stle
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Development of a more rational scuffing test protocol for use in a reciprocating tribometer

A G Plint

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Methods for precipitating wear transitions (such as scuffing)

- Increasing the severity of the contact, by ramping up the load
- Precipitating failure of the lubricant or additive film, by increasing the bulk temperature, by external heating

Load Ramp Tests

- Not a convincing as model of real systems
- Resulting damage usually catastrophic, producing the tribological equivalent of an ultimate tensile strength test
- Evidence, in particular in the case of scuffing in ring-liner contacts, that the process may involve surface fatigue. If so, we need the equivalent of a fatigue test, not a tensile test

Temperature Ramp Tests

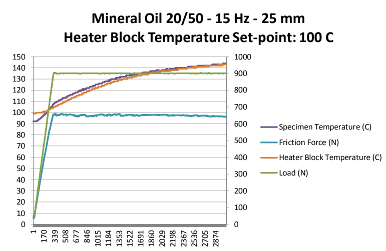
Not accurate model of real systems, where the temperature gradient is from asperity tip to bulk material and not the other way round, from external heat source to specimen surfaces

Speed Ramp and Stop/Start Tests

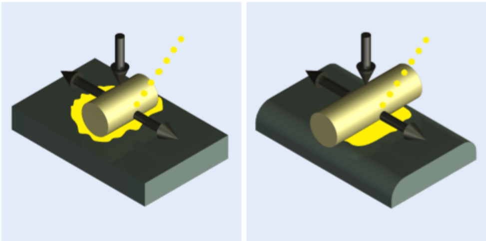
How to increase frictional energy input, hence surface temperature, while avoiding precipitating a single, catastrophic, failure event and without producing an inverted temperature gradient?

Increase sliding speed

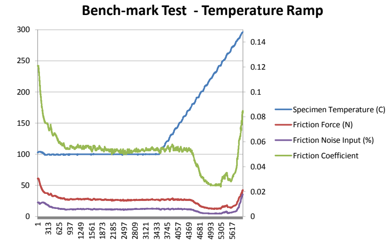
Background Observations
Frictional Heating



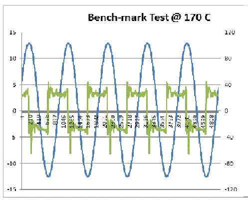
Background Observations Lubricant Feed

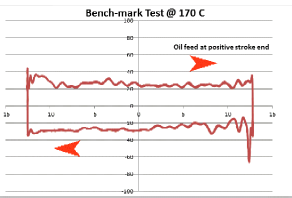


New Protocol – Bench-mark Test



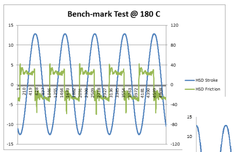
Bench-mark Test

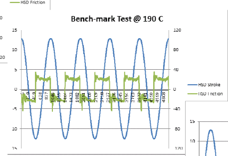


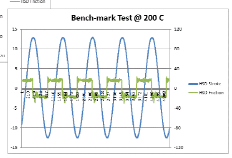


High speed data taken every 10 C rise in temperature

Bench-mark Test

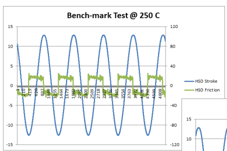


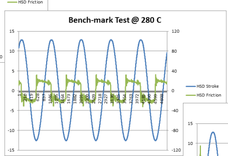




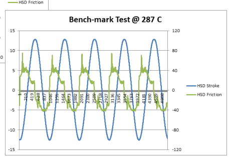
As the additive package is activated, the mean friction falls and the start of stroke friction spike disappears

Bench-mark Test



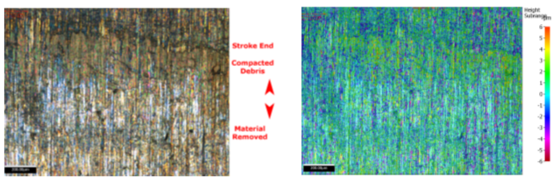


As At 280 C, the friction is rising and becoming more chaotic



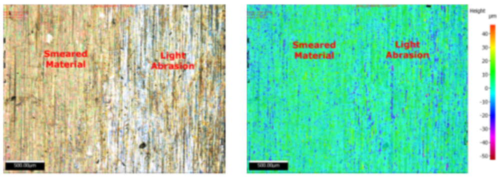
At 287 C, the friction has become completely chaotic, indicating some form of failure

Bench-mark Test



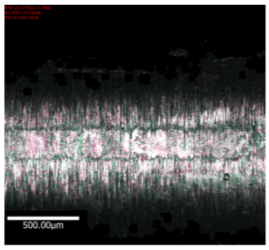
- Accumulation of compacted fine debris at the stroke end, with debris filling the grinding marks
- Away from the stroke end, shiny areas indicate material removal

Bench-mark Test



Away from stroke end (25% stroke and under higher magnification), mixture of smearing of material into the grinding marks (on the left) and light abrasion (on the right)

Bench-mark Test



Agglomeration of transferred fine debris material across width of the contact

More consistent with fine two body abrasive wear than adhesive wear, leading to accumulation of material on moving specimen as well as at stroke end

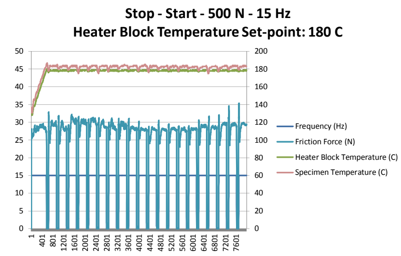
Bench-mark Test

Although this process may eventually lead to seizure between the transferred material on the moving specimen and the source of the transferred material, the fixed plate, this is not an example of an adhesive wear mechanism

If we define scuffing as exclusively an adhesive wear process, this experiment does not appear to be an adequate model

Summary of Process
Mild abrasive wear
Agglomeration of fine debris at leading edge of contact
Adhesion of transferred material
Like-on-like materials in contact may eventually lead to seizure

Stop/Start Cycle Tests

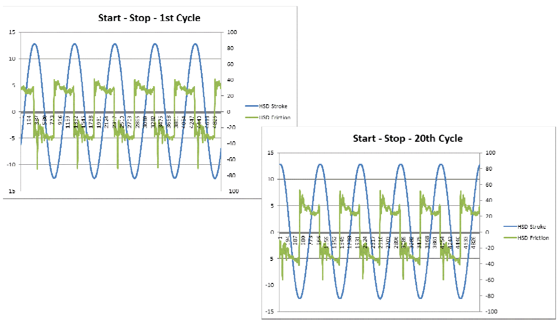


Stop/Start Cycle Tests

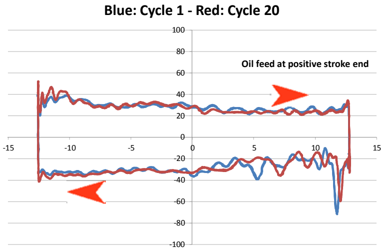
Key differences:

- The temperature feedback source no longer the fixed specimen surface temperature, but from a thermocouple embedded in the supporting heater block, hence the set-point temperature is heater block temperature, not the specimen temperature
- Instead of running at constant reciprocating frequency, a stop/start cycle is used, with each cycle resulting in a temperature excursion
- During each stop phase, the temperature of the heater block and the specimen are allowed to cool to the heater block set-point temperature
- Instantaneous friction traces taken at end of each stop/start cycle

Stop/Start Cycle Tests

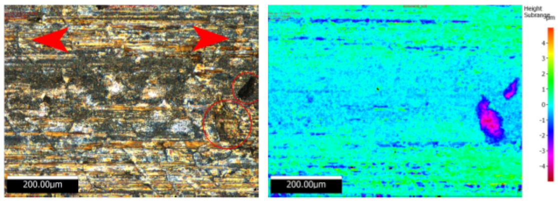


Stop/Start Cycle Tests



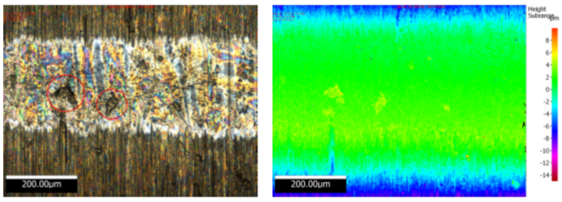
As with temperature ramp tests, friction traces indicate starved lubrication at beginning of stroke, moving away from lubricant feed

Stop/Start Cycle Tests



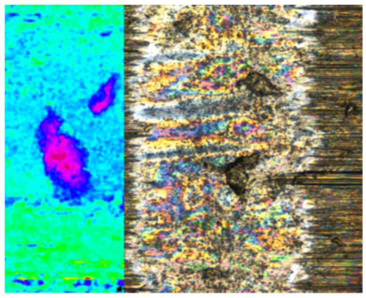
At the stroke end on plate specimen, material pull-out.....

Stop/Start Cycle Tests

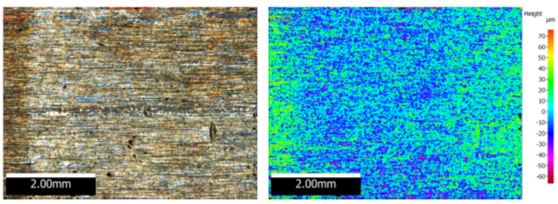


....with corresponding material transfer to surface of moving specimen

Stop/Start Cycle Tests



Stop/Start Cycle Tests

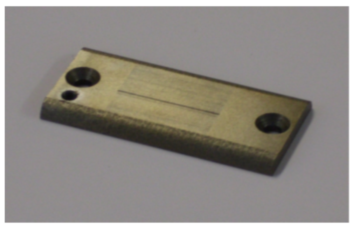


Unlike with temperature ramp tests, where debris accumulates at stroke end, with stop/start test, material removed at stroke end (white area) with less wear away from stroke end

Stop-start process spreads wear zones further along the contact

Note: Stroke end on left side of image

Stop/Star Cycle Test



Adhesion of a pulled out and transferred particle to moving specimen frequently results in observable groove in fixed plate specimen

Stop/Start Cycle Test

Summary of Process

Minimum lubricant entrainment at start of stroke

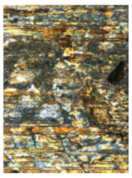
Surface propagated fatigue at asperities (?)

Adhesive pull-out

Onset of adhesive wear – scuffing

Conclusion

Temperature Ramp



Stop/Start

- The two test procedures produce very different wear mechanisms
- Temperature ramp test produced what one might term a "false" adhesive wear process
- Stop/Start test, with the temperature gradient right way round and cyclic frictional energy input, produces adhesive wear, much as illustrated in most text books
- If we consider scuffing to be either onset of adhesive wear, or at least, some form of adhesive wear, we should use tests that actually produce adhesive wear, not some other mechanism

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