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MANGANESE INFLUENCE ON CHROMIUM DISTRIBUTION IN HIGH-CHROMIUM CAST IRONS

WPŁYW MANGANU NA ROZKŁAD STĘŻENIA CHROMU W ŻELIWIE WYSOKOCHROMOWYM

It is shown that chromium distribution in the metal base of high-chromium cast irons depends on manganese content. According to the X-ray micro-spectral analysis data with the increase of manganese content from 0.72 to 6.49% chromium content decreased in the near-carbide zones. At the same time chromium content in carbides increased. This process obtained particularly strong development inside eutectic colonies of carbides. As a result of it, when total chromium content in the alloy has been 23%, its concentration in the local zones was 12,3%, thus the necessary level of corrosion resistance has not been provided. The minimal chromium content has to amount 23.2%, at 6.49% Mn and 2.2...2.5% C in order to provide corrosion resistance of high-chromium cast irons.
Keywords: cast iron, chromium, manganese, distribution, microstructure

Pokazano, że rozkład chromu w osnowie metalowej żeliwa o wysokiej zawartości chromu zależy od zawartości manganu. Zgodnie z wynikami spektralnej mikroanalizy rentgenowskiej zwiększenie stężenie manganu z 0,72 do 6,49% powoduje zmniejszenie stężenia chromu w osnowie metalowej na granicy z węglikami. Równocześnie wzrasta zawartość chromu w węglikach. Zjawisko to występuję z większą intensywnością w osnowie metalowej ziaren eutektycznych, pomiędzy eutektycznymi węglikami. W wyniku redystrybucji chromu w żeliwie o zawartości 23% chromu występują lokalne strefy o stężeniu tego pierwiastku obniżonym do 12,3%, co skutkuje niedopuszczalnym obniżeniem odporności przeciwko korozji. Dla zapewnienia odporności korozyjnej wysokochromowego żeliwa, zawierającego od 2,2 do 2,5% C i 6,49% Mn, stop ten powinien zawierać powyżej 23,2% Cr.

1. Introduction

High-alloyed C-Cr-Mn cast irons are used for manufacturing of cast articles of machines and mechanisms operating under conditions of abrasive and hydroabrasive wears in neutral and corrosive environments. Chemical composition of these materials is selected depending upon the particular exploitation conditions. The main alloying elements are chromium, manganese and nickel. Various combinations of these elements allow obtaining of alloys with different structures and a wide range of physical and chemical properties. At the same time chromium serves as a ferrite- and carbide-forming element and the main element which provides wear and corrosion resistance. Nickel serves as an austenite-forming element which increases impact strength and corrosion resistance. Manganese serves as an austenite-forming, austenite stabilizing, as well as carbide-forming element. Carbon serves as a carbide quantity regulator [1-6]. According to the chemical affinity for carbon manganese holds an intermediate position between chromium and iron. Besides, manganese is known to be used as a partial substitute of nickel. Literature data on the manganese effect don't allow to objectively assess its influence on the processes of structure formation in Fe-C-Cr alloys.

It is known [7] that during the precipitation of chromium containing carbides from the solid solution during the process of the casting's cooling depletion of the near-carbide zones with chromium takes place. As a result of it chromium content decreases in local volumes of metallic matrix and reaches unacceptable values in terms of corrosion resistance. Reduced chromium content zones are centers of fracture. Manganese, having a high affinity for carbon, replaces iron in cementite and chromium carbides, herewith iron concentration in the near-carbide zones increases, and alloying elements content decreases.

2. Experimental Results

The purpose of the work consisted in determination of influence of manganese on chromium distribution in structural phases of cast irons. Chemical content of cast irons is represented in Table 1. Cast iron has been smelted in the induction furnace with a capacity of 60 kg with basic lining. Liquid cast iron's temperature during pouring into dry sand moulds was 1400...1430°C. During the process of alloying with metallic manganese alloys containing 0.72 to 6.49% Mn have been obtained. In order to detect the structural components Mar-

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ble's etchant has been used. After etching the α-phase had a black and the γ-phase had a light background. By means of the X-ray micro-spectral analysis on the РЕМ 106И microscope the changes of metallic base's chemical content have been investigated. Structural analysis has been conducted on the optical microscope МИМ-8.

TABLE 1

Chemical content of high-chromium cast irons (mass. %)

Cast Iron Grade	C	Cr	Ni	Si	Mn
ЧХ16НС	2.9…3.2	16.3…17.0	0.96…1.20	1.3…1.6	0.72...6.15
ЧХ22Г2НС	2.69	22.59	1.05	0.99	1.86
ЧХ25С	2.2…2.5	23.2…24.5	0.20…0.25	1.3…1.6	1.71...6.49

Methodology of evaluation of manganese influence on chromium distribution in high-chromium cast irons consisted in determination of the chemical content of carbides and the metallic base at specified distances from the carbides and inside the eutectic colonies of carbides.

The structure of high-chromium cast irons consisted of the eutectic colonies and primary carbides (in hypereutectic alloys) or primary dendrites of metallic base (in hypoeutectic alloys) (Fig. 1 and 2).

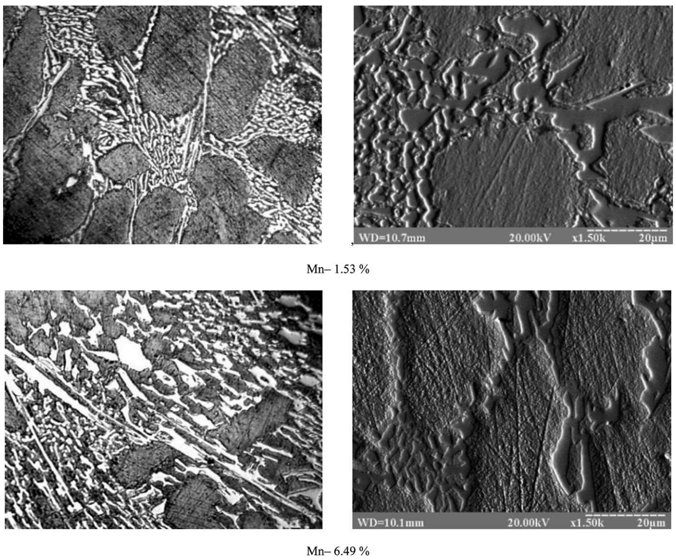

Fig. 1. Typical microstructures of ЧХ25С cast irons with different manganese content; light microscopy, Marble's etchant; ×370 (left column), and SEM, × 1500 (right column)

During the casting's cooling in sand moulds the following processes take place:

– the solubility of carbon in solid solution decreases;

– eutectic and hypereutectic carbides are enlarged;

– iron atoms are replaced by chromium and manganese atoms in the carbides;

– the near-carbide zones are depleted with chromium.

According to the X-ray micro-spectral analysis data with the increase of manganese content in the three cast iron grades which have been investigated from approximately 0.7 to 6% chromium content in the carbides increased by 5...7%. Herewith carbide quantity increased by 4...8%.

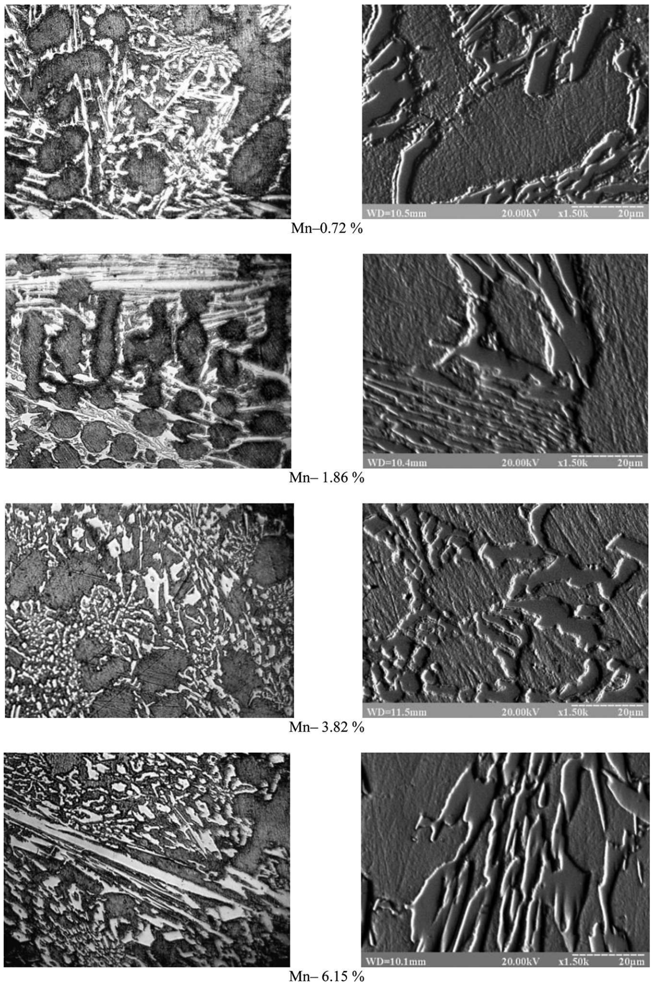

Fig. 2. Typical microstructures of ЧХ16НС cast irons with different manganese content; light microscopy, Marble's etchant; ×370 (left column), and SEM, ×1500 (right column)

Chromium content in the central part of the metallic base decreased from 10.8 to 10.3 with the increase of manganese content from 0.72 to 6.15% in the ЧХ16НС cast iron. Chromium content decreased to 6.6% in the near-carbide zones and inside the eutectic congestions of carbides. At the same time the value of depletion with chromium and the depletion zone width increased along with the increase of manganese content (Fig. 3).

The minimal chromium content in the metallic base must be more than 12.5% for those materials which operate in corrosive environments. In the ЧХ22Г2НС cast iron containing 22.59% Cr, depletion with chromium reaches 12.3%, which doesn't correspond to the necessary minimum. In order to provide cast iron's corrosion resistance it is necessary to increase chromium content along with a slight decrease of carbon content.

Manganese influence on chromium content in the near-carbide zones in the ЧХ25С cast iron had a similar nature (Fig. 4). With manganese content of 6.49% chromium content inside the eutectic colonies of carbides reached 12.7% Cr, and this provides corrosion resistance of cast iron.

Conducted researches have shown sufficient influence of manganese on chromium distribution in the metallic base of cast irons.

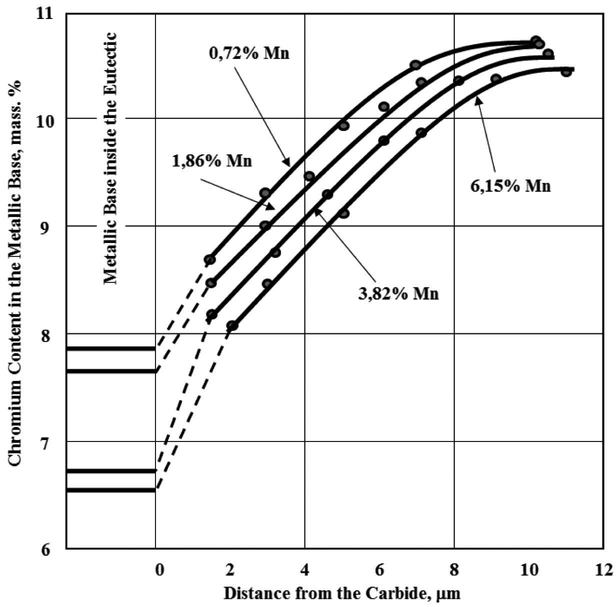

Fig. 3. Dependence of Cr content in the metallic base on Mn content and on the distance from carbides in the ЧХ16НС cast iron

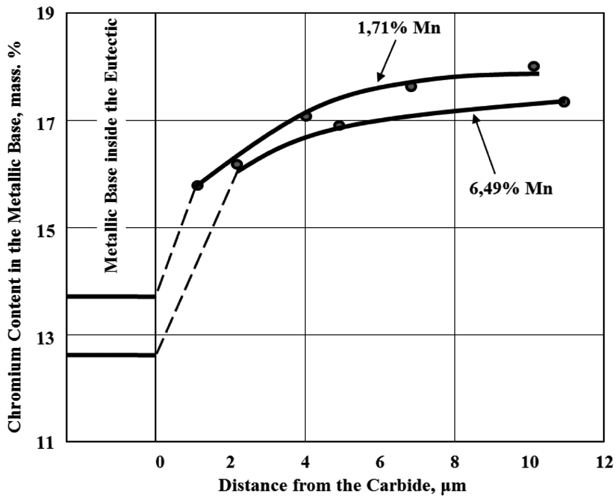

Fig. 4. Dependence of Cr content in the metallic base on Mn content and on the distance from carbides in the ЧХ25С cast iron

3. Conclusions

1. Manganese increases the depletion of near-carbide zones with chromium which results in the decrease of their corrosion resistance.

2. The minimal chromium content necessary for providing of corrosion resistance of high-chromium cast irons was 23% while manganese and carbon contents were 6,5% Mn and 2,2…2,5% C.

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