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OPTIMIZING THE NICKEL AND COPPER ADDITIONS TO ADI CONSIDERING THE CASTING COOLING RATE

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The effect of Ni and Cu additions on the mechanical properties of ADI in castings with different wall thickness was discussed. A plan of experiment was developed using a combination of Ni additions in an amount of 0.5 to 1.5% and Cu additions in an amount of 0.5 to 1.0%. The content of other elements was as follows: C = 3.3-3.6%, Si = 2.2-2.6%, Mn = 0.10-0.13%, P up to 0.05%, S up to 0.020%. Four cast iron melts were made and keel blocks with 25, 50 and 75 mm wall thickness were cast. Spheroidization of cast iron was performed using a flexible wire (steel shell filled with magnesium). The casting molds were provided with a special system for filtration and inoculation. From each melt and from each keel block samples were taken for testing of the mechanical properties. After austempering Rm were measured. Relevant approximating polynomials Rm, = f (Ni, Cu) were derived.

Keywords: *nickel alloys, computer simulation, computed tomography, technological conversion*

1. Introduction

Whilst obtaining the ADI grades of 800-8 and 1000-5 in castings with the wall thickness of up to 30 mm poses no problems in the modern industry, obtaining these particular grades in heavy-walled castings (> 50 mm) has not been sufficiently well mastered yet [1,5,8, 11].

The overall objective of studies conducted on heavy-walled castings is to obtain the best cast iron ductility, which is influenced by many factors, among others, by the chemical composition (elimination of Mo and reducing to minimum the content of carbide-forming elements such as manganese, molybdenum, chromium and phosphorus), cast iron metallurgy (spheroidizing treatment and inoculation), and heat treatment parameters (properly selected time and temperature of the austenitizing and austempering treatment) [2-5, 9].

Recently, some improvement of the cast iron toughness, especially in massive castings, has been obtained by the secondary inoculation treatment carried out in a foundry mold to increase the nodule count and refinement degree. [4,8,9].

2. Preparing samples

The keel blocks of the following dimensions, molded in one box, were selected: 25x50x200 mm; 50x65x200 mm; 75x80x200 mm

Metal was fed from one ingate and one cross-gate. Each keel block was fed by two blind risers provided with atmospheric cores. Between the ingate and the cross-gate there was a chamber in which the inoculating and filtering block was placed. Figure 1 shows the principle of operation of the reaction chamber.

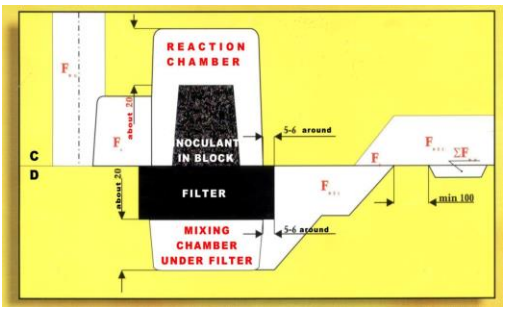

Fig. 1. The reaction chamber and the mixing chamber with inoculating and filtering block forming part of the gating system

A plan of experiment was applied in the study to enable development of mathematical relationships between Rm and a function of the Ni and Cu content[6]. Table 1 shows content of Mg, Ni and Cu.

Table 1 The chemical composition (Mg, Ni, Cu) of cast iron from different melts

Melt No.	Chemical composition, %		
	Mg	Ni	Cu
1	0.085	0.52	0.52
2	0.05	0.50	0.96
3	0.051	1.55	1.00
4	0.055	1.49	0.55

Altogether, four molds were poured from each melt, which gives the total of 16 keel blocks of the wall thickness of 25, 50 and 75 mm.

3. Mathematical processing of test results

Applying the developed plan of experiment, equations approximating the tensile strength Rm dependence on the content of Ni and Cu in keel blocks of different wall thickness were derived.

They were next used for plotting of the 3D diagrams illustrating the above mentioned relatioships (Figs. 2 – 3)

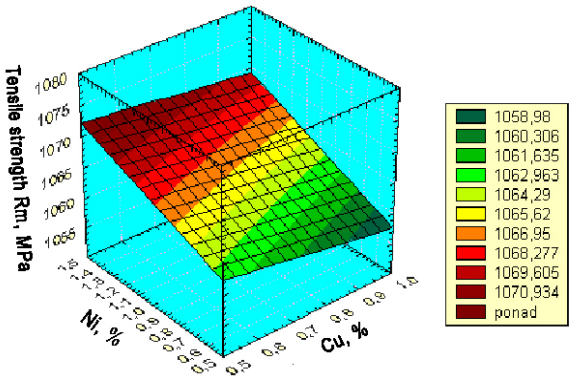

Fig. 2. Nickel and copper content vs ausferritic cast iron tensile strength. Keel block 50 mm

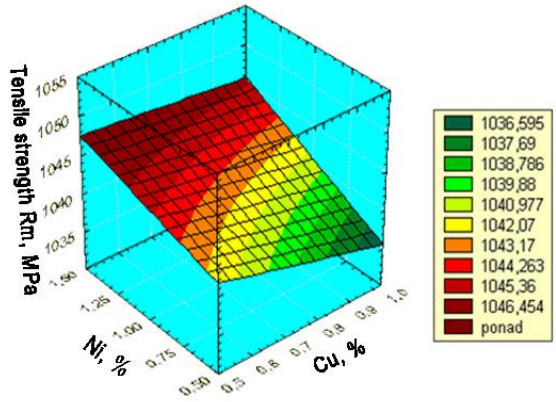

Fig. 3. Nickel and copper content vs ausferritic cast iron tensile strength. Keel block 75 mm

4. Summary and conclusions

- In-mold inoculation with the filtering and inoculating system gives very good results, as evidenced by the increase in nodule count and improvement of the cast iron ductility in keel blocks with 50 and 75 mm wall thickness.
- Contrary to previous studies, grades 800-8 and 1000-5 were successfully obtained in castings with 50 and 75 mm wall thickness.
- No significant increase in the mechanical properties of cast iron has been observed with the increasing addition of alloying elements. Studies have proved that the addition of 1% Ni and 0.5% Cu is sufficient to obtain grades 800-8 and 1005 in castings with the wall thickness of up to 75 mm. This conclusion requires, however, further confirmation in subsequent studies.

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