Experiment Number 19

What effect does a friction modifier have on a steel on steel reciprocating contact lubricated with PAO base oil?

Background

The effect of friction modifiers has been documented in great detail. This experiment seeks simply to demonstrate the benefits of adding an organic friction modifier to a PAO 4sCt base oil and examining the change in tribological performance.

Method

Initially, both specimens where run-in according to ASTM G181. The specimens were then tested to failure by increasing the load (P_{max}=390MPa) on the contact. The contact consisted of a 52100 cylinder in line contact, reciprocated at 10Hz at 25 mm stoke against an annealed steel plate. The test was run at 20^{0}C and lubricated using PAO (4cSt) with and without 0.5wt% organic friction modifier.

Wear Scar Images

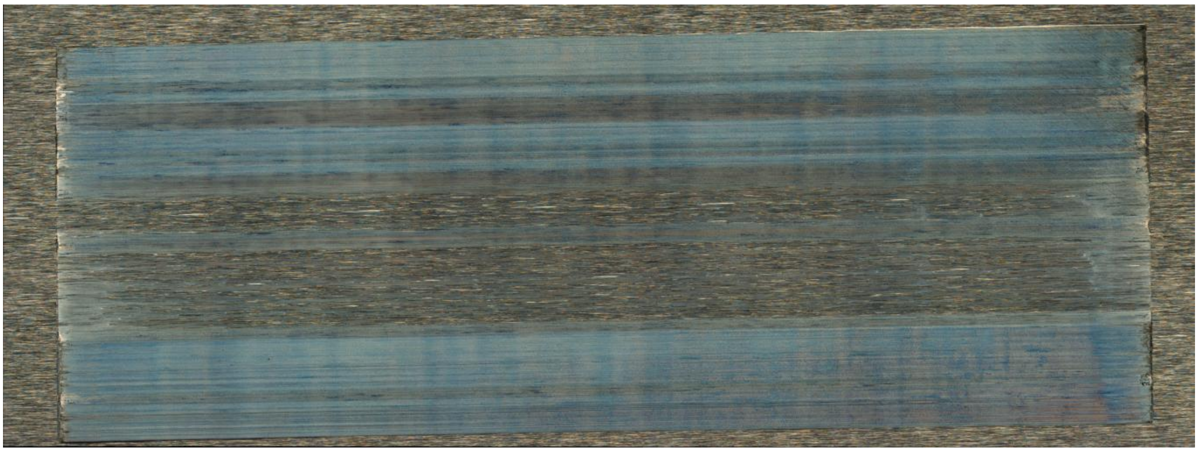

Figure 1: PAO

Comments

Grinding marks are only visible in the centre third of the wear scar. The outer sections are polished; significant volume of material is piled up at the ends of the stroke. The polished regions have a roughness of 3.7µm. The wear scar has a roughness of 6.3µm compared with the substrate roughness of 11.7µm.

The cylinder reciprocating specimen suffers a pressure distribution characterised by two pressure maximums occurring at each end. It is suspected that during the initial strokes, wear debris from the soft annealed plate form at the edges of the stroke due to the pressure distribution. The cylinder is lifted on the wear debris raising it out of contact with the middle of the plate, resulting in the observed wear scar.

Figure 2: PAO + 0.5% OFM

Comments

Grinding marks are visible across the entire wear scar with narrow strips of light polishing in the direction of reciprocation. There was a significant amount of wear debris from the annealed plate observed in the lubricant and wiped from the surface of the cylinder. The unpolished region exhibits an abraded surface which may be due to the friction modifier preventing adhesion of the wear debris. It is interesting to observe that with the addition of the friction modifier the polished areas of the wear scar move from the edges to the centre. This may be due to the friction modifier being activated by the increased pressure at the edges of the cylinder. The surface roughness in the wear scar is 5.6µm compared with a substrate roughness of 7.1µm. The unpolished (abraded) sections have roughness of 2.6µm compared with a polished section Ra of 2.2µm.

Results

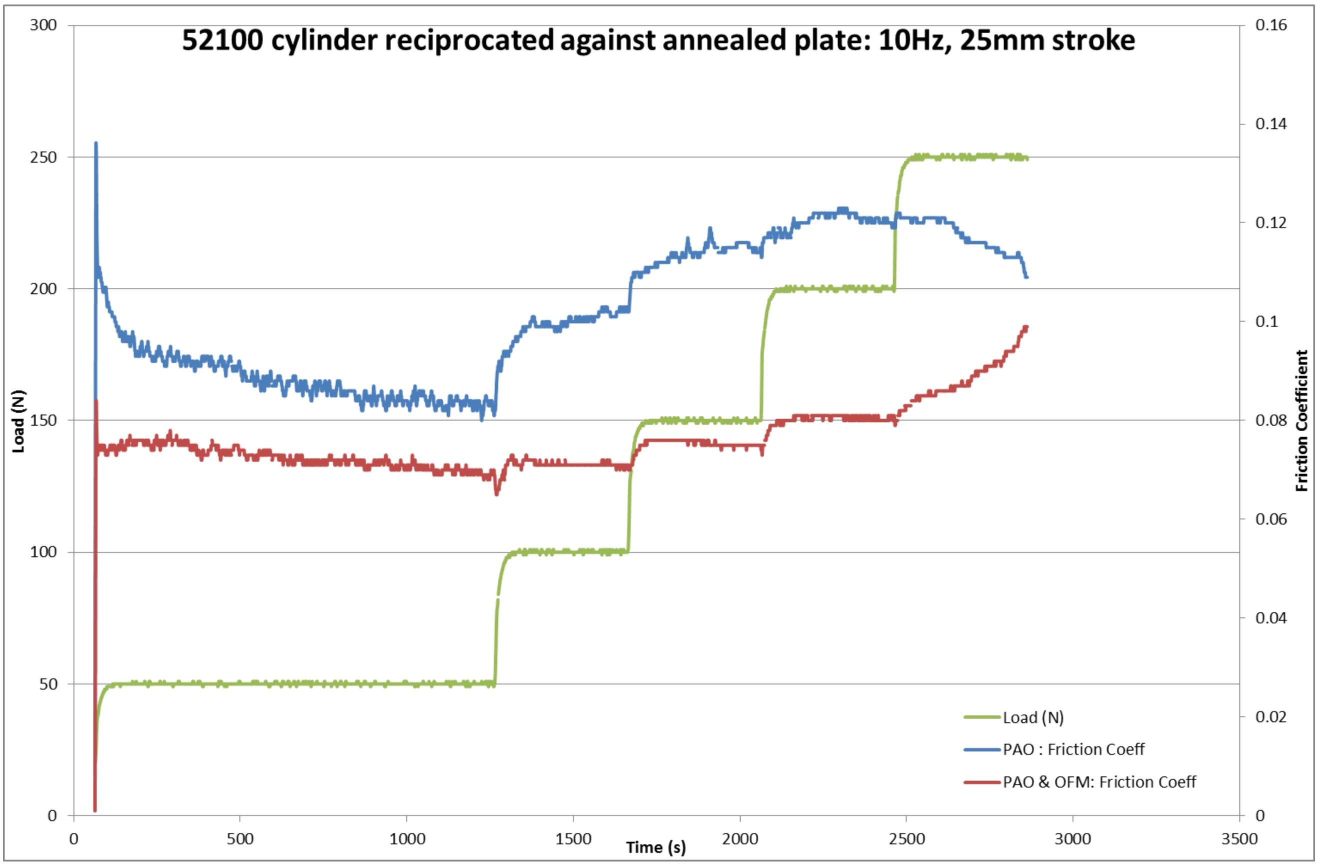

Figure 3: Low Speed Data

Examining the high speed data associated with the end of the PAO test, a square friction trace exhibiting both leading and trailing edge spikes can be observed. This is in agreement with the wear scar image which shows significant adhesive wear at the reversal positions. The addition of the friction modifier alters the high speed friction square wave, superimposing a velocity dependent parabolic profile. It also reduces the RMS to edge to peak ratio, indicating much lower adhesive wear at the reversal positions.

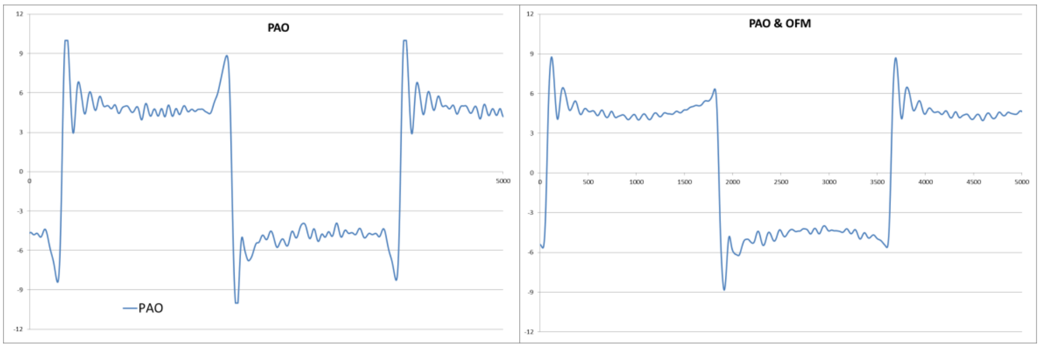

Figure 4: High Speed Data

Conclusion

The addition of the friction modifier reduces the friction coefficient and wear sustained, throughout the test. The effect of the friction modifier increases as the load is increased, until the load exceeds 200 N. During the 250 N load step, the friction coefficient for both tests begins to converge towards 0.1, suggesting that at this load, the friction modifier ceases to be effective.