EFFECT OF STRAIN PATH CHANGE ON MICROSTRUCTURE AND PROPERTIES OF HOT-ROLLED Q235 STEEL

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1. Introduction

Cyclic deformation, fatigue crack initiation and fatigue crack growth, as the basic fatigue properties of materials, have been widely studied by many researchers and many achievements have been reached[1]. In fact, nearly 90% of total fatigue of most materials is at the stage of cyclic deformation and crack initiation, so trying to clarify cyclic deformation behaviour of materials is of much importance not only in theory research, but also in engineering application[2]. Up to date, most research works in literature about this are on the cyclic deformation behaviour of annealed materials. Recently, the cyclic deformation behaviour of materials with prestrained history has also been studied because of its industrial application background. However, some aspects about it are not very clear yet, further system study is necessary. The present work is mainly about the cyclic deformation behaviour of low-carbon steel prestrained, the mechanical properties, the dislocation structures as well as the relationship between them are emphasized in this paper. In addition, the tensile deformation behaviour of low-carbon steel prestrained in fatigue is studied.

2. Experimental Procedure

The material used in this investigation was Q235 hot-rolled steel plate with chemical compositions of (in wt%): 0.14C, 0.17Si, 0.40Mn, 0.012P, 0.006S.For the mechanical tests, two angle value (namely φ=0º and φ=45º, φ is the angle between the loading direction and the rolling direction) were chosen in each case. The dimensions for the specimens are shown in Fig.1.

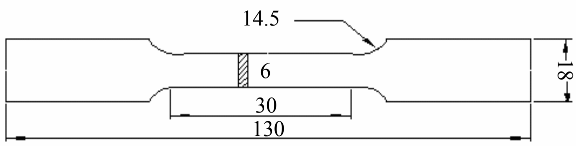

Fig.1 Dimensions of specimens (mm)

Tension-fatigue：For the preloading in tension, tests were performed until strain amount reached these value: 2%, 5%, 10%，the subsequent fatigue tests were performed under three different constant plastic strain amplitudes: 0.6×10^{-3}, 1.5×10^{-3}, 2.5×10^{-3}. All the fatigue tests were conducted until the specimens were saturated. Fatigue-tension：The preloading in fatigue as well as the subsequent fatigue of the tension-fatigue tests，the subsequent tension tests were conducted until the specimens were rupture.

3. Result and Discussion

Tension-fatigue: In the tests, the cyclic softening phenomenon happened at both case. In general, at both cases, a higher tension prestraining amount leads to a higher axial stress at the beginning of cyclic deformation under same applied plastic strain amplitude. The axial stress of all specimens in present study remains constant during the major part of cyclic deformation, which means stress saturation. With the amplitude increasing, the saturate stress of higher tension prestraining amount is lower than that of lower tension prestraining amount.

In $\varphi = 45^\circ$ case, the axial stress at the beginning of reloading and the saturation stress at the end of fatigue tests is a little higher than that of $\varphi = 0^\circ$ case under the lower tension prestraining amount and the same applied reloading plastic strain amplitude. However, the tendency of cyclic softening curves is independent of the amplitude of strain path change under the higher tension prestraining amount, i.e. φ value.

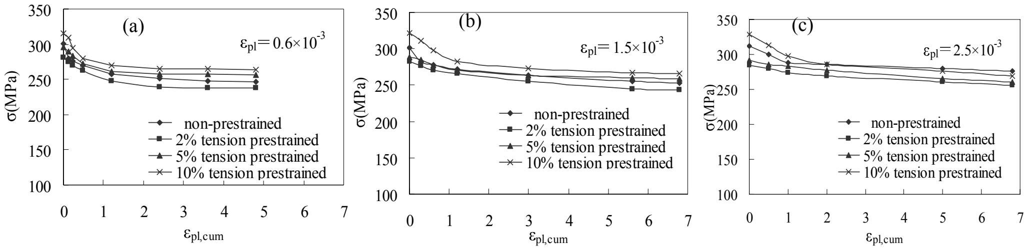

Fig.3 Cyclic softening curve of specimen with different tension prestraining amounts at various plastic strain amplitude, $\varphi = 0^\circ$

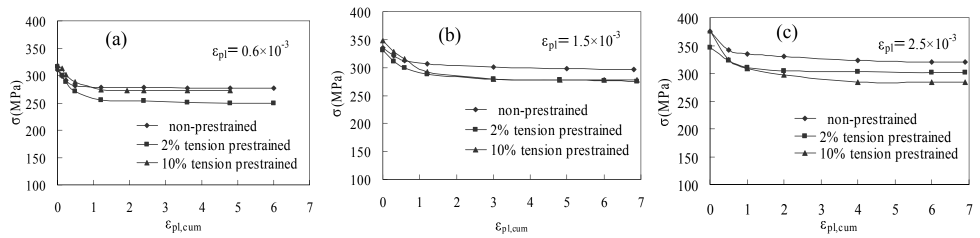

Fig.4 Cyclic softening curve of specimen with different tension prestraining amounts at various plastic strain amplitude， $\varphi = 45^\circ$

Fatigue-tension: For both case (φ=0º and φ=45º), the yield phenomenon graduate away with the applied plastic strain amplitude increasing. A higher fatigue prestraining leads to a higher tensile strength、yield strength and a lower elongation ratio at tensile tests. In φ=45º case, the stress level is a little higher than that of φ=0º case at tensile tests. However, the tendency of tensile curves is independent of the strain path.

4. Conclusion

(1) In the subsequent cyclic deformation, with the cyclic number increasing, the dislocation structure formed in preloading is resolved gradually, at the end of fatigue tests, for most specimens, the dislocation structures are almost the same as that of specimens as if the tension preloading did not happen.

(2) Tensile deformation behaviour of Q235 steel with fatigue prestraining at two amplitudes of strain path change was studied. It was found that for both case (φ=0º and φ=45º), the yield phenomenon graduated away with the applied plastic strain amplitude increasing. A higher fatigue prestraining leads to a higher tensile strength、yield strength and a lower elongation ratio at tensile tests. In φ=45º case, the stress level is a little higher than that of φ=0º case at tensile tests.

References:

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