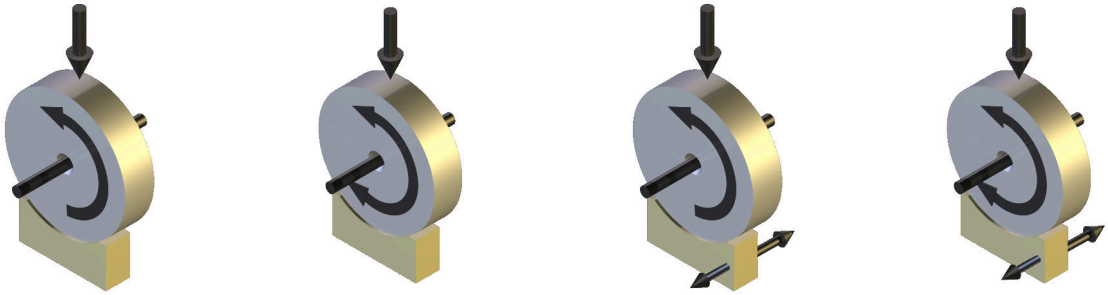
TRIBOLOGY UPDATE: *ISSUE 37 –November 2019*

This is the latest issue of our **Tribology Update** newsletter. For further information, we can be contacted by e-mail at ***info@phoenix-tribology.com***.

WORK COMPLETED – PRODUCTION

TE 39 Journal Bearing Friction Rig



We have completed design and manufacture of a journal bearing friction test rig capable of continuous rotation, rotary oscillation and axial motion. The bearing under test is carried in a cradle supported by an air bearing, with axial and rotational movement restrained by a combined torque and axial force transducer.

TE 47 Three Station Ring/Liner Tribometer

Having further rationalised the design of the TE 47 machine, we have recently completed production of two new units for two contract testing laboratories in Germany. We now have one definitive design that can be used, with appropriate tooling, for testing both small and large liners.

Falex Block on Ring Upgrade

To date, we have provided more than thirty COMPEND based upgrade packages for Falex Block on Ring machines. These upgrade packages comprise new motor, drive, electronics and computer interface, but no mechanical components.

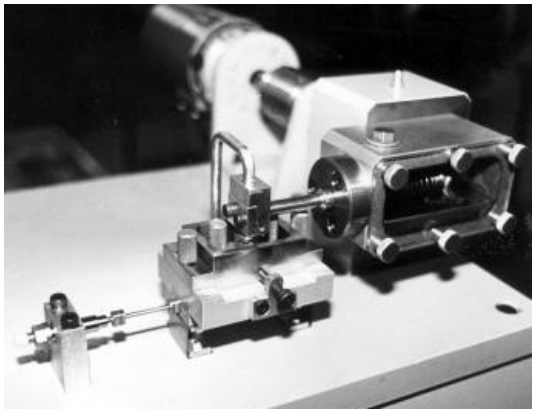
We have now completed a more comprehensive upgrade package incorporating the standard upgrade items, with electronics pre-packaged in a machine compatible base frame and including servo pneumatic load control, with force transducer feedback.

As well as normal rotational speed control of the servo motor, the motor can generate oscillating motion, thus eliminating the requirement for a crank mechanism. In addition to this, the motor can be operated in torque control mode, allowing the applied torque to be ramped progressively from zero, until slip occurs, thus allowing break-away friction to be measured.

WORK IN PROGRESS – DEVELOPMENT

TE 81 Bench-top Reciprocating Tribometer

The TE 81 was originally designed for SwRI for performing fuel lubricity tests, using line contact specimens. The original machine was designed against a tight budget and incorporated dead-weight loading. We are in the process of upgrading the design to include servo pneumatic loading, with a maximum load increased from 20 N to 100 N. With a maximum stroke of 5 mm, the machine has a specification very similar to the original "short-stroke" Cameron-Plint machine; a case of history repeating itself!

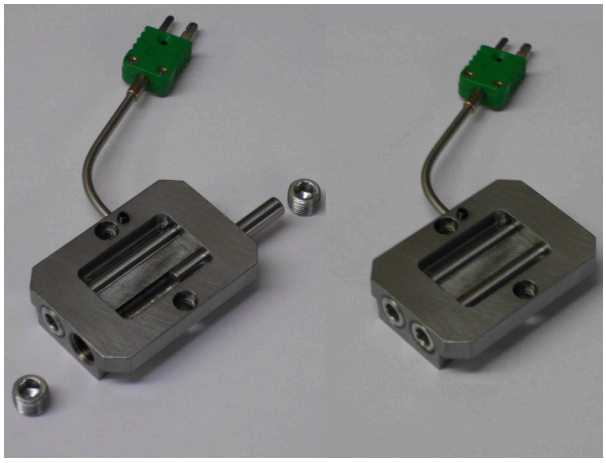


Cameron-Plint TE 77 Short Stroke - 1982

WORK COMPLETED – DEVELOPMENT

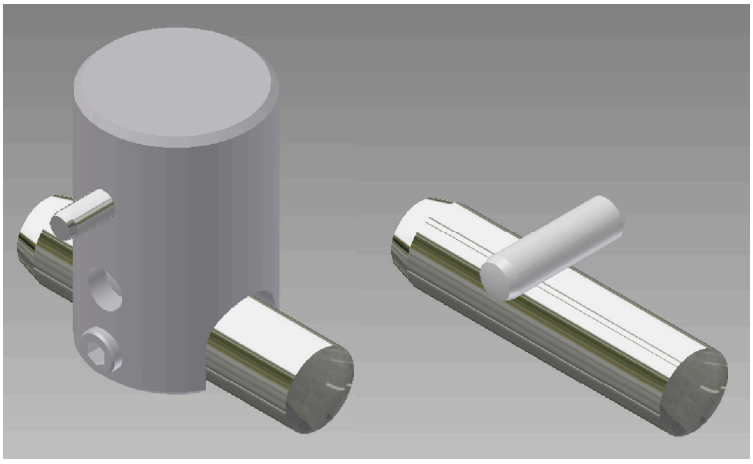
TE 77 High Frequency Friction Machine

Pin on Twin Tooling



We have added a new pin-on-twin specimen bath to the range of adapters available on TE 77. The bath mounts two 6 mm diameter x 40 mm long test rods as the "twin" pair.

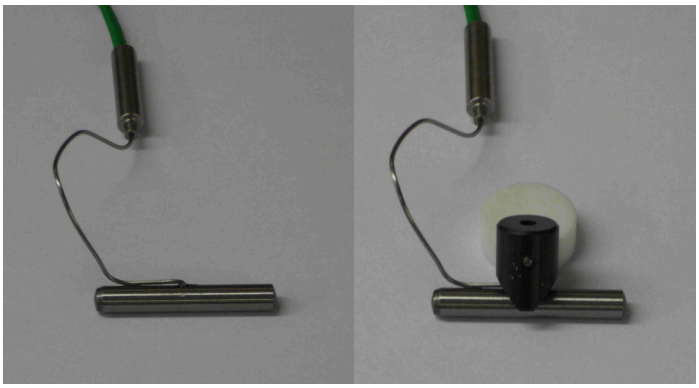
Self-aligning Line Contact Specimen Tooling



We have also produced a new self-aligning line contact specimen clamp that is some somewhat easier to use than earlier versions. This is now standard on all new TE 77 machines.

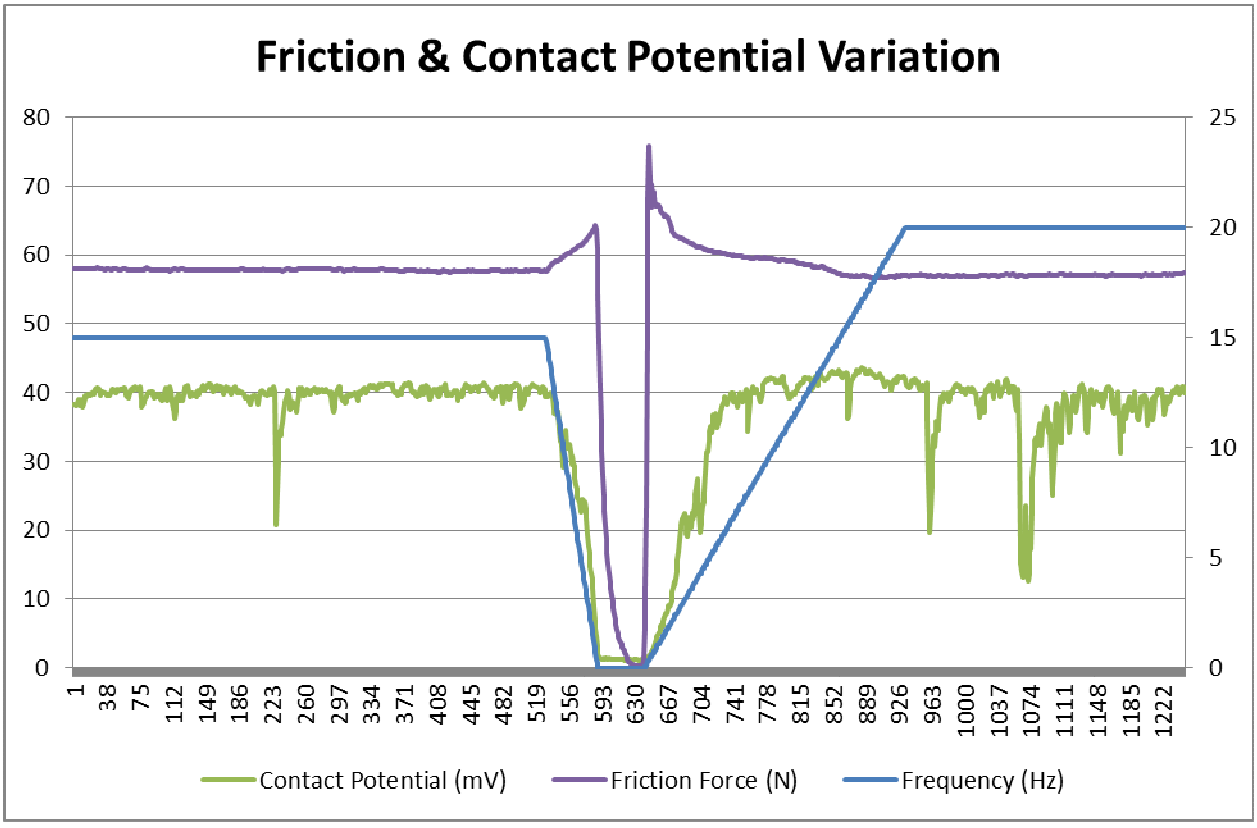
Adiabatic Reciprocating Tests

John Walker and Tim Kamps at the University of Southampton explored temperature fluctuations during stop/start cycles. We thought we should explore this ourselves, so manufactured some line contact specimens with embedded thermocoupoles.

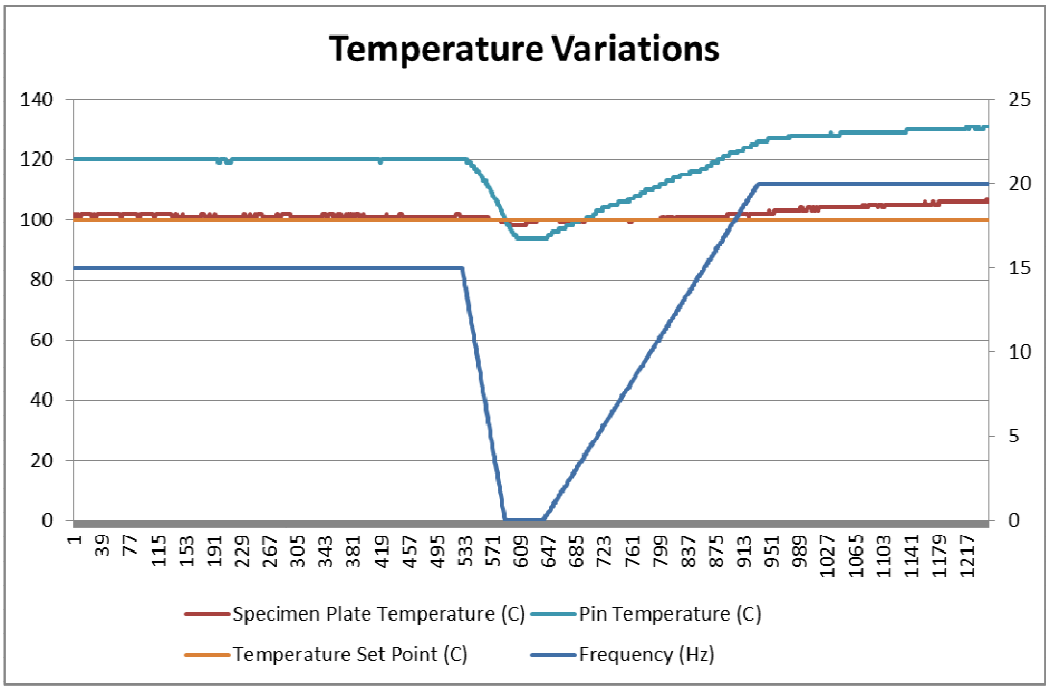


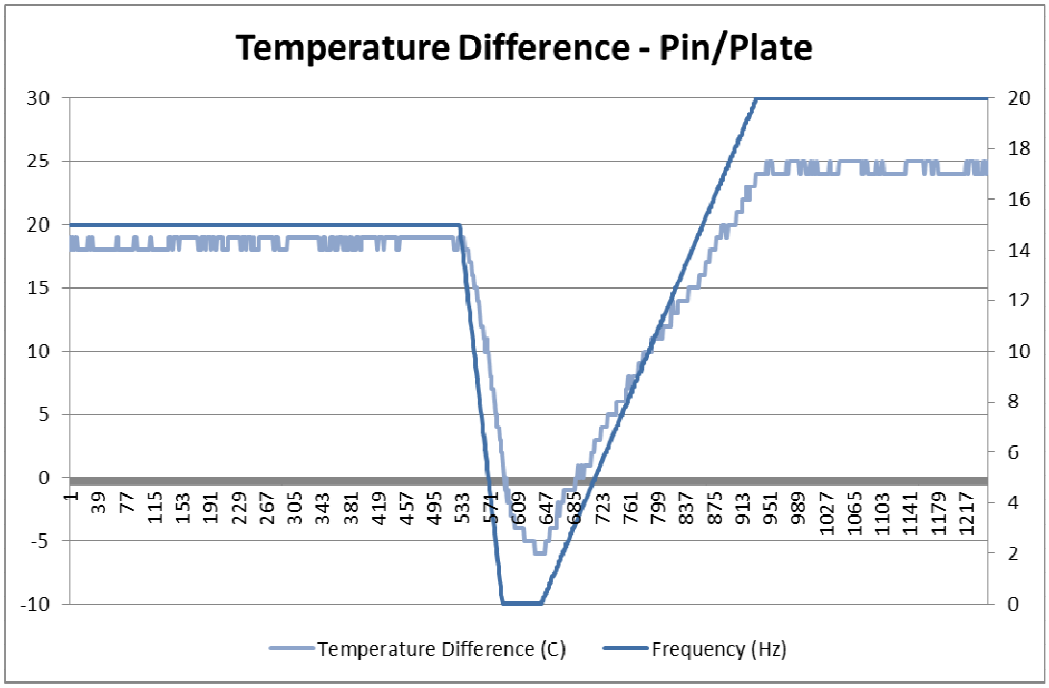
At 500 N load, 25 mm stroke and 20 Hz reciprocating frequency, assuming a friction coefficient 0.1, the contact produces 50 W of frictional heating.

Reducing the reciprocating frequency to zero, causes contact potential and friction to fall to zero. On re-starting motion, with a ramped increase in frequency, the friction initially starts high and then reduces to a steady state value as a steady frequency is achieved. At the same time, the contact resistance recovers to its pre-stop high value.



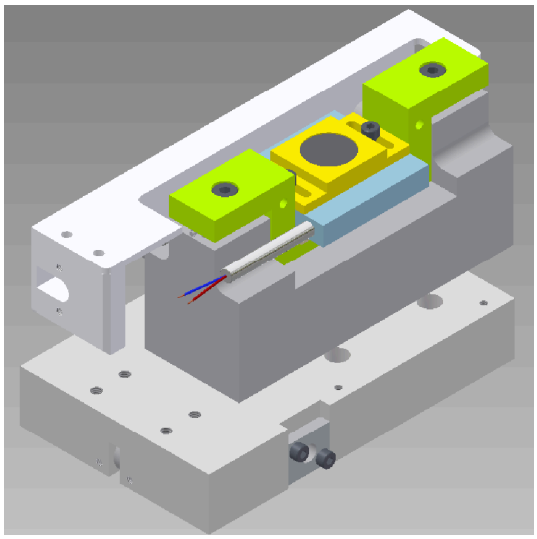
This experiment was run with a plate temperature set-point of 100°C, with a frequency, pre-stop, of 15 Hz and, post-stop, of 20 Hz. At 15 Hz, the pin temperature is 20°C higher than the electrically heated plate. When motion ceases, the pin temperature falls below the plate temperature. At 20 Hz reciprocating frequency, the pin temperature exceeds the plate temperature by approximately 25°C. The plate electrical heaters, under PID control, with a set-point of 100°C, are powered off.

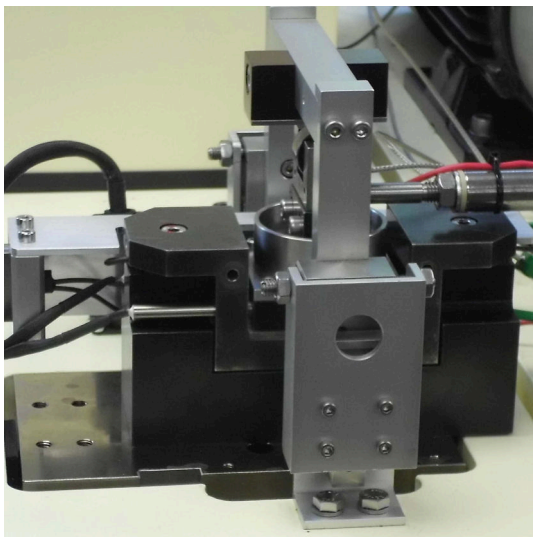




The advantage of this type of frequency controlled self-heating experiment is that the temperature gradient is the same way round as in the standard ring on liner contact.

High Load Short Stroke Adapter



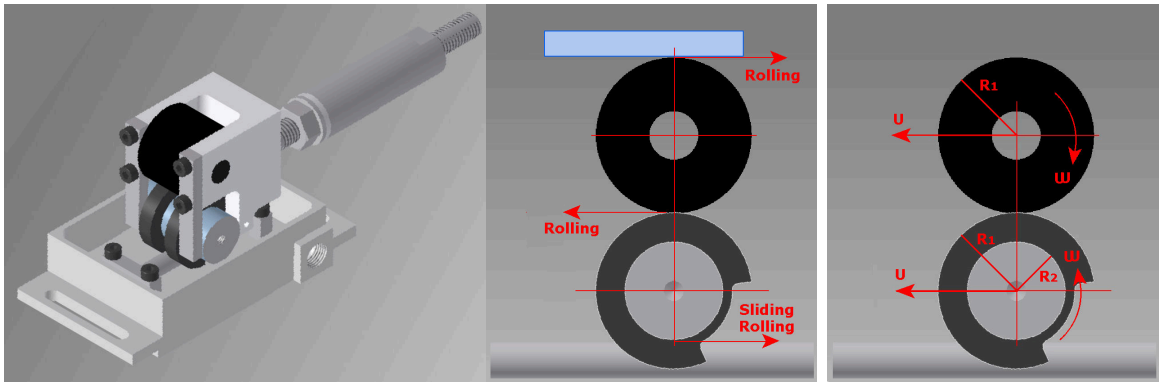


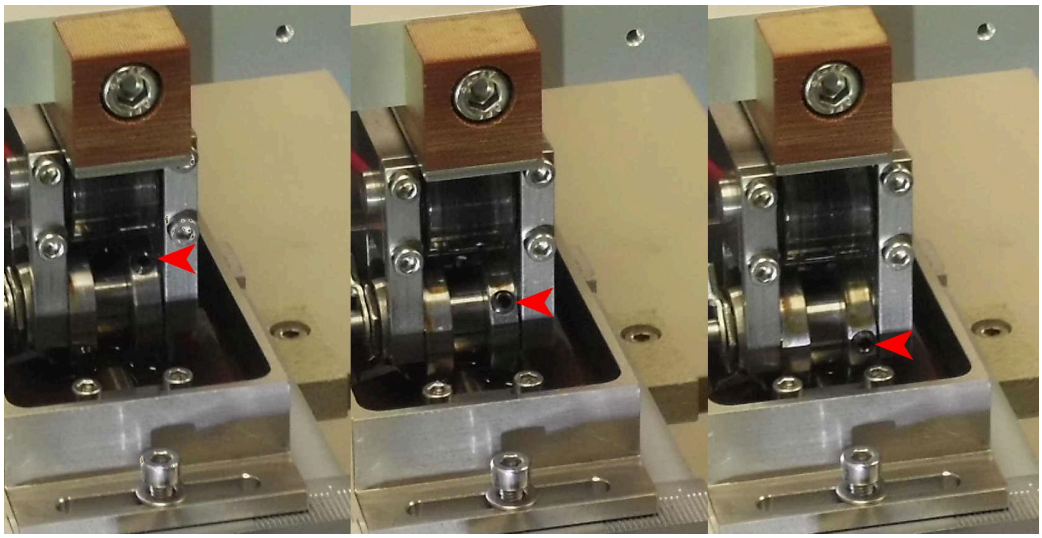
We have been asked by various clients to provide a high load, high friction force adapter. The limiting factor with the standard TE 77 fixed specimen assembly is the capacity of the friction force measuring piezo transducer, which is +/-500 N. This is well matched to the capacity of the standard machine and works well at all strokes up to 25 mm.

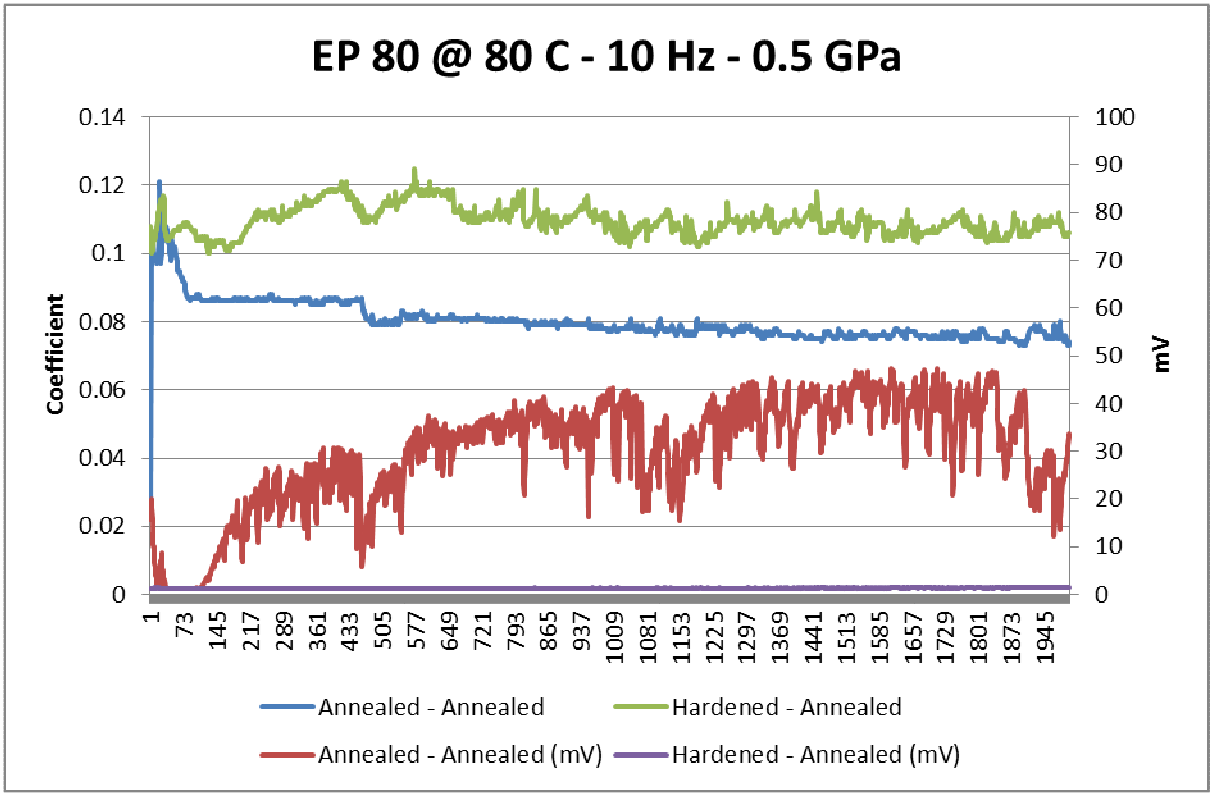
For higher loads, hence higher friction forces, the solution is to use two standard piezo shear transducers mounted in series. The lowest capacity transducers available from Kistler are rated at +/-900 N, so in combination the equivalent of a single sensor rated at +/-1800 N, hence the assembly is less sensitive than the standard fixed specimen assembly, but can work at higher loads, but with maximum amplitude limited to +/-2.5 mm.

New Slide/Roll Adapter

There are already two existing slide/roll adapter for the TE 77, of varying cost and complexity. The new design is much simpler and cheaper, but most importantly, uses a simple and low cost roller specimen, running on a flat.


Rolling
Rolling
Sliding
Rolling
R1
U
W
R1
U
W
R2

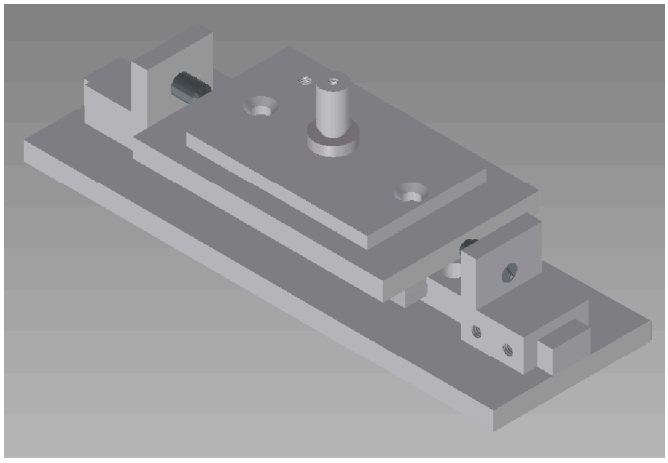


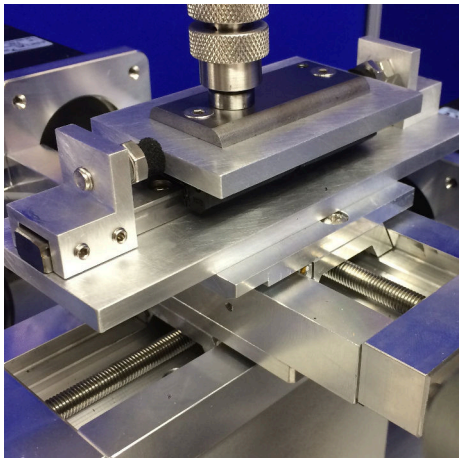

EP 80 @ 80 C - 10 Hz - 0.5 GPa
Coefficient
mV
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
100
90
80
70
60
50
40
30
20
10
0
1
73
145
217
289
361
433
505
577
649
721
793
865
937
1009
1081
1153
1225
1297
1369
1441
1513
1585
1657
1729
1801
1873
1945
Annealed - Annealed
Hardened - Annealed
Annealed - Annealed (mV)
Hardened - Annealed (mV)

In this experiment, hard on soft is compared with soft on soft. A hardened ground roller abrades a softer flat producing a significant amount of oxide debris in the oil. The hardened surface remains rough throughout, with friction levels typically associated with boundary lubrication and the ploughing component of friction dominant. A soft roller on a soft flat does not produce oxide debris. The surfaces run in, becoming progressively smoother, with mean friction coefficient, instantaneous friction force and contact resistance consistent with mixed lubrication. In this case, the adhesive component of friction is dominant.

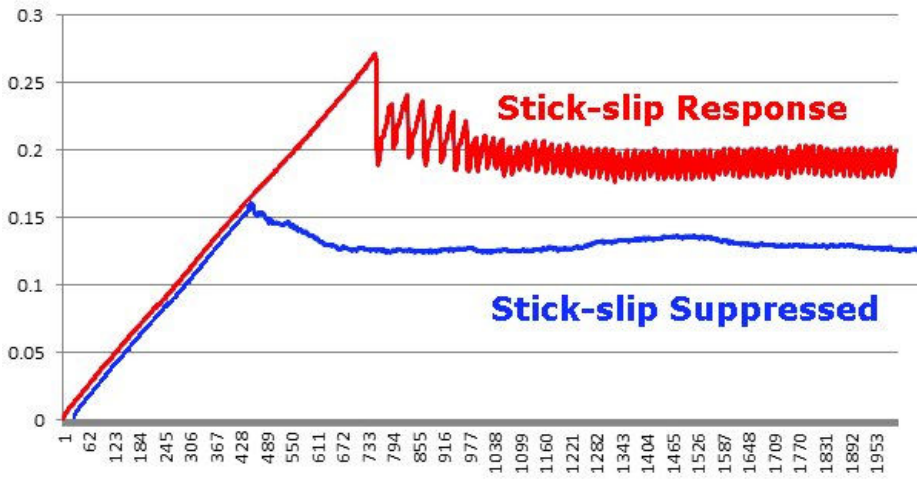
It would appear that extreme pressure and anti-wear additives have little effect on the ploughing component of friction, but have a significant effect on the adhesive friction.

TE 79 Stick-Slip Tooling





We have designed a new stick-slip adapter for the TE 79, to be used in reciprocating pin on plate mode. A plate specimen is supported on a linear bearing, with axial movement constrained either by elastomeric stops or adjustable springs. By adjusting the axial stiffness of the system, the stick-slip response can be tuned. For evaluating a slide-way lubricant, the system is first adjusted to give a stick-slip response, with a base oil or a poor reference fluid, then tested with the candidate sample, to determine its ability to suppress stick-slip.



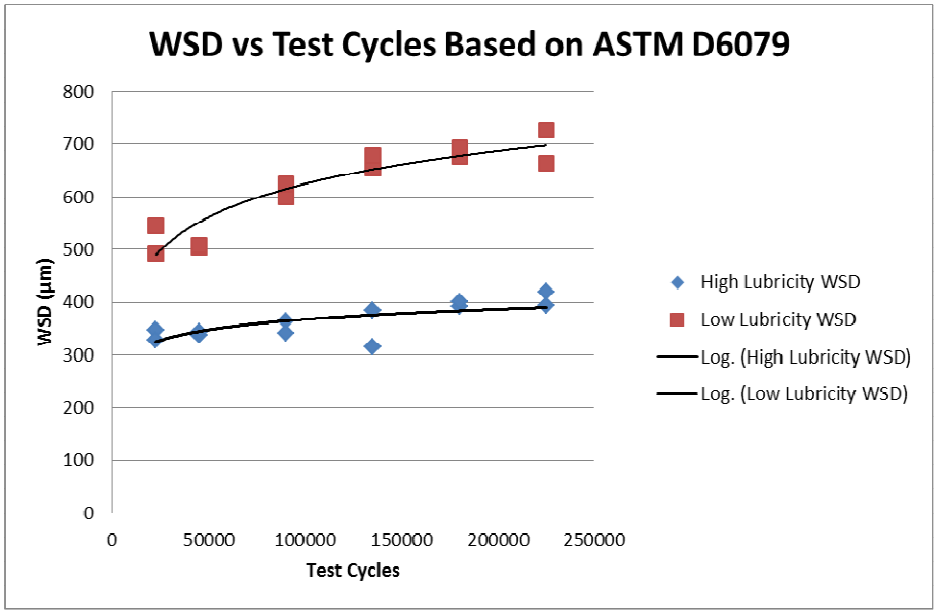
A similar adapter can be provided for the TE 77.

TE 80 Fuel Lubricity Bias - ASTM D6079 Tests

We have long been aware of the fact that in sliding hertzian point contact tests the majority of wear (or plastic deformation) occurs at the very beginning of the test and that once the difference in wear between candidate samples has been established, the number of cycles over which the test is run is somewhat arbitrary.

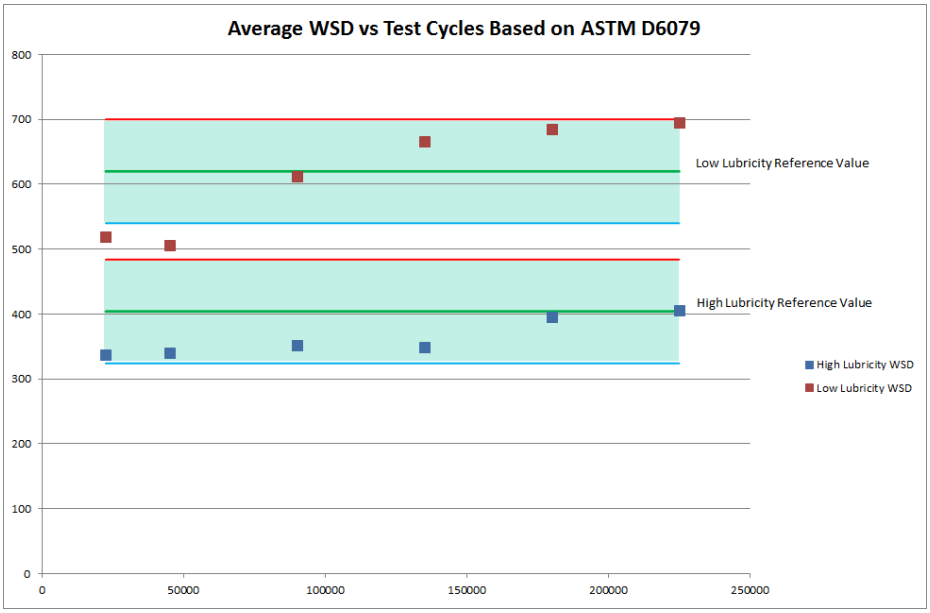
We have previously run tests to confirm this behaviour, including following the ASTM D6079 diesel fuel lubricity test procedure. These tests were run under the standard test loads, temperatures and frequencies, but for varying numbers of cycles. As a result, the amount of time that the fuel samples were exposed to the combination of air and temperature was variable. An alternative approach is to run the tests for the same time, but at different reciprocating frequencies.

Tests were run for 75 minutes each at 5, 10, 20, 30, 40 and 50 Hz, the latter being the standard test frequency. The number of cycles per test was therefore 22500, 45000, 90000, 135000, 180000 and 225000 cycles respectively. Two repeat tests were performed at each frequency.



It is apparent that after about 50000 cycles, the difference in wear between the high and low reference fluids has been established and that, as the wear rates decrease, self-evidently, not much changes after that.

ASTM D6079 gives a reproducibility figure of 80 microns; it transpires that, with the exception of a couple of outliers, tests of 90000 cycles and more, fall within the reproducibility limit. In essence, once the initial wear has taken place, the further cycles result in very limited additional wear.



It would appear that an acceptable result can be achieved within the limits of the standard, running the TE 80 at any frequency from 20 to 50 Hz, in other words, the choice of frequency and number of cycles is pretty much arbitrary. Comparative results could be achieved with much shorter tests.

OTHER NEWS

Cambridge Tribology Course 2019

The 27th and **final** annual Cambridge Tribology Course took place from Monday 9th to Wednesday 11th September 2019. With four of the contributors now past retirement age, and despite its continuing popularity, it was time to hand over to a new team.

Glyn Roper/ Nick Randall/Stephen Kukureka/Ian Hutchings/Michael Sutcliffe/John Williams/Steve Bull/George Plint

Imperial College Tribology Course 2020

The inaugural annual Imperial College Tribology Course will take place from Wednesday 23rd September to Friday 25th September 2020, in London.

A web site for the course is currently under construction; in the meantime, please contact Dr Marc Masen (m.masen@imperial.ac.uk) if you wish to be kept informed of developments.

Administrative Matters – CO_2 Emissions

At present we work four full days per week with a half day on Fridays. An obvious way to reduce the CO_2 emissions, associated with travel to work, by 20%, is to extend the length of the full working days and drop the half day on Friday. Please note that in future, on Fridays, phone calls will not be answered and e-mails received not answered until the following Monday. Please plan accordingly.

George Plint and David Harris

Phoenix Tribology Ltd