EHL Ultra Thin Film Measurement System

Overview

The EHL Ultra Thin Film Measurement System is a computer controlled instrument for measuring the film thickness and traction coefficient (friction coefficient) of lubricants in the elastohydrodynamic (EHL) lubricating regime. The instrument can measure lubricant film thickness down to 1 nm (1 millionth of a millimetre) with a precision of +/- 1 nm. Traction coefficient can be measured at any slide/roll ratio from pure rolling up to 100%. The instrument measures these lubricant properties in the contact formed between a steel ball and a rotating glass or steel disk. The contact pressures and shear rates in this contact are similar to those found in for example, gears, rolling element bearings and cams.

Applications of the instrument include:

- Evaluation of film forming and frictional properties of oils and greases
- Fuel economy prediction of candidate crankcase oils
- Performance prediction of oil in water emulsion rolling mill lubricants
- Fundamental investigations of the high pressure/high shear behaviour of fluids such as liquid crystals
- Investigation of boundary additive performance

The instrument has been developed from research work carried by the Tribology Group at Imperial College, London. It is the only commercially available system of its type in the world today.

Description of the EHL System

The EHL system measures film thickness and traction coefficient in the EHL contact formed between a ¾ inch steel ball and a rotating 100 mm diameter disc. For film thickness measurements the disc is glass and has a chromium and silica coating on the working face. For traction measurements the disc is made from polished bearing steel. The ball is mechanically loaded against the underside of the disc and can be allowed to rotate freely or can be driven to induce sliding between the ball and disc. The load is controlled automatically and is variable between 0 and 50 N. This gives maximum contact pressures between the ball and disc of up to approximately 1.1 GPa with a steel disc and 0.7 GPa with a glass disc.

The ball and disc are independently driven by DC servo motors. With standard gearing, the maximum rolling speed is 5 m/s and the minimum rolling speed is 5 mm/s. The ball can be allowed to idle freely in nominal pure rolling, or a drilled ball and drive shaft can be fitted. The ball can then be driven at any desired slide/roll ratio, the required ball and disc speeds being determined automatically by the control software. The traction force is measured by a high sensitivity torque transducer between the ball motor and the ball.

The liquid sample to be tested is contained in a reservoir constructed from a single stainless steel block. Heaters are fitted to allow measurements at temperatures from ambient up to 150°C. Two platinum RTD probes measure the temperature of the reservoir itself and of the liquid close to the ball surface. The system will shut down if either probe exceeds a user-set alarm temperature. Circulating cooling channels are provided in the block so that tests can be run at below ambient temperature using an optional refrigerated circulating bath.

Thin Film Measurement System

The lubricant film thickness is measured by optical interferometry. The contact is illuminated by a white light source directed down a microscope through the glass disc onto the contact. Part of the light is reflected from the chrome layer on the disc and part travels through the silica layer and any fluid film and is reflected back from the steel ball. The recombining light paths form an interference image which is passed into a spectrometer and then into a high resolution black and white CCD camera. The camera image is captured by a video frame grabber and analysed by the control software to determine film thickness.

Control System

The software controls all of the system functions for both film and traction measurements: temperature control; load control; motor speeds; image acquisition and processing; traction force measurement; data display and storage. The thin film software takes data from the spectrometer, determines the wavelength of maximum constructive interference and hence the lubricant film thickness. It also compensates for variations in silica spacer layer thickness and the overall spectral response of the optical system. Collected data is displayed in a small spreadsheet-like display, and also graphically as it is collected. The data may be cut and pasted into other applications or saved as a text file and opened in other spreadsheet or word-processor applications. The traction software allows the user to select rolling speeds and slide/ roll ratios and logs data from the ball torque and load transducers and calculates the resulting traction coefficient. System safety in both applications is ensured by a “watchdog” circuit which will shut the entire system down within 10 seconds should the controlling software or PC fail. An immediate emergency stop is provided to halt the motors.

Specifications

Film Thickness	1 to approx. 1000 nm, ± 1 nm
Speed	0 to 5 m/s
Slide/roll ratio	0 to 100%
Load	0 to 50 N
Contact pressure	Max 1.1 GPa (steel disc), 0.7 GPa (glass disc)
Temperature	Ambient to 150°C

Dimensions

Bench top mounting, 2 free standing units plus PC and additional monochrome video monitor:

Mechanical unit	50H x 50W x 30D cm (20 x 20 x 12 in), 25 kg (50 lb)
Electronics unit plus PC	60H x 55W x 40D cm (24 x 22 x 16 in), 25 kg (50 lb)
Power supply	Factory set between 100 - 240 V, 50/60 Hz, 750 VA.