The single phase constitutive relation of dual phase steel based on nanoindentation test and finite element modeling

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Abstract

Dual phase steel is widely used in manufacturing for its excellent combination of strength with plasticity. Previously, much attention has been paid in the strengthening mechanism of dual phase steel and a great deal of papers have been published while the plastic deformation mechanism has not been further discussed. In this paper, combining the nanoindentation test with finite element modeling , the single phase constitutive equations of dual phase steel was established. To solve the P-h curve, reverse analysis algorithms and five dimensionless function are adopted. In addition, the nanoindentation is simulated by ABAQUS to validate the accuracy of numerical calculation. A representative stress and corresponding representative strain are solved by dimensionless functions and updated with finite element modeling. Forty nanoindentation sites are tested and simulated to investigate the impact of friction and tip shape of indenter in modeling. Finally, we will give a complete method of solving constitutive relation from nanoindentation and provide a theoretical basis for the further study of dual phase steel's plastic behavior. The constitutive relation of ferrite and martensite are completed, which reveals the average yield stress and strain hardening index of martensite and ferrite are 830.06MPa, 0.182, 360.34MPa, 0.226 respectively. For complete martensite steel, the yield stress and strain hardening index are 1352.85MPa and 0.130. The uniaxial tensile results are 416.81MPa and 0.2.

Image

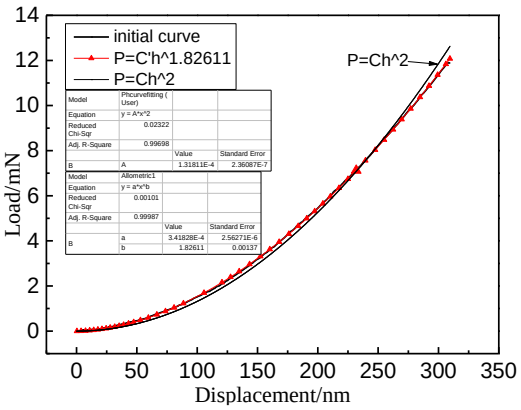


Fig. 1 The comparation of using two different functions (P=Ch2, P=Chn) to fit the loading curve

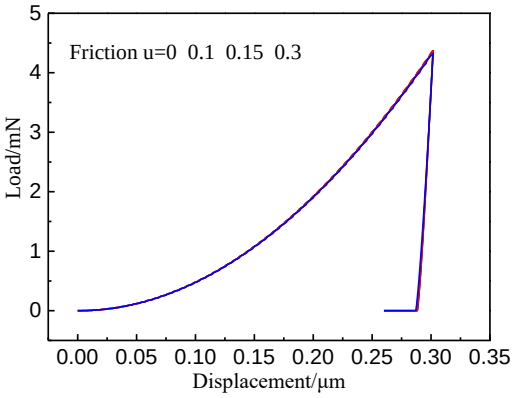


Fig. 2 The modeling results of different Coulomb's friction coefficient.

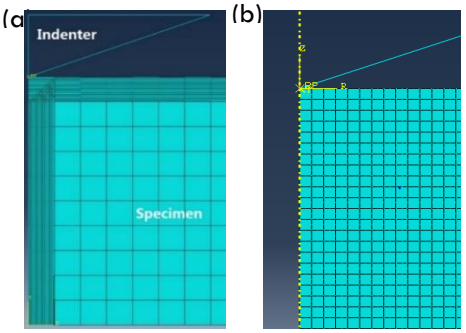


Fig. 3 The mesh design for computation calculation, (a) triangular element meshes of finite element model, (b) magnified image of contact segment meshes

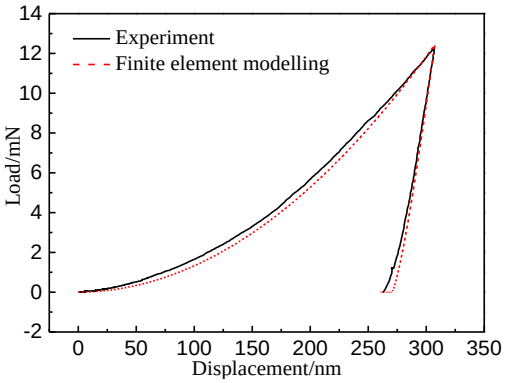


Fig. 4 The origin map of experimental and simulated P-h curves

(the parameters used in simulation is σ_r=1700.64, n=0).

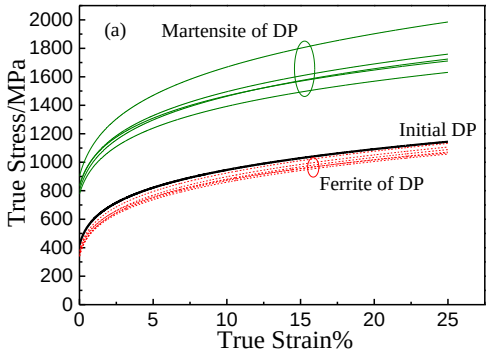
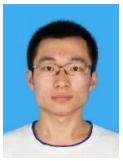


Fig. 5 The stress-strain curve of dual phase steel.

Recent Publications

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Biography

Lei Hao is a master of University of Science and Technology Beijing, China. He has his expertise in steel rolling and material technology. Recently, his projects contain the technology improvement of ultra-low/low carbon interstitial free steel and the plastic behavior of the substructure of martensie and bainite. What's more, he does a lot of research in HSLA with a process of QP or QPT. In this paper, he gives a complete method of solving constitutive relation from nanoindentation and provide a theoretical basis for the further study of dual phase steel's plastic behavior.

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