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Effect of Copper and Nickel on the Crystallization, Microstructure and Properties of Vermicular Cast Iron

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Abstract

The paper presents the results of studies of the effect of copper and nickel concentration on the solidification process, microstructure and selected properties of cast iron with vermicular graphite. The vermicularizing treatment of cast iron was done by an Inmold process. The effect of alloying elements on the temperature of eutectic crystallization and on the temperature of the austenite transformation was discussed. The relationship between the concentration of Cu and Ni, and the temperature of phase transformation were given. The effect of aforementioned elements on graphite shape and the cast iron matrix microstructure was tested. It was demonstrated that Cu and Ni are perlite-forming elements. A comparison of the intensity of their impact was showed. The conditions were given for which in vermicular cast iron with nickel or/and copper an pearlitic matrix is achieved. The effect of the above mentioned elements on the hardness and microhardness of the matrix components was given.

Keywords: *vermicular cast iron, Inmold, crystallization, copper, nickel*

1. Introduction

Vermicular cast iron is one of the modern and the developmental materials with high potential for utilitarian.

Compared to nodular cast iron, cast iron with vermicular graphite offers the following advantages: lower coefficient of thermal expansion, higher heat conductivity, lower modulus of elasticity, lower thermally induced internal stress level, better thermoshock resistance and lower tendency to distortion, better damping capacity, better pouring properties (shrinkage, mold-filling, etc.).

Very interesting complex of properties offered by this cast iron is the object of intensive research and numerous publications [1-6]. The standard specifies five grades of this cast iron with a tensile strength of 300 to 500 MPa at an elongation from 2.0 to 0.5%, respectively.

The increase in the mechanical properties of vermicular cast iron is associated with heat treatment of castings or the change of chemical composition.

There are very few publications, however, which would discuss the effect of alloying elements on the microstructure and properties of cast iron with vermicular graphite [7, 8]. So, the aim of this work was to study the effect of copper and nickel on the solidification behaviour, microstructure and hardness as well as microhardness of vermicular graphite cast iron.

2. Results

The chemical composition of tested cast iron is presented in Table 1.

Table 1
The chemical composition of tested cast iron

Chemical composition, mass %					
C	Si	Mn	Mg	Cu	Ni
3.28-3.83	2.23-2.48	0.27-0.34	0.014-0.025	0-2.92	0-5.21

The study of the crystallization process carried out by derivative thermal analysis method (DTA) indicated that copper (as a graphitizing agent) increased the eutectic transformation temperature of about 6°C per 1% Cu. The addition of Cu decreases the temperature of austenite transformation start of about 7°C per 1% concentration, and the end of about 13°C.

Nickel increases the eutectic transformation temperature of about 4.5°C per 1% of Ni. This element causes decrease in the temperature of austenite transformation start of about 23°C and finish 26°C per 1% Ni.

Figure 2 shows the microstructure of vermicular cast iron containing about 3% Cu.

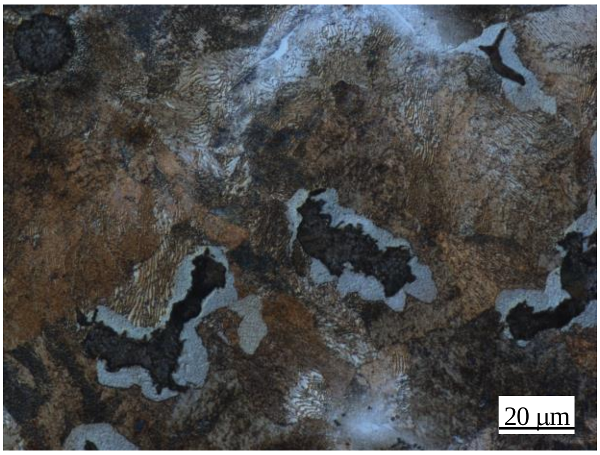

Fig. 2 Microstructure of vermicular cast iron containing about 3% Cu: vermicular graphite, pearlite, ferrite

Fig. 2 indicates that copper in concentration of about 3% caused an almost complete pearlitic matrix of tested cast iron. The small separation of ferrite remained around of graphite due to the formation of the barrier by Cu atoms impeding diffusion of carbon atoms.

In Figure 3 the microstructure of vermicular cast iron containing about 3% Ni is presented.

Fig. 3 Microstructure of vermicular cast iron containing about 3% Ni: vermicular graphite, pearlite, ferrite

The study showed that the surface fraction of ferrite in the cast iron containing about 3% Ni amounts to 35%. It is smaller than in unalloyed cast iron wherein the surface fraction of ferrite was 70%. The increasing of the nickel concentration to about 5% resulted in a further reduction of ferrite and the occurrence of martensite.

Figure 4 presents hardness of vermicular cast iron vs Cu and Ni concentration.

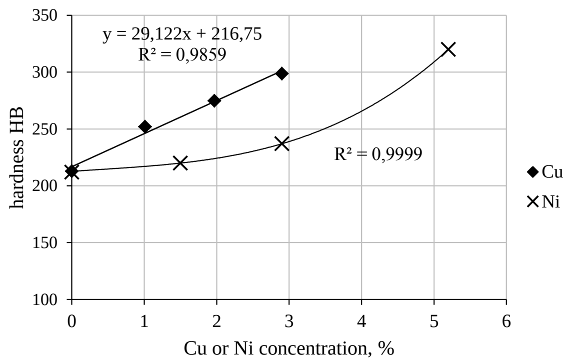

Fig. 4 Hardness of vermicular graphite cast iron vs copper and nickel concentration

Fig. 4 indicates that copper causes an increase in hardness of vermicular cast iron by approximately 29 HB per 1% Cu. The concentration of up to about 3% nickel causes an increase in hardness of the cast iron of about 8 units HB per 1% Ni. Further more intense increase in hardness is due to the precipitation of martensite.

Microhardness tests showed that Cu improves pearlite microhardness of about 14 HV0,1 per 1% Cu probably due to reduce the diffusion of carbon in austenite. The increase in concentrations of Ni did not result in a significant increase in microhardness of pearlite.

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