INDUSTRIAL TRIALS FOR THE "STRUPETZ" STUFFING QUARTZ MASS IN STEEL CASTING

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ABSTRACT

Experiments under industrial scale for using of acid stuffing mass in a 2.5 tone induction furnace located in ZTM Russe have been carried out. The mass originates from the white variety of quartz from the Strupetz deposit. The stuffing mass has been sintered according to the method of pot forming based on the SS221 and SS230 Swedish stuffing masses and has been used for production of steel under the brand of 25 GL. 35 L and 40 XL under discrete operation mode. The maximum temperatures reached under the different melting was 1650 – 1690 °C. The life expectation of the lining under furnace normal working conditions without technical and organisational problems was estimated between 16 and 22 melting cycles. The industrial trials are confirming the superior performance of the raw quartz material and are rendering it suitable for development of a wide range of acid-type stuffing masses for variety of furnaces and molten material **Key words:** guartzite, stuffing mass, induction furnace, steel casting.

INTRODUCTION

Following a detailed and time consuming investigations under lab-scale conditions upon different SiO₂ rich materials the acid-type stuff mass has been developed based on the white variety of quartzite deriving from the Strupetz deposit (Kuzev, et al. 1984). The stuffing mass has been tested under industrial conditions in CHLK Ihtiman in direction of formation of a crucible for the 10 tone induction furnace. More than 100 different molten forms were developed from the Strupetz mass under extreme parameters such as:

- fusion of Ni and Cr doped cast iron;
- metal overheating up to 1600 1650 °C;
- keeping the molten metal under temperature above 1600
 ^oC in the furnace from 3 to 5 hours before its forming etc.

Following crucible destruction it has been established its linings were partially weared (Kuzev, et al. 1987). This favourable results suggest that there are suitable materials of local origin with whose characteristics differ negligibly from those of the most frequently used masses manufactured by the Forshammer Group. This company offers acid-type stuffing masses developed on a single-source material and used for melting of variety of metals in temperature ranges from 1200 to 1700 °C. The development of a similar masses on the bases of local virgin material presents a challenging and serious task. Regardless of the good lab scale results for the Strupez material, their confirmation under industrial scale provides and added incentive. Stainless steel casting processes are aiming the most difficult ones regarding the stuffing masses, therefore it was decide to test the Strupez material under these conditions.

INDUSTRIAL TESTING

Industrial trials for the Srupez mass have been carried out in the blend melting section of the ZTM Russe on furnaces which originally are working with imported stuffing masses. Table 1 summarises the main characteristics of the principal imported stuffing masses used by that company.

Furnaces characteristics

The induction furnaces used during the experiments were N 3 and N 4, type MPG - 2500 manufactured by AEG ELOTERM. Maximum furnace power - 2000 kW. Their capacity based on molten metals for a single melting was 2500 kg. Furnace dimensions are:

- crucible light diameter 650 mm;
- crucible wall thickness 136 mm;
- crucible height 1400 mm.

The quantity of stuffing mass required for a single lining was 1.4 m³. The average duration of a melting cycle was According to the technical project guidelines N 3012, 16 melting cycles for a single quartzite lining for cycle duration of 90 minutes are presented in p. 3.2.4. 90 min.

"Strupez" stuffing mass characteristics

The stuffing mass was produced on the basis of the white quartzite variety of Strupez deposit, which deposit is a principal source for production of dynase refractors. Quartzite is characterised by fine grained structure and non-oriented solid structure. Limonite is met upon its micro cracks. Quartzite is presented by rounded grains having mean size of 0,44 mm (from 0,102 to 0,159 mm). The method for material preparation is described in Kuzev and Stoev, 1985. The

material taken from the ZTM Russe is characterised by the following parameters: moisture – 0.3%, refractoriness 1730 $^{\circ}$ C, density – up to 2,65 g/cm³, SiO₂ - 97,76 %, Al₂O₃ - 1,1 %, Fe₂O₃ - 0,8 % and ignition losses - 0,2 %.

Doromotor	Stuffing mass type			
Faiaillelei	HFP	Rodacorit	Silica mix	
Stuffing mass N	SS 221	SS 625	SS 230	
SiO ₂ content, %	98,00 %	13,00 %	98,00 – 99,00 %	
Al ₂ O ₃ + TiO ₂ content, %	0,3 - 0,6 %	85,00 %	_	
Grain size , mm	0 - 4	0 - 6	0 - 4	
Maximal operating temperature, ºC	1700	1550	1650	
Application	Carbon stainless- steel, Ni-hard, Cr alloys	Bronze	Cast iron, Carbon stainless- steel	

Table 1. Characteristics of the imported stuffing masses

Pot stuffing and sintering

The stuffing mass was processed manually by hand magnet for metallic iron rejection by layering into thin film and zigzag moving of the magnet above the layer. About 10 % are removed from the thus cleaned mass, which are homogenised several times with boric acid for 500 kg portions. After the proper homogenisation mixing with the whole mass follows, while for every 10 paddles form the stuff one is from that part which has undergone boric acid homogenisation. The procedure is performed triple to ensure good mixing. Pot stuffing starts from the bottom of the furnace while every care is taken in order to prevent the mass to be at maximum height of 500 mm in order to avoid size segregation. Layer processed without boric acid is placed at about one third of pot filling. The height of the following layers vary from 60 to 80 mm having boric acid content form 0,8 to 1,2 %. The total height is about 20% above those prescribed by the producer. Final densification is accomplished by vibrational studding device. It is placed by means of a crane. After removing of the vibrator the upper surface is levelled and the upper layer is skimmed out. The bottom is also levelled and flattened. A metallic standard cylindrical shape device is used for wall formation. It is placed axially at equal distances to the inductor. It is fixed from outside in 3 points at 120°. The bottom is filled in with ferrous scrap. Layers having 50 to 70 mm height are thus formed. Each single layer is pressed for ca 2 - 3 minutes after introducing in a new layer. Final pressing is done by e special vibration device for 8 - 10 minutes. Stuffing mass presenting a mixture of 1.5 % boric acid and 6-8 % liquid Na silicate "liquid glass" is used. The final height of the pot walls is 30 to 55 mm above the upper part of the platform. Levelling id accomplished after final sintering. The aim of the stuffing id to reach good air decompression and density of 2,0 - 2,5 kg/dm³, at which a ceramic body is formed which is able to resist the liquid metal.

Linings sintering is done owing to the working diagrams used of the Swedish quartzite. Temperature was kept constant

for certain time under the Fener critical values for quartz phase transformations. Heating rate does note exceed 120°C/h. After melting of the blend which is about 2500 kg a temperature of 1600 °C is reached, keeping it for ca 50 minutes. Immediately before pouring temperature is increasing up to 1685 °C.

EXPERIMENTAL RESULTS

The investigation was performed at furnaces N 3 and 4 in due course of several months in an alternative mode of using Strupez and imported masses. Table 2 presents the technological results from several successively sintered pots with Strupez mass as well as the reasons for rejection and destruction of the furnace N 3 pot.

Table 2. Technological results from pots sintering for furnace 3 with Strupez mass and imported stuffing masses

Nº	No of melts	Type of stuffing mass	Molten metal type number	Max. temperature of overheating, °C	Reason for pot rejection	
1	12	SS 221	35L –1, 25GL –11	1670	Interrupted regime	
2	13	SS 221	25GL- 13	1675	Interrupted regime	
3	14	SS 221	35L - 14	1670	Interrupted regime	
4	13	SS 221	25GL - 13	1660	Interrupted regime	
5	2	Silica mix	40HL –1, 25GL- 1	1700	Interrupted regime	
6	22	Strupez 1	25GL - 22	1690	Interrupted regime	
7	16	Strupez 1	40XL – 1, 25GL - 15	1670	Interrupted regime	
8	17	Strupez 1	35L - 3; 40XL - 2; 25GL - 12	1680	Interrupted regime	

Similar results from furnace N 4 are presented at Table 3.

Table 3. Technological results from pots sintering for furnace No 4 with Strupez mass and imported stuffing masses

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N	No of melts	Type of stuffing mass	Molten metal type number	Max. temp. of over- heating, °C	Reason for pot rejection	
1	22	SS 221	35Л - 15; 25ГЛ - 5; 45Л - 2	1650	Interrupted regime	
2	10	Strupez 1	35Л - 3; 45Л - 3; 25ГЛ - 4	1680	Metal cooling inside pot	
3	11	SS 221	25ГЛ - 10; 45Л - 1	1650	Interrupted regime	
4	4	SS 625	35Л - 4	1690	Non-suitable stuffing mass	
5	7	SS 625	25ГЛ - 4; 35Л - 3	1980	Non-suitable stuffing mass	
6	4	Strupez 1	25ГЛ - 2; 40ХЛ - 2	1670	Molten metal boiling for more than 1 hour	
7	13	Strupez 1	40ХЛ - 5; 25ГЛ -8;	1670	Interrupted regime	
8	7	Strupez 1	25ГЛ — 7	1665	Polluted with carbonate stuffing mass	
9	16	Strupez 1	25ГЛ - 16	1670	Interrupted regime	

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At Table 4 data from the melting map for the performed melting of lining 2 from Table 3 sintered with Strupez material are presented. For melt No 9 after melting of the bled the furnace has been switched off in emergency. The metal remained inside the furnace for 6 hours. Openings were drilled in the cooled metal and are poured about 800 kg metal. At the following day the metal was melted and formed. Upon pot inspections cracks in length up to 200 mm and width 1 mm were detected. A melt No 10 was done. Following its accomplishment further increase in crack size was noticed. Further two melts were done which were not noted at the map. During the second melting the furnace is switched of in emergency again. The following pot inspection has led to its rejection.

Table 4. Data for the melting performed with pot N 2 sintered from Strupez mass shown at Table 3

N Time мin.	Max.	Type of	Lining status		Mass of	
	Time мin.	temp. of overheati ng , ºC	molten metal	Walls	Bottom	molten metal
1	120	1680	45Л	New	New	2500
2	120	1685	35Л	Good	Good	2500
3	120	1673	35Л	Good	Good	2500
4	150	1676	35Л	Good	Good	2000
5	240	1678	45Л	Good	Good	2500
6	180	1680	25ГЛ	Good	Good	2500
7	210	1683	25ГЛ	Good	Good	2500
8	120	1680	25ГЛ	Good	Good	2500
9	120	1683	25ГЛ	Good	Good	2000
10	120	1690	45Л	Cracks	Cracks	2500

The following deviations from the technological requirements which have led to faster rejection of pot 2 were established during the experiments

- a) discontinuous working mode, i.e. the furnace has been cooled down to ambient temperatures 8 times before the emergency shut down in melting No 9.
- b) keeping of overheated material at temperature above 1670 °C, above which material mobility is intensive and pot wearing is increased
- c) increasing melting time in 30-50 % average, and for one of them 2,5 times;
- d) pot filling in with scrap non-suitable for furnace dimensions. When coarse scrap is fed in the pot mechanical damages to pot lining occur.

DISCUSSION

The Strupez quartzite stuffing mass tested under industrial condition on ZTM Russe is comparable in exploitation parameters to the imported similar materials type SS 221, SS 230 and others. The Strupez stuffing material is based on quartzite by-product. It derives from a range of acidic quartzite masses finding various applications for the induction furnaces. The hard industrial trial are confirming the feasibility of using Strupez mass in direction of production of acid-type stuffing. The most commonly met defects could be attributed to:

a/ furnaces feeding with scrap having dimensions larger than the required ones;

b/ exceeding the melting time duration – melting for 90 min., followed by pouring of 1/3 to $\frac{1}{2}$ of the molten metal, scrap adding and further pouring of part of the metal or the whole pot. Thus the molten metal is in practice 4 – 5 tones for 270 – 360 min, while at the temperature map only one melting with duration more than 180 min is indicated.

The lack of proper organisation and planning is leading to necessity of interruptions leading to non-steady temperature regime. This is leading to high energy consumption and to pot destruction. Stresses and micro cracks are thus formed resulting in further deformations. The data presented at Table 2 and 3 suggest the following:

- a) the Strupez quartzite mass seems robust an resistive for the studied conditions – it could sustain up to 16 melting while for one of the cases 22 were achieved. Organisational problems however are leading to shortening of the cycles
- b) the imported masses have a similar technological behaviour
- c) Strupez mass sintering is accomplished according to the diagrams used for the Swedish SS 221 mass. It is known form the practice that each mass is sintered according to its individual diagram. This fact suggests that the Strupez mass has not been sintered according to the best possible scheme which takes into consideration the mineralogical compositions and the sizes of SiO₂ crystals.

CONCLUSION

The detailed industrial scale investigations of the Strupez quartzite stuffing mass developed on the basis of the white variety of quartzite has suggested that this material possesses the quality which makes it suitable for the different types of pot induction furnaces.

The comparative test method for the Strupez quartzite stuffing mass and the similar Swedish materials SS 221 and SS 230 used in cast-iron and stainless-steel production have confirmed the results obtained under lab-scale concerning their physical and physicochemical characteristics indicating similarities between both quartzite sources. The following investigation stage should aim optimisation in sintering flowhsheet and development of range different materials for each specific case.

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