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INFLUENCE OF FELDSPAR CONTENT IN QUARTZ SAND ON THE PROPERTIES OF MOULD MIXTURES FOR MOULDS AND CORES FOR GREY CAST IRON CASTING

VPLIV VSEBNOSTI GLINENCA V KREMENOVEM PESKU NA LASTNOSTI MEŠANIC ZA FORME IN JEDRA ZA ULIVANJE SIVE LITINE

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In this paper the influence of feldspar content in quartz sand on properties and quality of mixtures for moulds and cores for grey cast iron products is presented. Technological tests of coating were performed and the values of cold and hot compressive strength and softening temperature for the samples with and without scale were obtained. Some results are related to mixtures for moulds and cores on the basis of coated sand are presented, also.

Key words: mould, core, moulding mixture, coated sand, feldspar

Opisan je vpliv vsebnosti glinenca v kremenovem pesku na lastnosti mešanic za forme in jedra za ulivanje sive litine. Izvršeni so bili tehnološki preizkusi oplaščenja in določeni sta bili hladna in vroča tlačna trdnost vzorcev brez dodatka škaje in z njo. Prikazani so tudi nekateri rezultati o mešanicah za forme in jedra iz oplaščenega peska.

Ključne besede: forme, jedra, formarske mešanice, oplaščeni peski, glinenec

1 INTRODUCTION

The traditional opinion is that the most important parameter of mould mixtures of coated sand quality is the type of used organic or inorganic binding material. The results in this paper demonstrate clearly that the values of cold and hot compressive strength depend directly on the content of feldspar in the sand, and that the softening temperature is related to the feldspar content in quartz sand samples. The results of examinations are related to mixtures for moulds and cores on the basis of coated sand.

As raw materials for production of sand moulds and cores, cast sand and appropriate binding materials were used. The technological characteristics of moulds and cores mixtures depend on the basic characteristics and the amount of starting raw materials, and also on the method of manufacturing of these mixtures[1]. For the investigation of the influence of feldspar content in quartz sand on the properties of moulds and cores mixtures for grey cast iron products different types of coated quartz sand were used.

The most often used quartz sand undergoes crystallographic transformations, which causes volume changes and it can also cause mould deformations and surface defects in moulds[2]. Because of the presence of admixtures (Fe_2O_3, $CaCO_3$, feldspar) and lower refractoriness natural quartz sand cannot be used for casting of metals of higher melting temperatures. For casting of these metals it is more appropriate to use synthetic casting mixtures of quartz sand and binders[3].

The processing of sand for the preparation of mould mixtures depends on the characteristics of the sand, i.e. it depends on the content of additions used as binders for the improvement of sand properties and on the homogenization of the obtained mixture. The casting surface quality, gas permeability and used binder amount are determined by the size and shape of sand grains. For the same compression grade round grains have greater density of packing than angular granes. These, unlike round grains, form insufficiently connected pores which decrease the gas permeability[4]. However, decreased permeability does not lower the quality of casting due to the thin mould walls which provide free passage to gasses expulsed by the casting of liquid metal. Feldspars, as admixtures in quartz sand, carry alkalis which cause the formation of eutectic liquid in quartz sand and lower the sintering temperature[5]. Mixtures of coated sand have a 30 % higher strength than the mixture of sand and pulverized resin with the same qualitative and quantitative composition[6,7]. Scale is a raw material which is obtained at hot rolling. It is delivered in the form of thin small brittle flakes (it contains 70 % FeO and 30 % Fe_2O_3). It has greater refractoriness and heat conductivity

Table 1: Chemical content of investigated species of quartz sand

Sample	SiO_2 $W(SiO_2)/\%$	Al_2O_3 $W(Al_2O_3)/\%$	CaO $W(CaO)/\%$	MgO $W(MgO)/\%$	Fe_2O_3 $W(Fe_2O_3)/\%$	Cr_2O_3 $W(Cr_2O_3)/\%$	Burning losses $W/\%$
"V"	98.73	0.86	0.09	-	0.26	-	0.06
"D.B.R."	95.80	0.98	0.10	1.63	1.22	-	0.27
"R"	98.93	0.32	0.07	0.02	0.56	-	0.10
"T"	97.35	0.19	0.08	1.29	0.95	-	0.14

than quartz sand. By adding scale the mechanical properties of coated sand are improved and also the temperature of sand sintering reincreased[7].

2 EXPERIMENTAL

Before coating tests, the characterization of investigated sand species was performed with the determination of mineral composition, of chemical content of grains shape and granulometry. Four different species of quartz sand (marked as "V", "D.B.R.", "R" and "T") were investigated. As technological tests of quartz sand coating, the softening temperature for samples with and without scale and the hot and cold compressive strength were determined. For tests of non coated mixtures phenol-formaldehyde resin Resofen FF600 was used and the mass fractions of the additions were 4 % of resin, 15 % of hexamine and 5 % of calcium-stearate. Phenol-formaldehyde resin mixed with sand provides high strength, resistance to heat and humidity and free flowing. Hexamethylenetetramine (hexamine) was added to resin to provide resin's polymerization, i.e. to obtain thermostable characteristics. Hexamethylenetetramine (hexamine or urotropine) with the chemical formula $(CH_2)_6N_4$ is added in powder form with different grain size or as in this investigation in form of 29–35 % solution in water, with 13–17 % of solid substance related to the content of resin. Hexamine is required to transform the thermoplastic resin, covering sand grain to a thermostable layer. Calcium-stearate $(C_{17}H_{35}COO)Ca$ is a white powder, soluble in water and weakly soluble in alcohol. It is used as self-lubricating addition aimed to increase the fluidity of coated sand and to cause the increase of the volume of moulds and cores because of lesser mutual friction of sand grains. It also improves the

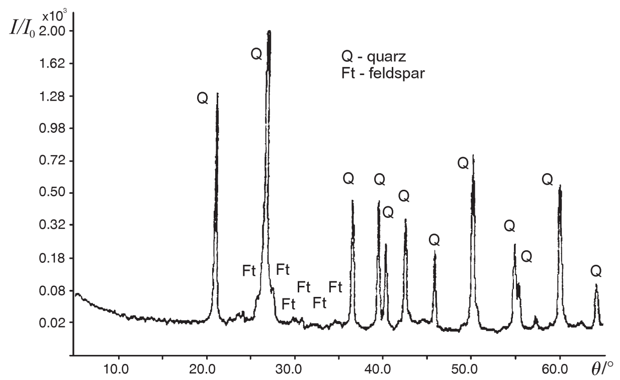

Figure 1: X-ray diffractogram of the quartz sand sample "D.B.R."
Slika 1: Rentgenski difraktogram vzorca kremenovega peska "D.B.R."

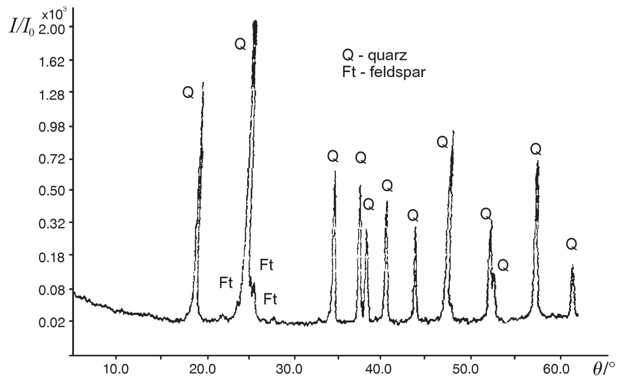

Figure 3: X-ray diffractogram of the quartz sand sample "V"
Slika 3: Rentgenski difraktogram vzorca kremenovega peska "V"

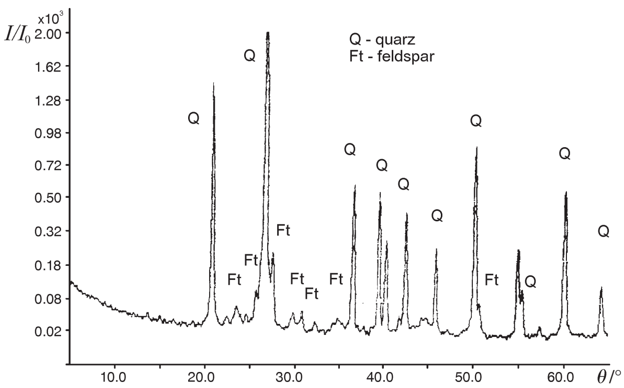

Figure 2: X-ray diffractogram of the quartz sand sample "R"
Slika 2: Rentgenski difraktogram vzorca kremenovega peska "R"

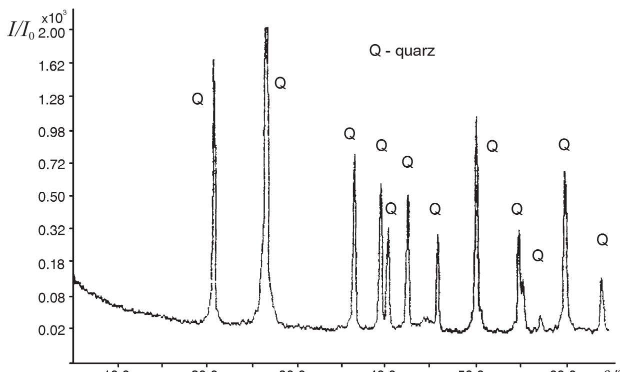

Figure 4: X-ray diffractogram of the quartz sand sample "T"
Slika 4: Rentgenski difraktogram vzorca kremenovega peska "T"

resin distribution in the coating process. The addition of resin amounts to 4–6 % and the addition of scale is of 2.5 %.

Since domestic raw materials were used, it was necessary to consider basic ecological criteria.

3 RESULTS AND DISCUSSION

The investigated species of quartz sand have a very similar chemical composition. Chemical analysis is shown in **Table 1**.

In all quartz sand samples the SiO_2 content is above 95 %. X-ray analysis showed the presence of quartz with feldspar admixtures in all quartz sand samples, except for the sample "T". (**Figure 1, 2, 3 and 4**). The different quartz sand samples have different average grains size (**Table 2**).

Table 2: Average quartz sand grain size *d* in the tested samples

Sand sample	Average grain size (MV) *d*/mm
"V"	0,30
"D.B.R"	0,27
"R"	0,21
"T"	0,21

Figure 5: magn. 50x. shape of quartz sand grains in sample "V"
Slika 5: Oblika kremenovih zrn v vzorcu "V"; povečava 50-kratna

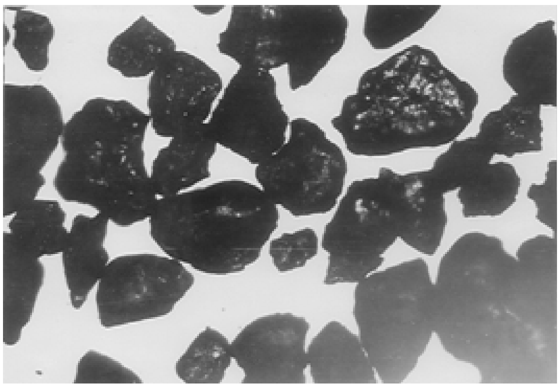

Figure 6: magn. 50x. shape of quartz sand grains in sample "D.B.R."
Slika 6: Oblika kremenovih zrn v vzorcu "D.B.R."; povečava 50-kratna

Figure 7: magn. 50x. shape of quartz sand grains in sample "R"
Slika 7: Oblika kremenovih zrn v vzorcu "R"; povečava 50-kratna

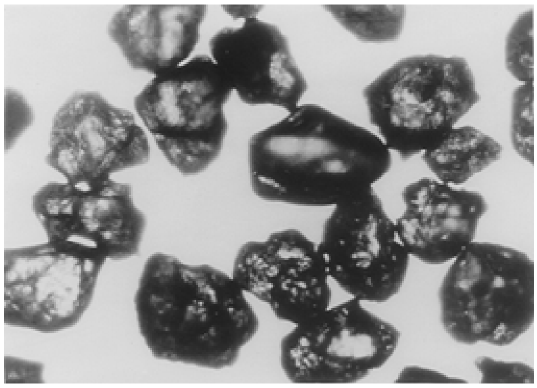

Figure 8: magn. 50x. shape of quartz sand grains in sample "T"
Slika 8: Oblika kremenovih zrn v vzorcu "T"; povečava 50-kratna

Microscopic investigations have shown that the grain shape of examined of quartz sand was mostly irregular and angular (**Figure 5, 6, 7, 8**). In **Figures 9** and **10** the dependence of compressive strength and softening temperature on feldspar content is demonstrated. The amount of present feldspar in quartz sand samples was not determined quantitatively and as measure of the feldspar presence the reflex intensity ("peaks") and surface size under "peaks" expressed in relative units are used (**Table 3, Figure 1, 2, 3** and **4**).

Table 3: Relative feldspar content in quartz sand samples

Sand sample	Relative feldspar content F_t
"D.B.R."	6
"R"	7
"V"	3
"T"	0

The obtained results demonstrate a linear dependence of compressive strength and softening temperature on relative feldspar content in quartz sand. For all established dependences the regression analysis with the first grade polynome, of the form:

$$y = a_0 + a_1 x$$

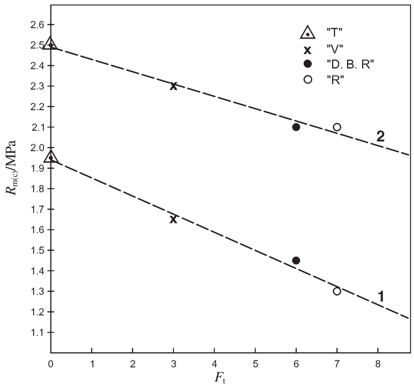

Figure 9: Influence of the relative content of feldspar on compressive strength of quartz moulding sand, 1. hot compressive strength; 2. cold compressive strength

Slika 9: Vpliv relativne vsebnosti glinenca na tlačno trdnost kremenovega peska za forme, 1. trdnost v vročem; 2. trdnost v hladnem

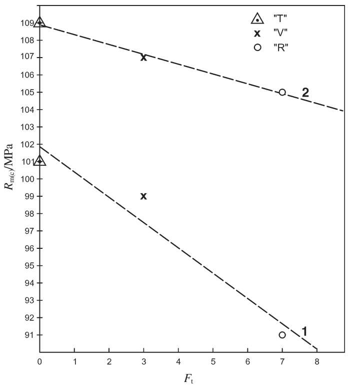

Figure 10: Influence of the relative content feldspar on softening temperature of quartz moulding sand, 1. without scale; 2. with scale

Slika 10: Vpliv relativne vsebnosti glinenca na temperaturo zmehčišča kremenovega peska za forme, 1. z dodatkom škaje; 2. brez dodatka škaje

was performed with the level of regression expressed by the correlation coefficient r^2. In this way, for the dependence of hot compressive strength (MPa) on feldspar content (rel. units) in sands, the following expression was obtained:

$$R_{m(h)}=1.9408 - 0.0883x;\ r^2 = 0.9882$$

For the dependence of cold compressive strength, $R_{m(c)}$/MPa on feldspar content x (relative unit), the following relation was obtained:

$$R_{m(c)} = 2.4900 - 0.0600\ x;\ r^2 = 0.9818$$

For the dependence of softening temperature t/°C on feldspar content (relative units) for coated sand without scale the following relation was deduced:

$$t_{soft} = 101.86 - 1.4595\ x;\ r^2 = 0.9382$$

and for coated sand with scale addition:

$$t_{soft} = 108.89 - 0.5676\ x;\ r^2 = 0.9932$$

These relations show a significant influence of feldspar content in quartz sand on hot and cold compressive strength and softening temperature of sand mixture samples. With the increase of feldspar content in quartz sand, hot and cold tensile strength and softening temperature decrease, while with the addition of scale, the softening temperature increases. All the deduced dependences have very high coefficient of linear regression of 0.9382 to 0.9932.

4 CONCLUSION

The aim of this work was to determine the influence of feldspar content in different types of quartz sand on properties of moulds and cores mixtures. Based on experimental findings, correlations for the influence of feldspar content in quartz sand on quality of casting mixtures for moulds and cores were deduced demonstrating a direct dependence of hot and cold compressive strength and softening temperature of casting mixtures on feldspar content in coated quartz sand.

5 REFERENCES

[1] M. Krgović, M. Lalović, N. Blagojević, *Journal of Metallurgy*, 3 (**1999**), 237–243

[2] A. Patarić, S. Marković, Z. Gulišija, *Journal of Metallurgy*, 2 (**1998**), 159

[3] Lj. Trumbulović, Z. Aćimović, Z. Popović, S. Tripković, A. Ćitić, *Foundry*, (**1996**) 1–2, 22

[4] J. Griffiths, *Industrial minerals,* 272 (**1990**), 35

[5] M. M. Krgović, Ž. K. Jaćimović, R. Zejak, *Tile* & *Brick Int.,* 3 (**2001**), 178–181

[6] W. E. Brownell, *Structural Clay Products,* Vienna, New York, Springer-Verlag, 1976, 130

[7] M. Branković, *Technology Casting Moulds,* TMF, Belgrade, 1982, 229