PHOSPHIDE EUTECTIC IN A HADFIELD STEEL STRUCTURE

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The structure of an austenitic manganese steel in the cast condition consists of austenite, secondary carbides, and a phosphide eutectic. All the castings were heat treated to obtain a homogeneous austenite structure, since the presence of other structural components degrades the properties. The phosphide eutectic is the only one of a number of structural components that is retained in place of the austenite after quenching. This paper presents the results of a metallurgical investigation into the phosphide eutectic in a Hadfield steel, the influence of the P and O contents, and also of the heat-treatment parameters on the shape and number of the eutectic formations.

The structure of a Hadfield steel (G13) casting, poured into raw sand molds, consists of austenite, a phosphide eutectic, secondary carbides and troostite (Fig. 1a). Nonmetallic inclusions and micropores are present in the structure. After a standard heat treatment, the structure consists of uniform austenite (Fig. 1b).

The chemical composition of the phosphide eutectic has remained uncertain over a long period. Moreover, it has often been ascribed to secondary carbides in production metallurgical laboratories. The application of microanalytical techniques recently, has made it possible to determine the basic constituents of the phosphide eutectic: P, Mn, Fe, and C. There are a number of papers concerning the phosphide eutectic in Hadfield steel [1, 2, etc].

The objective of this work is to continue the investigation into the phosphide eutectic in Hadfield steel. The necessity for such research is related to the fact that the phosphide eutectic has a negative influence on the Hadfield steel properties. A 2% solution of nital was used to reveal the structure.

It has been shown that the form and amount of the phosphide eutectic in the Hadfield steel is dependent on many technological factors, the chief of which are the cooling rate after casting, the heat treatment conditions, and the chemical composition.

Influence of Casting Cooling and Phosphorus Content. Normally, Hadfield steel is cast into raw sand molds in production conditions. In this situation, the phosphide eutectic is globular in form and is surrounded by needle shaped carbides (Fig. 2).

The cooling rate for castings obtained by pouring into shell molds produced by the lost wax method is somewhat greater than the cooling rate for castings produced by pouring into raw sand molds. Still higher cooling rates can be achieved by immersing the cast shell mold in water directly after solidification is completed.

We have examined the eutectic structure in castings containing 0.016-0.149% P, which were cooled during solidification at different rates.

After air cooling, the microstructure of the casting that contained 0.016% P revealed the phosphide eutectic only in exceptional situations (as a rule it was absent) (see Fig. 1c). Here, the eutectic formations that were noted, are globular in form and are surrounded by a dense cloud of secondary needle shaped carbides. The structure of the castings with this phosphorus level, that were cooled together with the shell molds from 1100°C in water, consists of austenite; no phosphide eutectic was noted.

The microstructure of castings with 0.051% P are typified by the presence of an eutectic with a globular form. After cooling in water from 1100°C, a few small sized phosphide eutectic formations develop, which are located either at the grain boundaries or in the spacing between the dendrite branches.

Fig. 1. Hadfield steel microstructure: a, c-f) cast condition; b, g) after a standard heat treatment; c, d) 0.016 and 0.149% P, respectively, casting air cooling; e) 0.149% P, casting water cooled; f) 1.4% P, casting cooled in water or air; h) thermal axis region of the casting with 0.08% P and 0.012% O; a-d, f) x200; e, g) x500; h) x50.