Proceedings of Asia International Conference on Tribology 2018, pp. 240-241, September 2018

Fretting wear characteristics of AISI 1040 steel alloy

Krishnamurti Singh*, Mayank Tiwari, Anirban Mahato

Department of Mechanical Engineering, Indian Institute of Technology, Patna, 801106, Patna, India.

*Corresponding e-mail: krishnamurti.pme16@iitp.ac.in

Keywords: Fretting wear; stick slip; optical profilometry

ABSTRACT – Most shrink fit joints, couplings and fasteners of machine components are generally made up of AISI 1040 steel. These components are subjected to the fretting wear due to vibrations induced from machine operation. Fretting wear test on AISI 1040 steel is performed at different normal loads in ambient condition using Rtec MFT 5000 tribometer. The effect of different normal loads on coefficient of friction, slip regime and wear profile are analyzed. The result reveal that normal load has significant effect on fretting wear performance of AISI 1040 alloy. Optical micrograph obtained from optical microscope shows that with increase in normal load transition of gross sliding to partial sliding takes place.

1. INTRODUCTION

In general, almost all the mechanical components have different type of contacting bodies which are subjected to vibration during running condition. These vibrations cause the loss of material from the contact interface which is commonly known as fretting wear. First systematic study of fretting wear was performed by Tomlinson [1]. Vingsbo & Söderberg [2] presented a classical fretting map representing the gross slip and partial slip regime as the function of normal load and slip amplitude. Fretting wear is categorized in three slip regimes out of which partial slip regime is most critical as in this regime crack initiation and propagation takes place at junction of stick and slip. Li et al.[3] conducted fretting wear test in ball on plate configuration on inconel 690 TT alloy. They have concluded that in gross slip regime degradation mechanism was deformation, oxidation and delamination crack in worn sub surface while in partial slip regime deformation of asperities in adhesion zone, oxidation at worn edge and fatigue crack at junction stick-slip. Li & Lu [4] performed fretting wear test on inconel 600 alloy and concluded that with increase in sliding amplitude coefficient of friction and wear volume increases. Jeong et al. [5] conducted fretting wear test on AISI 1045 steel and concluded that coefficient of friction decreases with increase in normal load and transition of gross slip to partial slip takes place.

Fouvry et al. [6] proposed the method for quantification of wear damage using dissipated frictional energy in the contact interface for different regimes of fretting and proposed transition criteria for various regimes of fretting. AISI 1040 steel is used in the couplings, crankshaft and shrink fit joints where fretting wear is one of the important failure modes.

In past, very limited number of fretting wear study have been reported on AISI 1040 steel. Which indicates the need of detailed investigation of AISI 1040 steel under gross and partial slip conditions.

In the present study fretting wear experiment on AISI 1040 steel plate sliding against AISI 4340 steel pin is carried out at constant sliding amplitude, constant sliding frequency and with different normal loads, to obtain the effect of normal load on coefficient of friction and wear damage.

2. EXPERIMENTAL METHODOLOGY

Before performing the fretting wear test, samples were polished up to average surface roughness 0.03 μm. Hardness tests were performed on both upper and lower samples using Vickers hardness tester. Figure 1a shows the indent of Vickers hardness test on upper sample and figure 1b shows the indent on lower sample at 2 Kgf.

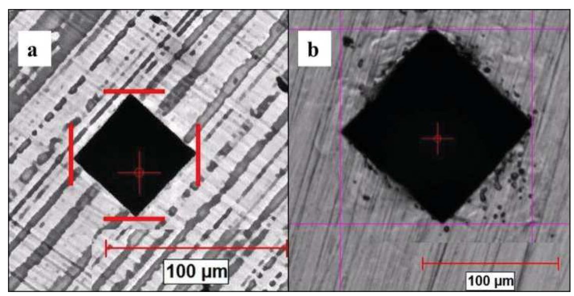

Figure 1 Optical micrograph of Vickers hardness test.

Figure 2 shows the stress-strain curve of AISI 1040 steel obtained from the tensile test conducted atcrosshead speedof 1.5mm/min. Yield strength is found to be 356 MPa obtained by 0.2% strain offset.

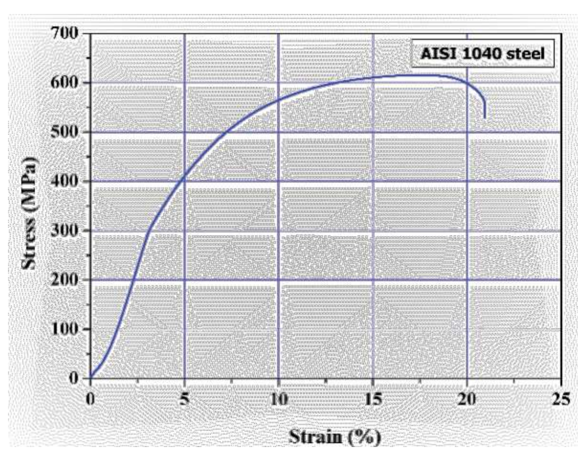

Figure 2 Stress strain graph of AISI 1040.

Mechanical properties of the test material are listed in Table 1.

Table 1 Mechanical properties of the materials.

Material	**Modulus of Elasticity (GPa)**	**Hardness, *HV***
AISI 1040	200	180
AISI 4340	210	776

Fretting wear tests of AISI 1040 steel alloy areperformed using Rtec multifunctional tribometer (Rtech Instruments, USA) in pin on plate contact configuration at room temperature in dry sliding condition. Target sample is lower specimen which is made up of AISI 1040 steel alloy plate with dimension $35 \times 25 \times 3\ mm$ and upper specimen was *6 mm* diameter hemispherical pin of AISI 4340 steel. Figure 3 shows the schematic contact configuration.

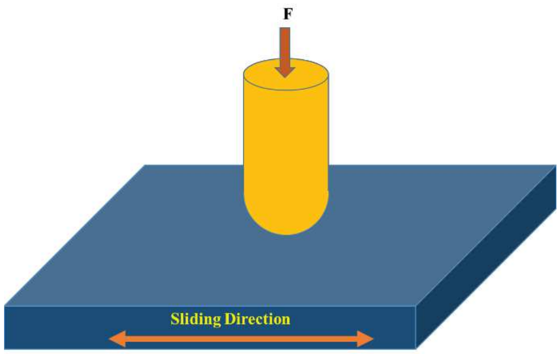

Figure 3 Schematic representation of pin on plate contact

Fretting wear test is performed at constant sliding amplitude $50\ \mu m$, constant sliding frequency $50\ Hz$ and different normal load from $10\ N$ to $45\ N$. Effect of displacement amplitude is discussed in next section.

3. RESULTS AND DISCUSSION

Figure 4 shows the variation of coefficient of friction with normal load.

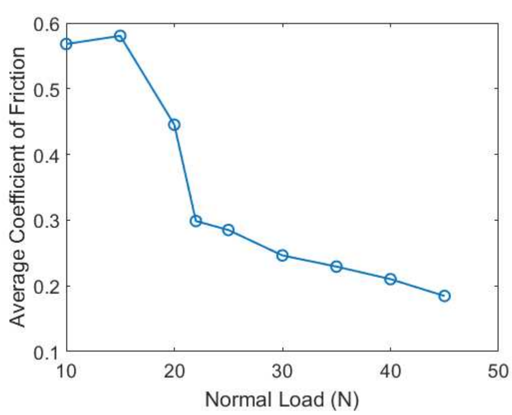

Figure 4 Variation of coefficient of friction with normal load.

With increase in normal load coefficient of friction decreases. In partial slip regime rate of decrease in coefficient of friction is small while in gross slip regime it is more. Highest coefficient of friction is observed at 15 N applied load. Figure 5 shows the worn surfaces obtained from the optical microscope in different sliding condition.

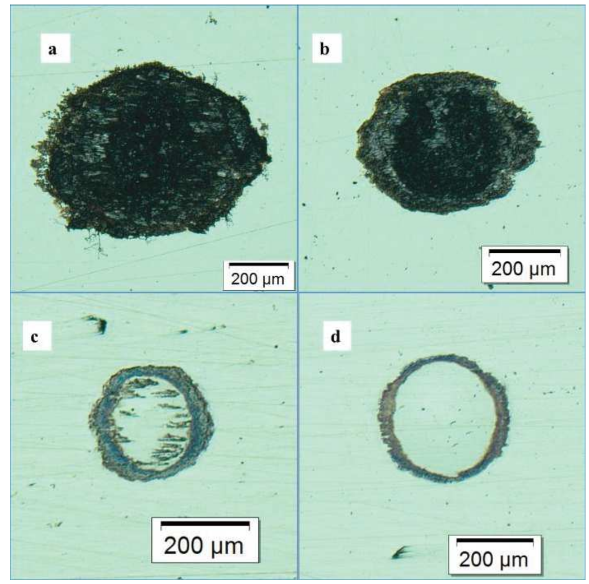

Figure 5 Optical micrograph at applied normal load (a) 10 N (b) 20 N (c) 22 N (d) 40 N

From Figures 5(a) and 5(b) it is observed that gross sliding in the contact interfacetakes place for the applied load 10N to 20N. After 20N transition from gross sliding to partial sliding takes place. At 22 N Normal Load, visible stick zone in the center of the contact is observed with small scratches which indicates that few wear debris are entrapped in the stick zone.

As the Normal Load increases from 22 N to 45 N, central stick zone extends towards outside and width of slip zone observed to be diminishing.

REFERENCES

[1] Tomlinson, G. A. (1927). The rusting of steel surfaces in contact. *Proceeding of the Royal Society of London A*, *115*(771), 472-483.

[2] Vingsbo, O., & Söderberg, S. (1988). On fretting maps. *Wear*, *126*(2), 131-147.

[3] Li, J., Yang, B. B., Lu, Y. H., Xin, L., Wang, Z. H., & Shoji, T. (2017). The degradation mechanism of Inconel 690TT induced by fretting wear in air. *Tribology International*, *116*, 147-154.

[4] Li, J., & Lu, Y. H. (2013). Effects of displacement amplitude on fretting wear behaviors and mechanism of Inconel 600 alloy. *Wear*, *304*(1-2), 223-230.

[5] Jeong, S. H., Yong, S. J., & Lee, Y. Z. (2007). Friction and wear characteristics due to stick-slip under fretting conditions. *Tribology Transactions*, *50*(4), 564-572.

[6] Fouvry, S., Kapsa, P., & Vincent, L. (1996). Quantification of fretting damage. *Wear*, *200*(1-2), 186-205.