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Friction and Wear of Nitrogen Supersaturated Tool Steels

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High density low temperature plasma nitriding process had been developed to investigate the effect of nitrogen supersaturation into stainless steels on their wear toughness. AISI420 die materials were plasma nitrided at 673 K for 14.4 ks to describe their friction and wear behavior by BOD (Ball-On-Disc) method. SKD11 and SKH51 tool steel punches were also nitrided to promote their wear toughness and to prolong their tool lives. Fine blanking experiments proved their toughness even under the narrow clearance.

Keywords: friction and wear, BOD, plasma nitrided stainless steels, nitrogen supersaturation

1. Introduction

A low temperature plasma nitriding has been utilized to improve the wear and corrosion toughness of stainless steels [1]. This plasma nitriding is characterized by the nitrogen supersaturation into steels without any precipitations. Their nitrided layer has two-phase, fine-grained microstructure; the matrix hardness increases to 1400 HV and the average nitrogen solute content is 4 mass%. Owing to these characteristics, this surface treatment has been utilized to harden and strengthen the austenitic and martensitic stainless steel dies as well as the tool steels [2, 3]. The plasma nitrided SKD11 tool steel discs and punches at 673 K for 14.4 ks are prepared to describe their frictional behavior in the ball-on-disc experiments (BOD) and to investigate their wear toughness in fine blanking (FB) tests.

2. Methods

SKD11 disc as well as SKD11, SKH punch species were placed into the hollow cathode device to intensify the nitrogen ion and nitrogen-hydrogen radical densities in plasma nitriding. RF (radio frequency) and DC (direct current) bias were constant by 250 V and -500 V, respectively. After nitriding and cooling down in the chamber, these specimens were utilized for BOD-test and FB-test, respectively. In the former, the austenitic stainless steel type AISI316 ball with the diameter of 6 mm was employed as a counter material under the normal load of 10 N by the sliding velocity of 50 mm/s. In the latter, the fine blanking simulator (Mori-Seiki, Co., Fukuoka, Japan) was utilized to investigate the role of nitrogen supersaturated layer to protect the SKD11/SKH punch from severe wear during blanking under the narrow clearance of 4%. AISI316 plates with the thickness of 3 mm were used as a work.

3. Results and Discussion

Evolution of the friction coefficient with the running distance in dry without lubricating oils is depicted in Figure 1. Its average is 0.67 with the deviation of 0.05. This constant friction implies that no galling takes place on the contact interface and that the abrasive wear advances slowly with relatively low friction.

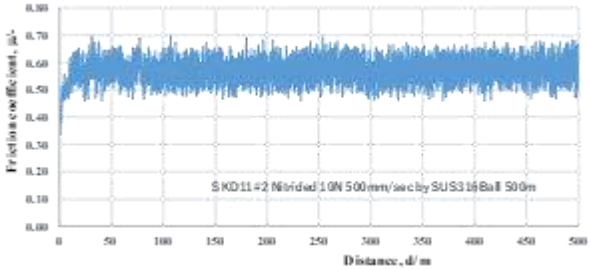

Figure 1: Evolution of the friction coefficient with the running distance.

Both the bare and plasma nitrided SKD11 punches were utilized for fine blanking experiments. As seen in Fig. 2a, the chipping occurred at the bare SKD11 punch edge because of severe stress concentration and strict change of plastic flow velocities at the punch head and around the punch edge. The plasma nitrided SKD11 punch has sufficient durability with less damages at the edges.

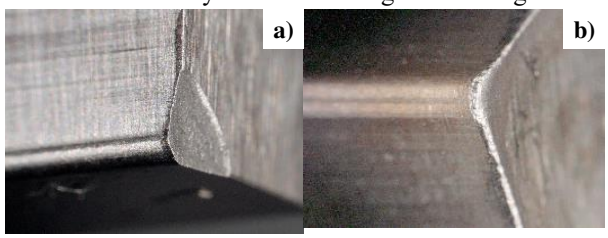

Figure 2: Punch edge durability in fine blanking under lubrication. a) A bare SKD11 punch at N = 32, and, b) nitrided SKD11 punch at N =260.

4. References

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