COATINGS FOR MECHANICAL COMPONENTS
Recent results from the Uppsala Load Scanner

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ABSTRACT

Introduction

A strong dependence on evaluation by practical testing is typical for the whole field of tribology. This is due to the complex conditions of geometry, pressure, temperature, contacting materials, and environment, experienced by interacting surfaces in relative motion. However, many of the more traditional wear tests for friction and wear are no longer applicable when developing or selecting thin coatings for mechanical tools and especially for mechanical components [1,2,3]. New dedicated tribological tests and testing procedures must be developed.

This paper presents some of the latest applications and findings by using the Load-Scanner first presented at the OECD conference in Amsterdam 1999. This test was originally developed to assess the ability of seizure between metals in sliding contact, but has proved to be very useful also in the evaluation of thin tribological coatings.

Experimental

The Load-Scanner

This tester uses a configuration involving two crossed, cylindrical specimens typically of Ø = 10 mm, which are forced to slide reciprocally against each under a constant speed [4-6], cp. Figs1 and 2.

During forward strokes, the normal load gradually increases from a low to a high level, see Fig. 1. On the reverse stroke, the load is correspondingly decreased. Each point along the contact path of both specimens will experience a unique load, also in reciprocal testing. Thereby, each point will experience a unique tribological history, which facilitates immediate friction and wear *vs*. load evaluation in one single test, and rapid determination of any critical load. The tests can be run dry or lubricated, cp. Fig 2, and the result is evaluated from the recorded friction history and by imaging the worn surface in the optical microscope (OM) or scanning electron microscope (SEM).

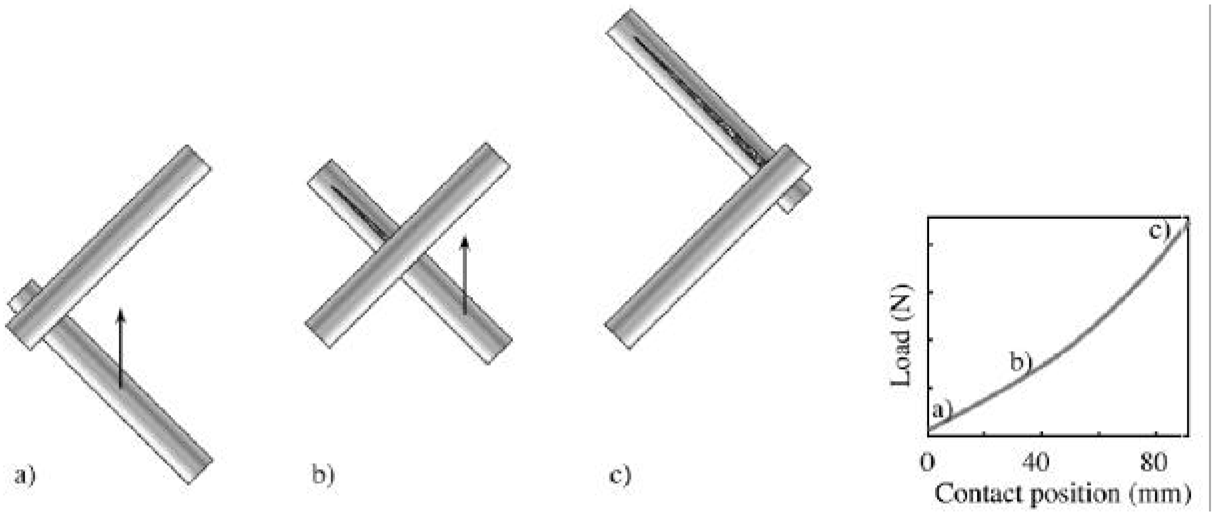


Figure 6. Principal function of the Load Scanner, showing the lower of the contacting specimens moving upwards under increasing load. The load *vs.* position relation is fixed, so that any single point will only experience one unique load also in repeated reciprocal sliding.

b)

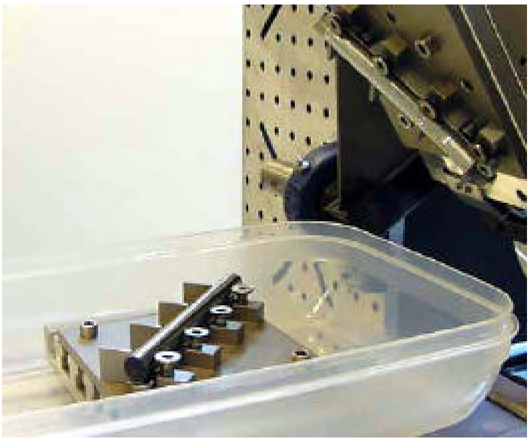


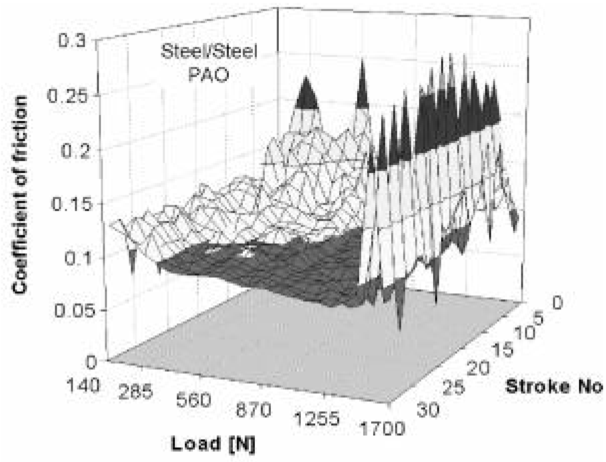
Fig. 2. a) The Load Scanner in operation. b) Detail of the clamped test rods and the oil container used in lubricated tests.

The Load scanner can be used in a single stroke mode to evaluate load carrying capacity of coated components or to establish critical loads for onset of high friction or seizure. In high cycle mode, the influence of load on running-in, friction, wear and fatigue damage is easily assessed. The technique offers a very rapid and convenient means of establishing 3-dimensinal *friction maps*, i.e. diagrams over the friction vs. load and number of strokes.

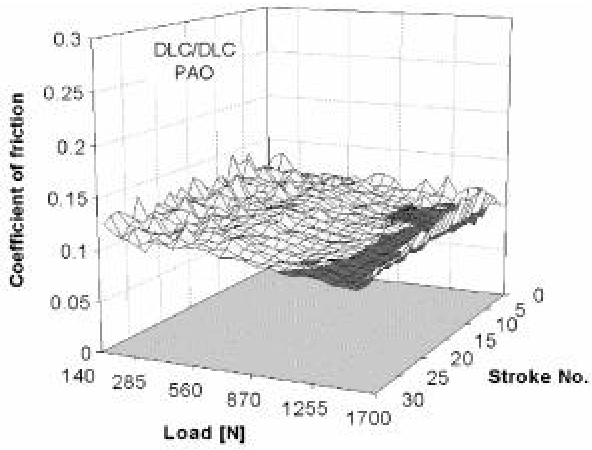
Results and discussion

DLC coated lubricated components

The effect of coating on one or both parts on running-in properties of boundary lubricated DLC coated components have been investigated. Hardened steel rods (H = 8.5 GPa) were used combined as self-mated uncoated steel (Steel/Steel), DLC coated steel against uncoated steel (DLC/Steel) and self-mated DLC coated steel (DLC/DLC). A sliding speed of 0.1 m/s and a load scan of 140 – 1700 N was used, and the friction coefficient during the first 30 strokes was recorded, see Fig. 3. The lubricant was PAO without any additives.



a)



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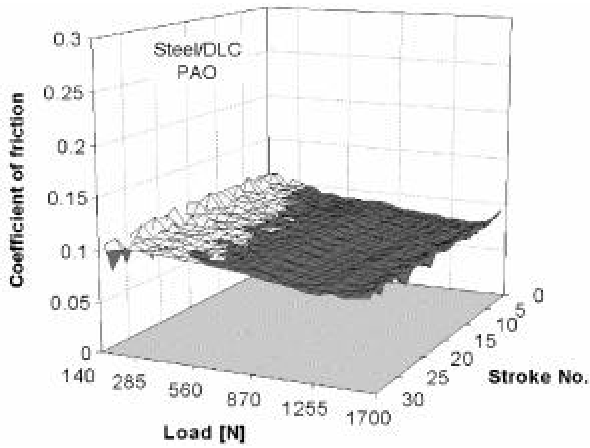


c)

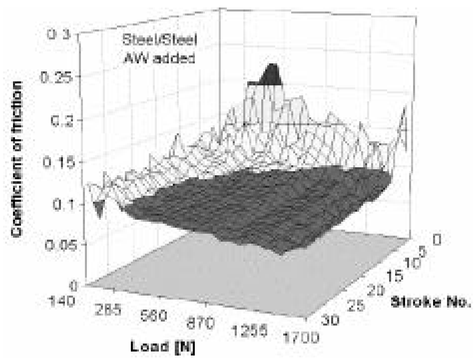
Figure 3. Friction maps demonstrating the influence of DLC coating on the ability of boundary lubricated mechanical components to minimise friction by running-in. Lubricant: Pure PAO oil. a) Uncoated steel against uncoated steel. b) DLC coated steel against DLC coated steel. c) DLC coated steel against uncoated steel [7].

The benefit of the DLC coating is obvious. The Steel/Steel combination initially exhibits rather high friction coefficient, especially at the low and high loads. For the intermediate loads, there is a rapid reduction of the friction coefficient to below 0.1 (dark shade in the diagrams) presumably due to surface smoothening by plastic deformation and wear of the asperities. The friction reduction is relatively slow at low, and especially at high loads, where the oil obviously is not capable of offering boundary lubrication.

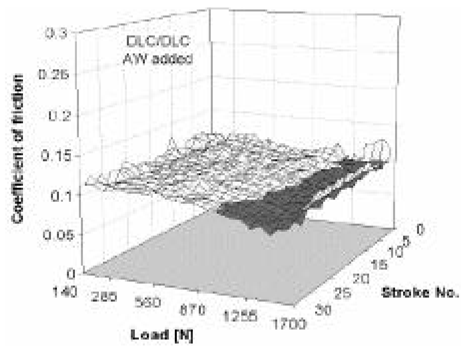
Having both surfaces DLC coated dramatically reduces the initial friction at all loads, but a running-in towards μ = 0.1 occurs slowly and initially only at a relatively high load level, due to the high wear resistance of this coating. The very best result is generated by the DLC/Steel combination, which instantly displays a friction coefficient below 0.1 for almost the whole load interval. The hard DLC coating obviously has the potential to rapidly smoothen the steel counter surface already during the first stroke.

5.4 Effect of coating on running-in with additivated oil

The above test was repeated with anti wear additives (AW) added to the PAO oil [7], see Fig 4. The additives efficiently reduced the high load friction for the steel/steel combination, see Fig. 8a. However, again DLC coating can have a significant effect in further reducing the friction reduction and totally avoiding the high friction during the first few strokes.



a)



b)

Figure 4. Friction maps demonstrating the effect of DLC coating on the running-in friction of boundary lubricated mechanical component. Tests performed in the LS set-up. Lubricant: PAO + AW additives. a) Uncoated steel against uncoated steel. b) DLC coated steel against DLC coated steel. c) DLC coated steel against uncoated steel [7].

c)

Conclusion

A positive effect of DLC coating on only one surface was observed. This is due to the fact that a tribofilm composed of both reaction products between steel and the lubricant, and elements from the coating is formed that seems to give a somewhat lower friction than the film formed on steel surfaces in self mated contact [8].

Acknowledgement

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