On the Relation Between Delamination Wear and Microcrack Propagation

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ABSTRACT

Compressive residual stress induced in shot peening enlarges the low crack growth rate region, it reduces delamination wear rate,

KEYWORDS

Delamination wear, residual stress, shot peening, microcrack growth.

INTRODUCTION

Delamination theroy proposed by Suh(1977) suggests that the cyclic loading occuring during wear is similar to that in fatigue. Thus, the compressive residual stress will reduce the wear rate.Previous work (He,1983) showed that a stress component normal to the surface does exist in a worn surface, but its magnitude is too small to affect the wear rate to a significint extent. Normally, residual stresses build up in the early stage of wear and distroy any initial stress pattern. However, if the compressive residual stresses are larger than that could eventually be induced by wear, the wear rate will decrease. With the hardness of the hardened AISI 4340 specimens kept in constant, the sliding wear rate of a shot peened specimen was six times lower than that of a ground one. Ritchie(1978) has tried to connect the fatigue behavior and delamination wear rate in ultrahigh strength steels, but the experimental results showed no correlation between wear rate and macroscopic fatigue crack growth rate. It was suggested that the wear rate was rather associated with the initiation and propagation of microcracks. Yamamoto(1980) found fan-shaped microcracks in the surface layer of a lubricated roller. Microcracks take a 20-30 degree angle from the surface to the core.

The purpose of this experiment is to examine how the compressive residual stress influence the propagation of a microcrack during fatigue.

EXPERIMENTAL RESULTS AND DISCUSSION

40Cr(AISI 5140) steel was 860°C oil quenched and 200°C tempered. The peening parameters were so selected as to keep the hardness from change.

Fatigue test was carried out with three point bending. The specimens fractured just above the fatigue limit were subjected to SEM and replica examination.

Observations of shot peened specimen show that a dark area is easily identified at low magnification (fig.1,a). In the ground specimen this is not very clear(fig.1,b). Under high magnification of the replica, a low crack growth rate region characterized by transgranular slip decoherence is extended after shot peening(fig.2,a). The features of the fracture surface are related to the microstructure. In the ground specimen, the striations appear not far from the fatigue origin(fig 2,b), it suggests that the crack growth rate increases rapidly through the depth.

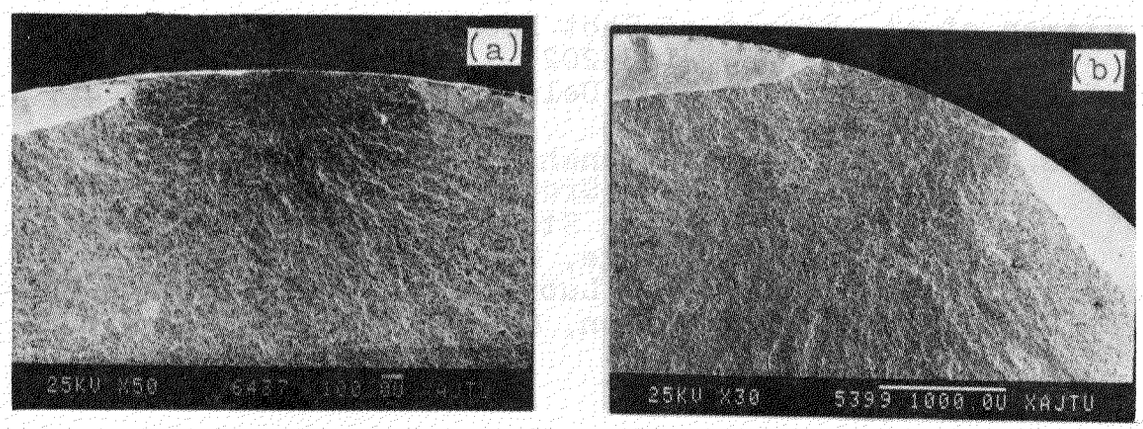

Fig.1 Fatigue origin area a, shot peened. b, Ground

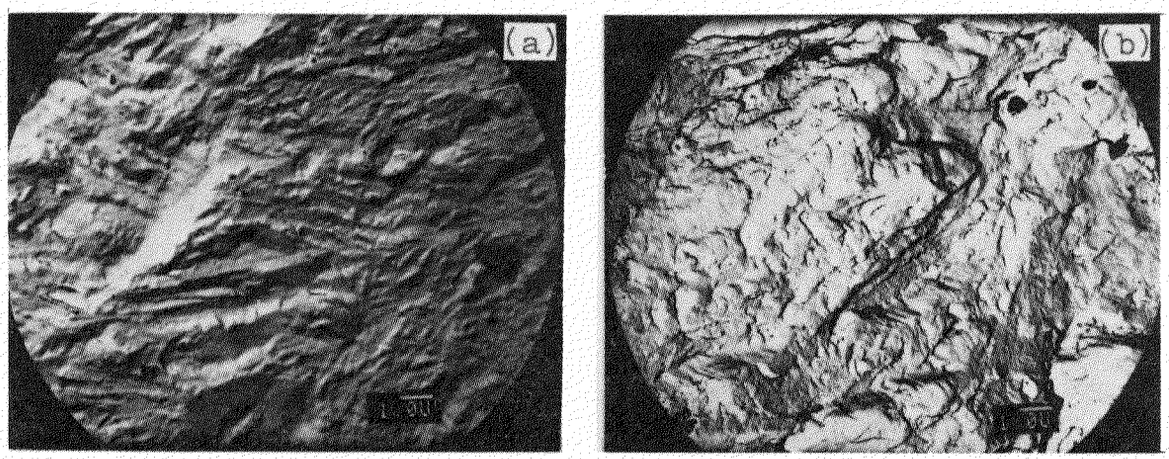

Fig.2 Replica near the origin a, shot peened b, Ground

Although the low crack growth rate region is only of the order of one hundred microns, most of the life of the specimen under cyclic loading will be spent in this region. From engineering point of view, o.1mm is always taken as a criterion for the initiation of a macrocrack. The crack growth rate region in a hardened specimen is somewhat less than 0.1mm and is still in the microcrack propagation stage. The compressive residual stress may reduce the ΔK value at the crack tip and lower the delamination wear rate.

CONCLUSION

With the hardness kept in contstant, compressive residual stress is the factor which enlarges the low crack growth rate region during fatigue. Thus, it reduces delamination wear rate.

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