Experiment Number 12

How does contact geometry affect behaviour for contacts with the same nominal contact pressure? Varying Ball Diameter

Background
A range of different ball sizes are used in a variety of different standard tests. In theory, there should be simple equivalence between tests run with different ball sizes but the same contact pressures. To investigate this, experiments were run using 6, 10 and 20 mm balls, with loads adjusted to give a nominal contact pressure of 2 GPa.

Test Conditions
6 mm ball @ 2 GPa: load = 28.4 N
10 mm ball @ 2 GPa: load = 78.8 N
20 mm ball @ 2 GPa: load = 315 N

Balls: 52100 bearing steel
Plate: NSOH BO1 ground gauge plate (annealed)
Stroke: 25 mm
Frequency: 5 Hz
Temperature: 50°C
Lubricant: PAO and PAO + 0.5% FM
Figure 1: Friction Coefficient - PAO

Figure 2: Friction Coefficient – PAO + 0.5% OFM
Figure 3: Friction Noise - PAO

Figure 4: Friction Noise – PAO + 0.5% OFM
Comments on Friction Coefficient and Friction Noise

The friction coefficient traces for the tests with the base fluid produced significant friction spikes, indicating scuffing type events, for all ball sizes. This behaviour is reflected in the corresponding friction noise traces, but with the friction noise level decreasing with increasing ball size.

The introduction of OFM results in much steadier friction coefficients, with the 6 mm ball producing higher friction than the 10 mm and 20 mm balls, plus significantly higher friction noise.

Comparison of Instantaneous Friction and Wear Scars

![Instantaneous Friction Coefficient - Test End](image)

Figure 5: 6 mm Ball - PAO

725 x 628 microns

761 microns
Instantaneous Friction Coefficient - Test End
10 mm Ball - PAO

Figure 6: 10 mm Ball – PAO
**Figure 7: 20 mm Ball - PAO**

Instantaneous Friction Coefficient - Test End

20 mm Ball - PAO

[Graph showing Instantaneous Friction Coefficient and HSD Coefficient vs. HSD Stroke]

650 x 566 microns ( ?)  
972 microns
Figure 8: 6 mm Ball – PAO + 0.5 OFM
Figure 9: 10 mm Ball – PAO + 0.5% OFM
Figure 10: 20 mm Ball – PAO + 0.5% OFM
Figure 11: Wear Scar Dimensions - PAO

Ball on Soft Plate - PAO

Ball on Soft Plate - PAO + 0.5% FM

Figure 11: Wear Scar Dimensions – PAO + 0.5% OFM
Conclusions
Regardless of ball size, the tests run with base fluid only produce wear scars indicating junction growth and seizure, with near round wear scars on the balls.

The tests with base fluid plus OFM produce a difference in behaviour between the 6 mm ball experiment and the 10 mm and 20 mm ball tests. In the former, plastic flow occurs on the plate specimen, resulting in a wavy edged wear scar. This results in unsteady instantaneous friction force around mid-stroke and a corresponding high value of friction noise. In all three cases, an elliptical ball scar is produced, consistent with severe adhesive wear.

It would appear that in an experiment with a hard ball running on a soft surface, the smaller the ball diameter, the greater the penetration depth and the greater the potential for plastic flow and work hardening.