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Production of thin walled compacted graphite iron castings using different moulding materials

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This article addresses the effects of six mould materials in obtaining thin walled compacted graphite iron castings with a wall thickness of 3 mm. During this research, the following materials were analyzed: fine silica sand, coarse silica sand, cerabeads, molohite and also insulated materials in the shape of spheres; including LDASC sand (Low density alumina-silica ceramic). Their thermophysical characteristics were examined, including their thermal conductivity, diffusivity and specific heat as well as their granulometric parameters. In addition, mould materials were examined by a Scanning Electron Microscope. Microstructural changes of TWCGI were evaluated by analyzing quantitative data sets obtained by an image analyzer. Moreover, the temperature profile in mould materials was determined during mould filling and metal cooling. The cooling rate of metal in the mould cavity could be effectively reduced by applying insulating sands to obtain the desired compacted graphite fraction and microstructure of thin walled castings.

Keywords: *Compacted graphite cast iron, thermal conductivity, graphite morphology, mould materials.*

1. Introduction

Compacted graphite cast iron (CGI) is an alloy with attractive mechanical and thermophysical properties [1-5]. Moulding materials play an important role [6-9] in shaping the structure of thin walled castings. The main component of these moulding materials is the moulding sand matrix-mostly quartz and, in the case of the regeneration process, the reclaimed sand. In published literature, there is limited data [3,10] concerning production and the shaping of the structure of thin walled compacted graphite iron castings using different moulding sand matrixes.

2. Experimental

The chemical composition of the investigated iron was: C = 3.60%, Si = 2.65%, Mn = 0.02%, P = 0.02%, S = 0.01%, Mg = 0.02%. The pouring temperature was approximately 1400°C. Experimental castings applied in investigations were test blocks, according to the ASTM A 536-84 Standard, with plate section sizes of *g*=3 mm at the bottom end.

Six casting moulds were made of moulding sands marked with symbols: **S-1** through **S-6** (**S 1** – fine silica sand, **S 2** – coarse silica sand, **S 3**– microspheres, **S 4** – Cerabeads, **S 5** – LDSC sand and **S 6** – Molohite). All tested moulding sands were prepared with a water glass M145 binder with flodur hardener.

3. Results and discussion

3.1 Granulometry and SEM-EDS analysis

Granulometry and SEM-EDS analysis indicate that the smallest value of the average particle diameter, and the largest surface area were attained for S 5 sand. SEM studies showed that most of the sand grains from an S 5 and S 3 population have a regular - spherical shape. Moreover, from SEM observations follows that both sands, namely S 3 and S 5 represents spheres, which are empty inside.

3.2 Thermal analysis

On the basis of the actual temperature curves, it follows that the insulating molds (S 3, S 5) have favorable thermophysical parameters from the point of view of heat accumulation. This manifests itself in obtaining a much higher maximum temperature at the selected measuring points. The result of this would be a much lower cooling rate of metal in the mould cavity.

3.3 Thermal Conductivity

The behaviour of mould based on coarse silica sand (S 2) indicates high instability of its thermophysical properties as compared to other moulds. In the case of a mould–based on fine silica sand (S 1) a similar instability, though to a much lesser degree, is visible. High values of thermal conductivity of S 4 leads to low thermal resistance (defined as the ratio of the mould thickness to thermal conductivity), thereby favouring a higher cooling rate of the metal in this mould cavity. However, in the case of insulation moulds (S 3 and S 5), the highest values of thermal resistance (approximately 6 times higher compared to cerabeads, S 4) was attained, which significantly slows down the cooling rate of casting.

3.4 As-cast Microstructure

Figure 1 shows the exhibited microstructures found in thin walled castings obtained in different moulds.

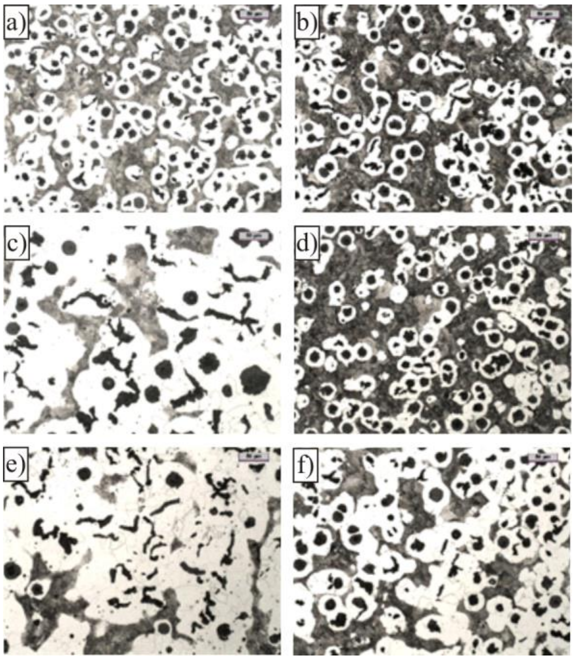

Fig. 1 The exhibited cast iron microstructures for castings with a wall thickness of 3 mm received in moulds: a) S 1, b) S 2, c) S 3, d) S 4, e) S 5 and e) S 6. Nital etchant used, mag. 200x

Thermophysical properties of moulding materials clearly show that the use of insulation sands (S 3, S 5) significantly affect values of thermal resistance, which slow down the cooling rate of metal in the mould cavity significantly. It has been reported [10] that when LDASC sand is used as a casting mould instead of silica sand, the cooling rates in thin walled castings with a 2 mm wall thickness decrease 5 fold. Compacted graphite as well as ferrite fractions are effectively increased, by employing insulating moulds (S 3, S 5).

It is recommended that this research be continued in terms of the heat transfer, reactions on the interface of the metal-mould and finally the surface quality. This data would assist in the effort made in the validation of the production of thin walled castings, where high dimensional accuracy of moulds is required. Moreover, as a result of large changes in the cooling rate in thin wall castings -may appear chill, misrun and cold laps.

4. Conclusions

Thermal data indicates high instability of thermophysical properties of moulds based on coarse silica sand. In turn, thermophysical properties of insulating sand (S 3, S 5) show high stability of thermophysical properties and low thermal conductivity (high thermal resistance) in the entire investigated temperature range. Studies have shown that moulds made with insulating sands possess thermal conductivity on average to be more than five times lower compared to those of silica sand. Metallographic examinations of thin-walled castings indicate a significant impact of various moulding materials in their microstructural formation. When using moulding materials S 3, S 5, ie. insulating moulds, it is much easier to get higher compacted graphite as well as ferrite fractions.

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