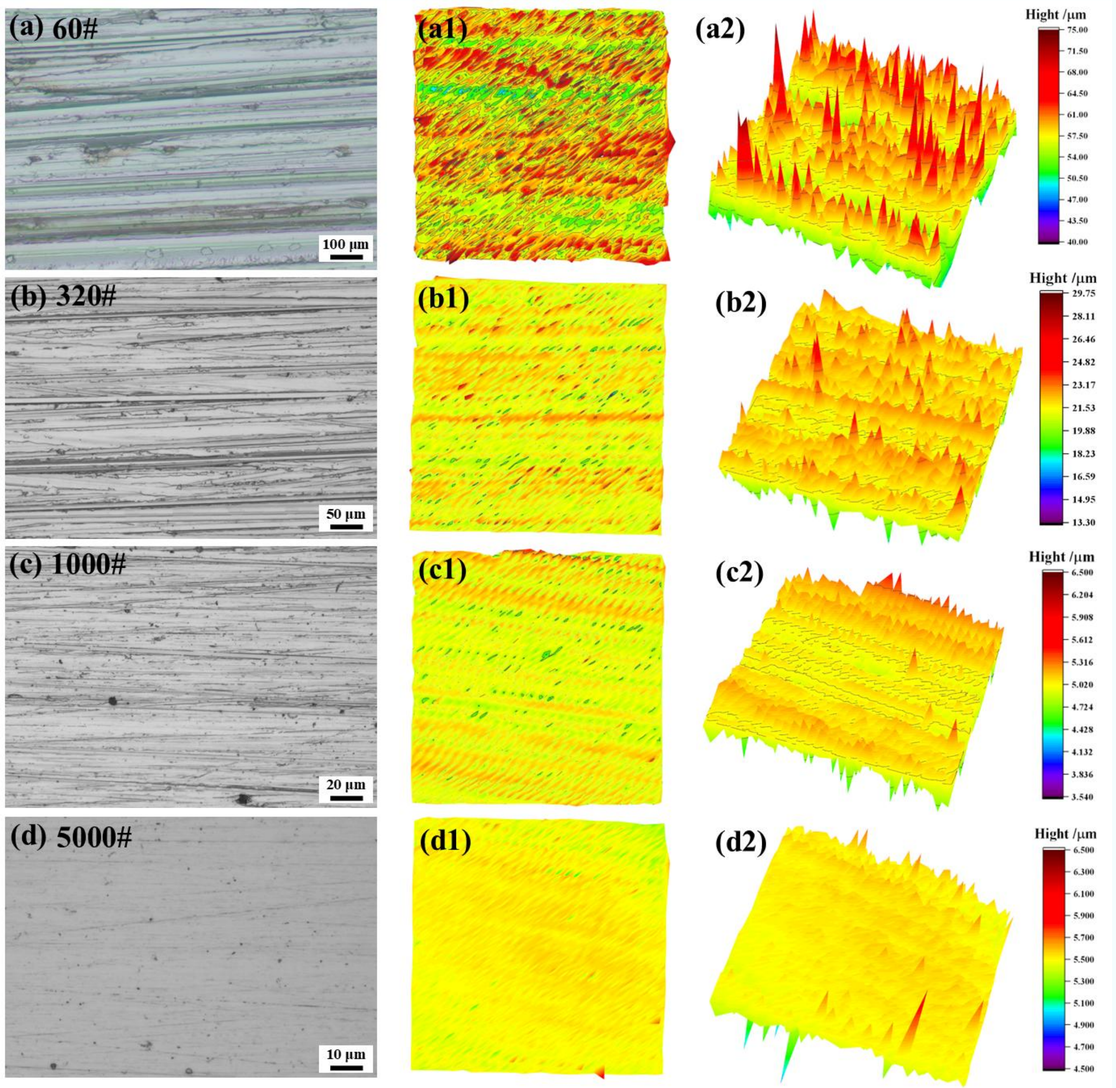
Non-monotonic dependence of hydrogen embrittlement susceptibility on surface roughness in X80 pipeline steel

Weiguo Li（*liweiguo@nimte.ac.cn*）, Xiao Xing*（*xingxiao@nimte.ac.cn*）, Y Frank Cheng*（*frankcheng@nimte.ac.cn*）

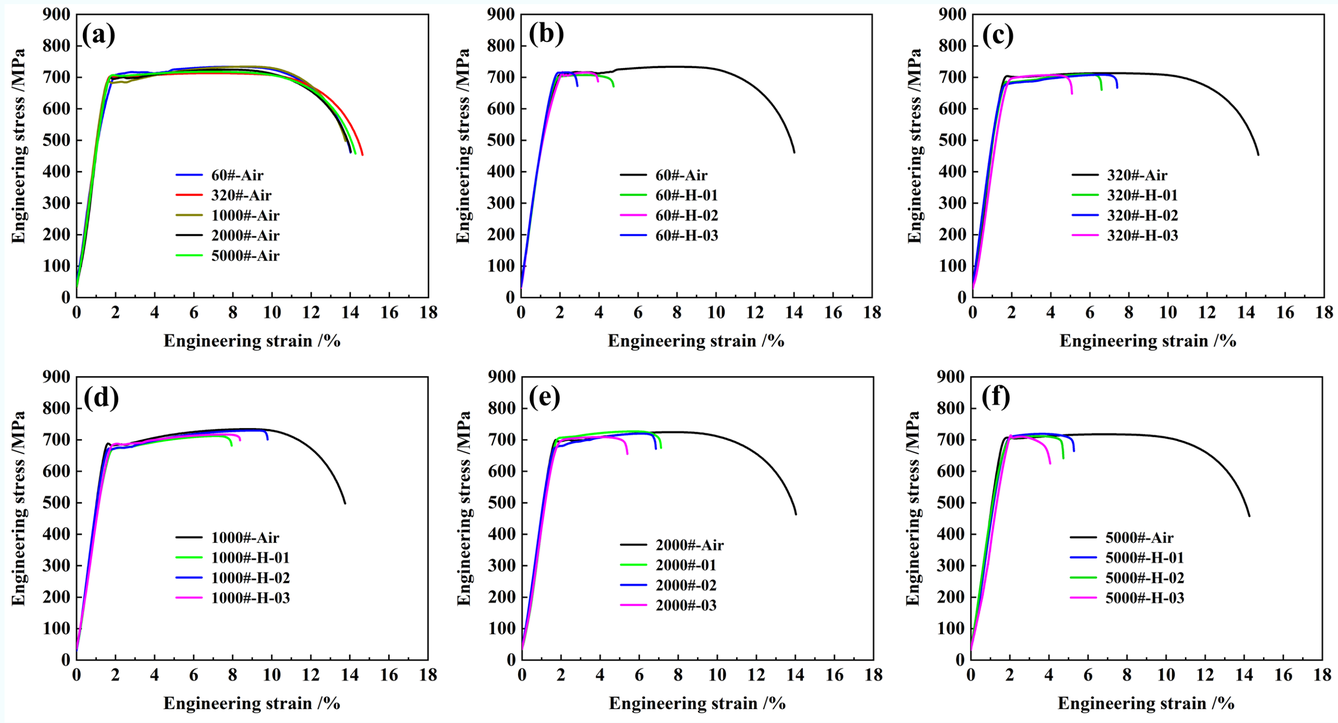
State Key Laboratory of Advanced Marine Materials, Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo, 315201, China

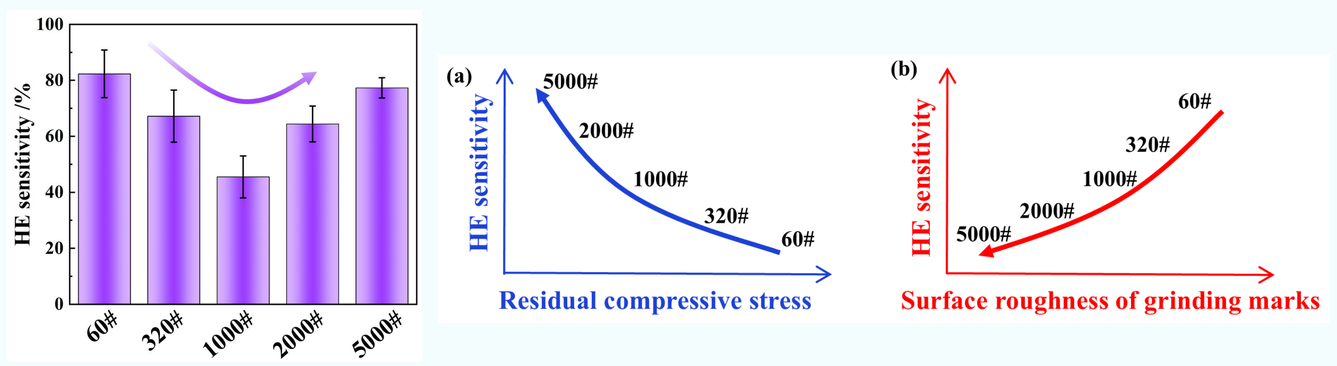
Abstract: Surface roughness non-monotonically affects hydrogen embrittlement (HE) in X80 steel. HE susceptibility minimizes at intermediate roughness due to competing effects: groove-induced stress/trap accumulation (promoting HE) vs. grinding-induced compressive stress (inhibiting HE). Coarse grinding and excessive polishing both elevate HE susceptibility, while moderate grinding achieves optimum. Hydrogen mapping confirms near-surface density is highest for coarse and polished surfaces. This challenges the smoother-is-better paradigm, advocating intermediate finishes for pipeline steels.

Keywords: Hydrogen embrittlement; X80 pipeline steel; grinding mark roughness; residual stress; hydrogen distribution

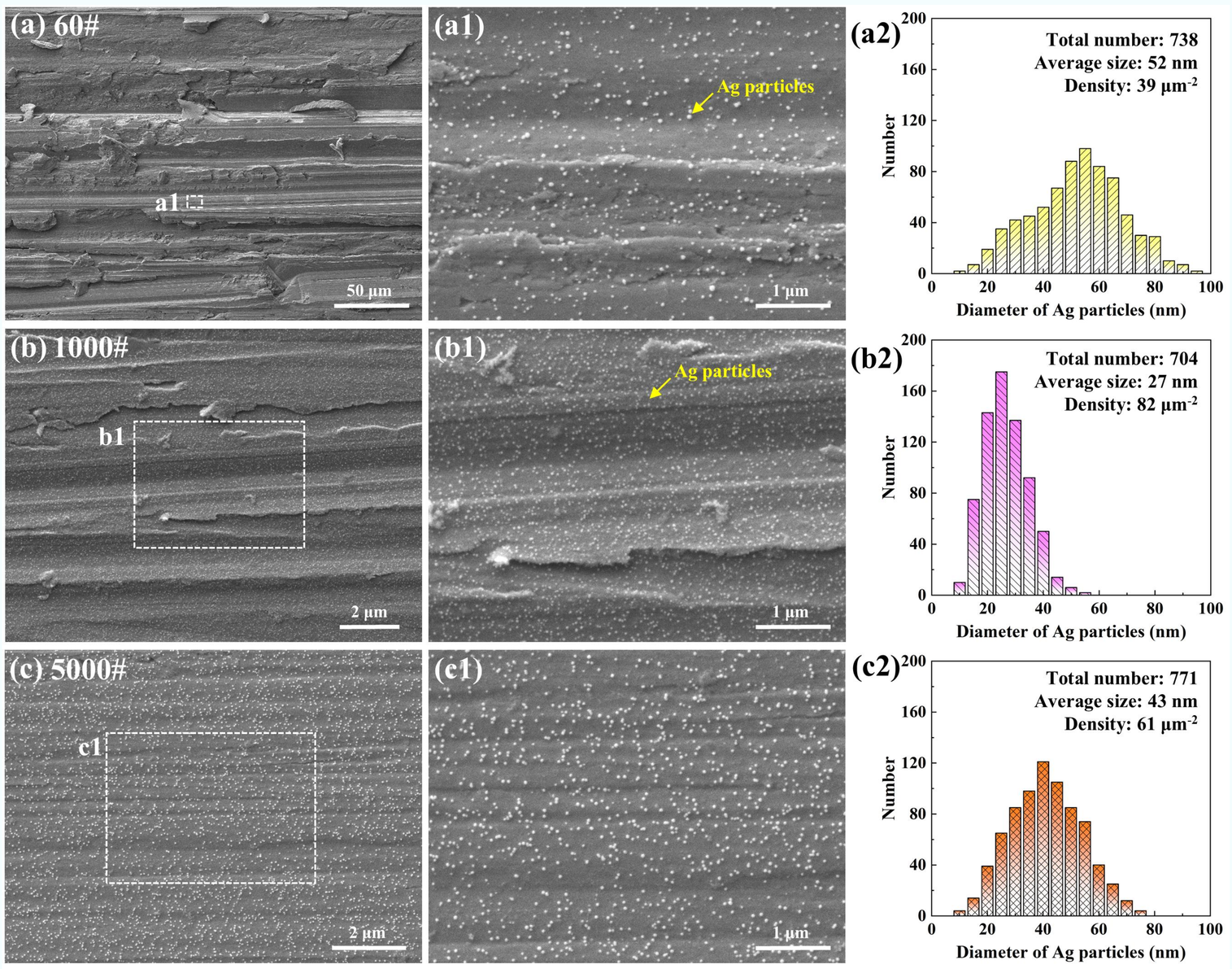


Confocal laser confocal microscope three-dimensional images of grinding mark morphology

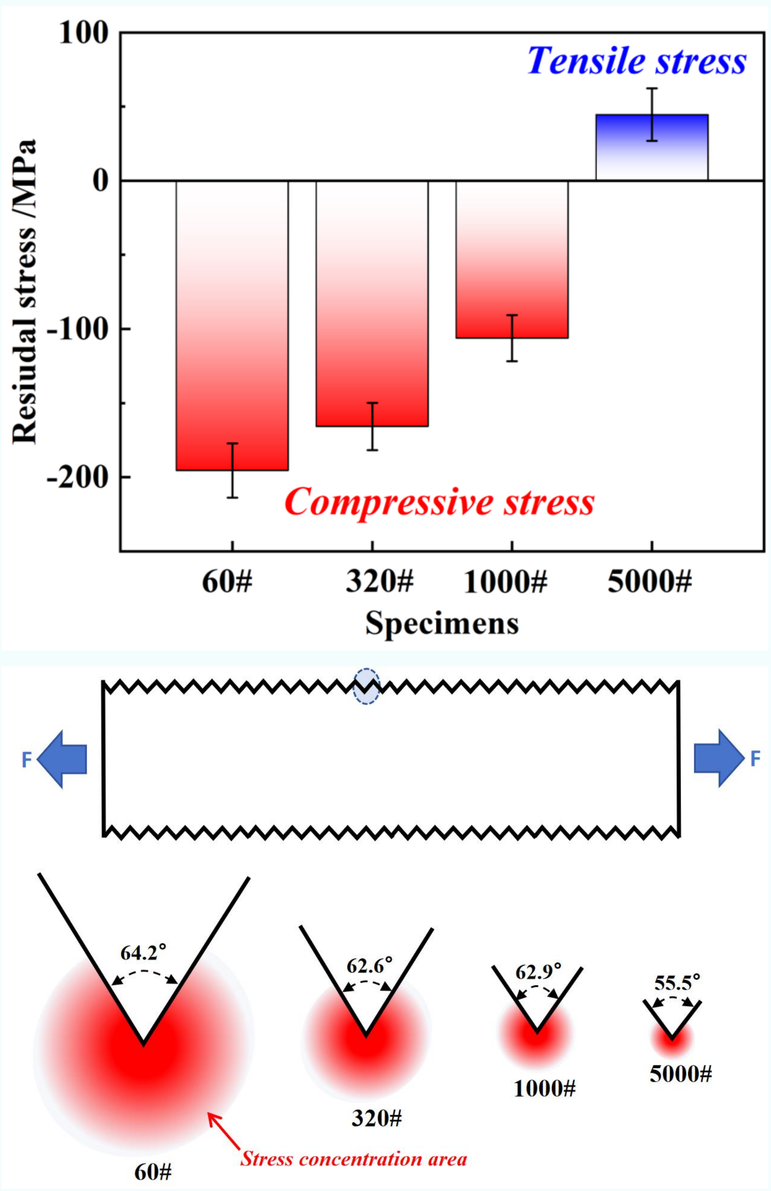




Stress–strain curves of H-uncharged and H-charged specimens and HE susceptibility for various specimens.



HMT test results of the unstretched specimens



Surface residual stress and Simplified V-notch model analysis of stress concentration characteristics

Key point: The hydrogen embrittlement susceptibility of X80 pipeline steel exhibits a non-monotonic dependence on surface roughness—first decreasing then increasing as roughness decreases—with intermediate roughness (1000#) achieving optimal resistance via a balance between stress concentration/hydrogen trapping and residual compressive stress, thereby challenging the long-held belief that smoother surfaces always improve HE resistance.