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Investigation of thermal processes during test operation of ingot mould with composite surface layer

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Abstract

The paper presents a method of usable properties of surface layers improvement of grey cast iron EN-GJL-200 ingot mould, by put directly in founding process a composite surface layer on the basis of corundum Al_2O_3 and quartz sand SiO_2. Technology of composite surface layer guarantee mainly increase in hardness and abrasive wear resistance of cast steel and cast iron castings on machine elements. This technology can be competition for generally applied welding technology (surfacing by welding and thermal spraying). The results of studies show, that is positive influence of composite surface layer with ceramic particles on increase in life of cast iron ingot moulds.

Keywords: Cast steel, Ingot mould, Composite surface layer

1. Introduction

In the last years in machine-building industry is required a large number of castings with special properties, for example [1, 2]:
- abrasive wear resistance,
- thermal shock resistance,
- corrosion resistance.

These elements are produced from expensive and difficult to available materials. However in many cases high properties are necessary for surface layers of castings. Therefore unprofitable is founding of complete element with expensive alloy additions i.e. Ni, Cr, Mo or Ti [1÷3].

In methods of composites production on special attention deserves founding method. This technology by put directly in founding process a composite surface layer is the most economic methods of enrichment of casting surface [2, 4, 5].

Modern technologies of surface engineering are connected with manufacturing of composite surface layer on casting surface sectors, where are very difficult conditions of working. These surfaces perform technical and useful requirements and moreover increase life of casting. In case of strengthening of complete surface, favourable is founding of complete casting from highly alloyed material. Then parameters of founding technology of composite surface layer are nearly identical with manufacturing of usual casting [1÷5].

2. Range of studies

The main aim of studies was increase in life during test operation of grey cast iron EN-GJL-200 ingot mould, by put directly in founding process a composite surface layer on the basis of corundum Al_2O_3 and quartz sand SiO_2.

To preparation of composite insert following components were used:

- 92% Al_2O_3 with granularity 0,3÷0,9mm or SiO_2 with granularity 0,8÷1,6mm,
- 5% soluble glass with water in proportion 1:1,
- 3% Polko flux,
- 3 drops of flotol,

which next were put on surface of mould cavity (Fig.1).

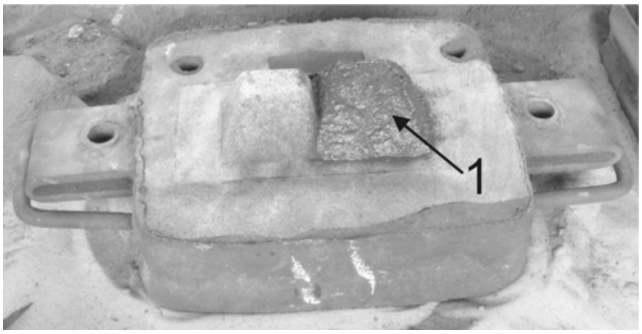

Fig. 1. View of mould cavity with composite insert - 1

In aim of assessment of quality of composite surface layer on the basis of corundum Al_2O_3 and quartz sand SiO_2 was made metallographic macro- and microscopic examinations with use of light microscopy Nikon EPIPHOT-TME with magnification from 50x to 600x. Surfaces of samples which were prepared for microstructure analysis were etched with use of Nital [6].

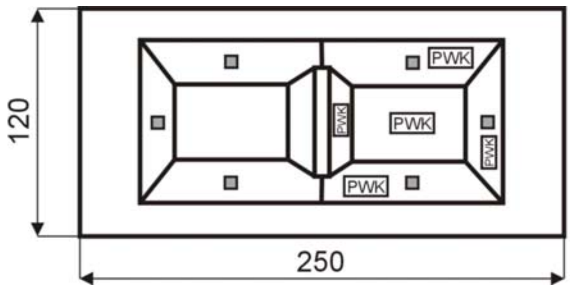

Fig. 2. Investigated ingot mould scheme: PWK – area with composite surface layer, ■ - position of thermocouple in distance 45mm from bottom of ingot mould

Degree of increase in life of ingot moulds with composite surface layer in relation to ingot moulds without surface enrichment was assessed on the basis of investigation of thermal processes during test operation.

Investigated ingot moulds were poured with use of silumin EN AW-AlSi12Cu2Fe alloy. Pouring temperature was set to 800^{o}C. Whereas preheating temperature of ingot mould before pouring was set to 100°C. After 180s from the end of pouring was pull out the ingot. Next, ingot mould was cooled in first stage with use of water-fog by 10s and in second stage in air-cooling by 120s. Next, ingot mould was poured again with liquid metal with the same time parameters. This process was repeat threefold.

On figure 2 was presented position of thermocouple in investigated ingot mould. To registration of temperature changes in time, 24 channels Cristaldigraph M24 and computer program M1lab was used.

3. Results and analysis

On figure 3 and 4 is presented view of cross-section of cast iron EN-GJL-200 ingot moulds with composite surface layer, which was put directly in founding process. Quality of surface in ingot mould with composite surface layer is comparable with quality of surface in ingot mould without enrichment.

In investigations was obtained large uniformity of composite layer. Average thickness of composite surface layers was 8mm for Al_2O_3 and 4,5mm for SiO_2.

On figure 5 and 6 is presented changes of temperature in time during test operation of investigated ingot mould.

On the basis of temperature characteristic analysis was observed, that in area of ingot mould with composite surface layer on the basis of Al_2O_3 (thermocouple T2, T4 and T6 on Fig.5) or SiO_2 (thermocouple T2, T4 and T6 on Fig.6) is slower heating and cooling in time of operation in relation to surface of ingot mould without enrichment (thermocouple T1, T3 and T5 on Fig.5 and 6).

Fig. 3. View of cross-section of cast iron ingot mould with composite surface layer on the basis of Al_2O_3

Fig. 4. View of cross-section of cast iron ingot mould with composite surface layer on the basis of SiO_2

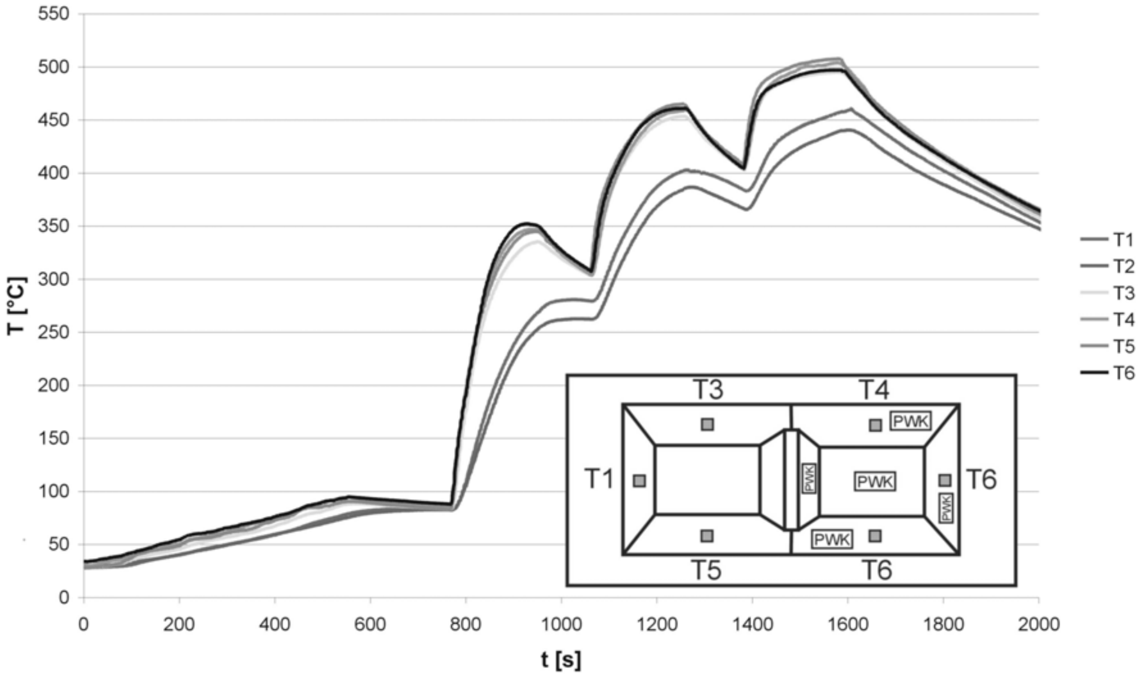

Fig. 5. Changes of temperature in time during test operation of cast iron ingot mould with composite surface layer (PWK) on the basis of corundum Al_2O_3

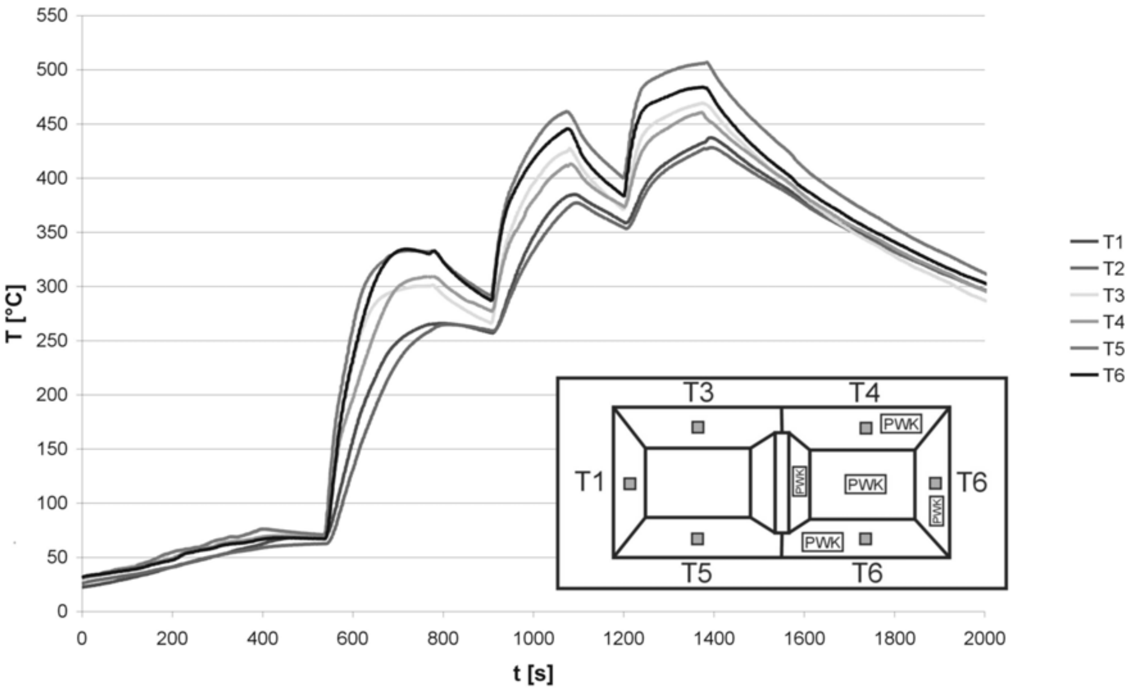

Fig. 6. Changes of temperature in time during test operation of cast iron ingot mould with composite surface layer (PWK) on the basis of corundum SiO_2

Whereas, on the basis of results of metallographic microscopic examinations was observed good wettability of composite material by liquid alloy (Fig. 7 and 8).

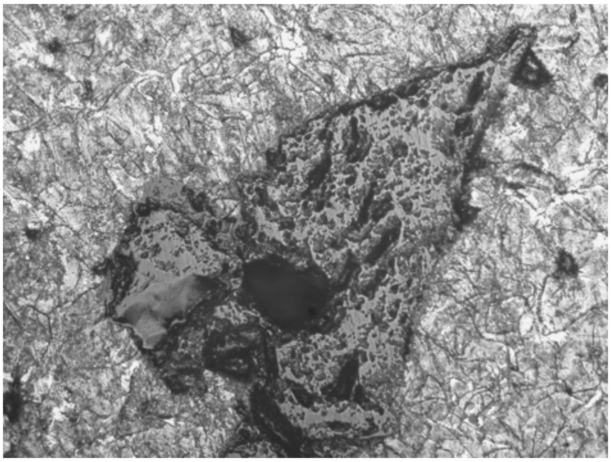

Fig. 7. Grain of Al_2O_3 in matrix of pearlitic cast iron with flake graphite – etching Nital, magnification 100x

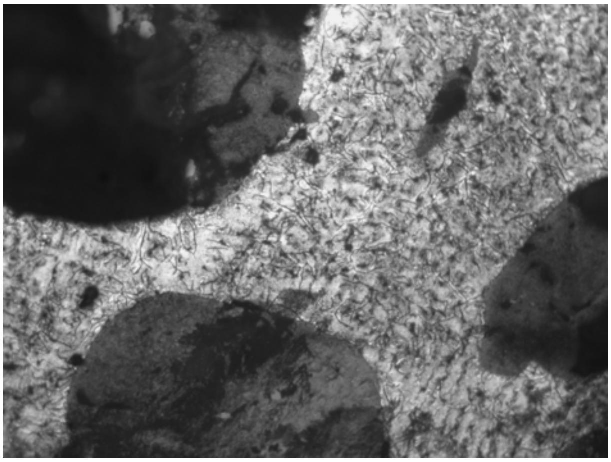

Fig. 8. Grains of SiO_2 in matrix of pearlitic cast iron with flake graphite – etching Nital, magnification 100x

4. Conclusion

Based on conducted studies following conclusions have been formulated:

1. Corundum and quartz sand are basic materials of composite mixture. Theirs use guarantee attainment of composite layer with ceramics particles and high quality of surface, which is comparable with quality of surface in ingot mould without enrichment.
2. Possibility have been shown of attainment of composite surface layer of type metal-ceramics with thickness 4÷8mm.
3. Composite surface layer on the basis of Al_2O_3 and SiO_2 improves operation conditions of ingot moulds. In first stage of process composite surface layer perform a function of non-conductor of heat. After pouring of liquid metal with temperature 800^oC composite layer brakes violent increase of temperature in ingot mould because has large heat capacity and small thermal conductivity. In consequence of this, occurs more uniform distribution of temperature and its more gradual increase than in traditional ingot moulds.
4. Investigated ingot moulds with composite surface layer possess good thermal shock resistance. Moreover results of studies forecast about twice longer time of operation in relation to traditional ingot moulds.

Acknowledgements

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