DOI: 10.1017/S1431927605510523
Microsc Microanal 11(Suppl 2), 2005

Studies on morphological parameters of carbides in 2.25 % Cr-1Mo steel

Vaidehi Ganesan and C. Babu Rao
Non-destructive Evaluation Division, Inspection Technologies Group,
Metallurgy and Materials Group,
Indira Gandhi Centre for Atomic Research, Kalpakkam-603 102, India.

Introduction

Cr-Mo steels are widely used in thermal reactors, fast breeder reactor applications and recently in fusion reactors as first wall and blanket structural material. The carbides in these steels greatly influence the mechanical properties of the steel under consideration. The correlations between microstructures and mechanical properties of 2.25 % Cr-1Mo steel are available in the literature [1]. The chemical compositions of this steel and the experimental details are also available in our earlier work [1, 2]. In the present work, the carbides are analysed using Philips CM12, Transmission Electron Microscope. The morphological parameters were determined using image analyser. The results are discussed in brief in this paper.

Results and Discussions

The aging treatments and salient features/ microstructures are presented in Table 1. The carbides Fe_3 C(cementite), M_7 C_3, Mo_2C, $M_{23}C_6$, M_6C and MC type carbides were observed with different tempering treatments. These observations were found to be consistent with those reported in the literature [3].

The width of the lath(martensite) and the width of the grain boundary were also determined accurately and presented. There is clear evidence of coarsening of grain boundary as well as carbides near grain boundary. The consequence of this lead to reduction in the mechanical properties and strength [1, 2]. The width of the lath size varies from 8.809 x 10^{-5} cm to 1.173 x 10^{-4} cm, i.e. about 881 nm to 1173 nm in the first set of analysis. And in the second set of analysis, width of lath varies from 8.8804 x 10^{-5} cm to 1.161x10^{-4} cm , i.e. about 888 nm to 1161 nm. In each set of experiments more than 25 measurements were obtained. Morphological parameters like area, perimeter, shape factor, X-bounding box, Y-bounding box and aspect ratio of carbides like Fe_3C, $M_{23}C_6$, M_7C_3, and MO_2C are measured and presented in (Table 2).

Typical MO_2C precipitate morphology is as shown in the Fig 2. The aspect ratio of Mo_2C is as high as 7.0. Presence of these precipitates in steel improve the creep rupture life. Special emphasis for morphological parameters of MO_2C is given, since the presence of these carbides improve the creep rupture life from 1x 10^5 h to 3.3 x 10^5 h at 540 °C operating conditions [1, 2].

Major conclusions:

There is coarsening of grain boundary and grain boundary carbides. This should be avoided because of the probability of cavity nucleation is more due to decohesion at the interface and the coarsening give rise to reduction in mechanical properties. The aspect ratio of fine needle shape Mo_2C precipites is as high as 7.0. This improves the mechanical properties of the present material.

References:

1. Vaidehi Ganesan, T. Jayakumar, K. Srinivasa Raghavan and Baldev Raj, Invited talk, International Conference on Physical Metallurgy(ICPM-94), march, 1994, Bombay. Trans IIM, (June 95) 229-236.
2. Vaidehi Ganesan and Placid Rodriguez, Proc. of International Symposium on Material ageing and life management, Oct 3-5, 2000, Kalpakkam, India. Ed: Baldev Raj et al. Vol -1, p 293-302.
3. R.G. Baker and J. Nutting, J. of Iron and Steel Inst, July(1959)257.

Table 1: Microstructural changes with different heat treatments in 2.25 Cr-1 Mo steel

S. No	Tempering treatment	Microstructural features
1.	Sol. Annealed-[950°C] 1223 K-2h/WQ –(referred to as S.A in 2-5).	Lath martensite, inter-lath boundaries, retained austenite, high dislocation density in between laths
2.	S.A+750°C- 30 min	Fe_3C, M_7C_3 and Mo_2C in between laths- Bainite
3.	S.A+650°C -5 h	Fe_3C (spherical), Mo_2C (needle shape)
4.	S.A.+600°C-100 h	Fe_3C, M_7C_3 (coarse rod), Mo_2C (needle shape)
5.	S.A.+700°C -50h S.A.+750°C-10 h	M_7C_3 , $M_{23}C_6$, strain field near the precipitates. Precipitate coarsening near G.B. [Fig 1], Epsilon contrast near M_7C_3 and $M_{23}C_6$. Selected area diffraction pattern confirms the precipitation [2]

* Serial nos 2 to 5 = 1 + tempering treatment

Table 2. Morphological parameters of different carbides (range)

Carbides	Projected Area 10^9 nm^2	Perimeter (nm)	Aspect Ratio	Shape factor
M_7C_3	0.328 - 14.04	497.3 - 1770	1.71 - 7.74	1.11 - 2.73
Fe_3C	0.328 - 0.441	319.6 - 367	1.06 - 1.29	1.09 - 1.11
$M_{23}C_6$	0.112 - 1.133	232.3 - 705.7	1.15 - 3.76	1.02 - 1.43

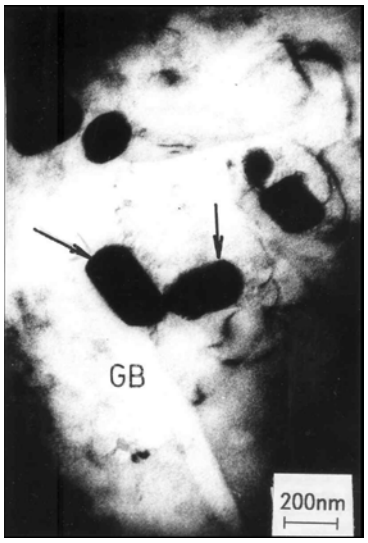

Fig (1)

Fig (1). WQ+tempered –1023 K -10h, coarsened grain boundary, G.B carbides, $M_{23}C_6$ –plate morphology near G.B.

Fig 2. Typical Mo_2C image with high aspect ratio. S.A.+600°C- 100 h/AC.

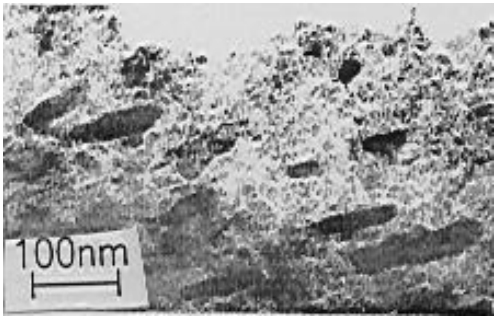

Fig (2)

https://doi.org/10.1017/S1431927605510523 Published online by Cambridge University Press