at 0.3% wt. in relation to the weight of the charge. The presence of REM was found only in some elements of the structure, i.e. in ferrite and in precipitations. An increase in wear resistance was observed for REM-modified cast iron as compared to the initial cast iron.

63. P. Hanusovà, W. Pakiela, M. Roszak, P. Palček
Influence of nitridation for internal damping of austenitic steel. In terms of internal damping, the ideal material should have low density, advantageous mechanical properties, and high internal damping. A problem with low-density materials is the damping ability. Vibration causes a range of adverse effects, in particular noise, contact and high cycle fatigue, reduced corrosion resistance and, in extreme cases, equipment damage due to resonance. This paper deals with the influence of nitriding on austenitic stainless steel. They are materials with high damping capacity, but various investigations

have shown that they have a certain degree of internal damping. Measurement of internal damping has proven to be a suitable method for investigating structural defects, phase transformations of solids, and also for studying transport processes in materials.

64. Volchenkova V.A., Kazenas E.K., Andreeva N.A., Penkina T.N, Mamuzić, I., Smirnova V.B., Fomina A.A., Grigorovich K.V., Mansurova E.R., Sprygin G.S.
Development of express methods for determination of the components contents in heat-resistant nickel alloys using AES-ICP, AES- GD AND AAS. Using AES-ICP, AES-GD and AAS the new methods have been developed for quantifying the contents of Al, B, Ce, Co, Cr, Cu, Hf, Fe, Mg, Mn, Mo, Nb, Si, Ta, Ti, W, V, Zr in a wide concentration range from 0.0005 to 30% in the new heat-resistant nickel alloys. Optimal analytical parameters were chosen for determining of the components. The influence of matrix elements (nickel and chromium) and methods of its elimination were studied. It is shown that the method of AES-GD is the dominant if you have a full set of standard samples of the studied alloys composition. The methods of AES –ICP and AAS are optimal for certification of new standard samples. New methods of analytical control were used to correct the processes of melting alloys by vacuum induction melting, compacting capsules and welding process with other heat-resistant alloys.

65. V. V. Roshchupkin, V. A. Ermishkin, V. M. Kirilova, N. A. Minina, I. Mamuzić, N. A. Palii
Evaluation of the strength characteristics of the structural components of alloys according to the photometric analysis of the luminance spectra of visible light reflection from their surface. The present work shows the possibility of generalizing the compositional approach to the case of multi component poly crystalline materials. A method for assessing the strength characteristics of individual structural components of such alloys using photometric analysis of structural images, which allows us to estimate the total number of structural components, their volume fractions in the alloy (Mo-Ta), and the values of partial strength characteristics separate structural components is proposed.

66. N. Martynenko, D. Temralieva, N. Anisimova, M. Kiselevskiy, I. Mamuzić, E. Li, M. Morozov, V. Yusupov, S. Dobatkin, Yu. Estrin
The effect of rotary swaging on the microstructure, mechanical and corrosion properties and cytotoxicity *in vitro* of the alloy Mg-1.0%Zn-0.7%Ca. The effect of rotary swaging (RS) on the structure, mechanical properties, corrosion resistance, biocompatibility and cytotoxicity *in vitro* of the alloy Mg-1.0Zn-0.7Ca was studied. The average grain size decreased from 54.1±2.5 μm to 4.5±1.2 μm after RS. RS leads to increase in the strength (the yield strength and the ultimate tensile strength rose up to 210±8 MPa and 276±6 MPa after processing, respectively), without decrease in the tensile elongation. RS did not enhance the chemical corrosion rate of the alloy. Cytological assay showed that the alloy can induce hemolysis of red blood cells without inhibiting the viability of leucocytes. An interesting observation was the occurrence of specific antitumor activity of the alloy *in vitro*.
This research was supported by the Russian Science Foundation (grant #18-45-06010).

67. L. L. Rokhlin, T. V. Dobatkina, I. E. Tarytina, E. A. Lukyanova, O. A. Ovchinnikova
The aging kinetics of the Mg-Y-Gd-Zr-X system alloys, where X is Tb, Dy, Ho, Er, or Yb. The data on the aging kinetics of the high-strength high-temperature IMV7-1 (Mg-5%Y-5%Gd-0.5%Zr) magnesium alloy, which additionally contains other rare-earth metals (Tb, Dy, Ho, Er, Yb), are presented. The analysis of the established properties of the alloys shows that the additional yttrium-group rare-earth metals in the IMV7-1 alloy decelerate the decomposition of the magnesium solid solution, and this effect increases with increasing atomic number of the additional rare-earth metal.

68. D. Romanov, K. Sosnon, A. Filyakov, I. Mamuzic, V. Gromov
The structure of the WC-Ag coating, obtained by electric explosive spraying, nitriding and following electronic beam treatment. The copper electrical contact with an area of 1 cm^2 was subjected to three-stage processing. On the first stage, the WC-Ag coating was sprayed by the electro explosive method. The surface layer was nitrogenized further. At the third stage, it was provided repetitively-pulsed electron-beam treatment on the sprayed coating. The phase composition of the multi-stage coating consists of tungsten monocarbide, solid solutions of nitrogen and silver, as well as silver nitrides. The sprayed coating layer belongs to a class of nanomaterials. As a result of electron-beam finishing, the coating surface acquires a shining gloss.
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69. 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.

70. A. Mamala, P. Strzępek, M. Zasadzińska, B. Smyrak, M. Sadzikowski
The influence of the axial tension on the linear resistance and mechanical properties of AlMgSi overhead line conductors. The paper examines the influence of axial tension on the linear electrical resistance of single-layer aluminum alloy conductors and showed that when the tension is applied the linear resistance stabilizes at a lower level in comparison to conductors with no tension or with low value of tension. The effect of pressure forces occurring in the inter-wire contact area was also examined and it was found that the hardness of the material and the range of deformation locally increases as the average pressure at maximum compression force increases.

71. P. V. Kovalev, S. V. Ryaboshuk, A. Z. Issagulov, M. K. Ibatov, Sv. S. Kvon, V. Yu. Kulikov
Studying nanopowder modifiers 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

72. 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. The article presents the information of the identified defects of fatigue failure of steel structures of the brake mechanism of mine cable hoisting machines used to transport metallurgical coke from the mine to the surface. Using non-destructive testing methods a survey was carried out of the brake mechanisms of sixty mine cable 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.

73. 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.

74. T. Kranjec, B. Kosec, J. Bernetič, B. Karpe, G. Kosec, M. Bizjak, A. Nagode
Thermal conductivity of armour steel. The presented study investigates thermal properties of the ultra-high hardness (UHH) armour steel. Steel is distinguished with high hardness and strength. Steel is sold in quenched or tempered state, because achieving planned hardness which has to be betwe-

en 590 HB and 640 HB. Chemical composition and mechanical properties are given in data sheet for material, while thermal properties are not avalible. Therefore in the experimental part the analysis of thermal properties of the steel was carried out on the device Hot Disk TPS 2200, which works according to the method of transient plane source (TPS) method. Measurements were carried out according to the standards group ISO 22007. In addition to thermal properties we measured hardness and analyzed microstructure of the steel. The aim of the study was to determine thermal properties at different temperatures. The results have shown that thermal conductivity increases up to the temperature 400 °C. Analysed steel can be classified as medium thermal conductive steel with an average value of thermal conductivity of 27.17 W/mK at room temperature.

75. B. Karpe, Ž. Ferčak, B. Bavec, A. Nagode, G. Janjić, M. Bizjak, B. Agarski, M. Zorc, L. Gnamuš, B. Kosec
Thermal properties of enamelled metal sheets. The results obtained from the measurements of the thermal properties of the thick layers are within the expected values of the enamels thermal properties. However, it has been established, that the density of the enamel layer has a significant effect on the thermal properties. The samples of the enameled steel sheet were metallographically prepared and analyzed by scanning electron microscopy and optical microscopy. We find that the layer of analyzed enamels has multiphase structure, consisting of amorphous regions with different chemical composition, crystalline phases and pores. From the microchemical analysis of the steel – enamel phase boundary, it is evident that chemical reactions occur during the firing of the enamel at certain points on the phase boundary, whereby the cobalt diffuses into the steel. An assessment of the influence of enamel layerthermal conductivity on the thermal transmittance of enameled steel sheet metal is also calculated.

76. Ye. P. Shcherbakova, S. K. Arinova, I. Ye. Medvedeva, G. S. Zhetessova, Sv. S. Kvon
Studying the properties and microstructure of parts obtained by different casting technologies. The paper presents some data of studying the microstructure, properties and surface quality of parts obtained in different modes. It is shown that in the case of quenching and tempering (QT) in the process of primary crystallization by vibration, in the future it becomes possible to replace QT with a simpler and cheaper method: normalization with accelerated air-water cooling. After this treatment, the steel structure is characterized by almost the same parameters as after QT. Tensile strength, hardness, average grain size are comparable with the performance of QT steels.

77. P. Strzępek, P. Osuch, M. Walkowicz, M. Zasadzińska, A. Mamala, T. Knych, T. Napióra
Impact of the heat treatment parameters on ultimate tensile strength, microstructure and wire drawing process of Zn-Al15. Research conducted in the current paper examines the impact of the heat treatment at temperatures from 150 °C to 300 °C with time intervals between 1 and 6 hours on susceptibility to drawing process of Zn-Al15 wire rod manufactured within the industrial continuous casting and rolling line. The mechanical properties studies proved that the heat treatment caused the increase in the ultimate tensile strength values of the alloy whereas the drawing process caused a significant decrease, which suggests that this alloy after the specific heat treatment cannot be subjected to strain hardening.

78. A. R. Toleuova, A. M. Dostayeva, O. M. Zharkevich, S. A. Abdulina, M. A. Adilkanovva
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.

79. 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

80. S. Spadło, P. Młynarczyk, D. Bańkowski
Structural and morphology properties of ESD layers deposited on EN AW 1050A alloy. The paper present preliminary research surface layers produced by electro-spark deposition (ESD) using copper electrode on the aluminum. Selected properties of covering and fusion zone were investigated. The macro and microstructural analyses of the surface were characterized and discussed before and after heat treatment. Scanning electron microscope (SEM) and energy-dispersive X-ray spectroscopy (EDX) analysis was conducted to characterize the microstructure and composition of the coating. Also the morphology analysis were carried out to confirm the formation of phases. Cu-enriched layers prepared on the Al surface were successfully produced by ESD spark eroding using an electrode made of Cu Copper.

PROCESS METALLURGY – SECTION "B"

1. A. K. Tarakanov, V. P. Lyalyuk, I. Mamuzić, D. A. Kassim, M. A. Fursov
Means for improving of blast-furnace performance by coordination of the batch distribution at the top and gas distribution in the hearth. In selecting blast-furnace conditions, the parameters of the charge and the blast must be harmonized for optimal productivity and coke consumption. In assessing individual parameters in coordinated choice of the optimal charge and blast, we must take account of the key role of the batch distribution at the furnace mouth, which largely determines the gas utilization and coke consumption, on the one hand, and the gas permeability of the batch column and the possible intensity of furnace operation, on the other.

2. A. K. Tarakanov, V. P. Lyalyuk, I. Mamuzić, D. A. Kassim, V. V. Efimenko
Maintenance of the uniformity of blast distribution over the circumference of blast-furnace hearth. A problem of the technology of blast-furnace smelting connected with the necessity of guaranteeing the uniform distribution of the blast rate along the circumference of blast-furnace hearth remains unsolved up to now. The degree of stable nonuniformity of the blast rate over the circumference of blast-furnace hearth caused, first of all, by the design of the joint of a straight-line air channel and an annular channel can be significantly reduced by realizing two-sided diametrically opposite hot-blast supplies from the straight air channel to the annular channel.

3. R. Andriukhin, L. Molchanov, I. Mamuzić, Y. Synehin
Innovative technology of melts alloying. The process of melts alloying is a necessary component of steel production in modern metallurgical enterprises. A significant reduction in the consumption of alloying materials is possible due to their input into the melt at the pre-crystallization stage. Therefore, a perspective technology for steel alloying is the process of input active reagents into the melt at the stage of filling the mold. The application of this technology will allow diversifying metallurgical products by steel grades, since the minimum amount of steel produced by one brand in this case is limited by the weight of one ingot.

4. B. M. Boichenko, O. M. Stoianov, I. Mamuzić, K. G. Niziaiev, K. V. Volodko
Peculiarities of exploitation of teeming ladle with magnesium-carbon lining. The researches allowed defining the technological regularities that directly influence the life of ladle's refractories. It has been determined that during the operation of magnesium-carbon refractories, it is necessary to take into account the diffusion of CaO from the slag into the surface layers of the refractory, and the following interaction of the seeped CaO with the refractory's carbon to form the carbide CaC_2, which is an active antioxidant. Schemes of adjusting the slag regime at the stage of ladle treatment have been developed, and the specific refractory costs have been reduced by 3-5%.

5. O. M. Stoianov, K. G. Niziaiev, I. Mamuzić, L. S. Molchanov
Analysis of the growth of the energy-consumption of hot metal after its pretreatment. As a result of the performed studies, the values of the increase in the energy consumption after the injection desiliconization of hot metal were obtained using various types of solid oxidants and carrier gas. It was determined a wide range of the energy consumption of the process of hot metal desiliconization from 12 to 138 kJ/kg, caused by the energy consumption of the solid oxidizers. It has been determined that the minimum values of direct energy consumption (3-12 kJ/kg) are provided by injection of scale in the oxygen flow.

6. O. M. Stoianov, K. G. Niziaiev, L. S. Molchanov, O. V. Ryzhkin, G. Šimunović
Energy consumption of steel with application of auxiliary materials in melt. It was analyzed the influence of the main parameters and quality characteristics of materials used in BOF melt on the consumption of metal charge and the energy consumption of steel. It was shown that solve of current production problems by using of auxiliary materials in converter melt, such as scrap, cold pig iron, magnesium flux, fuel, leads to a significant increase in the energy consumption of steel to 42 kg of standard fuel per ton.

7. B. M. Boichenko, K. G. Niziaiev, K. F. Chmyrkov, I. Mamuzić
Mechanism of assimilation of iron-containing silicon carbide briquettes, which are put during the steel production in bof to reduce the consumption of hot metal. Briquettes are prepared from slag of silicon carbide production and scale in a ratio of 1:1 and used in a BOF charge. Their application has reduced the consumption of hot metal by 2.6 kg per 1 kg of briquettes and showed: 1) the process of briquette dissolution in the melt is determined by the diffusion of silicon and carbon and occurs after the disruption SiO_2 film on the SiC surface caused by the thermal shock; 2) the process in the slag melt is determined by the chemical interaction of SiO_2 from the surface film with the components of the converter slag with the formation of low-melting compounds with FeO and further transfer of the reaction products.

8. B. M. Boichenko, K. G. Niziaiev, L. S. Molchanov, Y. V. Synehin, O. M. Stoianov, I. S. Ryshkova, I. Mamuzić
Contemporary approaches to improving the design of the lining of oxygen converters. Lining is one of the most important elements of contemporary steelmaking units. The duration of its operation affects the main technical and economic indicators of the steelmaking process, especially for BOF. The wear of the lining in the bath zone is determined by the abrasion action of the metal. Thus, an increase of lining resistance in the bath zone could be achieved by approximation of its shape to the segment of a sphere, which determines the rational circulation of melt. For the bottom part of the BOF bath zone it has been determined the shape of a refractory brick based on a truncated pyramid with an equilateral trapezoid in the base.

9. L. S. Molchanov, Y. V. Synehin, O. S. Lantukh, I. Mamuzić
Influence of the teeming ladle design on the steel pollution with nonmetallic inclusions. Considering the specifics of steel production at the modern metallurgical plant, it should be noted that the main sources of steel pollution with nonmetallic inclusions in a teeming ladle are furnace slag, ladle lining and deoxidation products (alloying). Summarizing the information on the operation of the BOF lining, it was defined that the bottom part is destroyed 2 times faster than the walls on any kinds of applied lining. The average rate of destruction of the magnesia-carbon lining is 1.22 mm per melt, and the lining of heat-resistant concrete is 1.34 mm per melt. By engineering calculations it is determined that the maximum weight of nonmetallic inclusions entering steel due to the destruction of the lining is 0.92 kg/t of steel for magnesia-carbon refractories and 1.07 kg/t of steel for heat-resistant concrete.

10. A. G. Cherniatevych, P. O. Yushkevych, L. S. Molchanov, I. Mamuzić
Three-level lance for BOF bath blowing. The carried out high-temperature experiments with use of a three-level lance on a laboratory facility which includes a 60-kg converter with magnesia lining allowed defining the main technological parameters. They include the peculiarities of the blowing regime (periodic change of the oxygen of the additional nozzles on a neutral gas) in order to avoid excessive overheating and overoxidation of the slag-metal emulsion, that adversely affect the life of BOF lining. At the same time, it is possible to provide the supply of oxygen through the upper nozzle block of the lance with the formation of postcombustion torches that spade only within the near-lance zone of CO release to the bath surface.

11. M. N. Boyko, N. V. Polyakova, I. Mamuzić
Analysis of mutual influence between parameters of the induration process for iron ore pellets. The crucial parameters of iron ore pellets induration process were estimatedin this work. The principle parameters in the process of pellets drying for the operations of pellets preheating, firing, cooling were determinated. The effect produced by the residual moisture content on the limestone decomposition and the magnetite oxidation was investigated. The influence of the principle parameters revealed for the firing process on the pellets strengthening and specific productivity was evaluated.

12. V. Bochka, A. Sova, L. Kieush, A. Dvoiehlazova, M. Vashchenko, I. Mamuzić
Sinter quality improvement by separateblend preparation for sintering process. The study to establish how the separate blend preparation affects the parameters of iron ore sintering process and the quality of the resulting sinter has been carried out. Granules are formed by their separate nucleation not only around large particles of return and iron ore, but also due to the separate interaction of small components with active surface properties.Then, there is afurther co-granulation of the obtained granule nuclei from the residual blend.This study is to provide a common groundfor the separate blend preparation for sintering, due to which the binder is formed in the sinter mainly of iron-calcium olivines and a small amount of calcium ferrites.

13. Koveria, M. Yaholnyk, L. Kieush, Z. Jurković, M. Boyko, N. Poliakova
Manganese Ore Sintering with Wood Biomass Application. Fine manganese concentrate or fine ores are required to be granulated before the use in blast furnaces or electric furnaces. Under the laboratory conditions, manganese sinterwas obtained with the participation of wood biomass, namely raw and pre-pyrolyzed wood biomass at the temperatures of 673, 873, 1073 and 1273 K.The amount of biofuel in the sinter blend was 25% of the total amount of fuel.It was concluded that in order to increase the efficiency of the woody biomass application in the manganese ores sintering, it is necessary to use less reactive material, thereby increasing the level of fuel carbonization, and/or to use larger biofuel particles, for instance, biomass pellets.

14. Bochka, A. Sova, L Kieush, A. Dvoiehlazova, O. Klypa, I. Mamuzić
Enhancement of mechanical loads on the sinter via drum type apparatus. The dependence of the separation of the strong sinter component from the applied energy loadshas been studied via the mathematical modellingof the mechanical processing of the sinter in the drum typeapparatus. The type of energy loads depends on the drum characteristics and the technological conditions of its operation. The efficiency of working zones creation with variable force action and range of energy load on the material by changing the number and width of shelves has beenrevealed. This leads to the formation of internal stresses within the sinter, further giving it a round shape and improving the size of 5-50 mm, and the strength.

15. V. Selivorstov, Y. Dotsenko, I. Mamuzić
The use of vibration casting of aluminum cast alloys in the process of solidification in metal form. Study of the mechanical properties of aluminum casting 356 alloy revealed that the alloys subjected to 100 Hz and 150 Hz vibration treatment showed the highest properties, as the tensile and the yield strengths improved by 20% and 10% respectively. The densities of the alloys subjected to the vibration treatment varied in the range of 2,5–3,7% as a result of the presence of segregation areas in the obtained cast ingots. The microstructural studies followed by an image analysis evaluated that the alloys subjected to the vibration treatment showed the refinement of α-Al grains with an increase in the Si network area around them.

16. T. Selivyorstova, V. Selivyorstov, M. Šercer
Evaluation of supply dynamics of a two-phase zone using percolation models. When developing new technologies related to improving the quality of cast products, it is important to take into account the peculiarities of the supply of the two-phase zone with one or another effect on the melt during solidification. Which in the course of their growth localize the melt, complicating nutrition and causing shrinkage defects in the form of pores. As a result of the study, a model was constructed that links the structural features and percolation properties of the model with limited diffusion of aggregation.

17. A. Y. Zimoglyad, A. I. Guda, I. Mamuzić, M. V. Andriukhina, V. Y. Tsaryk, A. H. Stanchyts, S. M. Klishch
Buck topology converter simulation for the vacuum heater control system. The mathematical model was developed and on its basis a Buck topology converter of the control system of the heater of thermal evaporation of the metal in a vacuum was created and practically realized during the creation of functional coatings. Comparison with the data obtained in the real experiment, confirmed the adequacy of the proposed model, and its subsequent use has made it possible to create high-quality functional coatings of special purpose.

18. C. N. Zhang, Y. R. Li
Optimization analysis based on intelligent control of the process of the blast furnace. The blast furnace needs to continuously improve of thermal efficiency so as to achieve the goal of energy saving and consumption reduction. By collecting a large amount of field data, the isolated point removal strategy of isolated point is introduced to carry out preprocessing, and the semi-supervised clustering algorithm is adopted to optimize the combustion control process of the blast furnace. This method has been verified by experiments, compared with the traditional data preprocessing strategy, the energy saving effect is obvious.

19. M. Lara, J. Camporredondo, A. García, L. Castruita, F. Equihua, H. Moreno, M. Corona
Thermodynamic simulation of reduction of mixtures of iron ore, siderurgical wastes and coal. The thermodynamic feasibility of reducing agglomerates in iron ore/carbon (ICA) from concentrate mixtures of goethite ore, siderurgical waste and carbon were performed using the HSC Chemistry for Windows V. 6.0 software. Removal by reduction and gasification of Na_2O, K_2O, ZnO and the metallization of iron oxides was performed by using a reducing atmosphere generated by heating the mixtures. Proposed mixtures generate reductions near 100 % of iron with 28 % of carbon and average removal percentages of 85 % of Na, K and Zn have been obtained.

20. S. Sukhovetskyi, Y. Synehin, I. Mamuzić, L. Molchanov, S. Zhuravlova
Non-metallic inclusions removal by centrifugal force in ccm tundish. A mathematical modeling of the efficiency of steel refining from non-metallic inclusions by centrifugal forces has been carried out. It has been found that the velocity of rotation of 45 rpm in a chamber with a radius of 350 mm allows inclusions removal of at least 200 μm to the axial zone of the chamber. As it has been shown through physical modeling the method allows creating rotation of liquid steel with the velocity at least 25 rpm that can be increased through a re-design of casting chamber.

21. R. R. Yin, Z. J. He, S. Qiu, J. H. Liu, C. Tian, Y. Q. Yuan, J. H. Zhang
The study on the interface reaction characteristics of different binary slag, CaO – MgO, Al_2O_3 – CaO, Al_2O_3 – MgO, SiO_2 – CaO, SiO_2 – MgO. In this paper, thermodynamic calculation and different binary slag interface reaction experiments are used to study the reaction characteristics of different binary slag. The differences in melting process, wetting and reaction behavior were studied. The wetting angle of acidic slag is higher than that the corresponding basic slag. The variation of wetting angle between different binary slag is relatively small. The variation range is only 18 °C.

22. A. Akberdin, A. Kim, R. Sultangaziyev
Mathematical model of charts melt viscosity of the CaO - SiO_2 - Al_2O_3 – MgO. Experimentally using electric vibration viscometer and the method of design of experiments on the simplex studied the melt viscosity of the system CaO - SiO_2 - Al_2O_3 - MgO. Developed its mathematical model and computer program that allows calculation of viscosity in the temperature range 1 573 - 1 823 K. Using the model diagrams are constructed in the form of isothermal sections of the tetrahedron on MgO. It is concluded that the use of the model is more efficient than Chart, so it does not require a complex geometric constructions tetrahedron when the viscosity values, and, moreover, can be used in automatic process control in real time.

23. G. W. Ao, M. G. Shen, Z. S. Zang, C. Y. Wen
Numerical simulation research on the influence of steel ingot of 76 tons and 8 corners with hollow riser. The effect of a hollow riser on the upper heat dissipation of 76 tons and 8 corners ingots is studied by numerical simulation in this paper. Through the simulation of the heat transfer of the traditional riser, the 1 gap riser and the 2 gaps riser ingot, this paper draws a conclusion that the solidification time of the riser part of the riser is the longest in the 2 gaps scheme, and the solidification time of the central molten steel is 31417s, which is far higher than the other two schemes. It is particularly significant to reduce the cooling rate of the shoulder joints, which is more conducive to expanding the angle of the solidification front and fully filling.

24. S. Qiu, J. H. Liu, Z. J. He, H. Di, C. Tian, R. R. Yin, J. H. Zhang
Study on interface reaction characteristics between different acidity and alkalinity slag. In this paper, the interface reaction between different acidity and alkalinity of slag was explored by comparing the changing of wetting angle and viscosity in the interface between the binary slags. And the results indicated that, the reaction temperature range of Al_2O_3 and basic slag was relatively larger when the reaction interface was acid slag, and the fusion temperature would change when the content of calcium and magnesium were changed in the base slag. Al_2O_3, SiO_2 are prone to react with other components and formed the new silicate phase compared to CaO, MgO, what made interfacial diffusion relatively better.

25. C. Gao, M. G. Shen
End-point prediction of basic oxygen furnace (BOF) steelmaking based on improved twin support vector regression. In this paper, a novel prediction method for low carbon steel is proposed based on an improved twin support vector regression algorithm. 300 qualified samples are collected by the sublance measurements from the real plant. The simulation results show that the prediction models can achieve a hit rate of 96 % for carbon content within the error bound of 0,005 % and 94 % for temperature within the error bound of 15 °C. The double hit rate reaches to 90 %. It indicates that the proposed method can provide a significant reference for real BOF applications, and also it can be extended to the prediction of other metallurgical industries.

26. K. F. Ji, M. G. Shen, R. T. Li, X. L. Zhu, Z. S. Zhang
Simulation study on influence of exothermic riser on ingot solidification. In this paper, the effect of exothermic riser on ingot solidification is studied by numerical simulation. Through the study, it is concluded that the combustion of exothermic risers delayed the solidification of steel in riser, and the solidification time increased significantly, extending about 8 143 / s. In the later stage of solidification, the temperature isotherm of the ingot is smoother than that of the ordinary ingot, making the angle of the solidification front larger, which is conducive to feed.

27. N. Arendach, L. Molchanov, Y. Synehin, I. Mamuzić
Carbon removal from steel by oxidation blowing in teeming ladle. Traditionally, carbon removal from steel is carried out directly in smelting furnace, but in the case of steel with a carbon content less than critical concentration (0.03%), there is a significant decrease in the yield of suitable liquid steel. To avoid this effect, special technologies AOD (*Argon Oxygen* Decarburisation) and GOR (*Gas Oxygen Refining*) are used. An alternative technology for the production of low carbon steels is proposed by blowing the mixture of neutral gas with oxygen through the bottom blowing blocks in a teeming ladle. The application of this technology will simplify the technological scheme of stainless steel production by avoiding the use of additional technological equipment.

28. L. Cheng, K. Liu, R. Z. Han, N. Luo
Study on the behavior of magnesium in molten salt electrolysis in-situ desulfurization during hot metal pretreatment. A desulfurization method based molten salt electrochemistry using magnesite-based desulfurizer for hot metal pretreatment was investigated. Through theoretical analysis, the conditions of the two different desulfurization processes, and the theoretical values of the critical current density at which mutual transition between the two desulfurization processes were specified. Through kinetic modeling, the behavior of magnesium and its main role on desulfurization were investigated.

29. X. Huang, L. H. Feng, W. D. Diao
Simulation research on molten steel flowing behavior in wide slab continuous casting mold. In this article, a three-dimensional solid model of 230 mm × l 600 mm is created based on actual wide slab mold, and analyze the influence of the casting speed, nozzle angle and immersion depth on the flowing behavior of molten steel. It is concluded that the suitable nozzle angle and immersion depth at a certain casting speed can provide theoretical support for continuous casting efficiently and the process optimization.

30. P. T. Iswanto, Akhyar, E. U. K. Maliwemu
Fatigue crack growth rate of motorcycle wheel fabricated by centrifugal casting. The aim of this study is to investigate the effects of the rotation speed of casting and T6 heat treatment on the fatigue crack growth rate of a motorcycle wheel manufactured using centrifugal casting. The results showed that applying increased rotation speed is effective in increasing the alloy's tensile stress and material density, as well in reducing porosity and fatigue propagation rate. T6 heat treatment also increases the aluminum's tensile properties and reduces the fatigue crack growth rate.

31. R. Mežibrický, M. Fröhlichová, J. Legemza
HIGH-SiO_2 iron ore sintering: Central & Eastern Europe scenario. Sinter plants in the region of Central & Eastern Europe are typical for the processing of iron ores with high SiO_2 content, which leads to an unusual high silica ratio in the sinters compared to the rest of the world. This study describes the scenario in sinter plants in Central & Eastern Europe and analyzes some iron ores exploited in Russia and Ukraine using the XRF and light microscope analytical methods.

32. C. N. Zhang, Y. R. Li
A combustion control strategy of hot blast stove based on kernel fuzzy C-means (FCM). During the combustion process of hot blast stove, controlling the steady rise of vault temperature and flue gas temperature is an important link. A large amount of data is preprocessed in the field, and the kernel-based clustering algorithm is used to optimize the combustion control process of hot blast stove. The experimental results show that the algorithm has high accuracy and fast convergence. Compared with the traditional combustion control method, the improved method has better optimization effect and better stability.

33. V. Selivorstov, V. Soroka, I. Mamuzić
Calculation of risers of large steel castings under gas-dynamic pressure and electroslag heating. The risers sizes of castings made using the combined technology of gas-dynamic pressure and electroslag heating are determined. Nomograms are constructed for determining the riser height by its diameter and the mass of cylindrical castings from steels the combined technology of gas-dynamic pressure and electroslag heating of the metal in riser, taking into account the possibility of varying the dimensions of the insert, which occupies a certain fraction of the volume of the part casting or ingot using different refractory materials.The calculations were performed for castings with a mass of diameter with variation in the ratio of the diameter of the casting to the diameter at 0.6, 0.65, and 0.7.

34. X. H. Wang, Z. M. Yu
Numerical simulation of solidification structure of continuously cast bloom of steel 20CrNiMo. A model for predicting solidification structure of continuously cast steel was developed using commercial software ProCAST, and verified by the metallographic examination. Later, the effects of operational parameters on microstructure of continuously cast bloom of alloy steel 20CrNiMo were investigated. The results show that the increase of superheat can promote the columnar grain growth and inhibit the central equiaxed grain growth. When superheat increases from 20 K to 35 K, the central equiaxed grain ratio decreases from 17,8 % to 13,5 %.

35. O. Stoianov, V. Ruban, I. Mamuzić
Simulation of hydrodynamic processes during argon bottom blowing in teeming ladle. It has been carried out the study of a bubbling zone formation and the slag eye diameter by blowing through the bottom devices in the steel casting ladle. It has been determined that for refining blowing (flow rate of 100 dm^3 per minute) the thickness of slag layer almost does not affect the slag eye diameter. Using the method of statistical analysis, an equation has been obtained that describes the effect of gas flow rate and slag thickness on the relative area of slag eye on the metal mirror in the teeming ladle.

36. Y. Xu, S. Li, J. Zhou, L. Yan, X. Ai
The effect of ruhrstahl and hereaeus (RH) Operation on the mixing of molten steel. The flow and mixing characteristics of molten steel in the RH refining process were studied. A hydraulic simulation system with the geometric similarity ratio of 1:4 was built with 210 tons of RH as the prototype. The influence of different locations of tracers and different operation processes on the mixing of molten steel in ladle was studied. The results show that the RH operation should adopt a large air blowing amount, the insertion depth of the impregnated tube should not be less than 560 mm, and the liquid level of the vacuum chamber should be kept small.

37. H. Liu, S. Yao
End point prediction of basic oxygen furnace (BOF) steelmaking based on improved bat-neural network. A mixed bat optimization algorithm based on chaos and differential evolution (CDEBA) is proposed for the end-blow process of basic oxygen furnance (BOF) after sub-lance detection, and a prediction model based on BP neural network optimized by chaotic differential bat algorithm (CDEBA-NN) is presented. The simulation results show that the prediction model of carbon content achieves a hit rate of 94 % with the error range of 0,005 %, and 90 % for temperature with the error range of 15 °C, the accuracy is higher than the traditional neural network model, and then it verifies the effectiveness of the proposed model.

38. Z. Y. Xu, B. W. Li, Z. W. Zhao
Oxidations behavior of C, Si, Mn, P, Nb IN Nb-bearing hot metal by bottom blowing oxygen. This paper focuses on oxidationS behavior of C, Si, Mn, P, Nb in Nb-bearing hot metal during bottom-blowing oxygen in a vacuum-induction furnace. This blowing process was carried out separately with and without slag at the flow rate of 0,4 m^3/min to 0,6 m^3/min. The results show that niobium is massively removed from the hot metal while silicon content in hot metal is decreased to lower than 0,01wt. % with adding slag , P content keeps unchanged, and sulfur content is decreased in hot metal at the beginning of blowing stage while it increased in hot metal with the extension of smelting time.

39. S. E. Shipilov, M. K. Ibatov, Zh. D. Zholdubayeva, A. D. Alkina, S. S Shipilova, E. V. Yurchenko, Mekhtiyev A. D.
The method to obtain of the aggloburden sintering material using the conversion of natural gas. The paper considers the processes of direct production of iron from ores, which are called solid-phase reduction processes. A technology for the production of metallized agglomerate is proposed, consisting of two stages: sintering of agglomerate and subsequent metallization of hot intact sintered material. The combined sintering process and metallization with the products of natural gas conversion of the agglomerate at an elevated pressure of the gas phase resulted in the metallization of 50 - 68 % metallized sinter.

40. E. Kardas, R. Prusak
The analysis of selected parameters of blast furnace operation. The paper presents results of the analysis of selected parameters of blast furnace operation and the influence of various factors on them. 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 one calendar year.

41. D. Yessengaliyev, S. Baisanov, A. Issagulov, A. Baisanov, O. Zayakin, A. Abdirashit
Thermodynamic diagram analysis (TDA) OF MnO–CaO-Al_2O_3-SiO_2 and phase composition of slag in refined ferromanganese production. It is determined that the system under consideration is divided into 19 elementary quasi-systems consisting of incongruently melting and congruently melting compounds. The sum of the relative volumes of the elementary tetrahedron of the MnO-CaO-Al_2O_3-SiO_2 system equals one (1,000000), which confirms the accuracy of the performed calculations. Quasi-volumes in the system MnO-CaO-Al_2O_3-SiO_2, simulating the composition of the resulting slag in the process of metallothermic recovery of manganese concentrates are found.

42. E. Mouele, A. Max, I. Mamuzić, L. Molchanov
Technological operations of steel refining from non-ferrous metals impurities. The quality of metal products is largely determined by the chemical composition of steel, and especially the content of non-ferrous metal impurities. Known methods of steel refinement from non-ferrous metal impurities are not very suitable for industrial use, since they are characterized by low productivity, high cost and the need to use significant quantities of auxiliary equipment. In order to implement the effective removal of non-ferrous metal impurities from melts, it is proposed to use the electrolysis method during secondary metallurgy, which will reduce the content of non-ferrous metals by 1.5-2 times.

43. V. Yu. Kulikov, A. Z. Issagulov, M. K. Ibatov, Ye. P. Shcherbakova, T. V. Kovaleva
Shell forming mode effect on casting quality. The paper deals with the influence of shell forming modes on some parameters of castings: the surface and internal defects. The degree of roughness and stress concentration were determined on the castings obtained under production conditions. According to the result, it was found that the use of variable pressure in the formation of the shell ensures the purity of the casting and the reduction of the stress level in the casting.

44. J. H. Liu, Q. Wang, Z. J. He, C. Y. Sun, Z. Zhuang
Reaction mechanism analysis of the Al_2O_3 in blast furnace (BF) slag. In the paper, ΔG_f^{θ} was used to analyzed the slag formation reaction process of the Al_2O_3,at the same time, the phase diagram and activity were calculated by FactSage with CaO - MgO - SiO_2 - Al_2O_3 slag system, it can be found that the complete liquid phase region temperature is about 1 500 °C and the content of the Al_2O_3 is 11 %. Activity of CaO is stronger than the others, from which the liquid phase can be formed easily in the high temperature, meantime the reaction energy barrier between CaO and SiO_2 is lower and stabilization of the product is better. By the high temperature experiment, a lot of $Ca_2Al_2SiO_7$ was separated out with the high content of Al_2O_3 and slag basicity, as a result, the transformation of the solid phase to the liquid phase was effected by the constantly increasing the content of Al_2O_3.

45. J. H. Liu, Q. Wang, Z. G. Guan, Z. J. He, Z. Zhuang
Reaction mechanism analysis of the TiO_2 in vanadium - titanium blast furnace (BF) slag. In the paper, the titanium slag was researched on, one iron and steel enterprise BF slags were detected and analysis by Scanning Electron Microscope (SEM), Energy Disperse Spectroscopy (EDS) and X - Ray Diffraction (XRD), then the $CaO{\cdot}FeO{\cdot}2SiO_2$ and $CaO{\cdot}TiO_2$ were tested beside the TiC that is the production of the reduction, at the same time, the residue iron was found in slag. By the thermodynamic calculation with the Factsage, the liquid phase regions contain magnesium titanate were changed when the percent of TiO_2 was enhanced. The smelting rate of slag system can be accelerated when the viscosity of the slag can be decreased, so the content of TiO_2 and B_2O_3 should be controlled.

46. D. Grigorova, R. Paunova
Thermodynamic activities of V_2O_3, MnO, and FeO in quaternary system V_2O_3 - FeO - SiO_2 – MnO. The activities of FeO, V_2O_3 and MnO in quaternary systems V_2O_3-FeO-SiO_2-MnO have been investigated. The oxygen potential in the systems was determined by the Electromotive force (EMF) method. The solid electrolyte was ZrO_2 (CaO), and the reference electrode - a mixture of Mo/MoO_2 was used as a galvanic cell. The Gibbs free energy and the activity were calculated based on experimentally obtained oxygen potential. On the basis thermodynamics of the calculations, the experimental results revealed the possibility of obtaining a complex alloy from the manganese concentrate and the vanadium waste catalyst.

47. S. Y. Guan, W. Y. Zhang, X. Xia, Y. F. Jiang
Study on neural network proportional-integration-differential (PID) control strategy of the molten metal pool level in the twin roll casting process. In this paper, the mathematical model about the pool level control is set up based on the process characteristics. Meanwhile, the limitations of the traditional PID control strategy are analyzed owing to the real-time change of the roll gap and roll speed. Furthermore, the neural network is applied to adaptively optimize the PID control parameters and the simulations show the neural network PID strategy can precisely control the molten metal pool level in twin-roll casting process under the condition of multiple factors interfering.

48. A. Z. Issagulov, A. F. Chekimbayev, T. S. Makayev, A. A. Babenko
Studying the fe-al-si system in relation to ferrosilicon-aluminum alloy crystallization. In the work there have been calculated the values of enthalpies for a number of ternary compounds and carried out triangulation of the Fe–Al–Si system. The main areas of the compounds crystallization have been determined in relation to industrial compositions of ferrosilicon-aluminum. There has been carried out the analysis of possible causes of some alloy compositions self-grinding and recommended compositions with guaranteed stable physical characteristics.

49. Ye. Samuratov, B. Kelamanov, A. Akuov, Ye. Zhumagaliyev, M. Akhmetova
Smelting standard grades of manganese ferroalloys from agglomerated thermo-magnetic manganese concentrates. Studies have been carried out to investigation the possibility of the agglomeration of thermomagnetic manganese concentrates from the Zhomart and Western Kamys fields (Kazakhstan) with obtaining from them conglomerates suitable for chemical and mechanical properties for subsequent ferroalloy processing. Their metallurgical properties are studied and the principal possibility of obtaining standard grades of manganese alloys from them in laboratory conditions is shown.

50. A. Z. Issagulov, M. K. Ibatov, Sv. S. Kvon, V. Yu. Kulikov, Ye. P. Chsherbakova
Studying furnace refractory lining properties with copper matte smelting. Today the most common copper matte smelting process is smelting in reverberatory furnaces. The problem is that due to the depletion of ore reserves, the poorer ore is involved in the processing. If in 2007, according to the data of the Kazakhmys Corporation LLP, the average copper content in ore was 1,24 %, in 2018 this indicator has already decreased to 0,91 % [1-4].

51. S. Baisanov, V. Tolokonnikova, G. Narikbayeva, I. Korsukova, Ye. Mukhambetgaliyev
Mathematical method of phase equilibrium of binary system Cr-Si based on Bjerrum Guggenheim concept. The procedure to study the phase equilibrium lines "solid - liquid" was developed for the binary systems with using a coefficient of Bjerrum Guggenheim. The universality of this procedure to solve a mathematical problem of phase diagrams and its efficiency to find the behavioristic characteristics of a solvent and the dissolved components in the equilibrium phases were demonstrated. Two types of the generalized mathematical expression as the modified Le Chatelier-Shreder equation were proposed to describe analytically the liquidus and solidus lines of phase diagrams of the whole class of systems.

52. O. M. Stoianov, K. G. Niziaiev, I. Mamuzić, Y. V. Synehin
Model of the bof melt. At the Department of Metallurgy of Steel, NMetAU, a model of material and heat balance of BOF melt has been developed. After adaptation of the model to the operating conditions of the BOF shop of PJSC "EVRAZ-DMZ", a sample of 300 melts of the current production was calculated. The results of comparison of the main melt indicators showed a high degree of convergence of the calculated and production data, so the absolute deviation of the steel temperature did not exceed 30%, the carbon content before tapping at 35%.

53. B. Kelamanov, Ye. Samuratov, Ye. Zhumagaliyev, A. Akuov, O. Sariev
Titanium and chrome oxides system thermodynamic diagram analysis. The paper presents the results of a thermodynamic diagram study of oxide smelting products from the processing of chromite and titanium raw materials in order to determine their most technologically advanced compositions, allowing for rational use of raw materials and energy resources. The reliability of the effectiveness of these developments was confirmed by tests carried out on a pilot industrial and industrial scale.

54. G. Shlomchak, I. Mamuzić, G. Shvachych, B. Moroz, I. Udovyk, E. Fedorov, M. Spilnyk
Metallurgical thermophysics processes identification based on extreme algorithms of high order of accuracy. The article is devoted the problem to researh the materials thermophysical properties by the inverse methods. Corresponding class of mathematical models is derived. The main research purpose is that the simulation models processing procedure as those that are controlled by input parameters, reduce, on the residual principle basis, to an extreme formulation. 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.

55. O. M. Stoianov, K. G. Niziaiev, Y. V. Synehin, L. G. Ahaian, I. Mamuzić
Ladle treatment technology of low-silicon steel grades. The reasons for the increase the silicon content in steel during processing in a LF the low-silicon steel at PJSC "DMK" were analyzed. It was found that the increase of silicon content in steel after treatment in the LF is caused by both the aluminothermic reduction of SiO_2 from slag during the deoxidization of steel with aluminum and carbothermic reduction of SiO_2 in the electric arc zone by the carbon of graphite electrode during prolonged heating of the metal.

56. Ye. Mukhambetgaliyev, S. Baisanov, A. Zharmenov, Yu. Khayn, V. Tolokonnikova
Industrial smelting tests and organization of production of ferrosilicon aluminum (FSA) in Kazakhstan. Results of the industrial tests on production development of ferrosilicon aluminum alloy are showed. The optimum parameters of the smelting process of FS55A15, FS55A20 and FS65A10 alloys were defined at the Ekibastuz mini-plant and "KSP Steel" LLP. The average power consumption varied within the interval of 9,1 - 12 MWh per 1 ton of alloy depending on a smelting grade of alloy. Increase in aluminum content in alloy composition might be with the rising in ash level of carbonaceous raw materials. The smelting process is characterized with hot furnace condition and active release of alloy.

57. W. X. Dou, C. B. Zhang, Q. Yue, H. Xiao
State of the art in tundish with induction heating (IH) for clean steel casting. In this work, the development of IH in continuous casting tundish was outlined. The current theoretical and experimental research on electromagnetic induction heating for molten steel flow and heat transfer were introduced. Meanwhile, the electromagnetic purification mechanism and research progress of non-metallic inclusions in molten steel were analyzed. Finally, the prospects for the application of electromagnetic IH are proposed.

58. B. K. Kassenov, Sh. B. Kassenova, Zh. I. Sagintayeva, E. E. Kuanyshbekov
Thermodynamic research of new nanodimensional lanthanum-cobalt(nickelite)-cuprate-manganites $LaNa_2CoCuMnO_6$, $LaNa_2NiCuMnO_6$. The thermal capacities of nanodimensional (nanocluster) cobalte (nickelite) - cuprate-manganites of lanthanum and sodium of $LaNa_2CoCuMnO_6$, $LaNa_2NiCuMnO_6$ were investigated with the calorimetry method on the IT-S-400 device in the temperature interval of 298,15 - 673 K. Based on the experimental data the equations of temperature dependence of thermal capacity of the studied compounds were set up. The temperature dependences of thermodynamic functions were estimated with using of measured values of thermal capacity and calculated value of standard entropy.

59. A. Akberdin, M. Karbayev, A. Kim, R. Sultangaziyev
Production of borbarium ferroalloy. In the present work, it was considered expedient to organize the production of binary borbaric ferroalloy. It was constructed a diagram of the phase composition of the Fe - Ba - B - C system, created its mathematical model and it was given the characteristics of the compounds formed in it. According to the data obtained, it was concluded that the possibility of implementing the technology is based on the formation of BaB_6 hexaboride, which is soluble in iron, between the barium and boron. It was estimated the size of the field of its crystallization and the features of coexistence with other phases of the metal. The possible binary compounds of borbaric ferroalloy are BaB_6, FeB, Fe_3C, B_4C and BaC_2. Melting of ferroalloy is offered by usual carbothermic method.

60. J. Boryca, C. Kolmasiak, T. Wylecial, D. Urbaniak
Effect of furnace efficiency on scale adhesion in the steel charge heating process. The paper presents the results of research on the influence of the efficiency of a metallurgical heating furnace on the adhesion of scale formed during the heating process of the steel charge. The methodology for measuring the adhesion of scale to the steel substrate as well as the measurement stand by means of which the research plan was carried out were presented. In addition, the method for determining the heating curves for selected furnace performance and measurement results are presented. The calculation results demonstrating the effect of efficiency on scale adhesion are summarized.

61. E. Kardas, R. Prusak
The influence of quality of ferrous charge materials on the efficiency of blast furnace process. The assessment of influence of quality of ferrous charge materials on the efficiency parameters of blast furnace process is presented. The analysis of structure of ferrous charge materials was made. As a main quality parameter charge richness was selected. Then influence of charge richness on four parameters of efficiency 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 one calendar year.

62. A. Akberdin, A. Kim, R. Sultangaziyev, M. Karbayev
Thermodynamic modeling of the borbarium ferroalloy smelting technological process. A complete thermodynamic modeling of chemical transformations during carbothermic reduction of barium and boron from oxides has been performed. It was shown that during the processing of charge with a high BaO: $BaO:B_2O_3$(3:1), barium carbide (BaC_2), iron boride (FeB), and barium hexaboride (BaB_6) are present as phase components in the smelting products, with the former predominantly noticeable. The data obtained allow us to conclude that it is possible to produce a new ferroalloy containing boron and barium.

63. S. Baisanov, V. Tolokonnikova, G. Narikbayeva, I. Korsukova, Ye. Mukhambetgaliyev
Estimation of dissociation degree of congruently melting compounds throughosmotic coefficient of Bjerrum-Guggenheim. A procedure was developed to calculate the position of lines of monovariant phase equilibria for crystallization areas of congruently melting compounds through the dissociation degree of a chemical compound.The relevant mathematical apparatus was recommended to describe analyticallythe lines and surfaces of crystallization phases using the Bjerrum-Guggenheim coefficient. The iron-silicon phase diagram demonstrated that the osmotic coefficient of Bjerrum-Guggenheim (its linear dependence) can be as an assessment criterion of the composition of melts.

64. L. Blacha, J. Łabaj, A. Smalcerz
Research on the reduction of cooper slag using an alternative coal range. The presented work shows the results of studies on the reduction of the slag with a carbon flotoconcentrate as a substitute for coke breeze. The microstructure, chemical composition and phase composition of slag samples were analyzed. Based on the results of chemical composition of the Cu-Pb-Fe alloy and the post-reduction slag, it was shown that carbon flotoconcentrate might be considered as an alternative for currently used reducers.

65. B. M. Boichenko, L. S. Molchanov, Y. V. Synehin, I. Mamuzić
The reasons of different effect of antioxidants composition on life duration of magnesia-carbon refractories during bof process. The problem was stated for increasing the resistance of magnesia-carbon refractories. The results of research of the use of Si, Al, Mg and their alloys as antioxidants are shown. It was found that antioxidant use effect depends on fireproofing of its interaction products with MgO, C and the converter slag too on the speed of their formation. That's why materials containing Al and Mg when correlation Mg/Al ≥ 0.75 either Al/Si = 2.0 are the most efficient.

66. B. Gajdzik
The analysis of steel production and utilization of production capacity in Polish steel industry. The analysis of steel production volume in relation to the level of capacity utilization in Polish steel industry is the content of this publication. This publication is based on numerical data on the volume of steel production and the degree of capacity utilization. The choice of the steel industry as a research object was dictated by the importance of steel production volume for the development of steel users' markets. The main purpose of the work was to reveal the connections between the volume of steel production and the level of steel production capacity involved in Polish steel industry.

67. H. L. Han, L. W. Zhou, K. Liu, Z. H. Lu, N. Luo
A process optimization on high temperature electrolytic desulfurization in hot metal pretreatment using magnesit-based desulfurizer. Results of single-tailed test show that when the temperature is constant, the desulfurization rate first increases with the increase of the current to a maximum value, and then, after dropping to the lowest level, gradually increases again as the current further increases. Finally, an optimum experimental condition is obtained as temperature of 1 400 °C and current of 1 A, achieving a desulfurization rate of 47,6 wt./% /min, which corresponds to a desulfurization efficiency of 62,6 %.

68. E. Kardas, R. Prusak
The assessment of efficiency of work of blast furnace. The paper presents results of the analysis of selected indicators used to assess the efficiency of blast furnace operation: running time operation, plan fulfilment, unit daily production of pig iron and the influence of these parameters on monthly pig iron production and intensity of coke combustion. 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 one calendar year.

69. J. Łabaj, L. Blacha
Lead and zinc removal from alloy Zn-Ag-Pb under reduced pressure. The presented work shows the results of vacuum melting of industrial Zn-Ag-Pb alloy arising from the processing of silver-bearing foam. The tests were carried out in an induction vacuum aggregate in the temperature range 773 - 873 K and pressure 10 - 1 000 Pa. Based on the results obtained, the values of the density of the evaporating stream of zinc and lead were estimated, which were at the level from $3{,}95\times10^{-4}$ to $9{,}53\times10^{-4}$ $g_{Zn}cm^{-2}s^{-1}$ and from $5{,}39\times10^{-5}$ to $30{,}9\times10^{-5}$ $g_{Pb}cm^{-2}s^{-1}$. In addition, silver losses were estimated in the analysed process. The maximum degree of dezincification of the alloy achieved for the assumed temperature and pressure was 99 %.

70. Y. R. Li, C. N. Zhang
A neural network prediction analysis of breakout continuous casting based on differential evolution (DE). In order to predict the breakout of continuous casting accurately and timely, a breakout prediction neural network (BPNN) model based on differential evolution algorithm was proposed. Differential evolutionary algorithm is introduced to solve the problem of fast optimization. The pretreatment of weights and thresholds improves the accuracy of breakout. The experimental analysis shows that the convergence speed of DE-BPNN breakout prediction model is faster than that of traditional neural network, and the recognition ability are significantly improved.

71. G. Q. Liu, G. X. Zhang K. Liu
The characteristic cavity size in basic oxygen steelmaking converter. In the present study, cold model experiments were carried out to investigate the cavity depth and diameter. Images of the cavities were captured by high speed video camera to study cavity performances. The experimental results show that the depth of bath has little influence on the shape of the cavity and the critical jet flow. The cavity depth and diameter exhibit linear growth by raising the jet flow rate with a fixed jet height. At the same gas flow rate, the cavity diameter has little relation with the nozzle diameter, but the cavity depth becomes deeper with the decrease of the nozzle diameter.

72. A. Smalcerz, L. Blacha
Vacuum refinning cooper blister to remove antimony. A research on kinetics of antimony evaporation from molten copper blister was made in a vacuum induction melting (VIM) furnace at temperatures of 1 473 and 1 523 K, and operating pressures of 8 - 133 Pa. The evaporation rate of Sb was found to be first order with respect to your content in the melt. The overall mass transfer coefficient of antimony evaporation from cooper blister are from $1{,}82\times10^{-5}$ ms^{-1} to $3{,}43\times10^{-5}$ ms^{-1} at 1 473 K (8 Pa) - 1 523 K (133 Pa).

73. S. Zhuravlova, V. Mameshyn, I. Mamuzić
Technological audit of secondary metallurgy. The paper considers the development and the world experience in the application of various units for ladle treatment of steel, their main advantages and disadvantages. Technological audit of the chain of secondary metallurgy at MZ "Dneprostal" was carried out. Measures are proposed to optimize the operation of the ladle treatment complex. The influence of the main technological factors on the degree of steel desulphurization in the ladle furnace unit was analyzed.

74. G. L. Tan, D. Tang, X. T. Yin, T. Mu, D. Wang, C. J. Xu
The activation energy determination in non-isothermal conditions for the solid-state phase transformation of 1035 steel. The activation energy of solid-state phase transformation for the steel has been evaluated by the isoconversional method. It is demonstrated that the linear fitting is a mathematically invalid procedure that generally invalidates the isoconversional method. The variation of the activation energy was interpreted by the nucleation and growth model. It is shown that the advanced isoconversional method can be recommended as a trustworthy way of determining the activation energy of solid-state phase transformation of 1035 steel.

75. B. K. Kenzhaliyev, A. K. Koizhanova, D. R. Magomedov, E. M. Kamalov, M. B. Erdenova, N. N. Abdyldaev
A study of the biohydrometallurgical method for extracting gold from flotation tailings. This paper shows the results of the comparative study of efficiency of gold extraction methods from technogenic flotation tails by agitation cyanidation and biooxidation followed by leaching. A representative sample of flotation tails was taken at gold extraction plant of Altyntau Kokshetau LLP. Experimentally, an increase in the efficiency of leaching gold from flotation tails during preliminary bacterial oxidation was found. By biochemical leaching, 72 % was extracted, which is 7 % more than using expensive sodium peroxide and 10 % more than using the traditional method of cyanidation.

76. M. Warzecha
Non-Metallic Inclusion Controling at the Ladle Furnace 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 non-metallic 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 of inclusions identified in the samples taken at the beginning and end of the process decreased, and in addition they were modified.

77. 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 - 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 affect the ecological properties of moulding sand. AB has been partly supported by the EU Project POWR.03.03.00-IP.08-00-P13 / 18 - PROM NAWA.

78. 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.

79. 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.

80. A. Kim, A. Akberdin, R. Sultangaziyev
Ways to improve texture technology reflective chromite ore of Kazakhstan. The article presents the results of laboratory tests on the use of fluxing agents for improving the sintering technology of refractory chromite ore in Kazakhstan. It is shown that reduction to solve the most efficient thermal process level through the use of fluxing agents having a low melting temperature and low temperature promote the formation of compounds in interaction with components of the ore phase. As an effective flux is proposed to use the calcined colemanite and basaltic rocks. The optimal cost fluxing agents, ensuring reduction of the thermal level the firing process at 100 °C.

81. B. Kosec, N. Petić, M. Ilić Mićunovć, M. Imširović, D. Klobčar, I. Budak, Z. Tanasić, A. Nagode
Emissions of the dust particles arrised at ARC welding of stainless steel. During welding procedures a lot of gases are emitted into the air, which can damage the health of the workers. Gases have different compositions and contain dust particles, which can provoke certain risks when inhaled by the workers. The degree of risk depends on the composition, concentration and time exposed to the harmful gases. Composition of gases depends on usage of different welding procedures, basic material and electrode. The idea of diploma work was to measure the emission of dust particles during manual arc welding of stainless steel with the usage and without the usage of ventilation device. Filtration of dust particles was conducted by EGO PLUS TT device. Composition and geometry of dust particles were examined according to the standard ISO 13322 using field emission scanning electron microscope Thermofischer Quattro S.

82. 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.

83. V. Yu. Kulikov, Sv. S. Kvon, M. K. Ibatov, Ye. P. Chsherbakova, D. A. Issagulova, A. M. Dostaeva
Studying the properties of shell molds manufactured under industrial conditions using unsteady-state pressure. The article deals with studying the properties of shell molds. A series of tests was carried out using ground broken chamotte bricks. The tests show that the most durable mold is obtained using the ratio of quartz sand and fireclay chips in approximately the same proportions. There were used different base pressures during shaping, the most rational was recognized 0,2 MPa. A field study showed an exponential dependence of density on base pressure. The pressure of 0,25 MPa allows obtaining dense molds that withstand transportation between workshops. The dependences of the sand density on forging pressure, bending strength on the applied static pressure, gas permeability of the sand-resin shell depending on the duration of the shaping, gas permeabilit

84. K. Sh. Akhmetova, B. K. Kenzhaliev, S. A. Trebukhov, A. V. Nitsenko, N. M. Burabaeva
Achievements in the titanium production development. Titanium sponge process flowchart includes the following main operations: concentrates reduction melting (example for concentrate from the Obukhovskoe field, the Republic of Kazakhstan), chlorination of obtained titanium slug, refining of industrial tetrachloride and magnesium-thermic reduction of titanium tetrachloride purified from any impurities. 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.

85. 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.

86. O. Sariev, S. Kim, Ye. Zhumagaliev, B. Kelemanov, M. Sultanov, N. Nurgali
Viscosity and crystallization temperature of ferroalloy slags from kazakhstan ore. Experimental research with synthetic mixtures imitating typical ferralloy 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 0-1800°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.

87. O. Sariev, B. Kelemanov, Ye. Zhumagaliyev, S. Kim, A. Abdirashit, M. Almagambetov
Remelting the high carbon ferrochrome dust in a direct current are furnace. The paper describes the results of pilot remelting of high-carbon ferrochrome dust in a 1,8 MVADC 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.

PLASTIC PROCESSING – SECTION "C"

1. M. Medvedev, V. Andreiev, O. Bobukh, I. Mamuzić

On the issue of evaluating deformation resistance during hot extrusion of tubes from nickel-based alloys. In the work, a method for assessing the value of deformation resistance during hot extrusion of tubes from nickel-based alloys, on tube-extrusion plants of various capacities, is developed. The case, the drawing coefficient for these conditions was 8, the degree of deformation was 87.5%, and the strain rate was 90 s^{-1}. Using the developed method, the force parameters of the hot extrusion of tubes from nickel-based alloys can be calculated, which allows us to determine the possibility of extrusion them on existing and designed tube-extrusion equipment both by steel and alloy grades, and by tubes sizes.

2. Y. D Vasilev, D.N. Samokysh, I. Mamuzić, R. O. Zamogilniy, V. A. Grynkevych

Method for calculating technological parameters during cold rolling of thin and ultralight. gagestrips. A methodology has been developed for calculating technological parameters during cold rolling of thin and ultralight gage strips. The technique takes into account the peculiarities of the elastic-plastic, frictional and kinematic interactions of a thin strip in the mill line, the influence of temperature and temperature conditions of rolling and tension. It also provides for the possibility of optimizing rolling technology and determining the hourly productivity of the mill. An experimental verification of the technique confirmed the sufficient accuracy and reliability of the forecasting of technological parameters on existing cold rolling mills, which allowrecommending it for practical use.

3. V. P. Ivaschenko, G. G. Shvachych, I. Mamuzić, A. V. Sobolenko, I. A. Pobochyi

The application features of mathematical apparatus of harmonic analysis to determine the accuracy of rolled pipes. The degree of influence of the tube rolling unit mills on formation of wall thickness variation is investigated. Using the mathematical apparatus of the Fourier transforms, the amplitudes of harmonic components 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.

4. P. Skubisz

Results of thermomechanical treatment implementation in hammer drop forging industrial process. Thermomechanical processing (TMP) has been widely implemented in forging technologies of automotive, truck and civil engineering components for a couple of decades now. Utilizing heat attained in a bulk of deformed billet and continuous cooling directly after forging under controlled conditions, good balance of strength and ductility with significant energy savings and overall process economy are obtained. While TMP is readily conducted in press-forging technologies, it is more challenging to cope with technical setbacks of hammer forging process. This paper presents the results of satisfactory implementation into hammer forging of a complex-geometry made of microalloyed medium-carbon steel 38MnVS6 in industrial conditions, producing UTS over 1120 MPa with elongation reaching 20%.

5. P. Szota, S. Mróz, A. Stefanik, K. Laber

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 modeling of the rotating extrusion of AZ31 alloy has been made by using the computer program Forge2011®. The experimental tests were carried out in the conditions of the STD 810 torsion plastometer using newly designed tools.

6. D. Malindžák, E. Mihaliková, B. Pandula

Heuristic model for production scheduling wide-strip rolling mill. The article deals with the methodology of creating the production schedule for wide-strip rolling mill, defining the rules, calculating types and number of campaigns, in the defined planning period, filling the campaigns, and campaigns sequence. In model creation is apply the heuristic approach, which is based on experiences of expert in production scheduling in metallurgy. On Induction thinking and analogy are defined heuristics rules.

7. D. B. Zhu, X. D. Shu

Effects of mold parameters on microscopic properties of cross wedge rolling (CWR) GH4169 alloy shaft parts. Using DEFORM-3D finite element software, the effects of broadening angle and forming angle on the micro performance of the GH4169 alloy shaft parts were studied systematically. The results show that grain refinement is mainly completed in the stretching section. As the broadening angle increases, the grain size expands constantly, and the fluctuation value decreases and then increases, while as the forming angle increases, the grain size and the fluctuation value decrease and then increase. The accuracy of the finite element model was verified through cross wedge rolling experiments.

8. B. S. Sun, Z. L. Zhao, C. W. Wang

Effect of process parameters on the end-face quality of cross-wedge rolling (CWR) shaft from titanium alloy Ti6Al4V. The results show that the concavity increase with the increase of length and the diameter of billet; they decrease with the increase of spreading angle; they increase firstly and then decrease with the increase of area reduction; they decrease firstly and then increase slowly with the increase of forming angle. Also the order of the influence degree of the five parameters in descending order is: diameter of billet, length of billet, area reduction, spreading angle and forming angle. And the simulation results were verified by experiments.

9. J. Y. Xu, B. S. Sun, N. Li

Research on forging forming force in the composite technology of cross wedge rolling (CWR) and forging for universal joint fork. In this paper, the forging process of universal joint fork of automobile transmission shaft is simulated and the change of forming force of die forging is studied on the basis of the blank produced by cross wedge rolling (CWR). The results show that the lower the temperature, the greater the friction factor, the slower the speed, the greater the forming force, the more difficult for forming. The orthogonal test is designed and it obtained the order of process parameters affecting the forming force of die forging that is T > c > V and the best combination of process that the temperature is 1 100 ° C the friction factor is 0,2 and speed of upper die is 150 mm/s.

10. Y. Zhu, X. D. Shu, D. Y. Tian, Y. C. Li

The quality analysis of multi-step forming the higher D/t cylinder. In order to solve the problem of large springback in higher D/t cylinder stamping, the method of hydroforming following drawing is adopted in this paper. It can reduce the residual stress of the cylinder after heat treatment. The effects of the stretching height, hydraulic pressure and blank holder force on the cylinder quality are investigated using the finite element software dynaform, and the optimal process parameters are obtained. In case that the stretching height, blank holder force and hydraulic pressure are relatively 55 mm, 12,5 MPa and 20 KN, the rate of wall thickness variation and springback are obviously reduced. The research results lay a theoretical foundation for improving the plastic deformation of thin-walled cylinder.

11. Z. M. Cai, H. C. Ji, W. C. Pei, X. M. Huang, W. D. Li, Y. M. Li

Constitutive model of 3Cr23Ni8Mn3N heat-resistant steel based on back propagation (BP) neural network(NN). The 3Cr23Ni8Mn3N heat-resistant steel was subjected to isothermal constant strain rate compression experiments using a Gleeble - 1 500D thermal simulator. The thermal deformation behavior in the range of deformation temperature 1 000 - 1 180 °C and strain rate 0,01 - 10 s^{-1} was studied. Based on experimental data, the stress-strain curves of 3Cr23Ni8Mn3N were established. The results show that the ANN constitutive model has high accuracy for predicting the thermal deformation behavior of 3Cr23Ni8Mn3N. The model can provide a good reference value for thermal processing.

12. Y. D Vasilev, D. N. Samokysh, R. O. Zamogilniy, I. Mamuzić
Mathematical model of neutral angle for cold rolling of thin and ultralight gagestrips. Using a solution based on a physically substantiated model of friction stresses, the length of the forward slip zone has been studied and the position of the neutral section has been determined during cold rolling of thin and ultralight gage strips An updated mathematical model of the neutral angle for cold rolling of thin and ultralight gage strips has been proposed. It follows from (1) that the extreme conditions of cold rolling do not occur at $\alpha=2\beta$, as is customary in the traditional theory of lengthwise rolling, but at $\alpha=n\beta$, i.e. much earlier since $n<<2$.

13. A. Di Schino
Pipe diameter and pipe thickness effect on the plastic deformation behaviour of austenitic stainless steels. The high quality standards required for metal forming call for compliance tests aimed to guarantee that such standards are faced. Such tests often implies a waste of time and of economic resources. In particular, if stainless steel pipe forming is considered, many factors need to be taken into account. Scope of the work presented in this paper is to analyse the effect of different process parameters and geometrical constrains on the cold forming of austenitic stainless steel pipes by Finite Element Method (FEM). Results of such analysis will allow to map the effect of different parameters.

14. T. Z. Chen, X. D. Shu
Effect of process parameters on volume loss of one-sided head of 42CrMo billet cross wedge rolling. A three-dimensional rigid-plastic Finite element model(FEM) for cross wedge rolling of square billet was established by using DEFORM finite element software. It is concluded that the influence degree of forming angle, section shrinkage and broadening angle on the volume of one-sided blank head decreases in turn, and the influence degree of corresponding process parameters in different sections is also different. The results of this study can provide references for expanding the types of cross wedge rolling billets and choosing reasonable process parameters in square billet rolling.

15. B. Z. Wang, X. M. Huang, C. Wang, Z. Y. Wang, C. Xing, H. C. Ji
Constitutive equations of AA6111 aluminum alloy. The results show that flow stress increases with decreasing temperature and increasing strain rate; the AA6 111 is positive stain rate sensitive material; the main softening mechanism is dynamic recovery. Furthermore, constitutive equation considering the effect of strain was obtained based on Arrhenius equation. The predicted flow stress values well agree with the experimental results with some little aberration. The coefficient of association can be as high as 0,9 954, which shows high reference value for industry and simulation analysis.

16. Y. D.Vasilev, I. Mamuzić
Mathematical model of medium contact stress during cold rolling of thin and ultralight gagestrips. Based on the results of studying a joint solution of the Karman equation using a new model of friction stresses, the dependences of the stress state coefficient n_σ have been constructed in the range of the parameter l/h_{av} from 4 to 100, which corresponds to the conditions of rolling thin and ultralight gage strips. As a result of approximation of the obtained dependencies, an updated mathematical model of the stress state coefficient has been proposed. Model (1) is valid for $l/h_{av} \leq 2{,}25–2{,}40$ and is recommended for the calculation of the average contact normal stress p_{av} during cold strip rolling.

17. R. W. Wang, H. Y. Long, L. N. Qi, Y. M. Li, H. C. Ji, Z M Cai
Study on Arrhenius model of TC6 titanium alloy. At the deformation temperature of 1 103-1 283 K, with strain rate of 0,01 – 10 s^{-1}, and total strain of 0,7, the deformation behavior of TC6 titanium alloy was studied. The results show that: the flow stress of TC6 titanium alloy increases as the strain rate increases and decreases as the deformation temperature increases; under different strains, the correlation coefficient (R) between the experimental value and the predicted value is greater than 98 %, and the average relative error (AARE) is lower than 10 %, which suggests that the established model has a higher prediction.

18. R. Wang, Y. Wang, H. Wang, J. Y. Chen, X. D. Shu
Study on roll-cutting forming method of conical end blank for cross wedge rolling (CWR) without stub bar. This paper proposes a roll-cutting forming method of conical end blanks based on metal-plastic forming. In order to clarify the roll-cutting forming mechanism of the conical end, the displacement field and strain field variation during the forming process of the conical end are analyzed based on finite element simulation analysis, and the metal flow during the roll-cutting process is obtained. Moreover, the conical end blank formed by roll-cutting is sent to cross wedge rolling, the results verify the feasibility of roll-cutting conical end blank used for cross wedge rolling without stub bar.

19. H. Dyja, A. Kawałek, K. V. Ozhmegov, S. Sawicki
The thermomechanical conditions of open die forging of zirconium alloy ingots determined by rheological tests. The article reports the results of investigation into variations in the rheological properties of the Zr-1 % Nb alloy when deformed under the conditions of physical modelling of the process of multi-stage hot open die forging of ingots. Based on the rheological test results, a new scheme of ingot deformation in forging process was developed and the experimental verification of the model study results was made in industrial conditions. From the obtained results, high effectiveness of the method of determining the thermomechanical conditions as applied to the process of forging zirconium alloy ingots has been found.

20. Y. D.Vasilev, V.A. Borodin, I. Mamuzić
Influence of elastic reduction of a strip on the length of the defomation zoneduring cold rolling. Cold strip rolling is carried out with small partial absolute Δh and percentageεreduction and with large contact stresses, i.e. under conditions when the elastic reduction deformation of the strip $\Delta_{1\Pi}$ has a significant effect on the length of the elastic-plastic deformation zone l_c. A solution has been proposed for determining the relative length of deformation zone, $x_{1\Pi}/l_c$, caused by the elastic reduction of the strip. An analysis of dependence showed that during rolling with reduction $\varepsilon>0.2$-0.3, the values of the parameter $x_{1\Pi}/l_c$ usually do not exceed 0.1, but for $\varepsilon<0.1$-0.15 its value increases to more than 0.15-0.25.

21. A. Kawałek, T. Bajor, S. Sawicki, M. Krakowiak, H. Jurczak
The effect of deformation conditions on the rheological properties of the Al 5754 alloy. The article presents the results of rheological testing of Al 5754 alloy in series 5xxx, obtained for deformation parameters corresponding to the process of extrusion of large-size sections on presses. The effect of deformation conditions on the variations in yield stress magnitude was determined. Then, using the least squares method., the actual values of the coefficients of the mathematical model describing the rheological properties of the material under investigation were determined, thus obtaining grounds for conducting the model studies of the extrusion process based on numerical methods.

22. J. T. Wang, X. D. Shu, S. Zhang
Effect of process parameters on average grain size and microscopic uniformity of the three-roll skew rolling forming of the railway hollow shaft. In order to obtain a fine and uniform microstructure, a finite element model of three-roll skew rolling hollow shaft for the coupling of heat, force and microstructure was established. The influence of process parameters on the average grain size and microstructure uniformity of the rolled product was analyzed by using the single factor research method. The results show that the grain size is remarkably refined and the distribution is relatively uniform. The optimum rolling temperature is 1 050 °C; the optimum feed angle is 9 °; the optimum roll rotate speed is 90 rad/min.

23. S. Zhu, W.F. Peng, X.D. Shu
Effects of annealing on interface microstructure and tensile fracture morphology of 42CrMo/Q235 cross wedge rolling (CWR) laminated shafts. The laminated shafts were prepared by CWR process. The microstructure and the tensile fracture were analyzed. The results showed that the tensile and shear properties of the laminated shafts were the best when annealing at 700 °C for 60 min, which could reach 576 MPa and 473 MPa, respectively. After annealing, fine interfacial spheroidal structure could be obtained and enhanced the bonding strength; the dimple holes at the tensile fracture became larger and deeper, and the fracture became uniform and stable, clarified the reasons of the change of mechanical properties.

24. A. Kozhevnikov, I. Kozhevnikova, N. Bolobanova, A. Smirnov
Chatter prevention in stands of continuous cold rolling mills. The article states new results of the theoretical and applied research on prevention of chatter in stands of continuous cold rolling mills. It is demonstrated that it is possible to influence effectively the difference of strip volumes per second

and prevent chatter by decreasing reduction in a stand subject to chattering and simultaneously increasing reduction in adjacent stands, and also by changing the ratio of rolling speeds in these stands of the mill. This has led to development of process conditions for thin steel strip rolling on the 5-stand mill 1700 of PAO Severstal, enabling rolling speed increase and process stabilization.

25. S. Rešković, I. Jandrlić, T. Brlić, F. Vodopivec

Effects of preferred grain orientation on the on Lüders bands appearance. In this paper, the influence of preferential grain orientation was examined. Parallel tests were conducted on the samples from the same steel strip, taken in the direction and perpendicular to the direction of rolling the strip. Steel strip has a homogeneous fine-grained ferrite-pearlite microstructure. Using the methods of thermography it has been found that at the beginning of the plastic flow Lüders bands occur, pointing to the fact that the preferential grain orientation, in the case of steel with the fine-grained ferrite-pearlite microstructure, has no effect on the appearance of the Lüders bands.

26. A. Kozhevnikov, N. Bolobanova, I. Kozhevnikova, D. Shalaevskii

The study of influence of work rolls vibration during cold rolling on the quality of steel strip surface. The article represents the results of the study of work rolls vibration influence on the quality of cold rolled strips on the basis of computer simulation of the rolling process in the DEFORM-2D program. It was determined that the size of alternating shadow zones on the surface of cold rolled strips received through simulation complies with experimental data. The results of computer simulation led to the conclusion that vertical vibration of work rolls as the oscillation curve according to the Harmonic Law does not significantly influence the longitudinal strip off gauge. It was found that work rolls horizontal vibration does not influence the nature of deviations in the strip surface profile.

27. D. N. Samokysh, S. V. Zhuravlova, I. Mamuzić

Experimental curves of plasticity during cold rolling with tension. The plasticity curves $P=\varphi(h_1)$ have beenbuilt (where P, $h_1$are the rolling force and strip thickness at the end of the deformation zone) during cold rolling of 08kp steel strips of 0.5 and 0.8 mm thick with relative tensions $(0,1\text{-}0,5)\sigma_T$ (where σ_T is the yield strength of material) according to the experimental data of the rolling force obtained in a laboratory facility. The calculated and experimental curves $P=\varphi(h_1)$ have been compared. It has been determined that modern methods of calculating the parameters of cold rolling with tension provide satisfactory accuracy of the plasticity curves $P=\varphi(h_1)$ for cold rolling.

28. H. Fu, B. Xu, J. Xiao, S. Li, T. Kang

Finite element simulation of deformation behavior of prefabricated holes in ultra-heavy plates by gradient temperature rolling. Based on the Deform-3D finite element simulation software, the numerical analysis of prefabricated holes in the core of ultra-heavy plates is carried out in different rolling schemes. In this paper, the deformation of the hole in core under uniform temperature rolling (UTR) is compared by different gradient temperature rolling (GTR) processes. The results show that the GTR can improve the core deformation compared with the UTR. The increase of the number of water cooling can accelerate the welding of the core holes and the healing of the final gap, and multi-pass water-cooled GTR should be used for ultra-heavy plate rolling.

29. D. G. Wang, X. D. Shu, R. Wang, T. Z. Chen

Influence of temperature field on surface quality of cross wedge rolling (CWR) aluminum alloy shaft. Reasonably determination of the rolling temperature of the cross wedge rolling (CWR) is the key to obtain the qualified surface of the aluminum alloy shaft parts. In this paper, the 6 082 aluminum alloy shaft parts with different section shrinkage rate between 43,75 % and 64 % are taken as examples. The thermal-deformation coupling finite element model (FEM) is established to analyze the effect of the process parameters on the temperature field. The influence law of the temperature field on the surface quality in CWR process is obtained and verified by experiment. The results provide theoretical and experimental basis for temperature selection and surface quality improvement.

30. S. A. Mashekov, G. A. Smailova, A. M. Alshynova A. E. Uderbayeva, N. S. Sembaev, A. Zhauyt

Structure formation of aluminum alloy D16 while rolling bars in the radial shear mill. This paper investigates the stress-strain state (SSS) of the workpiece during rolling in a radial-shear mill. The (FEM) and the MSC Super Forge program allowed us to obtain quantitative data and establish the main laws of the distribution of SSS and temperature while modeling the rolling in the RSM. The rational technology of rolling aluminum alloy D16 was developed and tested in laboratory conditions. Particular attention is paid to the analysis of the effect of rolling conditions in the RSM on the formation of UFG structures in the aluminum alloy D16.

31. S. A. Mashekov, G. A. Smailova, A. M. Alshynova, A. Zhauyt, N. S. Sembaev, M. R. Maulenova

Investigation of the formation evolution of aluminum alloy 1050 structure during rolling in the spiral rollers and the longitudinal wedge mill. This paper investigates the stress-strain state (SSS) of the workpiece during rolling in a spiral roller and a longitudinal wedge mill (LWM). A rational technology of rolling aluminum alloy 1050 was developed and tested under the laboratory conditions. It was proved that the system achieves an equilibrium state by diffusion along the grain boundaries accelerated by the flow of vacancies formed during the deformation. It has been established that rolling aluminum alloy 1050in the spiral rollers and LWM leads to an increase in the strength and plastic properties of the sheet metal.

32. Y. Chang, X. D. Shu, T. Z. Chen

The influence law of process parammeters on end concavity of hexahedral blank cross wedge rolling (CWR). In this paper, the three-dimensional Finite element model (FEM) of hexahedral blank CWR is established by DEFORM finite element software. The influence of forming angle, spreading angle and section shrinkage on the length of concavity is analyzed, compared with the round billet rolling results under the same parameters, the concavity length of the hexahedral blank is slightly larger than that of round billet, and the influence of process parameters on the concavity is basically the same. The research results provide theoretical guidance for the rational determination of process parameters for CWR of hexahedral blank.

33. G. G. Shvachych, A. V. Sobolenko, I. Mamuzić, I. V. Ischenko, A. A. Martynenko

Mathematical simulation of wall thickness variation of hot rolled pipes. The periodic components of the wall thickness function of hot rolled pipes are investigated. The analysis of the corresponding harmonic components and their parameters for a real experiment is carried out. This allowed applying the proposed approach for analyzing the wall thickness distribution along perimeter of hot rolled pipes, which is difficult in hot rolling. Special software has been developed for conducting practical experiments in a real process.

34. X. M. Huang, H. Y. Long, Y. M. Li, H. L. Duan

Modified Zerilli-Armstrong model for 21-4N heat-resistant steel. The Gleeble - 1500D thermal simulator was used to conduct the isothermal compression test of 21 - 4N heat-resistant steel under the T range of 1 273 - 1 453 K and $\dot{\varepsilon}$ of 0,01 – 10 s^{-1}. Using the obtained stress - strain data, various parameters of the modified Zerilli-Armstrong (m – Z - A) model were calculated. The results can provide some important basic data for the simulation of 21 - 4N heat resistant steel on plastic deformation process.

35. H. C. Ji, Y. M. Li, W. D. Li, S. H. Xiao, J. S. Zhang, Y. H. Lu

Study on forging process of valve based on response surface method. This article takes the 21 - 4N engine valve as the research object and studies the effects of die forging temperature (1 000 - 1 180 °C), die forging speed (0,15 - 200 mm / s) and friction coefficient (0,1 - 0,5) on die forging results. Response surface analysis method is used to analyze and discuss the results of die forging, and to optimize the process parameters with valve product damage as the optimization goal, and determine the best process parameters for 21 - 4N engine valve forging; finally, the obtained parameters are verified through experiments, and the experimental results and prediction results have a good consistency.

36. X. D. Shu, S. Zhang, J. T. Wang, J. N. Shi, Y. X. Xia

Flow stress behavior of 30CrMoA steel under high temperature compression. In order to reasonably select the process parameters of the rolling process of 30CrMoA steel, the rheological characteristics of 30CrMoA steel at high temperature were studied. An empirical constitutive model was established, and the material constants in the established constitutive model were determined by regression analysis of experimental data. Finally, the

accuracy of the constitutive model of 30CrMoA steel was verified. The results show that the error between the calculated value and the experimental value is within 5 %, which indicates that the 30CrMoA steel constitutive model has high accuracy.

37. N. Martynenko, N. Anisimova, M. Kiselevskiy, D. Temralieva, A. Tokar, G. Raab, S. Dobatkin, Yu. Estrin, I. Mamuzić
The effect of magnesium alloy WE43 structure caused by equal channel angular pressing on the mechanical properties and the cytotoxicity to tumor cells *in vitro.* In this study, a degradable magnesium alloy WE43 was subjected to equal channel angular pressing (ECAP). Grain refinement down to 0.7 – 1 μm and a transformation of texture induced by ECAP were shown to lead to increased the ultimate tensile strength (up to 300 MPa) combined with enhanced ductility (13.2%). The data presented show that co-incubation of tumor LNCaP and MDA-MB-231 cells with the WE43 alloy led to a decrease of their viability and proliferation. It was established that ECAP led to enhancement of the alloy cytotoxic activity against tumor cells. This study demonstrated that alloy WE43 can be considered as a promising candidate for application in orthopedic implants in clinical oncology.
This research was supported by the Russian Science Foundation (grant #18-45-06010).

38. S. A. Mashekov, G. A. Smailova, M. S. Kulgildinov, K. T. Tergemes, A. Zhauyt, K. S. Chezhimbayeva, T. M. Buzauova.
The study evolution of the structure formation of the foil workpiece during rolling screw rollers and longitudinal-wedge mill (LWM). The article presents the results of studies of the influence number of passes and single crimps during rolling strips, respectively, in helical rolls and longitudinal-wedge mill on the parameters of the microstructure of aluminum alloy 2017. Comparative assessment grain sizes of ultrafine-grained structure after rolling strips with different passes in the helical rolls and deformation of the longitudinal-wedge mill at a deformation temperature of 400 °C. It is shown that the aluminum alloy sheet material 2017 provides the formation of a homogeneous ultrafine grain structure with a grain size of about 240 nm, which leads to an increase strength and plastic properties of the alloy.

39. M. Abishkenov, Zh. Ashkeyev, S. Mashekov, G. Akhmetova, I. Volokitina
Investigation of the stress-strain state of balls under deformation in a closed die. The paper presents the results of the study of the production process of balls in a special closed die, which performs a full compression due to the alternate insertion of rams. The possibility of implementing the proposed method is proved experimentally, and the presence of high compressive stresses in the deformation center is shown using the method of sliding lines and mathematical computer modeling. Due to the alternate insertion of rams, the process of plastic deformation is intensified, which makes it possible to obtain high-quality balls. The maximum average stress in the deformation center obtained by the theoretical calculation method of sliding lines is – 436,94 MPa, and the values obtained by mathematical computer modeling is – 500 MPa. Metallographic analysis showed that the grain diameter of the obtained ball samples in the central part, compared to the initial samples, was crushed 3 times (up to 5 μm).

1. L. Molchanov, S. Zhuravlova, V. Mameshin, Z. Jurković

Decrease of harmful effect of steelmaking on environment. Optimization of existing smelting technologies and reconstruction of equipment of metallurgical workshops leads to an increase in environmental pollution. Therefore, the development of technological measures to improve the environmental friendliness of steel production is an urgent task for domestic iron and steel enterprises. The paper proposes a technology for converter steel production using additives based on CaO and Al_2O_3 oxides, and calculated the costs and composition of mixtures to ensure dust reduction in the converter.

2. Ya. V. Frolov, A. A. Samsonenko, O. M. Kuzmina, I. Mamuzić

Comparative analysis of energy power parameters of direct and lateral extrusion. The computer simulation of these processes for production of mono- and bimetallic rectangular profile, based on titanium and aluminum alloys, using the software product QForm was done. Four types of processes were considered: extrusion of direct extrusion of mono- and bimetallic rectangular profile, processes of lateral extrusion of similar profiles. Based on the obtained results, a comparative analysis of the compressive force for the conditions of direct and lateral compression was carried out. For lateral extrusion of a monometallic profile, the maximum increase in pressing force, compared to direct extrusion, is 40%. And with the lateral extrusion of the bimetallic profile, the maximum increase in the pressing force is 60%.

3. K. U. Ostrovskaya, A. N. Avramenko, M. Kostelac

Time series prediction based on the k - nearest neighbor method. As a result of the thesis, software was implemented for forecasting time series based on the K method, the nearest neighbors. To predict new data, the following methods are implemented: simple average - step by step; just average - group; local autoregression; long-term foresight. The result of early and final development of the economy, forecasting of economic, social and demographic processes in the general educational processes of ITS NmetAU department.

4. A. M. Dolzhanskiy, O. S. Maksakova, I. Mamuzić

Problems of standardization in the ukrainian metallurgical industry. The metallurgy of Ukraine is based mainly on the manufacture of products according to GOST requirements, which does not fully comply with the EU recommendations. In this regard, the transfer of the entire regulatory framework to Ukrainian metallurgy products in DSTU, harmonized with EN standards and others, which requires, according to expert estimates, investments of about $ 2 million, becomes particularly relevant. According to existing practice, such investments can be directed exclusively to meet the requirements of the EU Directives. So the feasibility of developing relevant EU policy documents is identified.

5. A. M. Dolzhanskiy, O. A. Bondarenko, Ye. O. Petlovanyi, G. Šimunović

Comprehensive assessment of the parameters and energy efficiency of a screw blower in a drawing. A method has been developed for determining the characteristic parameters and evaluating the energy efficiency of using a drive screw supercharger with the provision of the liquid friction regime of dry soap technological lubricant during wire drawing.The method is based on the use of the laws of non-Newtonian fluid flow and drawing process dynamics.

6. A. M. Dolzhanskiy, O. A. Bondarenko, Ye. O. Petlovanyi, Z. Jurković

Method for monitoring of the university departments activities. It is proposed to define such a base as the average value of the selected quality indicator of the object, and the level of discrepancy - by its exit in the negative direction beyond the "critical framework", taking into account the quantile and standard deviation of the parameter. The data obtained made it possible to clarify and evaluate the significance of subjective and objective factors that determine the quality of the university departments.

7. Y. S. Proydak, G. G. Shlomchak, I. Mamuzić, G. G. Shvachych, I. V. Ischenko

Simulation of heat treatment of metal billets by multiprocessor computing system. Development features and application of multiprocessor computing system with its mathematical support and software for heat treatment modes simulation of metal billets are considered. Modern multiprocessor computing technologies application was suggested for increasing speed and efficiency of computation, which enables to effectively control technological processes. The practical value of results obtained showed that the technological process by appropriate mathematical simulations was improved.

8. I. Mamuzić, G. G. Shvachych, I. M. Udovyk, S. D. Prykhodchenko, E. G. Kholod

Temperature and gradient mathematical simulations in problems of determining thermal physical characteristics of metals. 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.

9. G. G. Shvachych, I. Mamuzić, O. V. Ivaschenko, B. I. Moroz, I. G. Hulina

Maximum parallel forms of difference scheme 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 features of parallelization by piecewise-analytical method of lines and method of permutations are revealed. 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.

10. I. Mamuzić, G. G. Shvachych, B. I. Moroz, I. M. Udovyk, L. F. Sushko

Deceleration problem research in multiprocessional computing systems. 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.

11. G. G. Shlomchak, I. Mamuzić, V. I. Mazur, E. G. Kholod, M. A. Spilnyk

Distributed modelling of visualization of vectors of solutions for applied tasks› of metallurgy on the basis of schemes with 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. 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.

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

Analysis of the secondary cooling water distribution system based on differential evolution algorithm. In the continuous casting, the secondary cooling water distribution system has a decisive effect on the quality of billets. An intelligent optimization strategy, which is different from the traditional mode, is adopted to establish a new water distribution mode. In order to match the water volume of each segment, the objective function is designed by the metallurgical criterion and constraint conditions, and the optimal solution is obtained by differential evolution algorithm. It has been verified that the overshoot is low, the total water volume is reduced, and the quality of billets is significantly improved.

13. J. D. Li, H. Ren, Z. Gong, K. Wang, Y. Y. Wang, J. L. Lu, J. Li

Study on the process of preparing Al-Ce alloy by electrodeposition. The process of Al-Ce alloy prepared by electrodeposition was studied in molten LiF-KCl-CeF_3 salt at 820 °C. Several process parameters such as back electromotive force and current efficiency were measured by continuous pulse oscillograph. The results showed that the back electromotive force increased with the increase of the current intensity. With the addition of 2 *wt.*%Ce_2O_3, the back electromotive force decreased by 0,26 V on average, and increasing temperature could make the back electromotive force decrease as well. The

back electromotive force changing period with feeding measured was 50 min. Finally, at 820 °C, the largest current efficiency (68.8 %) was obtained by electrolyzing for 2 h at 4 A.

14. V. A. Pinchuk, M. Mohammed, I. Mamuzić, A. V. Starchenko

Experimental research of heat transfer during thermal activation of coal-water fuel. To determine the conditions of heat transfer during thermal activation of the fuel, experimental studies of heat transfer while the fuel moving in a horizontal pipe were conducted. In the temperature range of 50 100°C, the value of the heat transfer coefficient α from the wall to the coal-water fuel is set, which averages 600-800 W/m2·K depending on the heat transfer conditions. The criterion equation of heat transfer during the thermal activation of coal-water fuel of Nu=f(Re, Pr) type was obtained on the basis of the experimental data.

15. Y. X. Wang, H. Yin, Y. H. Yang, Y. S. Jiang, Y. Y. Guo, Y. W. Zhou, F. Y. Wu

Tuning resistivity and transmittance of AZO films through the electro-chemical treatment. Aluminum-doped zinc oxide (AZO) films were prepared. The microstructure and photo-electrical properties of the films were characterized by Raman spectroscopy, X-ray diffraction (XRD), UV-visible spectrophotometer and Hall Effect apparatus. The results show both resistivity and transmittance of the AZO film treated under the electrical and chemical action decrease as the pH of the electrolyte decreases. At pH = 5, the photo-electric property of the treated AZO film is the most excellent. The resistivity is reduced to $3,7\times10^{-3}$ Ω·cm from $7,1\times10^{-1}$ Ω·cm of the as-prepared AZO film, and the transmittance is reduced to 90,1 % from 91,3 % of the as-prepared AZO film.

16. L. I. Solonenko, I. V. Batsa, I. Mamuzić

The influence of the nature of clay, its content and method of water preparation on the properties of low-temperature forms. The nature of the clay, its content in the moldable mixture, as well as the method of preparing water and clay before molding, have a decisive influence on the strength and shedding of low-temperature forms. Mixtures of sand with 5% boiled water and 5% swollen bentonite clay have the greatest strength and least crumbling. Slightly lower than similar indicators in mixtures with non-swollen clays and carbonated CO_2 water. A mixture of sand with 5% tap water and 5% swollen bentonite clay has medium strength and one of the smallest crumbling.

17. J. Li, C. F. Zhang, R. M. Yin, W. H. Zhang

Preparation and properties of sialon ceramics by gel casting and pressureless sintering. The green bodies were sintered by one- and three-step pressureless sintering. Results showed that green bodies had a homogeneous microstructure with a high density of 1,9 g/cm3 and high flexural strength of 28,6 Mpa. Equiaxed α-SiAlON was prepared by one-step pressureless sintering, whereas β-Si4Al2O2N6 with an elongated morphology was fabricated by three-step pressureless sintering. Therefore, a low-temperature heat preservation stage reduces the nucleation rate, which is favorable for the development of elongated β-SiAlON grains.

18. V. F. Mazorchuk, S. I. Repyakh, R. V. Usenko, I. Mamuzić

Determination of the thermal stability of porcelain rods. The coefficient of thermal linear expansion of porcelain and semi porcelains products (rods), which is $(3,7\div5,2)\times10^{-6}$ °C^{-1}. Found that the maximum temperature difference between the initial temperature of the porcelain or semi porcelain rod (products) and the external environment is ~ 250 °C, the ratio of tensile strength to elasticity modulus – 0,00167. However, neither the initial temperature, no form of ceramic products (rods) of semi porcelain M01 influence on their thermal stability has not.

19. B. K. Kenzhaliyev, T. Yu. Surkova, A. N. Berkinbayeva

To the question of the intensification of the processes of uranium extraction from refractory raw materials. In the article, the catalyst "M-1", which is a compound of transition metals, is considered as an intensifier. Comparison of the kinetic dependencies of the sorption extraction of uranium by the ionites from the productive solutions of leaching of uranium-bearing ore in the presence of the "M-1" catalyst showed that they differ insignificantly. The possibility of sorption of uranium from productive solutions by natural sorbents in comparison with synthetic sorbents is investigated.

20. X. Z. Li, C. C. Zheng, C. Lou

Study on chloride migration in concrete under pressure. This paper used self-designed equipment to carry out chloride migration test in concrete samples under the conditions imitating subsea tunnel environment. It determined the permeability characteristics of chloride ions in concrete under different water pressure, concentration and time, and analyzed the influence degree of various factors.

21. M. Senthil Kumar

Investigation of hardness and surface roughness in end milling glass fibre reinforced polymer composite. In this paper, optimization of machining parameters in milling of horizontal axis wind turbine (HAWT) blade wrapped with E-glass fiber reinforced plastics (GFRP) composites with multi-response criteria-based desirability function analysis (DFA). The machining parameters such as spindle speed (A), feed rate (B) and depth of cut (C) are optimized by considering multiple response characteristics namely surface roughness (Ra) and hardness (HB). The desirability at a high of 0,83 provides minimum surface roughness about 2,64 μm 0,7 and maximum hardness about 49,12 BH.

22. I. Leššo, B. Pandula, P. Flegner, J. Baulovič, K. Feriančíková

Analysis of geophysical signals by using hilbert space geometry. The contribution presents some results achieved by the authors during several years of research of the process of rotary drilling of rocks by using metric spaces. The authors successfully apply this approach in the solution of specific problems in geophysics and also metallurgy. The authors use abstract structures – so called Hilbert spaces - for the implementation of process signals as algebraic vectors. Some space is also given to the visualization of the degree of divergence between geophysical or process signals being analyzed.

23. A. S. Vovk, I. Mamuzić

Testing of pipecross ring samples. Analysis of existing test methods to determine the properties of pipes shows that tensile testing of cross ring samples, or pipe section samples (PSS) are simple and comparatively accurate. To eliminate plastic deformation in one of the supporting cross-sections, usage of a stress concentrator was proposed. This is due to the relative simplicity of its implementation in comparison with the other technical solutions. For samples made of 1.4401 (EN 10027) austenitic steel and 1.0580 (EN 10297-1) steel, the ratio of the areas in the diametrically opposite sample parts were determined which ensure plastic deformation only in only one of the samples parts during the tension.

24. M. Beer, R. Rybár, D. Kudelas

Method of determining the essential geometric characteristics of the metal foam structure. The paper deals with the description of method, proposed by authors, that determining the essential geometric characteristics of the metal foam structure with using of the analytical imaging software. Method use economically available technical apparatus and software with emphasis on maximum consideration of the measurement uncertainty by Kline-McClintock method. The image analysis used three kinds of metal foams with a pore density of 10 to 40 pores per inch.

25. X. M. Wang, X. L. Wu, W. Q. Zhou

Analysis of oxygen enriched combustion characteristic of 350 MW utility boiler based on computational fluid dynamics. Three dimensional model of 350 MW utility boiler furnace was established by CFD to explore the combustion characteristics of pulverized coal at different O_2 / CO_2 ratios. The numerical results shows: the furnace temperature increases as the value of O_2 concentration and the peak value of radiation appears at 20 metres in furnace; Oxygen enrichment combustion process can effectively reduce the exhaust flue gas temperature; The combustion condition with 30 % oxygen concentration is the closest to air combustion.

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

Intelligent optimization strategy analysis of secondary cooling water distribution for billet. Aiming at the optimization of secondary cooling water distribution system for billet, an intelligent optimization model is established. The objective function is set according to metallurgical criteria, and the optimal solution is obtained by particle swarm optimization, which is applied to dynamic secondary cooling water distribution system. The experimen-

tal results show that at different casting speeds, all the indexes of the billet meet the requirements, the total water volume decreases obviously, the overshoot is low, and the water volume of each section meets the expectation.

27. S. Thangavel, M. Murugan, N. Zeelanbasha
Investigation of cutting force in end milling of Al/n-Tic/MoS_2 sintered nano composite. The main aim of the research analysis is to understand the influence of machining parameters for the cutting force (Fc) and surface roughness (Ra) in end milling of hybrid nano-composites Al + 10 % n-Tic + 7,5 % MoS_2. Experimentation was conducted by Central Composite Design (CCD), and the evaluation of surface roughness and cutting force was carried out using Response Surface Methodology (RSM) and Genetic Algorithm (GA).

28. S. Venkatachalapathy, P. Karuppuswamy, P. Raghunayagan
Optimization of process parameters for minimum cutting temperature and surface roughness in turning of AISI 410 stainless steel impeller. In the present scenario of work, an investigation of experiment on CNC turning of AISI 410 stainless steel impeller has been brought into presentation. Turning parameters such as cutting speed (C_s), feed rate (F_r) and depth of cut (D_c) are taken into investigation and thus modeled for performance characteristics like cutting temperature (C_t) and surface roughness (R_a). The desirability function (D_f) is employed in order to optimize the multi performance characteristics.

29. B. Oleksiak, G. Siwiec, A. Krabes, M. Bober
Research on electrochemical silvering process of brass elements. In the presented paper the authors attempted at analyzing the selected properties of silver coatings processed with electrochemical method on brass elements. The conducted research indicates that changes in cathode current density in the range 100 A · dm^{-2} to 333 A · dm^{-2} and the process time in the range of 60 s to 120 s have no effect on the basic properties of the obtained silver coatings (microhardness, corrosion resistance, adhesion), but it only seems to affect their appearance.

30. G. Musina, G. Zhaksybaeva, M. Baikenov, M. Ibatov
On the kinetics of the primary coal tar hydrogenation process. This paper presents the study of the kinetics of the primary destructive coal tar hydrogenation at coking factories of Kazakhstan. Under laboratory conditions, the dependence of fraction yield on the temperature and processing time duration was determined. As catalytic agents were used pseudohomogeneous ferriferous catalytic agents. Based on the studies, a mathematical model, describing the kinetics of the process, was developed. The results will be used in the development of tar processing equipment operating modes at coking factories.

31. V. Yu. Kulikov, Sv. S. Kvon, A. Z. Issagulov, S. K. Arinova
Studying refractory bricks structure impact on their performance properties. The refractory bricks structure impact on such operational properties as slag resistance and heat resistance is considered. Chamotte brick used in the RK metallurgical plants and refractory brick made according to the new technology with the use of non-stationary pressure have been used as samples. The products porosity has been studied. It has been shown that porosity, slag resistance and heat resistance of products manufactured using non-stationary pressure is higher than those of the reference.

32. G. Shlomchak, G. Shvachych, B. Moroz, E. Fedorov, D. Kozenkov, I. Mamuzić
Automated control of temperature regimes of alloyed steel products based on multiprocessors computing systems. Development features and use of multiprocessor computing system with its mathematical support and software for heat treatment modes simulation of metal billets are considered. Through the special software the multiprocessor system is able to set and control necessary temperature conditions on all plane of cross-sectional of standard at heating and self-control of metal, and if necessary maybe began to control the thermal mode of treatment in the interval of temperatures of annealing.

33. S. E. Shipilov, E. B. Ten, Zh. D. Zholdubayeva, D. K. Isin, A.D. Mekhtiyev, S. S. Shipilova, E.V. Yurchenko
Refining of metal melts by filtration method. The article describes the prerequisites of filtration refining of metal melts. When filtering the liquid metals the refining effect is caused by the deposition on the filter surface of suspended non-metallic particles in the melt, and by the release of the non-metallic phase directly from the melt. Along with this the mechanism of melt refining from a superequilibrium dissolved impurity is realized when filtering as a result of the reaction course of chemical binding of the impurity element.

34. O. Derevianko, I. Mamuzić
The imitation model of aggregation. Based on the principles of molecular dynamics the imitation model of aggregation of cluster formations was developed when gradient films were formed using the Physical Vapor Deposition technology due to a change in the interaction energy rather than the total temperature. The considered phase transition from the vapor state of the molecular system to the solid is due to the transition of its elements from chaotic to regular vibrations. This model enables to predict the formation of cluster microstructures influenced by the flow of injected inert gas with known characteristics.

35. Ľ. Kovanič, P. Blišťan, V. Zelizňaková, J. Palková, J. Baulovič
Deformation investigation of the shell of rotary kiln using terrestrial laser scanning (TLS) measurement. For the correct operation of the rotary kiln it is necessary to ensure that basic geometric conditions are fulfilled. For regular check the geodetic measurements are used. Based on the developments in survey technology, the geodetic total stations (TS) and terrestrial laser scanning method (TLS) are used. TLS method was used for an investigation of the longitudinal axis of the rotary kiln (RK), axes of the carrier tires, and mainly the kiln shell deformation during its shutdown. The results of the experimental use of the TLS method to obtain ovality ratio of the shell of the rotary kiln are presented in this article.

36. A. Pacana, K. Czerwińska, L. Bednárová
Comprehensive improvement of the surface quality of the diesel engine piston. An important requirement for the material for pistons concerns its parameters at different temperatures of piston operation at different ambient temperatures. The study uses penetration tests in quality control of diesel engine pistons used in passenger cars. The purpose of the tests was to determine, with the use of traditional quality management tools, the sources of incompatibility of castings detected in eddy current testing. The aim of the analysis was to reduce the number of non-compliant products or to eliminate them altogether.

37. Z. Skuza, C. Kolmasiak
Selected elements of quality management system in metallurgical enterprise. The article evaluates selected elements of a quality management system based on data obtained from one of the Polish steelworks. Analysis of the data obtained from 2018 indicated the importance of external factors not always directly dependent on the steelworks. Taking into account these considerations associated with proximal and distal elements of the enterprise environment, allowed the possible occurrence of a significant hazard to be indicated.

38. A. Pacana, D. Siwiec, L. Bednárová
Analysis of the incompatibility of the product with fluorescent method. The aim is to analyze the surface of the product (posterior bearing housing) with using the fluorescent method and to demonstrate the effectiveness of the sequence application like the fluorescent method and instruments of the quality management to analyze the incompatible of the product. The effective of the used the sequence containing the fluorescent method, the Ishikawa diagram and the 5Why method in order to identify incompatibility, and next the source cause was demonstrated.

39. A. V. Yurchenko, Z. D. Zholdubayeva, D. K. Issin, A. D. Mekhtiyev, A. D. Alkina, V. I. Syryamkin
Reduction of the content of harmful impurities during technical silicon melting using the filtering method. The article discusses the filtration method of cleaning silicon, the possibility of mechanical separation of inclusions, the effect of capillary phenomena, the wettability of the filter material on the efficiency of cleaning silicon from impurities. There are described the methods of obtaining filtering elements, the functions executed by the

filters depending on their type. There are presented the analysis results obtained in filter refinement of silicon which show the impact of different filters materials on the content of impurities.

40. A. O. Zhurba, O. I. Levanovich, I. Mamuzić

Influence method of the binarization on fractal dimension. An important step in calculating of fractal dimension is binarization. When binarizing an image, it must be determined whether there is a useful signal or background in the image pixel. Next, the pixel is assigned a value of "0" or "1". As a result, the image is split into two areas, one containing all pixels with values below a certain threshold and the other containing all pixels with values above that threshold. Of great importance is the determination of the binarization threshold. The fractal dimension of the image with different binarization thresholds will be different. Each image binarization method is used for different types of images and for solving different problems.

41. D. Kumar Sharma, M. Filipponi, A. Di Schino, F. Rossi, J. Castaldi

Corrosion behaviour of high temperature fuel cells: Issues for materials selection. In this framework materials selection is a key issue. Comparing different experiments it can be concluded that the choice of stainless steel (SS) is good choice. In particular, SS316L is good choice but long term test show high degradation of the components. This degradation is mainly due to migration (diffusion) of elements in oxide layer and in base material. Therefore, further studies are needed in order to deeply analyze such behavior. It will allow to better alloy compositions aimed to mitigate degradation and to design alloys showing stable performance of fuel cell.

42. Y. Cui, D. L. Qu, G. H. Li, L. Tian

Wetting and spreading mechanism of MgO substrate by impurity phase. In this study, the wetting behavior of different C/S silicate impurity phases on solid MgO substrates at 1 450 °C was explored by the sessile drop method, and the spreading mechanism of the system was discussed. The driving force of the wetting process is the dissolution of the MgO substrate. At 1 450 °C, the equilibrium contact angles of M1-M3 were measured to be 0, 4 ° and 11 ° respectively. The M4 sample did not wet and the contact angle hardly changed.

43. H. L. Duan, X. M. Huang, H. C. Ji, Y. G. Li

The Arrhenius constitutive model of steel 42CrMo for gear. Thermal compression test temperature ranged from 800 to 1 200 °C, the strain rate ranged from 0,01 to 10 s^{-1}, and the deformation degree was 60 % of engineering strain, the deformation behavior of 42CrMo gear steel was studied. By polynomial fitting the relationship between strain(0,05 – 0,9, at intervals of 0,05) and material constants, the strain-compensationed Arrhenius constitutive equation for 42CrMo gear steel is established. The correlation coefficient between the experimental data and the predicted data reached 0,9925. This shows that the Arhenius constitutive equation has high accuracy in predicting steel 42CrMo for gear.

44. G. Balamurugan, R. Sivasubramanian

Prediction and analysis of electric discharge machining (EDM) die sinking machining of PH 15-5 stainless steel by using Taguchi approach. In this study, the important machining process parameters such as peak current, pulse on time, pulse off time and fluid pressure are inspected that incitement to distress the performance of the operation Material removal rate (MRR) and Tool wear rate (TWR). Subsequently tool geometry and materials that are predominantly affect the work piece response factor as Surface roughness (SR). Hence copper electrode with coating of brass material and different tool geometry are also considered. PH15-5 stainless steel precipitated hardening steel was machined up to 5 mm depth with EDM die sinking machine using 27 number of experiments designed.

45. I. Dmytriieva, O. Ipatov, I. Mamuzić

Design and analysis of security system reliability. Refined mathematical models, effective methods and algorithms for assessing probabilistic reliability indicators and deterministic fault tolerance indicators for non-recoverable multi-channel safety control systems and emergency protection as systems. Algorithms have been developed for calculating the probabilities of the system being in a working state, in a state of false (excessive) operation and in an inoperative state of a latent (dangerous) failure of the safety control systems, which leads to failure of the protection in the event of an emergency (upon receipt of a "request" for operation).

46. K. Nowacki

Environmentally responsible policy of wastes in steel industry. The steel industry is an industry in which, alongside of mining and energetics, large amounts of waste are generated. These wastes in the EU are classified as thermal wastes and hazardous wastes. New technologies are being developed in many countries to reduce the amount of waste deposited. This study presents the results of research of iron-containing wastes in terms of their environmental impact in the case of storage, the possibility of iron recycling through the process of reducing iron oxides and the metallisation grades of selected wastes. The conducted research indicates the directions of waste management friendly to the natural environment.5

47. I. M. Oskembekov, G. L. Katkeyeva, K. S. Turebekova, Ye. M. Zhunussov

Application of modified sulfidizing reagent (MSR) in processing flowsheet of oxidized copper ore. This paper demonstrates the research results on flotation of the oxidized copper ore with the preliminary sulfidization by a modified reagent. The planning method of an experiment investigated the influence of various factors on flotation process of the oxidized copper ore with a preliminary sulfidization by the modified reagent. Dependence of copper extraction in a flotation concentrate was received from consumptions of sulfidizer and collector, pulp agitation time with a sulfidizing reagent. A mathematical model of process was received.The optimal conditions of flotation providing the copper extraction in flotation concentrate at a level of 85,12 % were determined with this model.

48. A. Y. Jiao, F. L. Chen, B. H. Liu, J. W. Deng

Failure analysis of a diesel engine crankshaft. In this paper, the macroscopic observation and chemical composition analysis of the third crankshaft journal have been carried out. Moreover, macroscopic observation, chemical composition analysis and metallographic analysis were carried out, and were compared with the journal with cracks and without cracks. Based on the experimental results and the causes of crankshaft neck cracks, it can be concluded that the crack form of crankshaft goes along with the grain brittle direction.

49. B. K. Kenzhaliyev, T. Yu. Surkova, A. N. Berkinbayeva, Z. D. Dosymbayeva, B. E. Abdikerim

Revisiting the Kazakhstan natural sorbents modification. Hydrometallurgical processing of uranium raw materials results in a significant amount of liquid technogenic wastes containing radionuclides. The high cost of synthetic sorbents and the low sorption capacity of natural ones is a deterrent to their use. So, to increase the sorption capacity of natural sorbents by their modification is an urgent problem. In this paper, a method to modify Kazakhstani natural zeolite was proposed by us and previously not investigated. Also the data of physicochemical studies of the initial raw material and the modified product was given and the increase in the natural sorbent specific surface in the modification process was demonstrated.

50. I. N. Lomov, O. B. Kazanovskaya, N. N. Mos'pan, I. Mamuzić

Improvement of quality assessment method. For a comparative assessment of each of the homogeneous objects, for example, processes, products, personnel and others, the sum of single quality indicators is usually compared, which are determined by experimental way. If it is necessary to operative change the number of single quality indicators, it is necessary to change all significance coefficients, what is inconvenient. The method for estimating of the object quality was proposed, which supposes expert assessment of the significance coefficient with a 100-point scale. Ease implementation of new single indicators and clarity for users are advantages of this method.

51. B. Gajdzik, J. Piątkowski, P. Kliś

Prognostic methodology of forecasts steel production for Poland until 2022. The publication presents the prognostic methodology used in forecasting of quantity of steel production. On the basis of empirical data (yearly steel production) from period 2000 - 2017, forecasts of steel production for Poland until 2022 were estimated. The prognostic methodology in the first step consisted in: determining separate forecasts for: steel production in total and BOF steel and EAF steel. In the second step the equations were used: total steel production – (minus) BOF steel = (is) EAF steel and total steel

production – (minus) EAF steel = (is) BOF steel. The forecasting methodology adopted was possible because the sum of BOF and EAF processes is the total production (100 %) in the steel sector in Poland.

52. D. Malindžák, I. Leššo, E. Mihaliková, A. Gazda

Application of balance models in metallurgy. In general, management is the planning and coordination of all processes and their elements in enterprises in order to achieve the objectives with the highest efficiency. The basic management tools, especially in companies with complex production processes with high inertia and long production time, include balance models. The paper points out the methodology, principles and importance of balance models in metallurgy and describes the methodology for material-energy, capacity and economic balance of this process.

53. B. S. Baimbetov, A. A. Bekisheva, K. D. Aytenov, B. E. Abdikerim

Kinetics of roasting of copper and iron sulfides with soda in a vibratory boiling layer. The kinetics of the roasting of iron and copper sulfides in a pulsating layer was studied, and the kinetic parameters of the processes were determined. The determination of the order of the roasting reactions and activation energy in the MeS - Na_2CO_3 - O_2 system is based on the differential method. Using the dependences of the degree of conversion of copper and iron sulfides in the reactor of the vibratory pulsating layer at a pulsation frequency of 50 Hz and a pulsation amplitude of 0,1 - 0,5 mm, the values of the apparent activation energy in the temperature ranges of 500 – 550 - 600 °C were obtained for FeS 1,60 - 1,64 and for Cu_2S 1,44 - 2,41 J*mol. (CO_2).

54. T. Karkoszka

Emergency preparedness and response in metallurgical processes. The main aim of the presented paper is to feature the operational model of the emergency preparedness and response. It is based on the risk analysis and allows for fulfillment of the requirements of ISO 9001, ISO 14001 and ISO 45001 norms. The model in question represents the base of the real aims' unification within the range of proceeding in case of the metallurgical processes' failures.

55. P. Vavrek, B. Pandula, J. Ďurove

Research of geomechanical and geophysical parameters for assessing of rock mass stability. The paper presents the results of laboratory such as in situ geomechanical and geophysical measurements. The results were the basis for mathematical modeling of slope stability in the design of foundations for new technological line for crushing stones. In situ research aimed to verify the strength of dolomite on Schmidt Hammer tests. Geophysical measurements were determined the speed of propagation of seismic waves and the degree of fracturing of the rock massif. Slope stability assessment of new technological line was made planar and spatial mathematical model and have been proposed rock slope stabilization.

56. I. Mamuzić

Press of publically available materials requests responsibility – proceedings of the editor Đure Tadić about the steelworks Sisak, 1938–2018. The beginnings of the world metallurgy date back to the 7000 years B.C. The industrial production start date was in 1853 (Foundry in Rijeka), in 1937 (the production of aluminium and Al-alloys in Lozovac) as well as in 1939 with the construction of the blast furnace in Caprag. In the period after 1945, until 1990, Croatia had several metallurgical companies and acceptable production was 2.670.000 tons of coke, iron, which up to 2.000.000 t/y came from Steelworks Sisak. From 1990 to 2012, over 2.600,00 t/g of metallurgical products were demolished or discontinued, which represented the collapse of Croatian metallurgy. The paper cites more important publications on the Steelworks Sisak, which was a long-standing carrier of metallurgical production in Croatia. There is also a review of the last published Proceedings of the Sisak Ironworks (2019).

57. F. Vodopivec

The life and achievements of acad. Ilija Mamuzić. On the occasion of the 80th birthday of Acad. Ilija Mamuzić for 35 years as Editor-in-chief of the journal Metalurgija, 42 years as the President of the Croatian Metallurgical Society, the goal of this article is to give an overview of his life and achievements. Rarely has an individual not only in Croatia but in the world had influence on his profession as I. Mamuzić his own – metallurgy. He was involved and worked in all metallurgical areas: science, profession, education, organising of Faculty or Institute, Symposiums, editing, popularisation and responsability for the profession and he is an author of the history of metallurgy on the territory of Croatia, during 6000 years. In Croatian Bibliografphy base CROSBI by registration, accepted and on print will be 925 works. By the same conditions in foreign bibliography ORCID 800 works. He participated even in the education of 47 generations students (1963–2010. He received 75 various acknowledgments etc. He is an exceptional personality as individual, scientist, pedagoge, and professional. Ilija Mamuzić has achieved plenty, not because he had or was obliged to, but because he wanted to. He didn't work to live, but to live to work.

58. K. Draganová, K. Semrád, L. Főző, M. Spodniak, R. Jurč

Methodology for structural analysis of hyperelastic materials with embedded magnetic microwires. The article processes the issue of the structural analysis of the hyperelastic materials, where the methodology for hyperelastic materials laws together with its implementation in the Creo-Simulate software is described. After the comparison of the simulation results with the experimental results a very good compliance was achieved. The created methodology together with the application of the tensile stress sensors based on the magnetic microwires embedded directly in the conveyor belts mean a significant improvement of the manufacturing and operation of the conveyor belts.

59. B. Gajdzik

Trends and forecasts of steel intensity in Poland on the based apparent crude steel use until 2022. The publication presents historical trends and forecasts of quantity (volume) of steel intensity in Poland. The analysis of steel intensity was realized on the based of apparent consumption of steel. Such formula was used: apparent steel use is production steel minus export of semi-products and plus import of semi-products. Empirical data were: yearly crude steel production, yearly export of crude steel (semi-products) and yearly import of crude steel (semi-products) from 2000 to 2017. On the based of empirical data trends of steel intensity in Poland in 2000-2017 were analyzed and forecasts of steel intensity until 2022 were estimated. Obtained forecasts of apparent crude steel use can be used in building of the scenarios for Polish steel industry.

60. A. Y. Jiao, B. H. Liu, G. F. Zhang, M. S. Xu, J. P. Li, F. L. Chen

Failure analysis of EB03 crankshaft. Study on the fracture specimen of EB03 crankshaft which produced by a crankshaft company. It is found that there is a phenomenon of high temperature oxidation on the surface of EB03 fractured crankshaft's journal by the macroscopic analysis of the fracture of the crankshaft. And there are a lot of sintered metal particles on the surface of the neck journal. It is found that the graphite has different degrees of deformation by observing the graphite morphology on the surface of the neck journal.

61. B. K. Kassenov, Sh. B. Kassenova, Zh. I. Sagintaeva, E. E. Kuanyshbekov, A. A. Mukhtar

Thermodynamic and electrophysical properties of nanosized cobalt-cuprate-manganite and nickelite-cuprate-manganite OXIDES. Cobalt-cuprate-manganite $LaCaCoCuMnO_6$ and nickelite-cuprate-manganite $LaCaNiCuMnO_6$ oxides, were synthesized with ceramic processing technology from calcium carbonate and oxides of La(III), Co(II), Ni(II), Cu(II) and Mn(III). The nanodimensional particles were received with the milling at Retsch (Germany). The experimental and calculation methods determined their thermodynamic and electrophysical characteristics.

62. E. Kuldeyev, I. Bondarenko, R. Abdulvaliyev, S. Temirova, B. Abdikerim

Processing of low quality Ekibastuz coals ashes and natural diatomites to obtain alumina and foamed glass. Analysis of technological solutions on complex processing Ekibastuz coals ashes displays efficiency of complex alkaline technologies. However their significant drawback is the necessity to utilize big volumes of alkaline-silicic solutions. This research demonstrates possibility of their rational utilization by using natural raw diatomites to obtain formed and pelleted foamed glass widely used in construction industry as a heat-insulating material. Based on the data from scientific literature and their own research the authors suggest an improved scheme of complex processing Ekibastuz coals ashes.

63. A. Mamala, P. Strzępek, M. Zasadzińska, B. Smyrak, M. Sadzikowski

The influence of the axial tension on the linear resistance and mechanical properties of AlMgSi overhead line conductors. The paper examines the influence of axial tension on the linear electrical resistance of single-layer aluminum alloy conductors and showed that when the tension is applied

the linear resistance stabilizes at a lower level in comparison to conductors with no tension or with low value of tension. The effect of pressure forces occurring in the inter-wire contact area was also examined and it was found that the hardness of the material and the range of deformation locally increases as the average pressure at maximum compression force increases.

64. J. S. Musayev, T. O. Chigambaev, Y. B. Kaliyev, B. T. Kopenov, M. Zh. Turkebayev, M. A. Nartov, A. Zhauyt
Study on stress-strain state and deformations occurring in existing roller tables. The design of a new diverting roller table is presented, containing continuous series of sections with diverting rollers. Using the program product of finite element analysis of Autodesk Inventor, the stress-strain state rollers of the new outrigger roller table is calculated. It is proved that the maximum concentrations of stresses and deformations are observed in barrels and necks of rollers a new outrigger roller table. At the same time, the value of these indices is much smaller in comparison with the values of stresses and deformations occurring in existing roller tables.

65. A. M. Dolzhanskiy, Ye. M. Kolot, I. Mamuzić
New method for the determining of heterogeneous liquids impedance components. The authors have developed a new method for determining the components for the liquid impedance with the calculation according to the certain algorithm, based on the measurement of electric current and voltage at two close frequencies. It was shown for the first time that the same change in a certain property index of a heterogeneous liquid corresponds to a greater sensitivity of one of the components of the impedance than to the impedance of the entire measuring circuit. These data reveal the possibility of practical use of the development results.

66. K. Semrád, D. Marasová, Ľ. Ambriško, Ľ. Caban, M. Spodniak
Numerical and experimental analysis of innovative support system of belt conveyor. The article processes an issue of the strength of a support system of a belt conveyor applying the numerical and experimental analysis approach. The results obtained using the numerical analyses are identical to the results from the experimental analysis. Maximal damage of the support system of a belt conveyor is estimated and according to the proposed methodology verified by the comparison of the experimental and numerical results, the design and optimization of the support system for the practical operation can be performed.

67. Z. Skuza, C. Kolmasiak
Impact of structural and technological changes on selected aspects of the steel industry of Poland. The Polish economy, due to a number of investment projects in the construction, the railway, the power engineering, and the machinery industry, needs more and more steel products. A number of factors have influenced the changes that have occurred in the steel industry. They ranged from cost increases in almost all areas of market activity, through regulatory conditions, to structural and ownership changes. The article presents how the restructuring process that has taken place in recent decades has influenced the structural and technological changes in the steel industry and the current situation of this sector of industry.

68. M. Spodniak, K. Semrád, M. Hovanec, P. Korba, T. Musil
FEM modeling of magnetic microwire and its using for stress monitoring inside the composite beam. The proposed article is devoted to the stress evaluation inside the composite beam using the embedded magnetic microwire sensors. It is essential to monitor the stresses and to increase the lifetime of the composite materials by using the embedded magnetic microwire-based sensors. In the article the results of the mechanical stress distribution between the magnetic microwire coating and core and the discussion about the experimental application of the magnetic microwire inside the composite beam are presented.

69. W. Zang
Investigation of molybdenum carbides as catalyst for hydrogen evolution in ph universal environment using density functional theory simulation. Transition metal carbides (TMC) have intriguing physical and chemical properties, especially when structured down to nanoscale. The temperature and chemical resilience of this family of materials made it ideal candidate for electrochemical applications in harsh environment. Among the TMC family, molybdenum carbide has been demonstrated as efficient catalyst for hydrogen evolution reactions (HER). This paper will use density function theory to investigate of the efficiency of molybdenum and tungsten carbide as catalyst for HER in neutral and alkane environment.

70. T. Karkoszka
Process safety in metallurgical producion. As a consequence of technological accidents regular conditions of metallurgical processes can change into operational discontinuity. For that reason the main aim of the paper is to present a concept of the risk based process safety assurance. It is directed at the arrangement of the supervised processes realization resulting in prevention and minimization of uncontrolled damages to employees' health and environmental pollution. The fundaments of the described concept is risk management and systemic approach required by guidelines of: environmental and occupational management systems as well as Risk Based Process Safety (RBPS) management system. The exemplary actions of the risk based process safety assurance in metallurgical production are presented.

71. R. V. Usenko, L. I. Solonenko, I. Mamuzić, S. I. Repyakh
Heating of solid bodies by microwave. One of the reasons restraining the use of microwave radiation in the foundry is the uneven heating of the processed solids and molding sand. An urgent task is to assess the type of radiation power distribution in the chamber of a microwave oven. In the heating chamber of the microwave oven, the microwave power beams are distributed cyclically and geometrically coincide with the antinodes of the standing wave in it. Accordingly, the bodies or mixtures installed in the chamber between the antinodes of the standing wave will not be heated during their processing in the microwave oven.

72. T. Karkoszka
Risk management system in metallurgical production. The main aim of the paper is to characterize the proposed model of risk management system which allows for fulfillment of different requirements. Threats identification and risk acceptability assessment result in taking action of the systemic character directed on risk minimisation. Those actions guarantee technical condition of the used equipment as well as organisational solutions, which make it possible to reduce the risk in the effective manner. The model in question can be treated as a guidelines for proceeding in case of the potential metallurgical risk occurrence.

73. I. Mamuzić
Review of the Đuro Tadić monograph "Steelworks Sisak, company of steel and lifetime" / Sisak, 2017. In the period after 1945 until 1990 Croatia had several metallurgical companies and acceptable production. In ex-Yugoslavia Croatia was the only manufacturer of seamless pipes among 34 countries in the world Steelwork Sisak, with of welded pipes, strip and billets, in addition to cold processing (drawing, pilgering), steel production (Martin furnaces) and 1 electric furnace together. Per year in 1990 until 2014 this plants were form down and put out operation. In monograph Đ. Tadić "Steeworks Sisak, Company of steel and lifetime", gave the period (quote) "lifetime one Company in developing" 1956 – 1989 y. Contents are from published selected Articles from Journal of Steel work Sisak "Vjesnik Željezare".

74. 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.

75. I. E. Uskova, N. L. Chekunova-Tomacheva, I. Mamuzić
Mechanisms for transforming research results into the business sector of the economy. An innovation mechanism is an organizational and economic form of implementation of innovative activities, search for innovative solutions, as well as a lever for stimulating and regulating this activity. Innovative mechanisms should form the functional support of innovations in its relation to the stages of their life cycle. Functional support is under-

stood as innovative, investment and financial support. Special attention should be paid to improving existing and developing new mechanisms for transforming scientific research into corporate practice.

76. N. L. Chekunova-Tomacheva, I. E. Uskova, I. Mamuzić

Features of selecting potential investors for scientific and technical developments. For the correct choice of the ratio "investor-innovation-oriented scientific development", i.e. which potential investor should be placed on the sale of a particular innovation-oriented scientific development, it is necessary to conduct: - technical analysis, on the basis of which the most suitable for this innovation-oriented scientific development technique and technology is determined; - commercial analysis, covering the analysis of the sales market of the products that can be produced as a result of the implementation of an innovation-oriented scientific development; - institutional analysis, whose task is to assess the legal, administrative and commercial environment in which innovation-oriented scientific developments will be implemented and adapt them to this environment; - financial analysis.

77. J. Svetlík

Assembly aspects of the third generation universal rotary module intended for the construction of serial robotic structures. At the Department of Production Engineering, Faculty of Mechanical Engineering TUKE, we have been dealing with experimental development of the Universal Rotary Module, in short - URM. The main benefit of URM is the possibility of unrestricted rotational movement, which is an exceptional feature compared to other known solutions currently available on the market. This feature has a major influence on the design of the internal organs of the module. The cable harness has been completely eliminated, which is a characteristic of competitive solutions. From the management point of view, only NFC wireless nationwide technology was used. The paper deals with aspects of assembly of the third generation URM. Problems of cracking of the glued joints of passive curved modules have arisen. These shortcomings had to be overcome by using brazing technology. The melting temperature of the Al-Si12 eutectic solder was 580 °C.

78. 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.

79. 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.

80. J. Dobránsky, M. Pollák, M. Kočiško

Application of pressure sensors for pressure monitoring in injection mold. The paper deals with design and application of sensors for monitoring pressure parameters in injection mold. The mold is used for the production of plastic connectors for the automotive industry by overmolding technology. The paper deals with a new solution and results of the design of pressure sensor application, which were designed in cooperation with the workers of the processing company for monitoring the pressure course in the injection mold cavity. For the successful application of the sensors, it was necessary to mount an external additional monitor with software. On this monitor it is possible to control the pressure in the mold cavity during injection independently of the machine control system. By applying pressure sensors, it is possible to monitor the pressures in the mold and thereby detect possible defects. The application of pressure sensors has significantly reduced the number of produced unsupports.

81. J. Dobránsky, M. Kočiško, M. Pollák

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.

82. S. Spadło, D. Bańkowski, P. Młynarczyk

Research on vibratory machining of objects produced by the rapid prototyping. The paper presents the results of finishing objects produced by the additive technique. The geometric accuracy of manufactured items made by additive engineering is determined by the resolution of the 3D printer. It should be noted that the resulting model has "stepped" surfaces. Workpieces made on a 3D printer were vibratory machining. The three-level, three-factor Box-Behnken experiment was carried out. Based on the results, influence of machining time of vibratory machining, the type of used finishing media and degree of tumbler fillings on geometric structure of the surface and on the mass loss was determined. Statistica software was used to make dependency graphs. The form profiles before and after vibratory machining were determined with the Talysurf CCI Lite - Taylor Hobson optical profiler. To illustrate the surface taper ratio and edge optical microscope Nikon MA 200 Eclipse with the image analysis system NIS 4.20 was used**.**

83. S. Spadło, D. Bańkowski, P. Młynarczyk

Diagnosing laminar composites by non destructive method. In the power industry, chemical industry and aviation technology, thin-walled elements are applied as a pipe, reactionary chambers etc. which should be ready to operate under mechanical loads. In most cases, the operational and maintenance safety is strictly correlated with the expected reliability of these elements. These constructions often operate under additional exposure to heat, erosion and chemical influence of the flowing agent and their protection is therefore necessary. In many cases these elements are being carried out as thin metal shell coating from the inside with an insulating layer. Any visual inspection of the glue joint quality between metal and insulating layer is practically impossible. Up to now, the parts have been inspected manually by guiding the ultrasonic transducer by the surface. Lack of special equipment caused difficulties connected with precision guidance of the ultrasonic probe along the examined surface. The paper presents the arrangement and components of a computer measurement setup used to examine adhesive joints of thin-walled metal shell with laminar composites. The proposed system makes it possible not only to assess glue joints, record and analyze the ultrasonic signal but also get a graphical representation of the examination results. The use of special so-called broadband probes which generate very short (0.2 μs) pulses of longitudinal waves has made it possible to observe the influence which the quality of the bonding of the laminar composite layer with the thin-walled steel casing has on the conditions of ultrasonic wave propagation. The example of investigation results was presented.