Characterization of precipitates in a 7.9Cr–1.65Mo–1.25Si–1.2V steel during tempering

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ABSTRACT

In this paper, the precipitates formed during the tempering after quenching from temperature 1150 °C for 7.90Cr–1.65Mo–1.25Si–1.2V steels are investigated using an analytical transmission electron microscope (A-TEM).The study of this tempering is carried out in isothermal and anisothermal conditions, by comparing the results given by dilatometry and hot hardness. Tempering is performed in the range of 300–700 °C. Coarse primary carbides retained after heat treatment are V-rich MC and Cr–Mo-rich M_7C_3 types. In turn, it gives a significant influence on the precipitation of fine secondary carbides, that is, secondary hardening during tempering. The major secondary carbides are Cr–Mo–V-rich M′C (and/or) Cr–Mo-rich M_2C type. The peak hardness is observed in the tempering range of 450–500 °C. In the end, we observe between 600 and 700 °C, that this impoverished changes the phase. At these high temperatures of tempering, we observe that there is a carbide formation of the types M_6C developing at the expense of the fine M_7C_3 carbides previously formed.

1. Introduction

The purpose of the present work is to study new nuances of steels likely to be used to manufacture hot rolls. The choice was made on chromium–molybdenum–silicon steels, intended to replace other materials, such as cast iron with high chromium content. From the above mentioned elements of addition, these alloys have a specific addition of vanadium, to modify the nature as well as the morphology of primary carbides and to confer a secondary hardening by precipitation of fine carbides [1] of the type M′C (V_4C_3).

The nuance studied here results from modifications of composition made to a more traditional alloy containing Cr (12%), but less Mo (1.5%). These modifications have been done, on one hand to decrease the volumic fraction of primary carbides being able to be at the origin of the crack initiation in service. On the other hand, they allow the formation of oxidized surface layers low thickness exerting a protective action with respect to later oxidation (such oxide coatings have not a notable role on the starting of fissures). The reduction in the chromium content is partially compensated by an increase in the molybdenum amount. We observe that the hot resistance of the matrix is caused by the increasing of this element.

2. Experimental Procedure

Cr–Mo–Si–V steel samples of 5 mm×5 mm×20 mm size, having specified chemical composition (C: 0.80%, Cr: 7.90%, Mo: 1.65%, Si: 1.25%, V: 1.2%, balance Fe) are heated at 1050 and 1150 °C during 15 mn, followed by a water quenching.

After the last quenching (50 °C/s) from $\theta_\gamma > 1050$ °C, the structure consists of martensite (α'), residual austenite (volumic fraction of this phase — determined by the integrated intensities method [2,3] — is retained at 20 °C: up to 20% for $\theta_\gamma > 1150$ °C) and non-dissolved primary carbides of the types M_7C_3 and MC [4–9].

In the quenched state, the material has a high hardness and a low capacity of deformation, thus it is advisable to temper it to

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