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Ductile cast iron obtaining by Inmold method with use of LOST FOAM process

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Abstract

The possibility of manufacturing of ductile cast iron castings by Inmold method with use of LOST FOAM process was presented in this work. The spheroidization was carried out by magnesium master alloy in amounts of 1% casting mass. Nodulizer was located in the reactive chamber in the gating system made of foamed polystyrene. Pretests showed, that there are technical possibilities of manufacturing of casts from ductile cast iron in the LOST FOAM process with use of spheroidization in mould.

Keywords: Ductile cast iron, Inmold method, LOST FOAM process, Innovative foundry technologies

1. Introduction

Attempt of connection of two well-known processes applied in founding was introduced in the work; cast iron spheroidizing process within the mould (inmold method) and production process of castings in the lost foam process.

The method of the production of ductile cast iron is known from 1948. Initially, its consisted in the addition of the nickel and magnesium alloy to the open ladle, then pure magnesium, and at present often special nodulizers FeSiMg - masters alloys.
Introducing magnesium to cast iron leads to many problems mainly resulting from its properties. It is connected with [1]:

- Boiling point of the magnesium is 1107 ^{o}C; in connection with the high temperature of liquid cast iron (about 1500 ^{o}C) the vapor pressure of magnesium is high, what conducts to violent evaporation and can even lead to throwing out liquid cast iron from the reservoir during the modification in open ladles,
- Low density of magnesium (1,74 g / cm^3) in the relation to cast iron (about 7,3 g / cm^3). This results in his floating on the surface of liquid cast iron reducing the effectiveness of the modification.
- High affinity to oxygen. Magnesium creates the oxides MgO which during the modification have the form of the white and thick smoke causes pollution.
- • Low ability to dissolves in liquid as well as in solid state of cast iron; dissolution of even small quantity of (0,04 Mg) in liquid cast iron is difficult.

For the most known and widespread methods of cast iron spheroidization process belongs: spheroidization process carrying out with open ladles and sandwich methods [1, 2]. Recommended height of open ladle should be at least two times more than its diameter to increase of Mg yield. Then introduced ladles with Tundish cover type [3]. Spheroidization process can be carrying out with use of pure Mg by immersion method or in converters. For the modern methods of spheroidization could be included cored wire process [2, 4].

An innovative spheroidization solution is Inmold method developed in Great Britain in 1970 [5, 6, 7]. Inmold method possess many advantages:

- the high magnesium yield upper to 90%,

- the lack of smoke and shine,
- easy of automation

Some limit of this method is the cast size. In practice this method can be apply for 50kg mass casts of ductile cast iron. Location in gating system reaction chamber and mixing chamber in parting plane of mould decrease of number of casts. Therefore seems to be reasonable appliance of spheroidization by this method in LOST FOAM process where such limits do not exist because in this method there is no parting planes.

The great interest in the Lost Foam technology was mainly due to a definitely lower cost of castings manufacture and financial outlays very encouraging when compared with the traditional process [8, 9, 10].

Respective of the traditional casting process using standard moulding sands, this novel technology offers a number of undeniable advantages, including also the following ones:

- significantly lower costs of the production
- it is possible to reproduce holes in castings without the necessity of using cores,
- the lack of parting planes and drafts improves in a natural way the dimensional accuracy of castings and reduces the number of operations necessary for casting fettling and finishing,
- the use of pure sand instead of moulding mixture eliminates the effect of moisture causing casting defects, with an extra advantage of cheaper sand reclamation,
- less of foundry tooling and equipment is needed (no moulding machines, mixers for moulding sand, etc.)
- lower labour input in final fettling operations due to the absence of flashes, burn-on defects, etc.

Many factors have an influence on the quality of casts made by this technology among other things: density of foamed polystyrene from which its the strength depends of the pattern and the quality of its surface; the kind of sand, and in the peculiarity its permeability, and refractory coating applied on the pattern which makes the working surface of the mould. This coating allows to obtain a necessary quality of cast surface and prevents metal penetration inside the sand grains.

The preliminary investigations of the production of casts in the process Lost Foam from ductile cast iron received the inmold method were introduced below.

2. Research methodology

In the laboratory of Department of Materials Engineering and Production Systems at Technical University of Lodz researches concerning production process of the casts from ductile cast iron by the Lost Foam method with the spheroidization in the mould are conducted.

Pattern set consisting of the pattern of experimental cast, ingate, reaction chamber, sprue with pouring basin was made from foamed polystyrene of the density $\rho = 20\ kg/m^3$.

The suitable quantity of nodulizer was located into reactive chamber. So prepared pattern set was coated by Ashland's refractory coating - KERNTOP Z85. After drying of the refractory coating, fill up the pattern set by dry sand without binder and compact by the pneumatic vibrator. Cast iron was melted in 30 kg induction furnace of 15000 Hz. For cast iron melting Norwegian pig iron OB (the chemical composition is shown in Table 1) and St3 scrap-steel were used. Silicon content was supplemented FeSi75 ferrosilicon.

The magnesium master alloy was applied to the spheroidization, in the quantity 1% mass of the cast iron which composition was showed in table 2. Cast iron pouring temperature was 1450 ^{o}C. Cast iron to the reaction chamber was lead from the top, and draining from the bottom. Filling of the cavity of the mould was realized from the bottom. The scheme of the gating system with experimental casts A and B was showed on fig . 1. The places of which the samples were cut out to the definite of microstructure were marked dashed line.

Table 1.
The chemical composition of Norwegian pig iron OB

Chemical composition, %				
C	Si	Mn	P	S
3,94	1,09	0,015	0,023	0,004

Table 2.
The chemical composition of magnesium master alloy

Chemical composition, %				
Si	Mg	Ca	MZR	Al
40,0 – 49,0	3,0 – 6,5	0,3 – 1,0	0,4 – 1,4	0,5 – 1,2

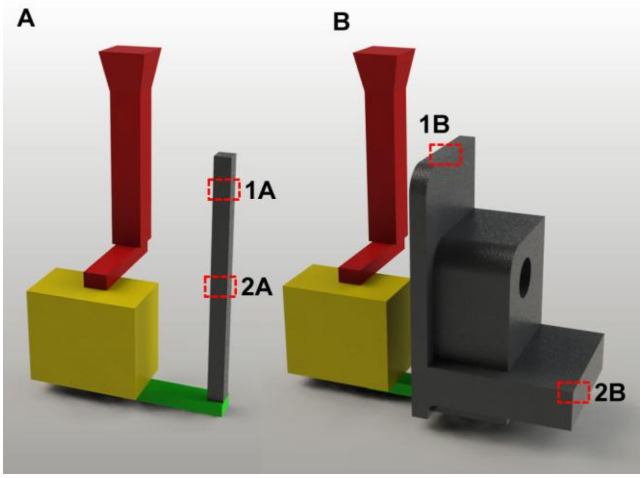


Fig. 1. The scheme of the gating system with experimental casts A and B; the places of cut of samples to the investigations of microstructure were marked dashed line

After filling of the mould and cooling the cast, the moulding sand (dry sand without the binder) fluidized in the mould, what enabled to easy removal of the cast. Samples predicted for microstructure investigations were cut out from places presented in the fig. 1.

3. Results

Results of investigations of two different casts made of ductile cast iron obtained by Inmold method with use lost foam process were introduced in the paper. One of the cast has the shape of quadratic prism with a small mass - the cast A and second with more complex shape and thicker walls - the cast B. Cast iron microstructures of cast A is shown in figures 2 and 3. Nodular graphite was got in the cast, what means, that can be also obtained ductile cast iron by spheroidization process in the mould in the LOST FOAM process.

a) b)

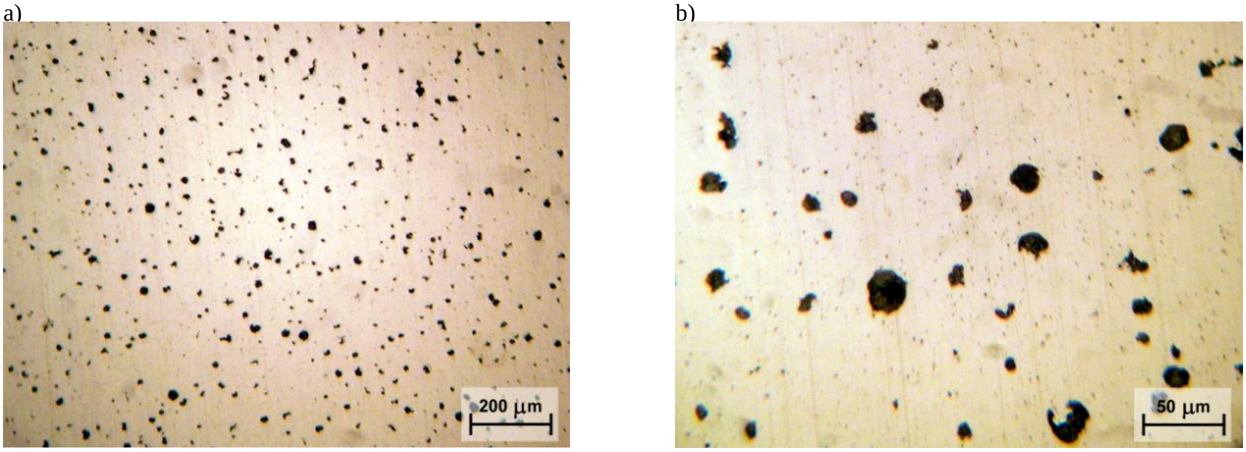
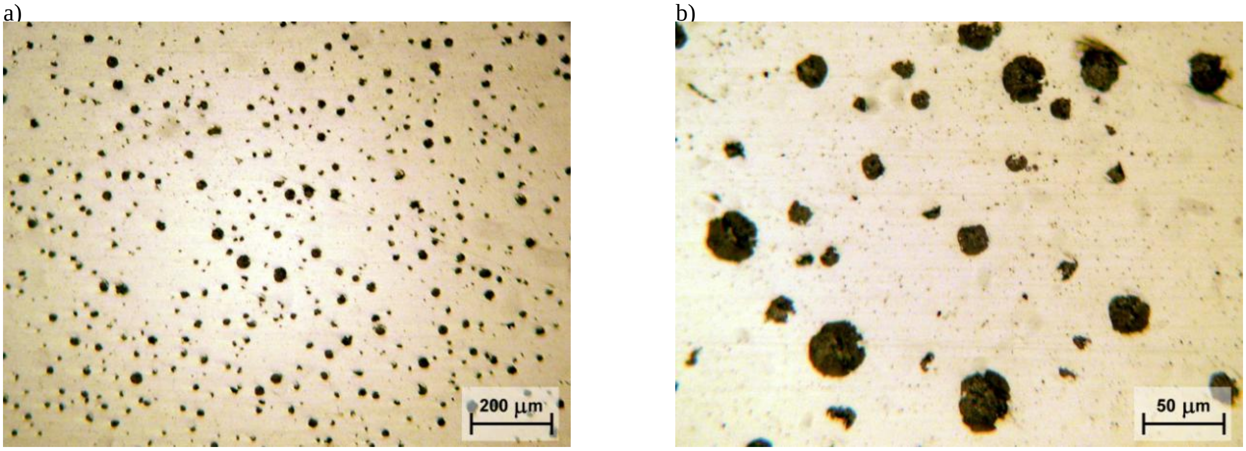


Fig. 2. The cast iron microstructure of the section 1A of the cast A a) magnification x100 b) magnification x400

a) b)



Rys. 3. The cast iron microstructure of the section 2A of the cast A a) magnification x100 b) magnification x400

a) b)

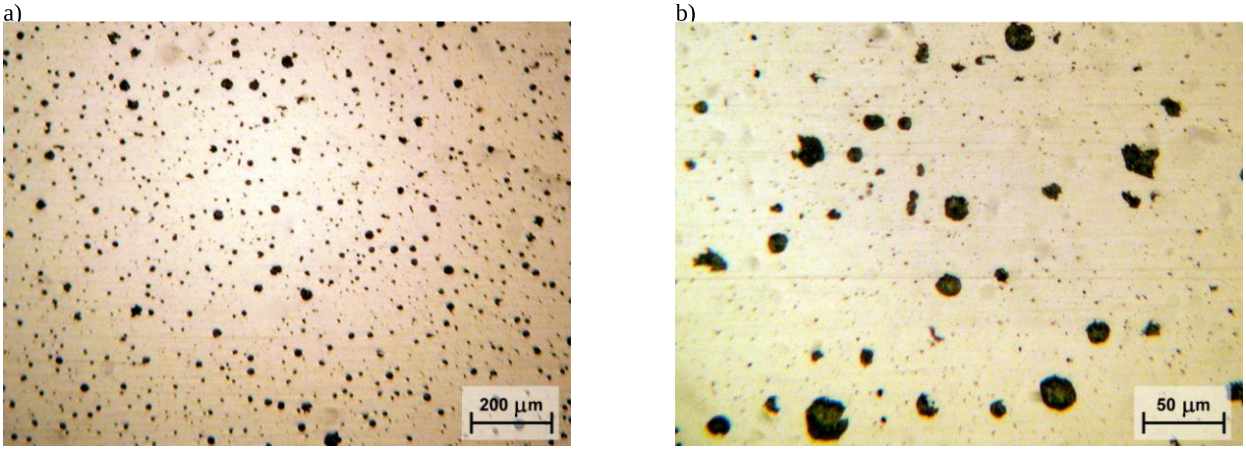


Fig. 4. The cast iron microstructure of the section 1B of the cast B a) magnification x100 b) magnification x400

a) b)

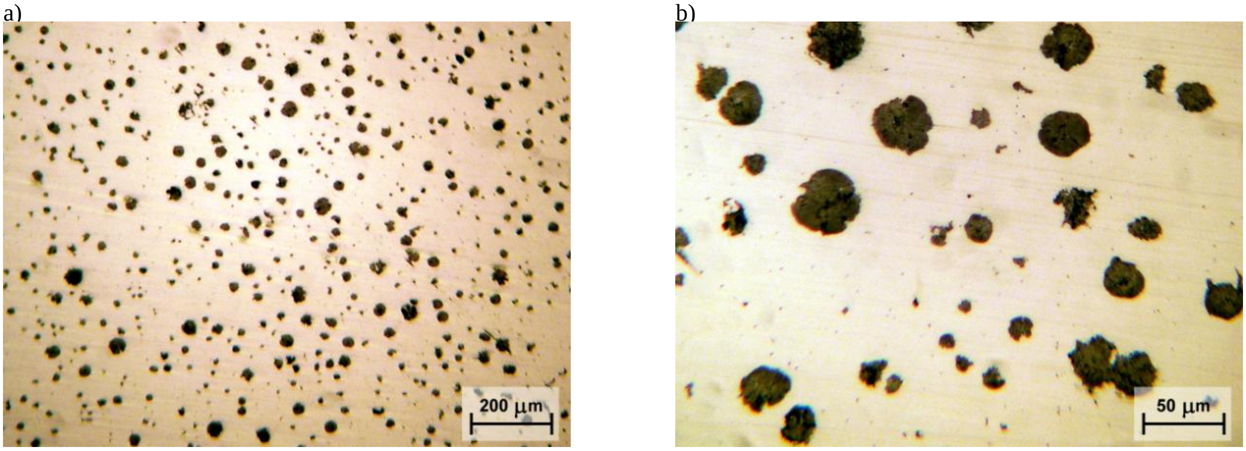


Fig. 5. The cast iron microstructure of the section 2B of the cast B a) magnification x100 b) magnification x400

By comparing the microstructure in fig. 2 and 3 and fig. 4 and 5 can be affirm that at higher casting parts (1A and 1B) graphite nodules have the smaller diameter, about 10 - 20 µm, the shape of graphite nodules is frayed. This indicates that the spheroidization will not proceed to the end. This is probably due to too short presence time of cast iron in the reaction chamber at the very beginning of flooding. The preliminary studies indicate a very important role of reaction chamber, its size and shape as well as the filling speed of mould cavity. The filling rate in mould has a decisive influence on the nodulizer reaction with liquid cast iron. Continuing research should be noted that dissolution of a nodulizer was uniform over the whole process, both at the beginning and at the end of flooding.

4. Conclusions

Introduced in this work investigations of ductile cast iron obtaining by the Lost Foam process with use of Inmold method indicate that it is appropriate to continue the work of both experimental and theoretical on this very promising technology. Bearing in mind the advantages of both the Lost Foam process and Inmold method it is believed that the technology of production of ductile cast iron castings with use of Inmold method will be an economically efficient process and technologically attractive.

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