Characterization of the fatigue fracture in dual-phase steel

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The dual-phase steel (DPS) consists of ferrite (soft phase) and martensite (hard phase) microstructure and are generally produced by intercritical annealing, i.e, heating between A_1 and A_3 in the ferrite-austenite phase field. The DPS presents high initial work hardening and good combination of strength and ductility [1,2].

In this work, low-carbon steel was submitted to intercritical quenched, above 760°C, obtaining dual-phase microstructure, basically formed by ferrite and martensite. The volume fractions were estimated by using point counting method (ASTM E-562). The volume fraction was 62% ferrite and 38% martensite. The microhardness (load =10gf) of ferrite grain was 250±10 HV and martensite grain was 400±14 HV. The specimens were prepared for bending fatigue tests according to machine's manual. Before the tests the specimens were mechanically polished. The fatigue tests were carried out on a Shenk machine. The aplication load was sinusoidal tension at load ratio R= -1. The frequency was 25 Hz. The test environment was laboratory air maintained at a constant temperature at 25°C.

The figure 1 shows the high-cycle fracture surface of a specimen tested at 400MPa. Notice the stretched zone near at center. This view shows entry of the fatigue crack from bottom, and sharp onset of final fast fracture near at center. The fatigue crack is believed to have been initiated by defects in the cold rolling process (figure 2). The figure 3 shows high magnification view of the fracture surface shown in figure 1, with the fatigue-crack surface at bottom and the fast-fracture surface at top. At botton, fatigue has produced numerous secondary cracks. Considering the loading conditions, fatigue crack propagation and therefore striation spacing were affected by alterning stress. It was observed that increasing the magnitude of the alternating stress produced an increase in the striation spacing . This was due in part to changes in local stress conditions as the crack propagated on an inclined surface. The complex microstructure changed the orientation plane of fracture and altered the diretion of striation alignment.

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References

1. Cai X., et al., The development of some Dual-Phase Steel Structure from Different Starting Microstructures, Metallurgical Transaction, 16-A (1985) 1405

2. Sakaki T., et al., Role of Inetrnal Stress for Continuous Yielding od Dual-Phase Steels, Acta Metallurgica,31(1983)p.1737, 1983.

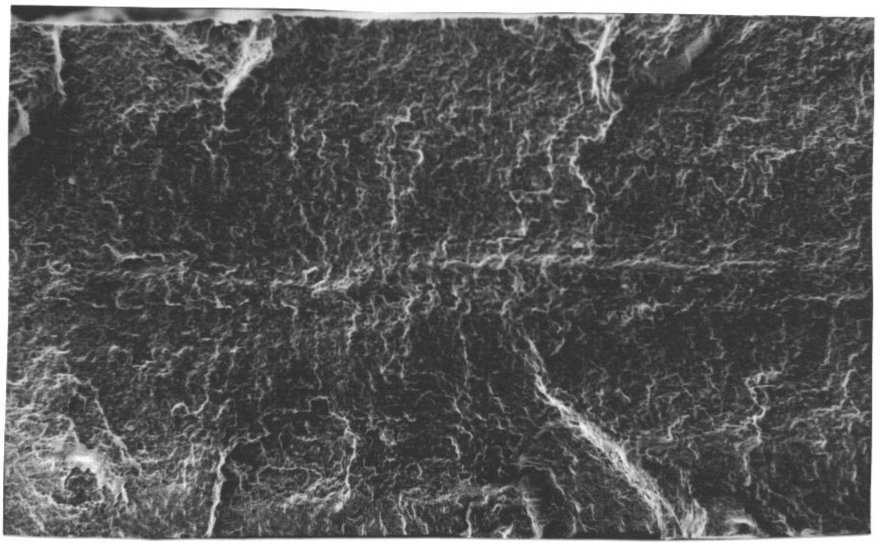

FIG. 1 - Fracture surface of DPS tested at 400 MPa. This view shows the stretched zone near at center.

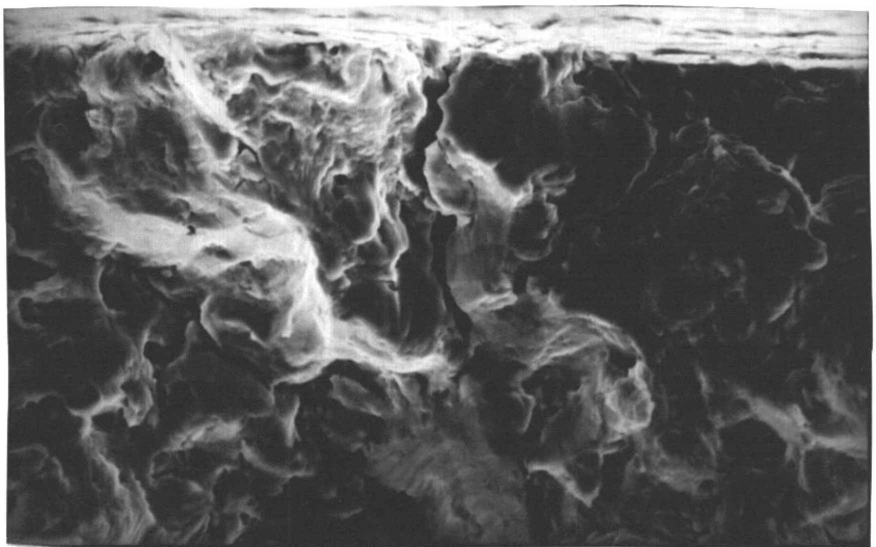

FIG.2 - Fracture surface near to specimen surface. Notice the region where the fracture crack is believed to have been iniciated.

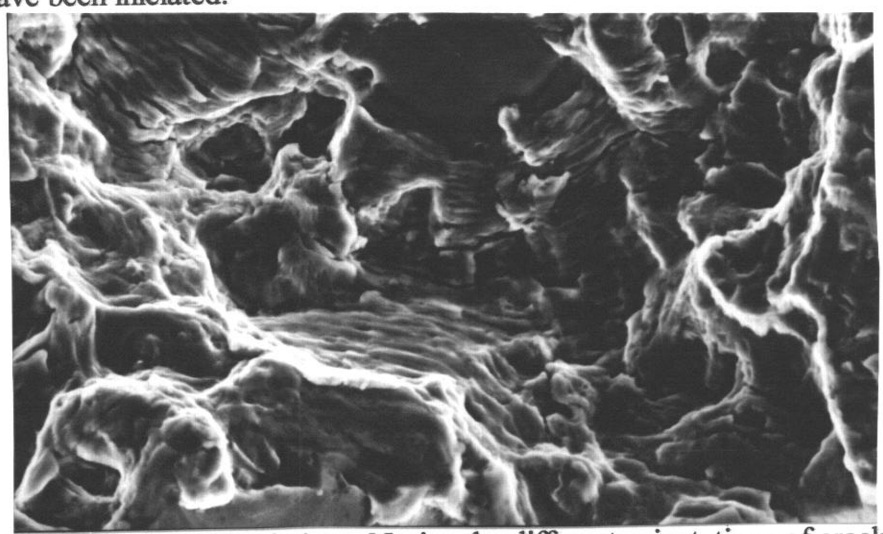

FIG. 3 - High magnification of striations. Notice the different orientations of crack propagation.