# TRIBOLOGY UPDATE: *ISSUE 38 –June 2020*

This is the latest issue of our **Tribology Update** newsletter. We find ourselves living in strange times! We very much hope that you and your families have remained safe.

We were in lock-down since the middle of March, with most staff working from home. Nobody has been laid-off; everybody has been retained, ready to contribute to our future.

With restrictions gradually being lifted in May, we started allowing up to two people into the workshop at a time, so production continued slowly. We are hopeful that we will soon be able to get output back up to more normal levels.

The one area where we can, at present, see no end in sight, is the restriction on international travel. Even after countries lift travel bans, there is currently no indication when it will again be possible to get insurance cover for our staff, travelling and working abroad.

## WORK IN PROGRESS – DEVELOPMENT

### TE 92 Plain Thrust Bearing Test Adapter

A paper by researchers at the University of Leoben reported on experiments performed on a TE 92 rotary tribometer, using a novel plain thrust bearing type test geometry:

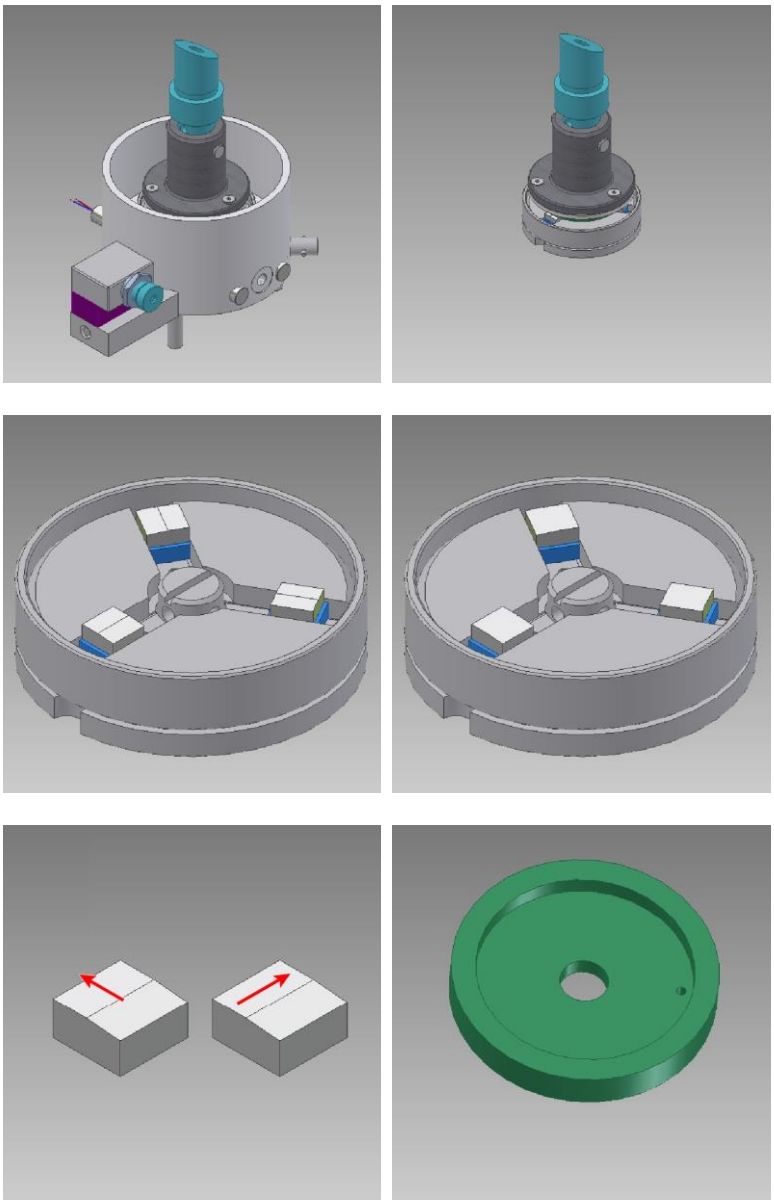
> **Tribological performance of thin overlays for journal bearings**
>
> F Grun, I Godor, W Gartner
>
> Tribology International Volume 44, Issue 11, October 2011, Pages 1271-1280

An interesting feature of their experiments was that they used a conventional parallel taper land/flat land thrust bearing arrangement, with six lands. In a flat land thrust bearing, where the surfaces are parallel, there is no mechanism for generating hydrodynamic pressure, so the contact will always run under boundary or, at best, mixed lubrication. The converging wedge, formed by a tapered land, will generate hydrodynamic lift, providing there is sufficient entrainment velocity.

At low speeds, there is low entrainment, so minimal hydrodynamic lift. This means that the load is carried more or less entirely on the flat land area, which is running under boundary lubrication. As the speed is increased, the entrainment velocity increases and the converging wedge starts to generate hydrodynamic lift, progressively separating the flat land surfaces and moving the contact from boundary to mixed and, eventually, hydrodynamic lubrication. Controlling the velocity thus provides an effective means of controlling the lubricant film thickness in the contact.

There are a couple of practical issues with this arrangement. Firstly, it is obviously an expensive and difficult process manufacturing a small, six land, taper land/flat land bearing sample. Secondly, with a small mean friction diameter, the contact width is potentially too small to prevent significant radial leakage, from the contact.

To address these issues, we have been developing a new adapter that uses just three removable bearing pads, which can be either taper/flat, pure taper or pure flat profile. By mounting the pads centrally on a diameter, the contact width is maximised; this would not be the optimum choice if we were designing an actual thrust bearing, but is a good practical choice, for a test geometry.



The pad specimens can be manufactured as a single strip of material and finished either transversely or axially, then cut to the required length.

By electrically insulating each pad, independent electrical contact resistance measurements can be made, for each contact.

## High Throughput Tribometers

At STLE 2018, Brendan Nation, John Curry, Michael Dugger and Greg Poulter, of Sandia National Laboratories, gave a presentation with the title:

> **"High Throughput Tribometry"**

It included the question:

> **"Can we do 100 tests per day on the same piece of equipment?"**

More recently, an industrial client commented:

> **"Capital cost is of importance as funding is tight and will not get better in the near future. You must bear in mind that for industry, testing time is seen in money terms: we need quick results, with dedicated units, which can easily be operated by an ordinary worker and not require 'scientists'."**

We have, ourselves, been thinking about the requirement for high throughput friction and wear testing, and indeed, already have a number of multi-station rigs, which address the requirement. However, we have never really had time, until now, to address the matter in a concerted and coordinated fashion; we have taken the opportunity of the pandemic lock-down to do just that.

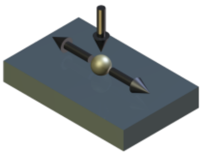
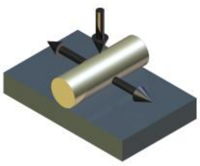
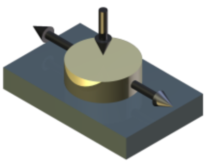
There is a further motivation behind designing a range of low cost, easy to operate, single function, high throughput machines and that is that we can substantially eliminate the requirement for installation, commissioning and training, which is usually necessary with more complicated, multi-function tribometers. The reason for this, of course, is that for the foreseeable future, visits to clients' facilities, are not possible.

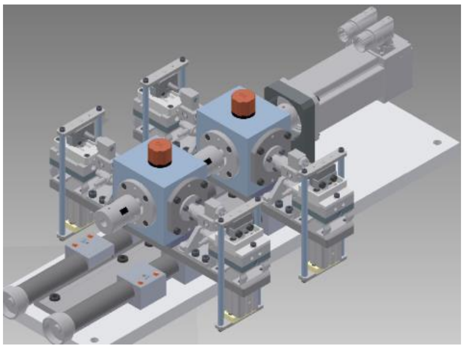
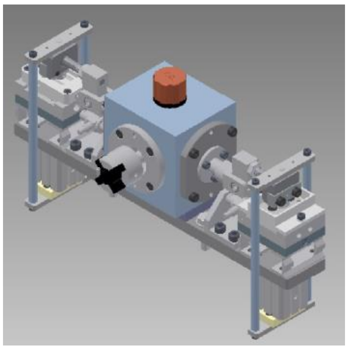
## General Concept

- Single function
- Multi-station
- Simple to Operate
- Control via PLC
- Data exported on USB stick

## HTP 010 Two/Four Station Short Stroke Reciprocating

Evolution: TE 90 Two/Four Station Reciprocating Tribometer

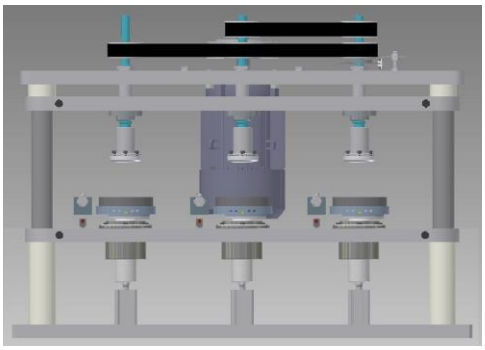
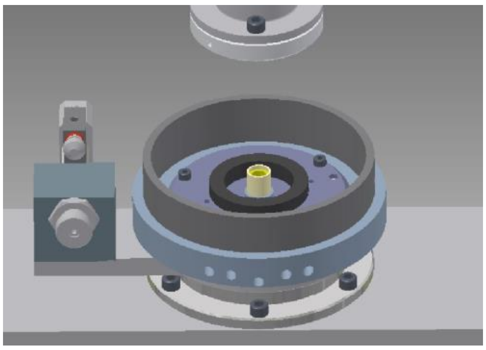

 

| Specification | Short Stroke Reciprocating | |
|---|---|---|
| Motion | Reciprocating | |
| Load | 5 to 100 | N |
| Stroke | 5 | mm |
| Frequency | 3 to 30 | Hz |
| Temperature | Ambient to 200 | °C |
| Test Stations | 2 or 4 | |
| **Manually Set Parameters** | | |
| Load | Yes - pneumatic | |
| Frequency | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Temperature | Yes - each sample | |
| Friction Force | Yes - each sample | |
| Contact Potential | Yes - each sample | |

## HTP 020 Three Station Thrust Washer

### Evolution: TE 94 Three Station Rotary Tribometer

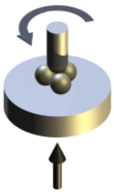
 

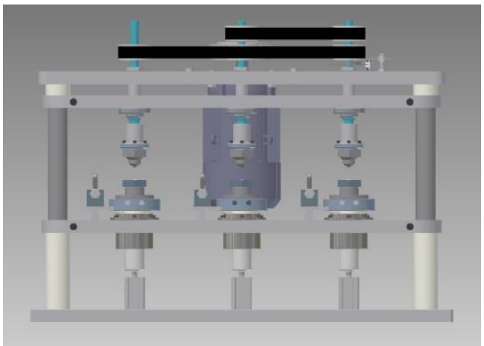
 

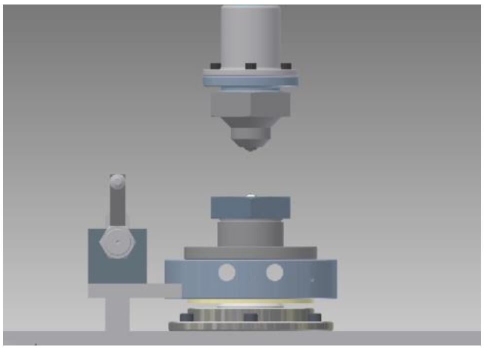
| Specification | Thrust Washer | |
|---|---|---|
| Motion | Rotary | |
| Load | 20 to 400 | N |
| Diameter | ASTM D3702 Small/Large | mm |
| Speed | 6 to 600 | rpm |
| Temperature | Ambient to 150 | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - pneumatic | |
| Rotational Speed | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Temperature | Yes - each sample | |
| Friction Force | Yes - each sample | |

## HTP 030 Three Station Four Ball Friction & Wear

### Evolution: TE 94 Three Station Rotary Tribometer







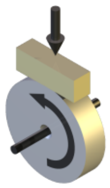
| Specification | Four Ball Friction & Wear | |
|---|---|---|
| Motion | Rotary | |
| Load | 20 to 400 | N |
| Diameter | 12.7 | mm |
| Speed | 50 to 1200 | rpm |
| Temperature | Ambient to 150 | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - pneumatic | |

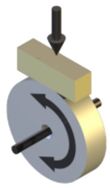
| | | |
|---|---|---|
| Rotational Speed | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Temperature | Yes - each sample | |
| Friction Force | Yes - each sample | |

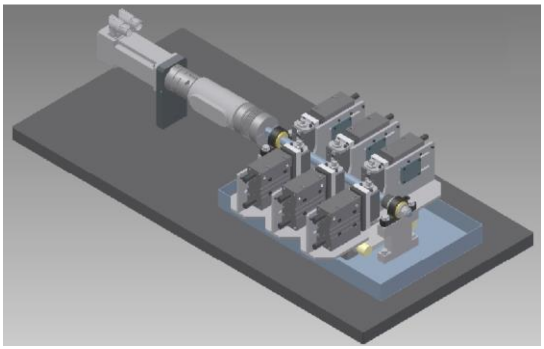
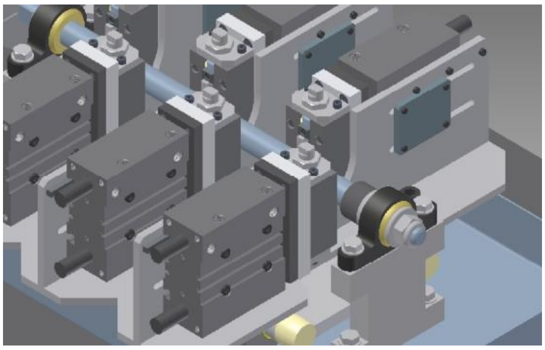
## HTP 040 Six Station Cross Cylinder/Block on Ring

### Evolution: Lathe Wear Generator





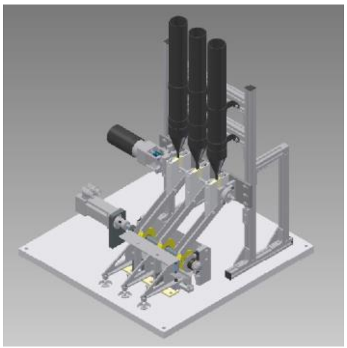
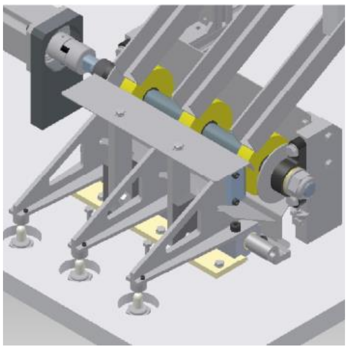
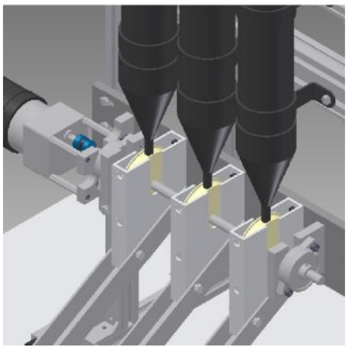


| **Specification** | **Cross Cylinder/Block on Ring** | |
|---|---|---|
| Motion | Rotary | |
| Load | 20 to 400 | N |
| Diameter | 20 | mm |
| Speed | 6 to 600 | rpm |
| Temperature | Ambient | °C |
| Test Stations | 6 | |
| **Manually Set Parameters** | | |
| Load | Yes - pneumatic | |
| Rotational Speed | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Friction Force | Sum total for all samples | |

## HTP 050 Three Station Sand - Wheel Abrasion - Dry & Wet

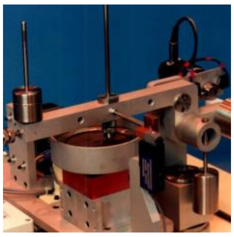
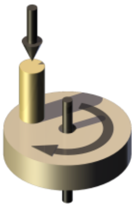
Evolution: TE 65 Sand/Wheel Abrasion Tester

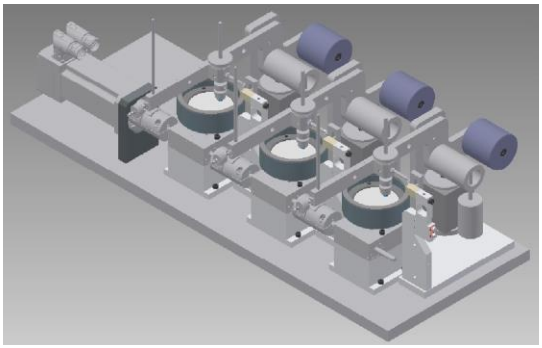





| **Specification** | **Sand - Wheel Abrasion - Dry & Wet** | |
|---|---|---|
| Motion | Rotary | |
| Load | 5 to 100 | N |
| Diameter | 80 | mm |
| Speed | 30 to 150 | rpm |
| Temperature | Ambient | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - Pneumatic | |
| Rotational Speed | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | N/A | |

## HTP 060 Three Station Pin on Disc

Evolution: TE 79 Multi-Axis Tribology Machine

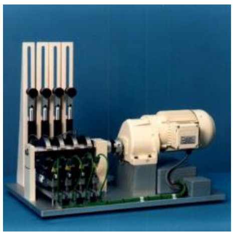



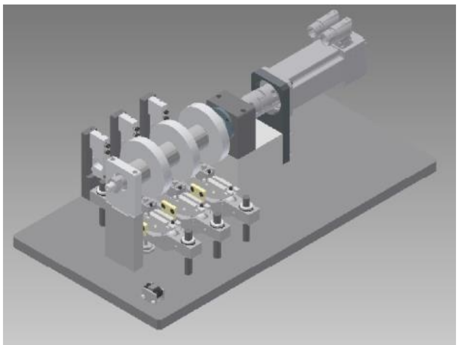


| Specification | Pin on Disc | |
|---|---|---|
| Motion | Rotary | |
| Load | 1 to 60 | N |
| Diameter | 75 | mm |
| Speed | 2 to 200 | rpm |
| Temperature | Ambient to 200 | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - dead-weight | |
| Rotational Speed | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Temperature | Yes - each sample | |
| Friction Force | Yes - each sample | |

## HTP 070 Three Station Block on Ring Friction

Evolution: TE 56 Multi Station Block on Ring Machine



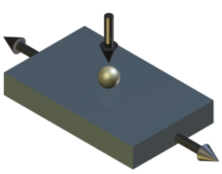
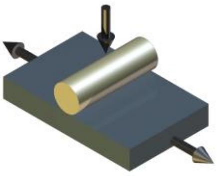
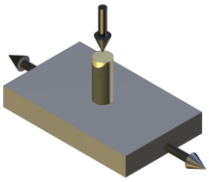


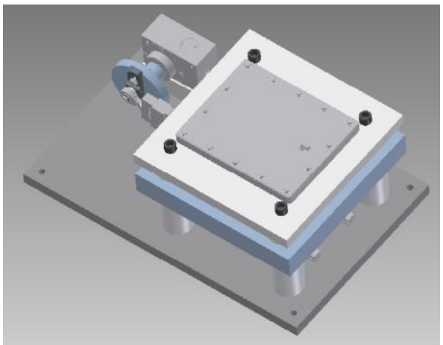
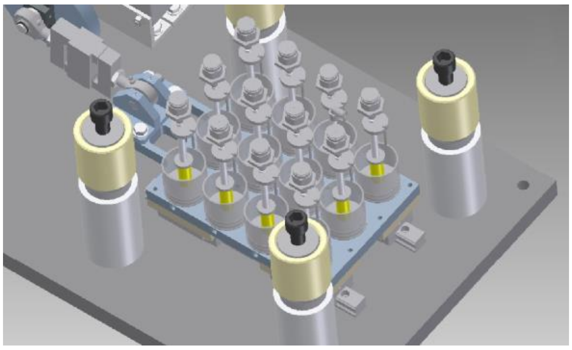
| Specification | Block on Ring Friction | |
|---|---|---|
| Motion | Rotary | |
| Load | 5 to 150 | N |
| Diameter | 100 | mm |
| Speed | 10 to 380 | rpm |
| Temperature | Ambient | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - Pneumatic | |
| Rotational Speed | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Friction Force | Yes - each sample | |
| Temperature | Yes - each sample | |

## HTP 080 Twelve Station Long Stroke Pin on Reciprocating Plate

### Evolution: TE 87 Circular Translation Pin on Disc + TE 88 Friction & Wear Tester



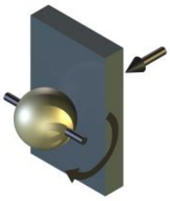



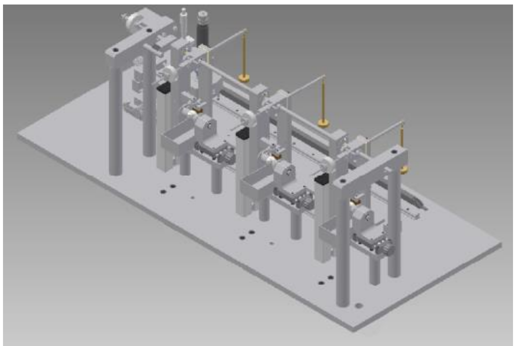
| Specification | Long Stroke Pin on Reciprocating Plate | |
|---|---|---|
| Motion | Reciprocating | |
| Load | 5 to 100 | N |
| Stroke | 25 | mm |
| Frequency | 1 to 3 | Hz |
| Temperature | Ambient to 150 | °C |
| Test Stations | 12 | |

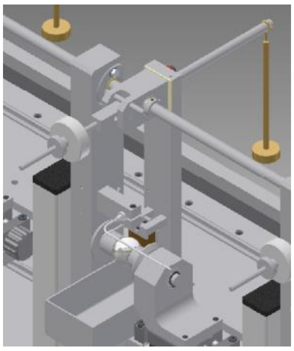
| | | |
|---|---|---|
| **Manually Set Parameters** | | |
| Load | Yes - pneumatic | |
| Frequency | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Load | Pressure Transducer | |
| Temperature | Yes | |
| Friction Force | Sum total for all samples | |

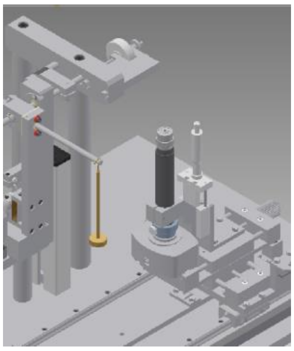
## HTP 090 Three Station Ball Cratering/Microscale Abrasion

### Evolution: TE 66 Micro Scale Abrasion Tester





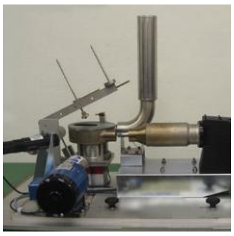
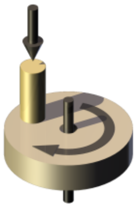
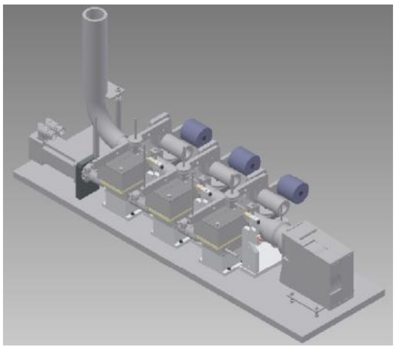
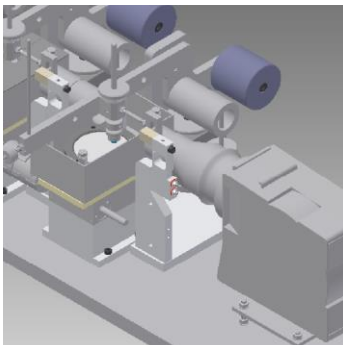




| **Specification** | **Ball Cratering/Microscale Abrasion** | |
|---|---|---|
| Motion | Rotary | |
| Load | 0.1 to 5 | N |
| Diameter | 25 | mm |
| Speed | 30 to 150 | rpm |
| Temperature | Ambient | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - dead-weight | |
| Rotational Speed | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | N/A | |

# HTP 100 Three Station High Temperature Pin on Disc

## Evolution: TE 98 High Temperature Pin on Disc Machine

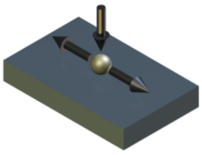





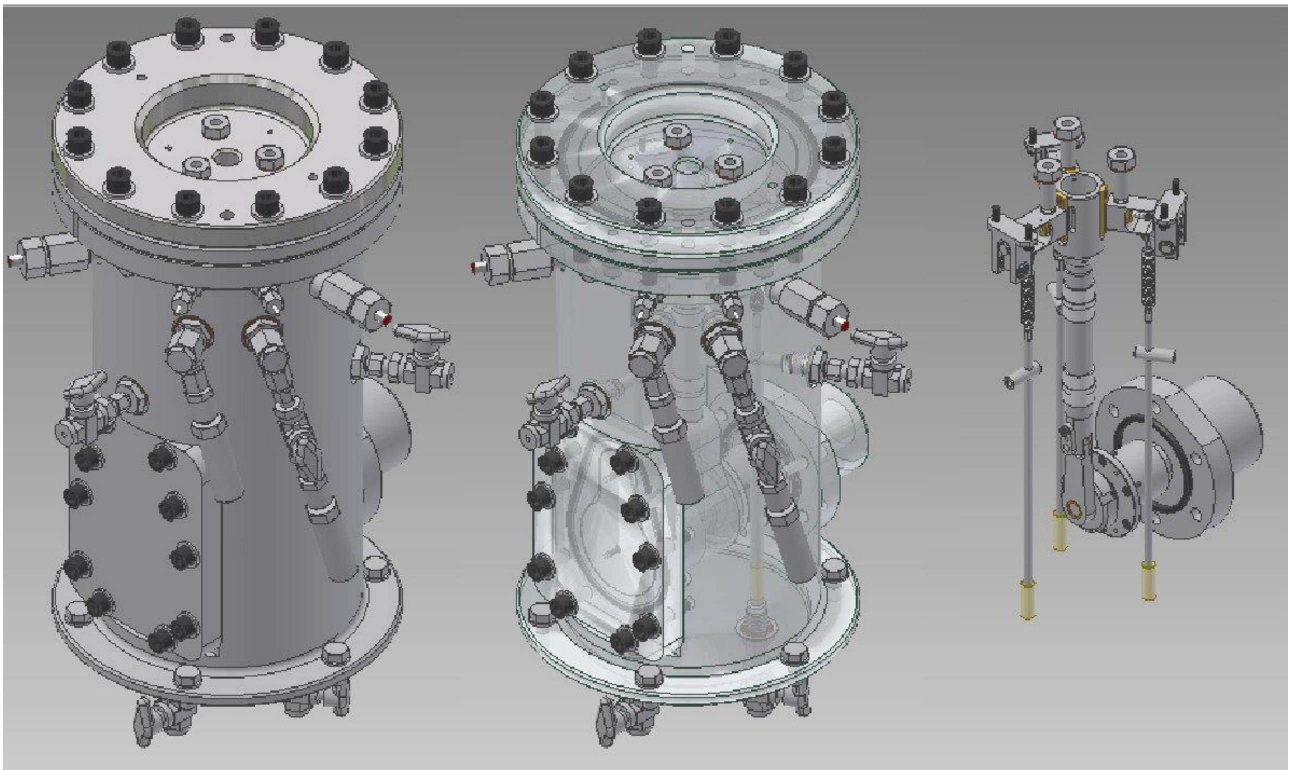
| **Specification** | **High Temperature Pin on Disc** | |
|---|---|---|
| Motion | Rotary | |
| Load | 1 to 60 | N |
| Diameter | 75 | mm |
| Speed | 2 to 200 | rpm |
| Temperature | Ambient to 500 | °C |
| Test Stations | 3 | |
| **Manually Set Parameters** | | |
| Load | Yes - dead-weight | |
| Rotational Speed | Yes | |
| Temperature | Yes | |
| Test Duration | Yes | |
| **Data Logged Parameters** | | |
| Temperature | Yes | |
| Friction Force | Yes - each sample | |

For further information please e-mail: high-throughput@phoenix-tribology.com

# WORK IN PROGRESS – PRODUCTION

## High Pressure Hydrogen Reciprocating Tribometer





We are currently designing a reciprocating tribometer to work under pressurised hydrogen. This is, of course, somewhat more complicated than simply putting a conventional atmospheric tribometer in a pressure vessel. Firstly, the design has to be compliant with a number of EU directives including Pressure Systems Safety Regulations 2000 (PSSR), Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) and ATmospheres EXplosible Directive 2014 (ATEX). Secondly, because of the time taken to purge the chamber of oxygen, then slowly pressurise with hydrogen, then allow the test specimens to absord hydrogen, it makes sense to fit as many test stations as possible, into the smallest enclosed volume as possible. A further complication is a requirement both to heat and to cool the test specimens.

| **Specification** | |
|---|---|
| Number of Test Stations | Three |
| Test Configuration | Ball on flat |
| Gases | Hydrogen, Argon, CO2 |

| | |
|---|---|
| Working Pressure | 0.1 mbar to 120 bar |
| Stroke Range | 0 to 20 mm Continuously Adjustable |
| Frequency | 0 to 5 Hz |
| Load (dead-weight) | 5 to 50 N |
| Temperature Range | -55°C to 150°C |
| Wear Range | 0 to 100 microns |

# OTHER NEWS

## On-line Tutorials

We have now produced YouTube videos, based on material delivered during the Cambridge Tribology Course, plus other events at STLE, Wear of Materials etc. These can be viewed either via our web site or direct on YouTube at:

Tribology Testing

Engine Tribology

Lubricated Friction

Lubricated Wear

If you would like copies of the PowerPoint slides, please e-mail tutorial@phoenix-tribology.com, with the subject the title you wish to receive.

## IET TV Video

The following was recorded at a Tribology UK meeting in 2015. If you have time to waste, you may find it entertaining!

Why Become a Tribologist? - A personal view, with reference to those who have influenced me

George Plint and David Harris

**Phoenix Tribology Ltd**