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A Transmission Electron Microscopy Study of Dual Phase High Strength Steels

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The development of Grade 690 (σ_y = 690 MPa) linepipe steel having the best combination of strength, toughness and weldability requires a fine-scale bainitic microstructure. The bainitic ferrite laths nucleate intragranularly ("acicular ferrite" –AF) and grow with random orientations, and the remaining carbon-enriched austenite forms dispersed islands of martensite/austenite (M/A). The dual phase AF+M/A microstructure is achieved in low carbon microalloyed steels by a combination of thermomechanical processing and accelerated cooling. This paper presents the results of a study of AF+M/A microstructures by transmission electron microscopy.

For the current Grade 550 steel, an accelerated cooling rate (CR) of about 50 ^{o}C/s is required to obtain 100 % AF+M/A [1]. Fig.1b shows a typical microstructure comprising randomly oriented, high dislocation density bainitic ferrite laths and ~0.5 μm equiaxed M/A islands. The M/A islands are clearly distinguished by their light contrast in SEM-SE (Fig. 1a) and dark contrast in TEM (Fig. 1b). Carbon enrichment of the M/A relative to the bainitic ferrite matrix has been confirmed by SEM-EDS [2].

The current research investigates new steel compositions which produce the dual phase AF+M/A microstructure at CR ≤ 25 ^{o}C/s. The microstructures of 2 new steel compositions are shown in Fig. 1c-1f. The compositions of both steels are identical, except for carbon. Steel NC2 has 0.04wt% C and steel NC3 has 0.07wt% C. Both steels were produced as 15 mm thick plate, by the same processing schedule, with a CR of 20 ^{o}C/s. The microstructures for both steels are dual phase AF+M/A, with 13.7% M/A in NC2 and 17.9%M/A in NC3.

The M/A islands are completely martensite, with no evidence of retained austenite (Figs.1d, 1f). The detailed structure of the martensite is seen in Fig.1d to be a combination of blocky martensite and twinned martensite (Fig.1d@T). The martensite forms by the strain which develops in the C-enriched austenite adjacent to the growing bainitic ferrite laths [3,4]. The blocky martensite is due to accommodation strain which results in the formation of areas having different orientations. The twinned martensite is due to locally increased C concentration and/or a complex shear stress condition.

References.
[1] I.A. Yakubtsov et al., 43nd MWSP Conf. Proc., ISS, XXXIX (2001) 531.
[2] I.A. Yakubtsov and J.D. Boyd, Mater. Sci.& Technol., 17 (N3) (2001) 296
[3] E. Swallow and H.K.D.H. Bhadeshia, Mat. Sci. & Technol., 12 (1996) 121.
[4] G.B. Olson and M. Cohen, J. Less Common Met., 28 (1972) 107.

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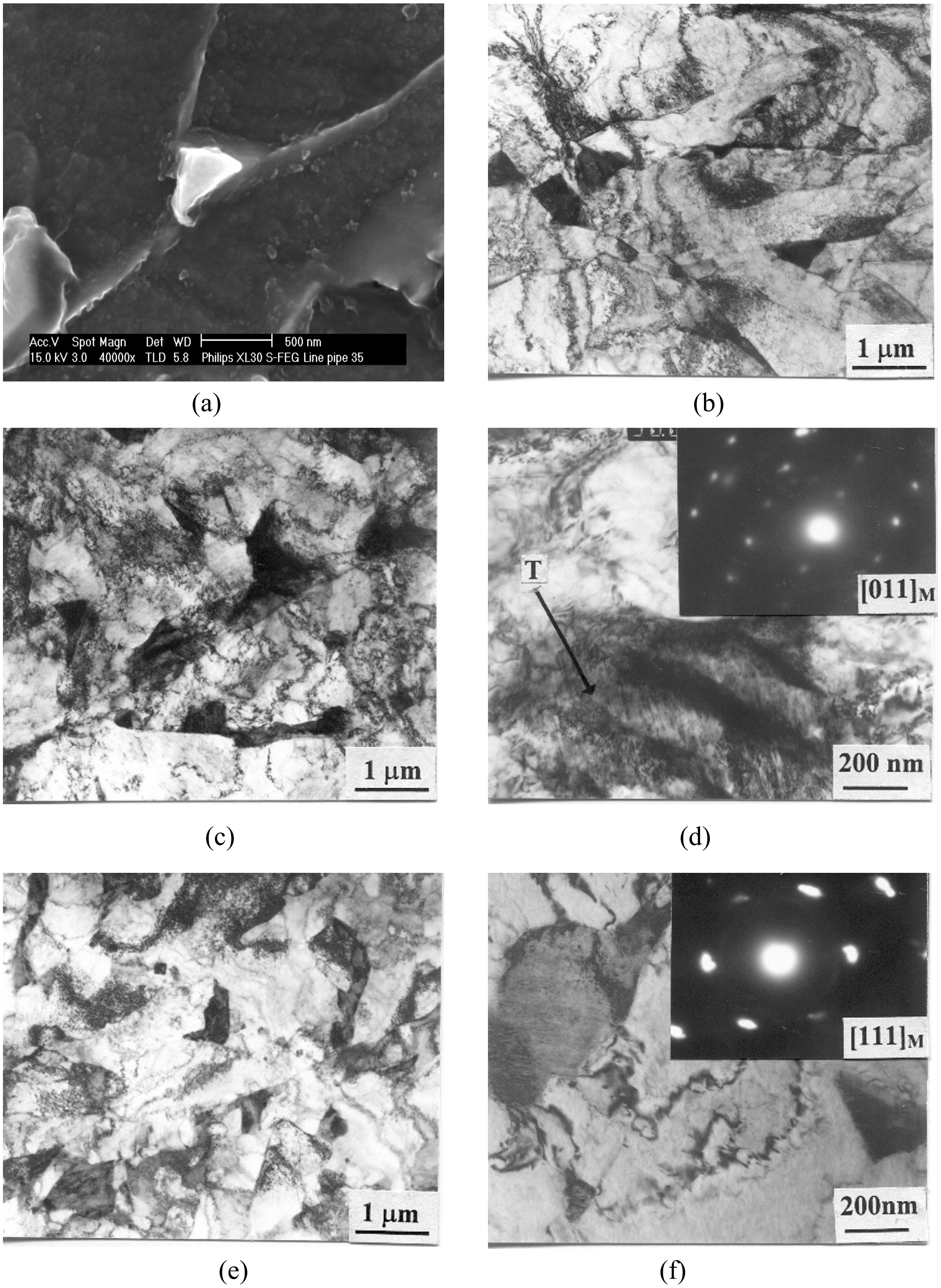

FIG. 1 Dual phase AF+M/A in thermomechanically processed +accelerated cooled steels: (a, b) Grade 550 steel composition, CR = 50 ^{o}C/s; (c, d) NC2 steel, CR = 20 ^{o}C/s; (e, f) NC3 steel, CR = 20 ^{o}C/s.

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