

Vanadium in cast iron

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Synopsis

The effects of vanadium in several types of cast iron have been investigated and the results are as follows.

In grey cast irons the marked strengthening of up to 0.5 per cent vanadium and its strong tendency to promote the formation of eutectic carbide have been confirmed. However, the carbide-forming tendency can be confined to thin sections by efficient inoculation or by modification of the base composition. The marked improvement in strength is still present in grey irons that have been annealed to a ferritic structure to facilitate machining.

Vanadium promotes the formation of eutectic carbide by:

causing a significant increase in the metastable (carbide) equilibrium eutectic temperature;

causing a marked depression of the stable (graphitic) equilibrium eutectic temperature.

The addition of up to 0.5 per cent vanadium to nodular (SG) iron can produce significant increases in proof stress values and tensile strength. The most significant increases occur in irons which have been annealed to give a full ferritic matrix and the increases are accompanied by only a marginal decrease in elongation and notched impact values. It is concluded that ferritic nodular (SG) irons with vanadium could have better combinations of tensile properties, elongation and impact resistance than previously accepted.

A very fine particulate precipitate occurs in ferritic irons when vanadium is added. This is believed to be a form of vanadium carbide, and it is suggested that it contributes to the increases in strength conferred by vanadium.

In abrasion-resistant, 15 per cent chromium irons, 5 per cent vanadium content produces as-cast structures and hardness values similar to those normally obtained by high-temperature heat treatment of equivalent irons with no vanadium content. It is suggested that this effect of vanadium might be of use in complex castings that are subject to cracking during heat treatment.

Introduction

A number of authors¹⁻¹⁰⁰ have published information on the influence of vanadium in cast irons, but many of the more detailed publications are quite old and some of the conclusions are questionable in the light of present-day knowledge. In some cases, also, the results from different authors are contradictory, and in a number of instances the claims made for a particular effect of vanadium are not supported by any technical details.

The effects of vanadium in several types of cast iron have been investigated at BCIRA, and the present paper describes the results obtained and suggests some situations where the use of vanadium as an alloying element might be considered.

Summary of the literature

The general effects of vanadium in cast irons which could be expected, from the published data, can be summarized as follows:

Effects on general structure

Vanadium combines with the carbon present in the iron to

form particles of vanadium carbide having the formula V_4C_3 or VC .^{2, 13-16}

Vanadium promotes the formation of eutectic iron carbide, which results in an increased tendency to form white iron structures in thinner sections.^{2, 3, 18-22, 24-27, 29-31}

Quite small amounts of vanadium promote pearlitic rather than ferritic structures in the as-cast condition, and also make the pearlite more resistant to removal by heat treatment.^{2-4, 19-23, 28}

Small quantities of vanadium give more uniformity of graphite flake size and structure, particularly in heavier sections.^{2-4, 19, 23, 25, 28, 29}

Effects on the properties of grey cast irons

Up to contents of about 0.5 per cent, vanadium increases the strength of grey iron by about 12-15 N/mm² (0.8-1.0 ton f/in²) for each 0.1 per cent vanadium.^{1-4, 18, 19, 22, 23, 26, 28-31, 40-45, 60, 62}

The tendency for vanadium to promote the formation of eutectic carbide is between one and four times that of chromium. However, much of this effect of vanadium may be offset by the addition of three to four times as much nickel or copper, or by increasing the silicon content.^{2, 3, 18-22, 24-27, 29-31}