The shield effect of phase transformation stress field at crack tip

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Introduction

Metal always be used as main materials of advanced industry. Thus, fracture or crack propagation problem is difficult to avoid. If the problem could be solved, the metal equipment's service life would be extended and the disaster due to the brake of crack propagation could be prevented. From the above, we know the technique of crack arresting is strongly needed in practice.

Experimental observation presented that: heat concentration can be formed by electric current flowed around crack tip when the current direction is not parallel with crack direction in a current conductor and small welded joints also can be formed by the melting of metal as a result of heat concentration effect at crack tip. It can be observed that the structure around the crack tip has been refined; means the phase transformation has been occurred. Around the crack tip, a white-bright layer is formed after discharging. It is the new phase transformation structure to prevent the crack propagation. The technique of arresting crack propagation by electromagnetic heat effect could be used in practice someday.

Compressive stress field of phase transformation at crack tip

The thermal compressive stresses around crack tip increase instantly in a very short time. It is the thermal compressive stress to help preventing the crack propagation at the moment of discharging. After cooling, a white-bright layer around will be formed, and high compressive stresses field of phase transformation will be there to prevent crack propagation.

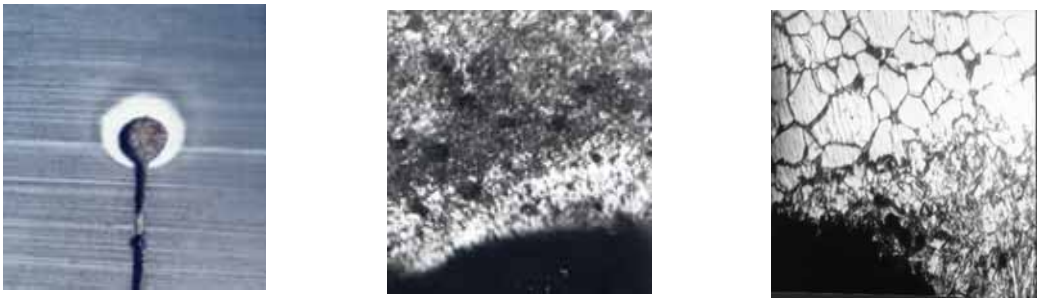

Fig1. White-bright layer macroscopical appearance and microstructure around crack tip

Measurement of phase transformation volume expansion

The measurement of phase transformation volume expansion is done by using equipment made in the US. Because of the word limit of the summary, the detail will be presented in the final paper.

Fig2. The specimen and the state around crack tip after discharging

Mechanical Property Test Under Nanometer Scale by SPM

The mechanical properties tests under nanometer scale have finished by using SPM (Scanning Probe Microscopy). The conclusion shows that the micro-hardness and Young's modulus under nanometer scale have been promoted greatly after discharging. This test provided the experimental supporting of the technique of arresting crack propagation by pulse current discharging in engineering application.

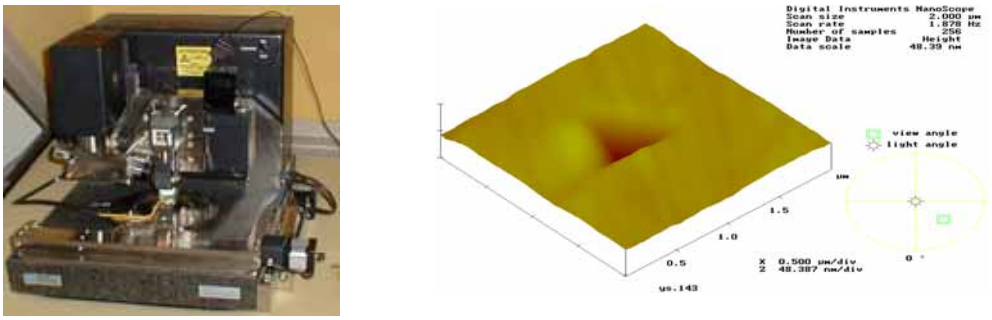

Fig3. The equipment of SPM and the pressure mark

Calculation and analysis of the shield effect of the compressive stress field

The following phenomena can be observed at the crack tip: heat concentrate effect, area of melting and tiny welded joints, the sharp crack tip turning into a blunt ball shape, and the radius of curvature increasing instantly etc. The microstructure around the crack tip after discharging is shown in Fig.2. It is clear that the structure around the crack tip is obviously refined, the content of pearlite is greatly increased, and lathy martensite also appears. The material of the white-bright layer is made up of super fine martensite and carbon particles. It is the new phase transformation structure to prevent the crack propagation. We will shown the calculation for the compressive stress field in the final paper.

Conclusion

After stop crack propagation by using electromagnetic effect, the microstructure around the crack tip is refined. The white-bright layer is the fundamental reason to stop crack propagation. It is the new phase transformation structure to prevent the crack propagation. All these provide the references for engineering practice.

References

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