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Correlation Between Surface Roughness and Rheological Properties of Liquid Ductile Cast Iron

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Abstract

The investigation of filling process of ductile cast iron flow in sand mould was showed the correlation between casting roughness surface and rheological properties of metal. Evidently of castings surface roughness was state of distance, from a few to a dozen diameters of vertical channel inlet. The method of rod fluidity test permit to study of rheological properties of metal and the roughness surface of castings.

Keywords: Ductile cast iron, Rheological properties, Roughness surface

1. Introduction

The roughness surface of casting are arising as results of unevenness of sand moulding. Casting surface layer contains the metal-ceramic and metal layer underneath. The metal – ceramic layer was formed by chemical reaction of liquid metal and sand mould in zone of boundary layer, during of pouring, self-cooling and solidification [2, 7, 9].
To examine roughness of castings surfaces according to rheological properties of liquid metal, in the modifier rod fluidity test were made. The rod fluidity test consist in filling of liquid metal for a lot vertical channels which there are in equal distance from pouring gate [1, 4, 5, 8].

2. Analysis of ductile cast iron in test castings

The rod fluidity tests made in green sand mould with the bentonite bond. The green sand moulding by hand has been consolidated. The heights of middle metallostatic pressure was about 0,4 m. The sand moulds hand were pouring of spheroidal graphite iron with various temperatures and various chemical elements (table 1).

Table 1.
Wt. per cent participation of chemical elements in castings of spheroidal graphite iron

% C	% Si	% Mn	% P	% S	% Mg	% Ce
3,67	2,66	0,221	0,048	0,014	0,046	0,010
3,68	2,61	0,224	0,049	0,016	0,051	0,011

The degree of eutectic saturation ratio for research spheroidal graphite iron have value about 1,09.
Microstructure of research rod before macroetching on fig. 2 has been showed.

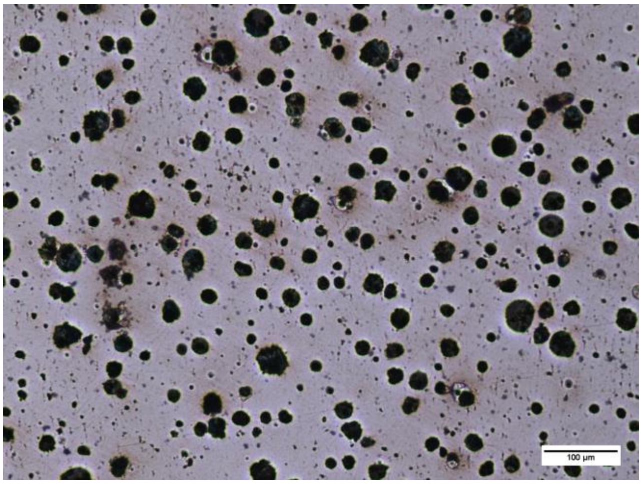

Fig. 1. Microstructure of spheroidal graphite iron bar before a macroetching

The section in middle part of roller simple before macroetching rool was showed speroidal graphite shapes with diameters from 10 to 40 µm.

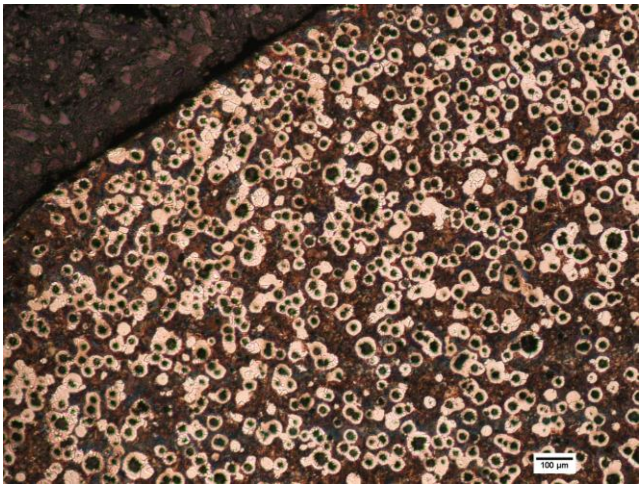

Fig. 2. Microstructure of simple surface of spheroidal graphite iron bar after macroetching

Microstructure of simple surface iron bar after macroetching with pearlite matrix and ferrite releases in round of spheroidal graphite (fig. 2).

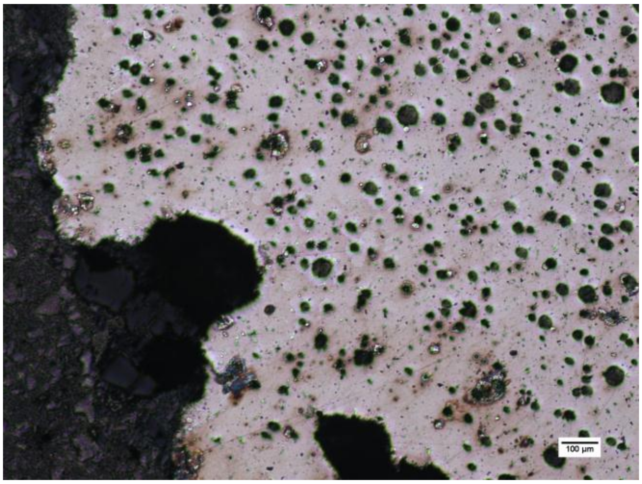

Fig. 3. Microstructure of roughness surface simple section of spheroidal graphite iron

Microstructure of roughness surface simple section of rod spheroidal graphite iron has been showed, on fig. 3. The spheroidal graphite releases there are in distance about 100 µm from edge sample.

3. Description of achieved results of own researches

The investigation of rod fluidity test of spheroidal graphite iron in sand mould has been showed the depend of the casting roughness surface with height vertical rods.

Fig. 4. The rods of fluidity test of spheroidal graphite iron, pouring temperature 1591 K (1318^{0}C)

The investigation has been showed, that casting rods have a various roughness surface for all height, fig. 4, 5, 6, 7 and 8.

Fig. 5. The rods (φ 6 mm) of fluidity test of spheroidal graphite iron, pouring temperature 1591 K (1318^{0}C)

Evidently casting roughness surface was in inlet zone to the channel in distance, from a few to a dozen of diameters.

Fig. 6. The rods of fluidity test of spheroidal graphite iron, pouring of temperature (131 3^{0}C) 1586 K

Especially big casting roughness surface in inlet zone to the channel can to be caused by turbulence of stream. The maximum velocity of stream were of inlet of channel and decrease with of lessen metallostatic pressure. Besides on the casting roughness surface there are the knops, which are of local deformations. Knops created in sand mould then, that of part sand moulding is an insufficient consolidated. The depends of casting roughness surface with diameter of rod has been showed on the fig. 6.

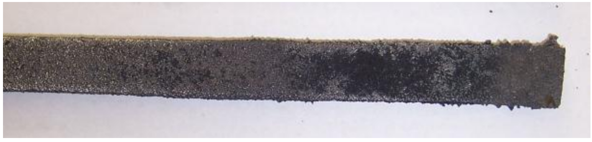

Fig. 7. Rods (of rectangular section) of fluidity test of spheroidal graphite iron, of temperature pouring (1318^{0}C) 1591 K.

The rods of rectangular section the most casting roughness surface has been showed in inlet to channel and systematic decreased with of metallostatic pressure decrease, fig. 7.

Fig. 8. The rods (of dimension φ 4 mm and φ 3,3 mm) of fluidity test of spheroidal graphite iron, of temperature pouring (1368^{0}C) 1641 K.

The investigation of spheroidal graphite iron flow in sand mould has been showed of depend influence of rheological properties of metal with the casting roughness surface.
Evidently of castings surface roughness was state of distance a few diameters from vertical channel inlet.
The values of substitute rheological parameter Θ was calculated from formula (1) with dimensions of bars of fluidity test which in research has been obtained [3].

$$\Theta = \frac{\delta_R \cdot \sqrt[4]{h}}{0{,}672 \cdot \sqrt{l}} \tag{1}$$

where:
δ_R – thickness of boundary layer of metal, m,
h – height of metallostatic pressure ,m,
l – length of channel, m.

In calculation results of values of substitute rheological parameter Θ of spheroidal graphite iron, for described temperatures, has been obtained, table 2. The heights, diameters of rods and parameter Θ depends also from super cooling [3, 6].

Table 2.
Values of substitute rheological parameter Θ of spheroidal graphite iron

signify of sample	Diameter of rod [mm]	Sc	T_z [K]	Θ m/$\sqrt{s}$
ZsOD 1/2011	4	1,047	1641	0,0035
ZsOD 2/212	4	1,047	1591	0,0043

The small sand strength, high temperature liquid metal and long time of pouring are the factors conductive to the sand buckle formation. Moreover, long time of pouring causes that superheated liquid metal strongly heats the top surface of cavity niche.
The swell of the mould is distinct deformation of casting surface. The reason of swell of the mould can be the little compression strength of sand moulding wall with the metallostatic pressure.

4. Conclusions

1. The method of rod fluidity test permit to study of rheological properties of metal and the roughness surface of castings.
2. The surface roughness of casting spheroidal graphite iron in sand mould depends with of rheological properties of metal.
3. Evidently of castings surface roughness was state of distance, from a few to a dozen diameters of vertical channel inlet.

Acknowledgements

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