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DEPENDENCE OF QUALITY PROPERTIES FOR GREY IRON ON USED RAW MATERIALS

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Preliminary Note – Prethodno priopćenje

Grey iron castings keep the first place among castings on base of iron. Present trend in growing entrance production costs of cast stock force manufacturer to cost minimizing. Therefore is most actual deal replacement pig iron by steel scrap. In contribution are presented results research work relating to influence of raw materials on grey iron properties

Key words: grey iron, raw materials, mechanical properties

Ovisnost svojstava kakvoće sivog lijeva od rabljenih sirovina. Sivi lijev zadržava prvo mjesto između odljevka na bazi željeza. Sadašnji trend ima pristup što većeg smanjenja cijena proizvedenog odljevka. Glede toga se veći dio sirovinskog uloška zamjenjuje čeličnim otpatkom. U članku se daju rezultati istraživanja utjecaja sirovina na svojstva sivog lijeva.

Ključne riječi: sivi lijev, sirovina, mehanička svojstva

INTRODUCTION

Cast iron castings keep the first place among castings on base of iron. The designers prefer them against carbon steels thanks to excellent casting properties (excursive, shrink) in combination with good mechanical properties.

The primacy in the group of castings is kept by the cast-iron with fret graphite (LLG), while the basis of the melted cast-iron serves also for production of other types of cast iron. Mainly the cast-iron with spherular graphite (LGG) has found its place from the half of the 20th century and almost entirely pushed away the malleable iron. LGG is one of the youngest iron materials and its discovering belongs to the biggest success of metallurgists.

Continually growing demands of the new components with higher utility parameters exact the technology modernization and technological facility innovation. By the current trend of growth of input costs for castings production, of demands raising on their quality and vendor pressure on products prices reduction the producers are forced to bear the disproportions of the market mechanism. The mentioned facts force foundries to the production rationalization and so to the production costs reduction.

Nowadays it is the most actual from economic point of view in framework of cast iron research to deal with possibility to substitute a part of pig-iron in batch with price more preferable raw materials. For reaching the favourable costs for castings production from cast iron it is important to obtain desired cast iron attributes by the cheap batch by using the high rate of the steel scrap, returnable material, fragments and other secondary raw materials. The worldwide trend is increasing of steel scrap rate in a batch on the expense of pig-iron. It has been given by the price of pig-iron and high appearance of suitable steel scrap produced by the automobile industry. From the production cost point of view the production of synthetic cast iron with uniform utility properties has the illimitable significancy.

In Slovak foundries for cast iron production in batches the imported pig-irons from Tule area of the Russia, sorelmetal and steel scrap of the domestic origin are used the most frequently. There are differences in prices of the mentioned raw materials up to 100% and the batch composition can significantly influence costs per casting. The important component of a batch is also the own returnable material from a foundry.

The results of a research of influence the batch raw materials on mechanical and qualitative properties of a cast iron with petalled graphite produced from various batch raw materials in two Slovak foundries are presented in the paper.

EXPERIMENTS RESULTS AND THEIR ANALYSIS

In operational conditions of two foundries the influence of batch composition from aforementioned components on qualitative properties of the cast-iron with pet-

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Table 1. **Statistical data of results for mechanical properties and basic chemical composition for the foundry A**

The basic batch (average) n = 24	C	Mn	Si	S	P	Cu	Cr	Sc	Rm / MPa	HB
	Weight / %									
SŽ – Z 58,43% Zlomk + VM 22,18% steel scrap 18,03%	**3,124**	**0,867**	**1,538**	**0,042**	**0,133**	**0,503**	**0,128**	**0,838**	**271,04**	**198**
	0,12	0,08	0,07	0,005	0,07	0,186	0,059	0,034	6,59	7,66
	2,96	0,74	1,41	0,033	0,05	0,22	0,03	0,790	255	189
	3,35	1,06	1,71	0,047	0,19	0,73	0,20	0,910	285	217
Scrap 100%	**3,28**	**0,78**	**1,79**	**0,063**	**0,18**	-	**0,09**	**0,901**	**226**	**293**

SŽ – Z – casting pig iron
Zlomk + VM – fragments + returnable material
Notice: the first row means arithmetical average, the second row represents standard deviation, the third row the minimum value of a file and the fourth row the maximum value of a file, symbol n stands for the number of analyzed melts

Table 2. **Statistical data of results for mechanical properties and basic chemical composition for the foundry B**

The basic batch (average) n = 24	C	Mn	Si	S	P	Cu	Sc	Rm / MPa	HB
	Weight / %								
SŽ – O 13,25% returnable material 54,50% steel scrap 32,33%	**3,267**	**0,730**	**1,704**	**0,016**	**0,025**	**0,373**	**0,880**	**278,88**	**200,08**
	0,045	0,097	0,113	0,005	0,0023	0,082	0,014	19,38	6,22
	3,17	0,613	1,41	0,011	0,021	0,271	0,848	250	185
	3,33	0,906	1,80	0,020	0,028	0,488	0,899	300	215

SŽ – O – steel pig iron
Notice: the first row means arithmetical average, the second row represents standard deviation, the third row the minimum value of a file and the fourth row the maximum value of a file, symbol n stands for the number of analyzed melts

alled graphite was monitored (STN 42 2425 eventually EN-GJL-250).

Foundry A: batches were realised in two 6 t low-frequency induction furnaces with acid lining. The cast-iron was by the bar gauge treated FeSi. For statistical evaluation were selected 24 batches with different batch composition. The pig-iron rate was 58,43% in average; steel scrap 18,03% and fragment cast-iron 22,18%. In the foundry also one batch with 100 % rate of the steel scrap in batch was realised.

Foundry B: batches were realised in two 6 t medium-frequency induction furnaces with acid lining. The cast-iron was by the bar gauge treated FeSi but in contrast to the first foundry it was used SiC in quantity approximately 0,5 weight. % into the batch by melting. Also from this foundry 24 batches LLG with different batch composition were selected. The average pig-iron rate was 13,25%; steel scrap 32,33% in average and returnable material 54,5%.

From every batch the test samples were cast with Ø 30mm for tensile strength test and hardness measurement according to Brinell.

Statistical data of results for mechanical properties and basic chemical composition for given foundries are presented in table 1 and table 2.

According to t – test of statistical confidence (with confidence p = 0,05) there were found statistical considerable differences in mechanical values for analyzed files of batches (table1 and table 2) .

According to measured values of mechanical properties (Rm and HB) there was realised the dependency of steel scrap in a batch influence on mechanical properties for cast iron. The dependency is documented in figure 1.

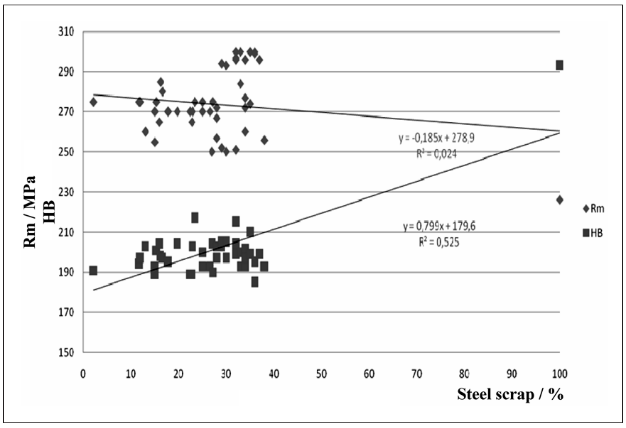

Figure 1. Steel scrap influence on the mechanical properties

For batch with 100% steel scrap rate in the batch the hardness that was greater at approximately 45% (HB 293) was recorded, but on the other side the cast iron had lower tensile strength (Rm = 226 MPa) against average values from other batches.

According to multiple regression the equations for dependency of tensile strength (Rm) and hardness (HB) on the basic elements (C, Mn, Si, S) were calculated.

Foundry A:

tensile strength / MPa:

$$Rm = 340{,}19 - 7{,}74.\%C - 22{,}61.\%Mn - 30{,}97.\%Si + 525{,}39.\%S$$

deviation s = 6,59

Brinell hardness:

$$HB = 219,3 - 20,54.\%C + 21,08.\%Mn + 18,89.\%Si - 104,9.\%S$$

deviation s = 7,66

Foundry B:

tensile strength / MPa:

$$Rm = - 270,33 + 146,4 . \%C - 65,02 . \%Mn + 44,44 . \%Si + 2622,98 . \%S$$

deviation s = 19,38

Brinell hardness :

$$HB = 248,11 - 20,524 . \%C + 7,34 . \%Mn + 4,64 . \%Si + 354,52 . \%S$$

deviation s = 6,22

From the presented equations results can be concluded that the biggest affect on tensile strength and hardness has the content of C element in cast iron. The interesting experience from the listed regression equations is related with the sulphur content. Its positive effect on mechanical properties is related with the generation of heterogeneous graphite nuclei that are created as the result of treating. The mentioned fact also corresponds with results stated in literature [3]. Up to 90% of the all particles that play some role by the graphite nuclei generation are sulphides type $(Mn_x)S$.

Besides standard evaluation of quality for cast iron by tensile strength, by hardness eventually by chemical composition the quality criteria were also evaluated. (table 3) It was the criteria that quantitatively represent the effect of particular production conditions on reached cast iron properties in comparison with the optimal statistically valid conditions. Really quality cast iron should show the highest degree of maturity RG and the lowest relative hardness RH.

The quality criteria for cast iron produced from 100% steel scrap rate are shown in table 4.

From the quality criteria (table 3 and table 4) it can be stated that produced cast irons show lower degree of maturity it means they have lower strength than it correspond with their chemical composition. On the other side the synthetic cast iron shows the high relative hardness that in the final result decreases its quality number.

The effect of carburization and alloying of cast iron by using SiC was also studied that is considered as an effective front inoculator. The positive effect of the alloy was demonstrated by the turbidity decrease and so by the occurrence of free cementite in the basic metal matrix.

Table 3. **Quality criteria LLG**

Foundry A	
Degree of maturity for cast iron RG / %	83,87
Relative hardness RH	0,903
Quality factor m	1,369
Quality number GZ	92,87
Foundry B	
Degree of maturity for cast iron RG / %	93,698
Relative hardness RH	0,931
Quality factor m	1,315
Quality number GZ	100,64

Table 4. **Quality criteria of synthetic LLG**

Foundry A – 100% rate of the steel scrap	
Degree of maturity for cast iron RG / %	82,57
Relative hardness RH	1,469
Quality factor m	0,771
Quality number GZ	56,21

CONCLUSION

The effect of increased steel scrap rate in a batch was shown for synthetic cast iron by marked hardness growth while the strength was consistent with standard produced cast iron. The higher steel rate in a batch in foundry B (in average 32,33 %) was shown by the higher degree of maturity for cast iron at about 10 % and by the higher quality number 100,64. The next experience is the positive effect of SiC in a batch for decrease of turbidity and the appearance of the free cementite in structure of the produced cast iron. Generally it can be stated the low effect of treating in both foundries (low degree of maturity for cast iron) associated with imperfect metallurgy of fluid metal preparation (degree of maturity for treated cast iron should be more than 100 %). Equally it is not suitable to use charging raw materials with low content of S for production of quality treated cast irons.

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Note: The responsible for English language is the Author G. Weis.