Experiment Number 07

Is it possible to generate an analogue signal to indicate "disorderly" friction?

Background

It can be demonstrated that surface damage can give rise to a disorderly instantaneous friction signal and that this can be analysed and quantified through post-processing the instantaneous (high speed) friction signal. In the absence of high speed data, an analogue measure of "friction noise" can provide useful data.

Signal Conditioning

The standard (low data rate) r.m.s. friction signal is generated by passing the input voltage through a true r.m.s. to d.c. converter. This produces a time smoothed r.m.s. value of the friction force, integrated over a period of just over 1 second. Because the friction force signal approximates to a square wave, the r.m.s. friction signal can be considered as an average friction force as measured over at least one complete cycle, assuming a reciprocating frequency greater than 1 Hz.

By rectifying the instantaneous friction force signal and subtracting the r.m.s. average, a resulting signal corresponding to the perturbations (friction noise) can be produced. If this signal is subsequently passed through a second true r.m.s. to d.c. converter, an r.m.s. signal of friction noise can be generated. This can be used, in real time, as an analogue measure of the friction noise, hence the orderliness or otherwise of the friction signal. By dividing the r.m.s. friction noise value by the r.m.s. friction signal value, a percentage friction noise value (as a derived channel in software) can be generated.

Test Method

Tests were running using a hard ball on a soft steel flat, as this arrangement is know to be susceptible to producing surface damage and hence disorderly friction.

Specimens:	6mm Steel Ball on annealed NSOH BO1 steel gauge plate
Stroke:	20 mm
Frequency:	5 Hz
Load:	28 N
Temperature:	50°C
Lubricant Samples:	Base Oil and Base Oil + ZDDP

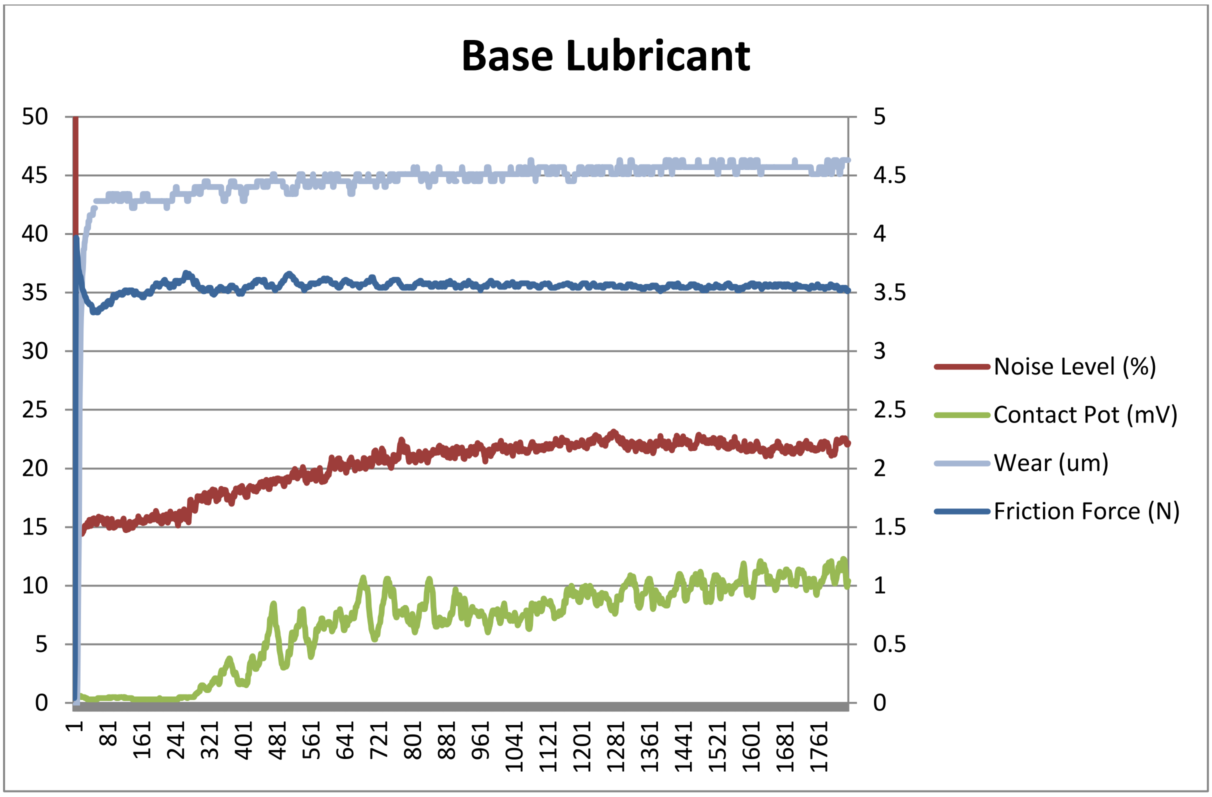

Figure 1: Test with Base OIl

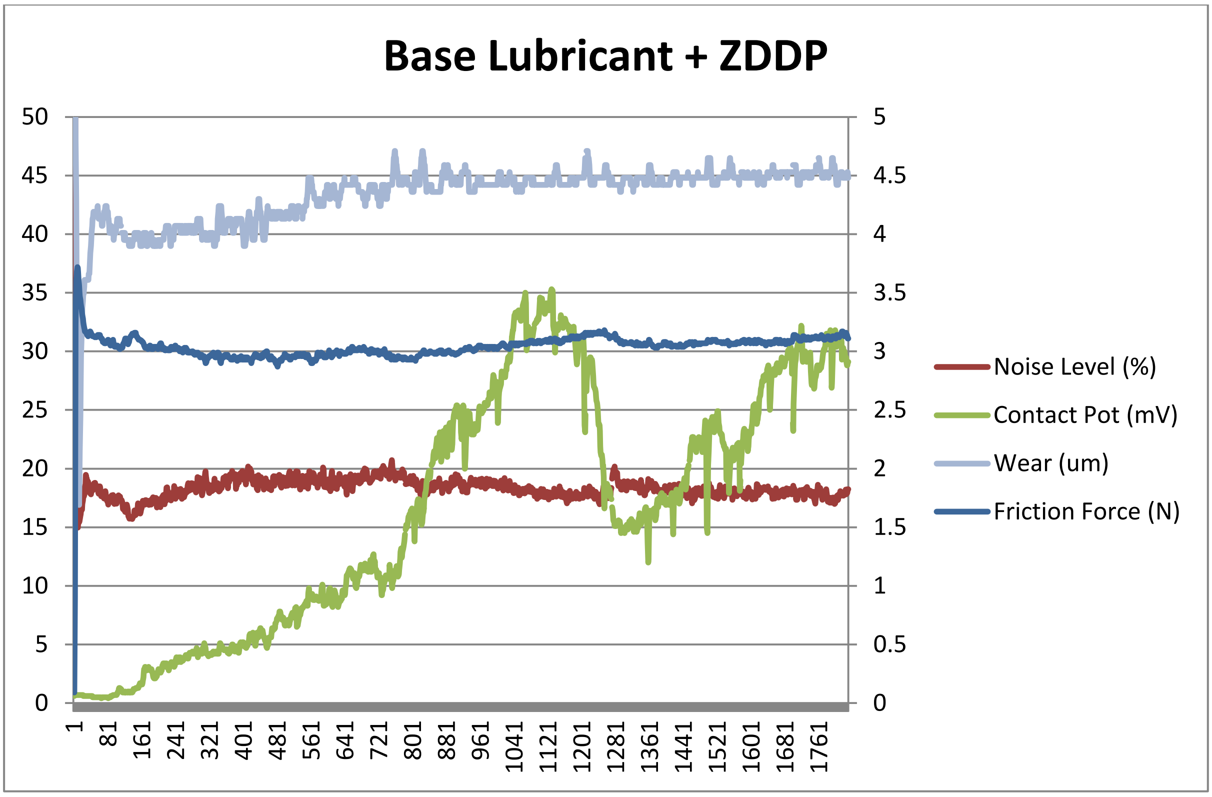

Figure 2: Test with Base Oil + ZDDP

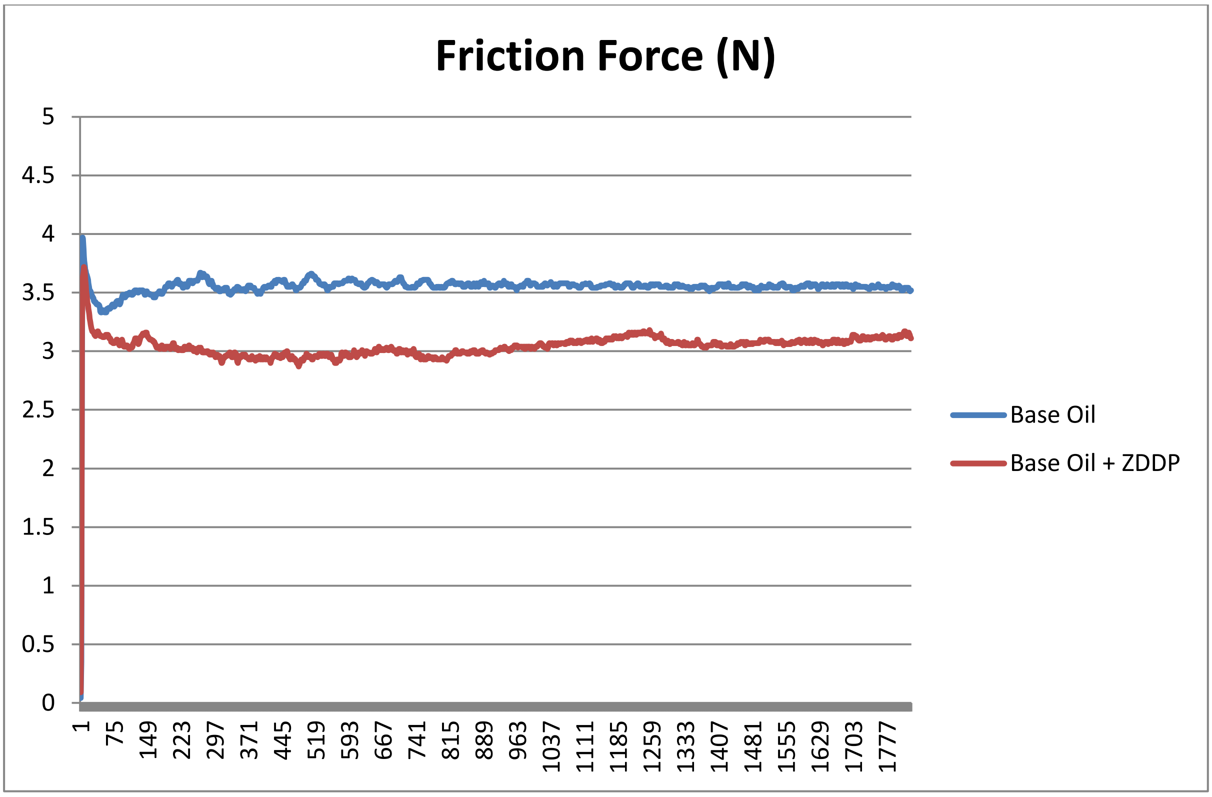

Figure 3: r.m.s. friction force

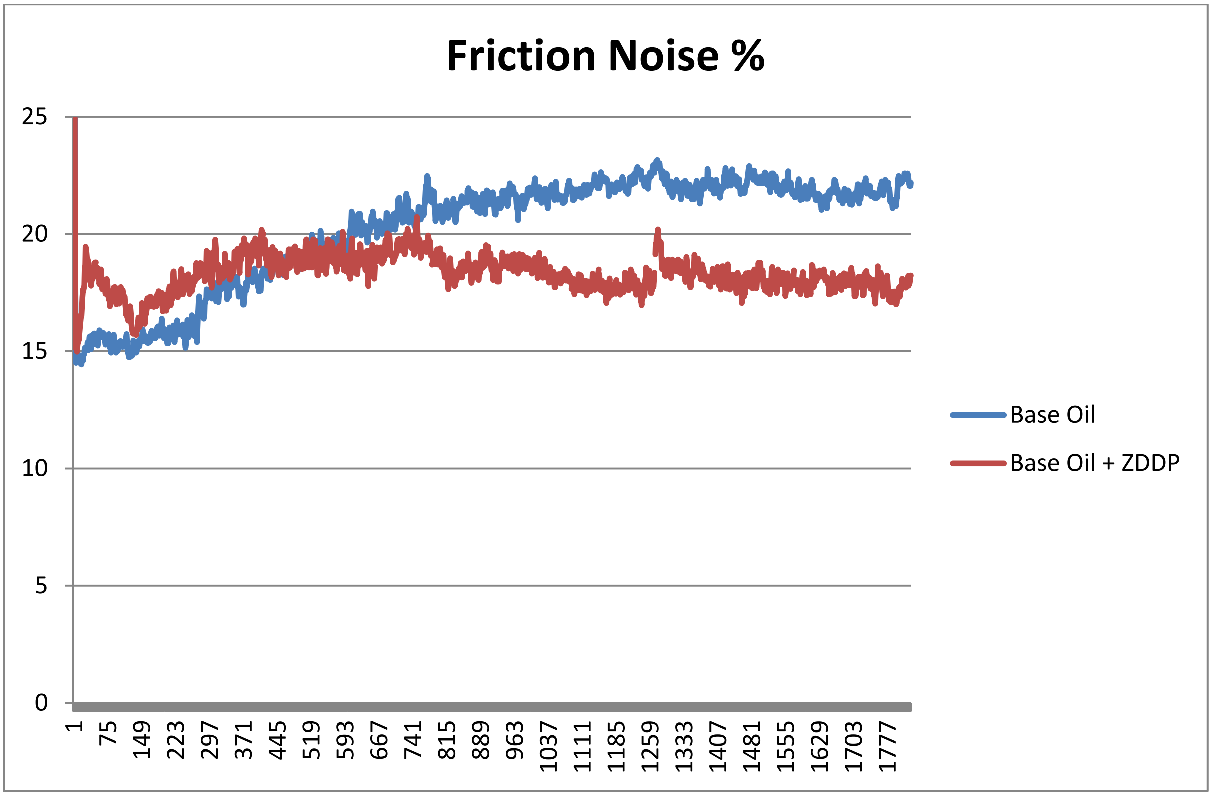

Figure 4: Friction noise percentage

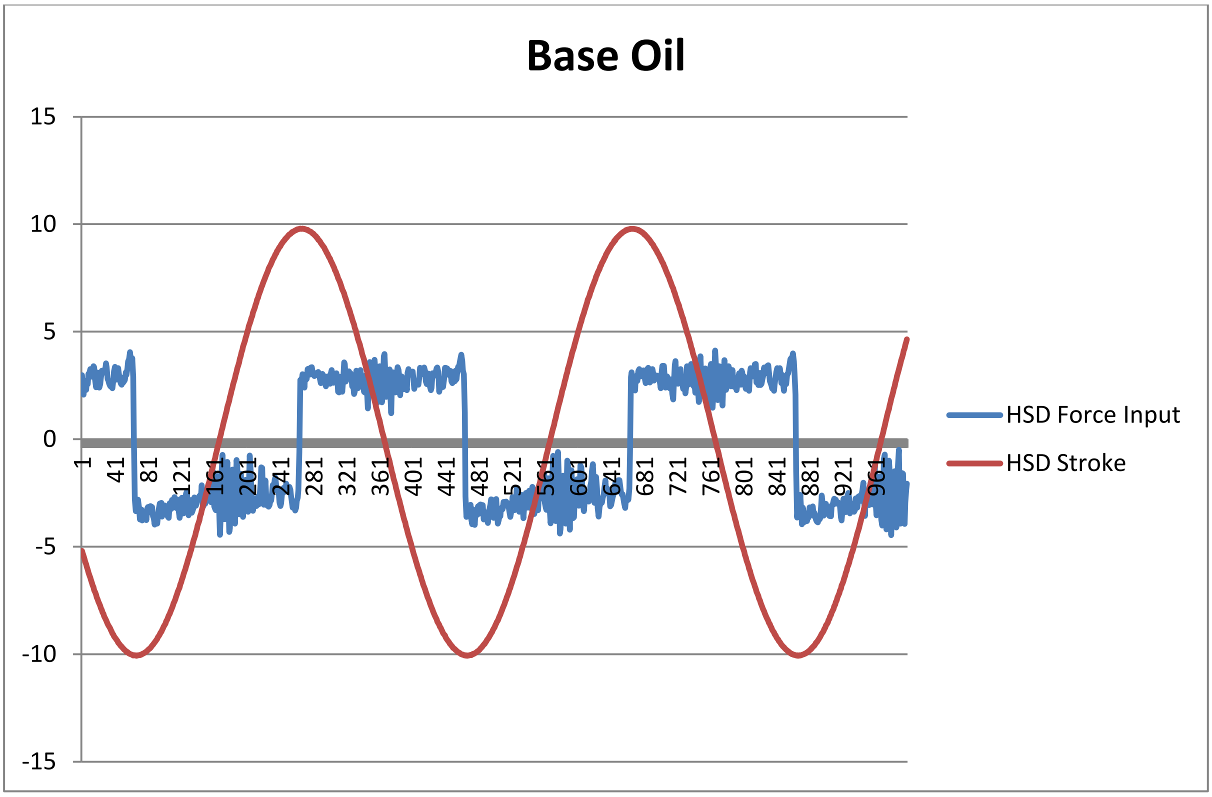

Figure 5: Instantaneous friction force – test end

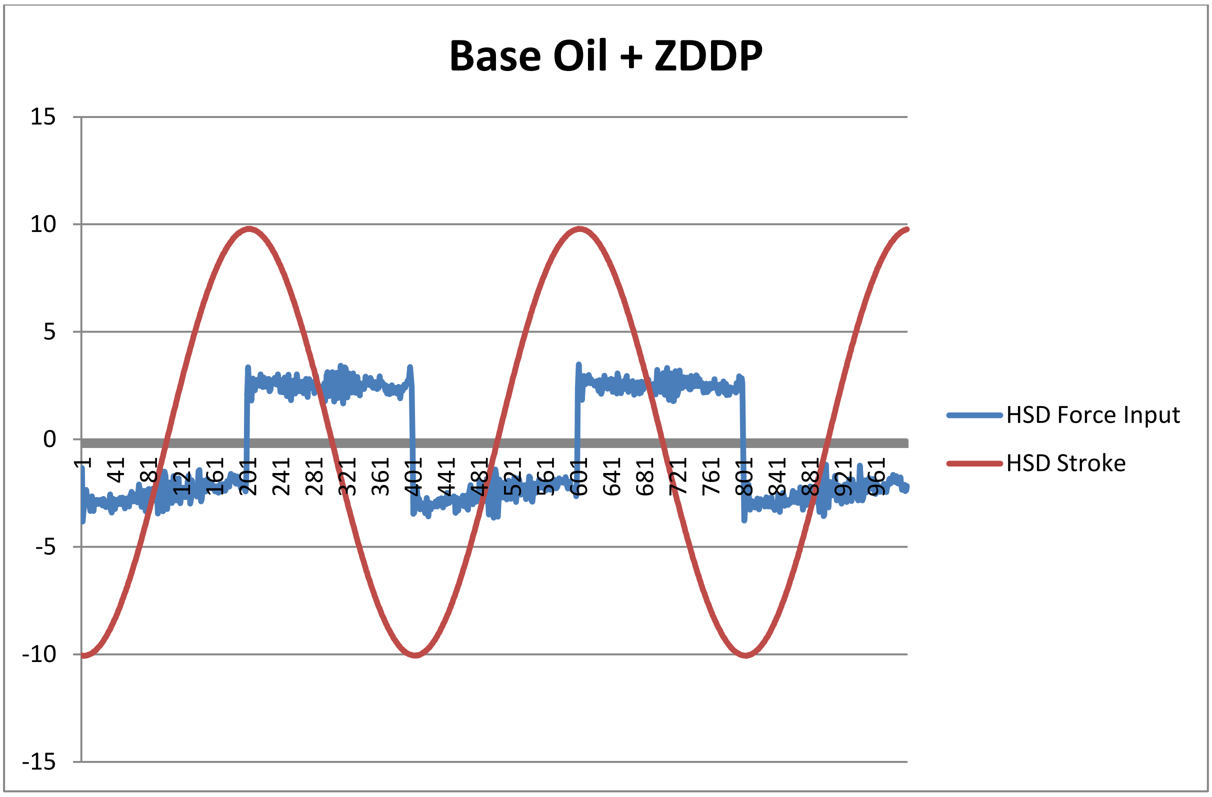

Figure 6: Instantaneous friction force – test end

Comments

The friction noise signal indicates that the instantaneous friction signal for the base oil is more disorderly than the friction signal for the base oil plus ZDDP. Examination of the high speed data friction signals indicates a mid-stroke perturbation to the base oil friction signal.

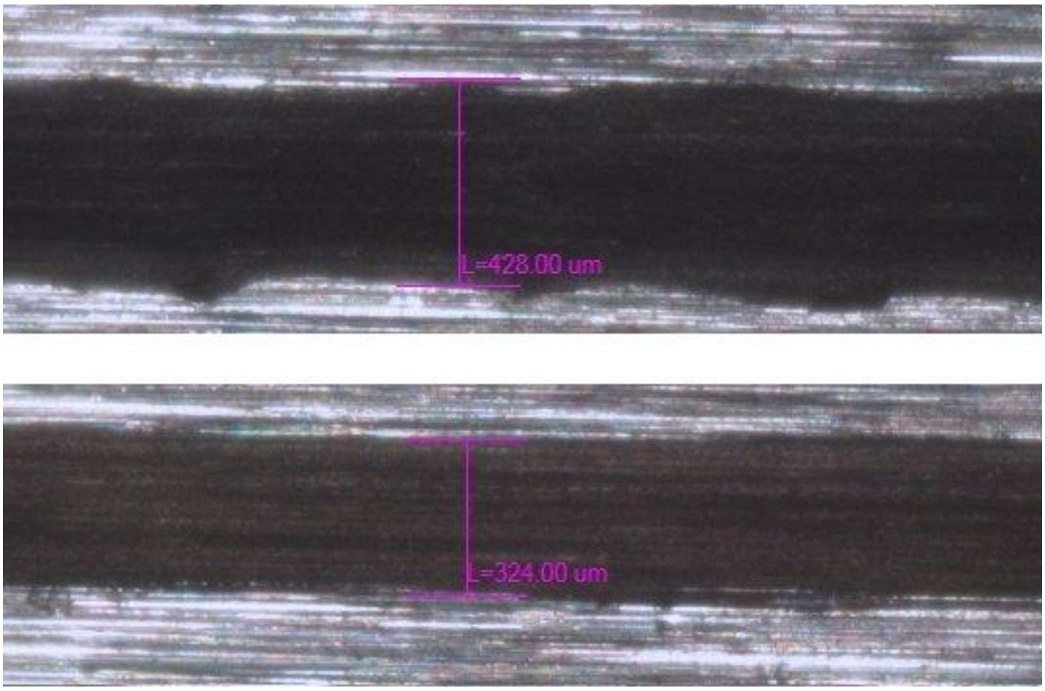

Figure 7: Microscope measurements of wear scar

Upper – Base Oil / Lower – Base Oil + ZDDP

Examination of the wear scars indicates a smaller and smoother wear scar for the base oil plus ZDDP test plate.