The Influence Of Contact Pressure And Load On Metallic Wear On Both Smooth And Rough Surfaces

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1. INTRODUCTION & OBJECTIVE

Wear is most related to interactions between surfaces and, more specifically, the deformation and removal of material on the rubbing surface. The five main wear categories are adhesion, abrasion, fatigue, erosion, and corrosion. The present study is related to the parametric dependence of adhesive and abrasive wear on contact pressure and load.

In various papers, their analysis exhibited that adhesion wear may be the function of surface roughness, contact area, and the applied load)[1],[2] In dry rubbing surfaces, the wear rate is proportional to the applied load[3]. The wear process is multistage in behaviour, first a more or less abrupt rise, then a levelling-off, and finally a transition to accelerated wear. It was observed that the depth rate of wear depended on the nominal contact pressure rather than the load[4]. Hertz's theory calculated the contact area and pressure between the two surfaces and predicted the resulting compression and stress induced in the objects. On continuous and non-conforming frictionless surfaces, only a normal pressure is transmitted between the contact of two elastic bodies[5]. Contact pressure and load are essential parameters in metallic adhesive and abrasive wear. In the present work, the dependence of wear on contact pressure and load is investigated, analyzed theoretically and experimentally, and concluded which parameter is more dominant.

2. METHODOLOGY

We used different experimental methods to obtain the proper parameter which affects the wear the most under dry and wet conditions. The following experimental wear mechanisms were used for the analysis.

I. A Four-Ball Tester Experiment was used to get the data on the depth of metal worn out on the high chrome steel balls under wet conditions. Later, it was compared with the balls' contact pressure and applied load on them. It results that wear varies monotonically with applied load, but the wear rate increases or decreases with the asperities contact, leading to a change in contact pressure. That is, contact pressure has more dominancy on wear than the load applied. The results are given in below figures 1 and 2.

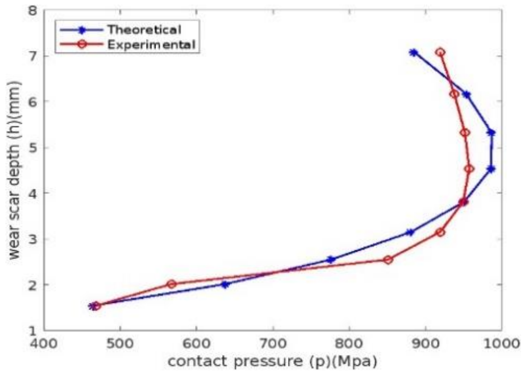

Figure. 1. contact pressure versus depth of metal worn out for Four-Ball Tester.

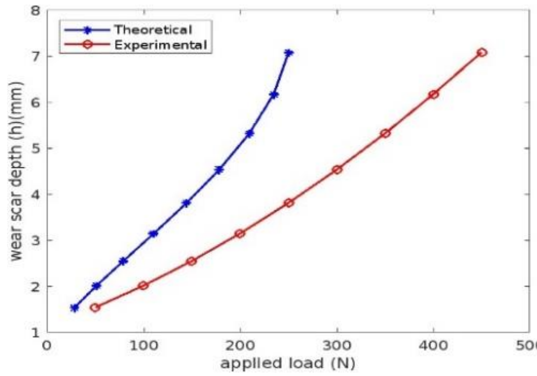

Figure. 2. Load versus depth of metal worn out for Four-Ball Tester.

II. Pin-on-Disc Tester was used on a mild steel cylindrical pin placed over a flat rough rotating disk under dry conditions. We calculated the material removal rate on the pin for different roughness conditions by measuring the pin- weight before and after using it for the test. It gives that the wear rate shows more dependency on contact pressure. At the points at which the pressure levels are low and high, the wear rate is observed to be low due to more asperities contact area, whereas, at medium pressure level, the wear rate is more due to less contact area.

III. A Universal Tribometer experiment was carried out on the smooth stainless steel ball, rubbed on the rough mild steel disc under a load less than or equal to 10N. The depth of the ball in contact with the disc is monitored continuously during the test for different roughness. We could observe a similar result to pin-on-disc analysis and concluded that pressure depends more on a smooth surface ($\sigma = 0.81\ \mu m$) than a rough surface ($\sigma = 1.02\ \mu m$).

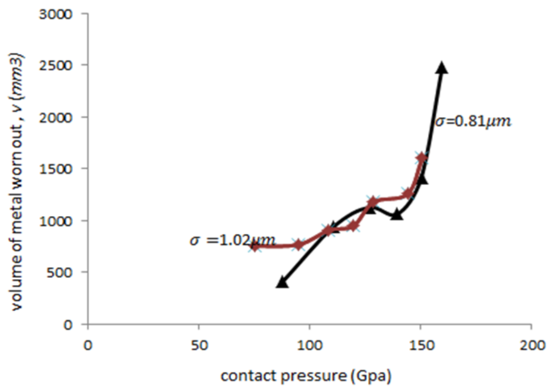

Figure.3. Results of universal tribometer analysis - Contact pressure versus volume of metal worn out for varying roughness.

3. RESULTS & HIGHLIGHTS

It was concluded that for smooth surfaces at low-contact pressure levels, adhesion wear increases slower with pressure; the reason may be that poor intimate contact between the opposing asperities keeps the wear level low. Due to a high close contact, as more and more tiny asperities come into contact, the wear rate increases suddenly to a very high value at medium pressure levels. With the rise in load, contact pressure comes down by establishing a larger contact area. Meanwhile, the wear rate varies as directly proportional to the applied load. The pin-on-disc wear mechanism produced a similar result for dry rubbing of rough surfaces and higher loads (0.5-3.5kg) show pressure has more influence on abrasive wear. Adhesive wear was negligible in this experiment. Universal tribometer analysis provides the same results as the pin–on–disc machine experiments on dry rubbing and smooth rubbing of rough surfaces with smaller loads up to 10N. But here, we found that the wear rate increment is more on smooth surfaces (σ=0.81μm) than on rough surfaces (σ=1.02μm). In most experiments, load and wear rates were monotonically varying. In this investigation, we may conclude from these results that the contact pressure seems to be the more dominant parameter than the load in abrasive and adhesive wear.

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