

P5013

HYDRODYNAMIC LUBRICATION UNIT

FEATURES

- ◆ Horizontal 50 mm shaft and journal bearing
- ◆ Three alternative shaft sleeves provide variable bearing clearance
- ◆ Uses automotive thin wall main bearing shells of various widths
- ◆ Variable speeds up to 1000 rev/min
- ◆ Radial loading of the bearing of up to 500N is applied vertically by weights via an hydrostatic pad
- ◆ Air cylinder driven reciprocating oil pump and accumulator
- ◆ High quality oil filtration and pressure regulation
- ◆ Direct measurement of bearing friction torque
- ◆ Indication of oil film thickness and detection of metal to metal contact based on electrical resistance between journal and housing
- ◆ Instrumented for oil pressure and temperature, and drive motor current

OPTIONS

- ◆ **P5014** Special bearing housing and instrumentation for measurement of bearing pressure distribution
- ◆ **P5015** Air gauging system for the measurement of bearing attitude (eccentricity)
- ◆ **P5016** Air compressor and receiver with filter regulator unit

EXPERIMENTAL CAPABILITY

- ◆ Friction Torque in a Journal Bearing assembled with any combination of 3 shaft sleeves and any 3 bearing shell widths
 - During running-in of the bearing shells
 - Preparation of torque-load parameter curves under different conditions of journal speed, load and including boundary lubrication conditions
 - Comparison of friction torque with that predicted by the Petroff equation
- ◆ Pressure Distribution in a Journal Bearing
 - Comparison of summated pressures with applied load under different conditions including conditions of limited boundary lubrication
- ◆ Bearing Attitude
 - Measurement of approximate running-in wear
 - Measurement of bearing attitude for different conditions of load and speed

INTRODUCTION

Cussons Hydrodynamic Lubrication Unit has been developed to provide a wide range of laboratory experiments on journal bearings from a self-contained piece of apparatus. The recent up-surge in interest in the science of tribology has resulted in a greater emphasis on lubrication studies in many types of syllabus from craft to degree courses. A major section of a lubrication syllabus is always a study of hydrodynamic effects and this unit will have many uses in such a study.

By the use of different items comprising the range it is possible to measure the journal friction, map the hydrodynamic pressure of the oil film and determine the bearing attitude of a journal bearing using only the instrumentation provided. These tests can be carried out under conditions of varying speeds, varying load, varying bearing clearance and varying bearing width.

Special features of the unit are the hydrostatic loading system, the sensitive torque measuring instrumentation and the direct pressure measuring probe. All the equipment and instrumentation is of very high quality. The bearing under test closely resembles actual working practice and it is particularly valuable for demonstration and experimental work in elementary courses, as well as being capable of experiments suitable for degree and post graduate work.

DESCRIPTION

The Journal Friction Apparatus is the basic item in the Cussons Hydrodynamic Lubrication Unit which enables the friction in a journal bearing to be measured under various conditions of load and speed, including boundary lubrication conditions, and the comparison of the results with the friction torque predicted by the Petroff equation.

The apparatus consists of a sturdy tubular steel frame on which is carried a counter shaft mounted in ball bearings having an overhung mandrel at the front. The shaft is driven by a variable speed DC motor via a toothed belt and pulleys. The bearing system, which is to be the subject of the investigation, is assembled around the mandrel.

THE JOURNAL SHAFT

The journal shaft consists of an accurately ground hardened steel sleeve which fits over the mandrel and is retained by a screw. Two additional sleeves of graded diameter are provided which permit the running clearance to be varied.

JOURNAL BEARING

The bearing consists of a split bearing housing which permits the use of standard motor car engine type thin wall shell bearings. Provision is made to accept shells of different width and thus assess the effect of bearing length. Replacement shells are low in cost and hence it is of little consequence if they are damaged when running under boundary conditions. Three sets of bearing shells are supplied.

The use of low cost bearing shells also allows the economic evaluation of bearing wear during the initial running-in of bearings.

VARIABLE SPEED DRIVE

A DC motor with AC solid state speed control unit provides very sensitive and stable control of the mandrel speed over the range 20-1000 rev/min.

THE LOAD

The load is applied to the journal using masses and a mass hanger attached to a specially developed hydrostatic pad. In this way the journal housing is completely isolated from the loading system except for vertical load and very accurate friction torque measurements can be made.

THE OIL SUPPLY

The oil supply to the test journal and to the hydrostatic pad is pressurised using a reciprocating pump and accumulator system that results in very little heating effect in the oil. Oil and bearing temperatures quickly stabilise at just above

ambient temperature and it is possible to run experiments without delay. The oil system is complete with a ten micron filter, over pressure relief valves, pressure gauges and reducing valves for controlling the oil supplies to the hydrostatic pad and journal.

INSTRUMENTATION

The bearing friction torque is measured using a torque arm and a sensitive strain gauge load cell with an electrical meter for direct read-out in Nm. The transducer is very quickly calibrated since it is located magnetically and can be transferred to a vertical face on the frame and directly loaded using a small mass which is supplied. Mandrel speed is displayed by an electronic (analogue) tachometer. There is also an electrical resistance meter to demonstrate the effect of bearing clearance and an ammeter for armature current.

P5014 - PRESSURE DISTRIBUTION APPARATUS

The Pressure Distribution Apparatus, which is to be used in conjunction with P5013, enables the pressure of the oil film in a journal bearing to be measured at 30 separate points over the bearing surface.

A special journal housing is supplied which is formed in a block of cast iron and has an accurately honed bore designed to run on the bearing sleeves supplied with P5013.

The block is drilled and lapped with the necessary passages for measurement of the oil pressure and blanking plugs are provided for those passages not traversed by the pressure probe provided.

The pressure probe comprises a bourdon type gauge mounted on an accurately lapped spool which is used to traverse the drillings in the bearing block.

P5015 - BEARING ATTITUDE APPARATUS

This equipment, which is to be used in conjunction with P5013, consists of an air gauging system for use in determining the bearing attitude. A pair of nozzles is used to measure the X and Y displacements of the bearing housing relative to the journal shaft. The gauges are extremely sensitive and little affected by the curvature of the journal shaft. Calibration is carried out on a separate fixture using a micrometer head.

P5016 - AIR COMPRESSOR

A fully automatic reciprocating air compressor driven by a single phase electric motor and supplied with an air receiver and filter regulator unit.

Capacity	77.9 l /min
Working pressure	8.5 bar
Electrical supply	240V, 50Hz or 110V, 60Hz

TECHNICAL SPECIFICATION AND BEARING PARTICULARS

Speed	20-1000 rev/min
Maximum bearing load	500 N
Nominal Shaft Diameter	50.55 mm (1.99")
Shaft Sleeve Diameters	50.52 mm 50.50 mm 50.47 mm
Width of bearing shells	44 mm, 34 mm, 28 mm
Width of P5014 bearing	45 mm
Oil	Normally Tellus 15
Supply Pressure	6 bar approximately
Hydrostatic Pressure	14 bar approximately

OUTLINE OF THE PRINCIPLE OF HYDRODYNAMIC LUBRICATION IN A JOURNAL BEARING

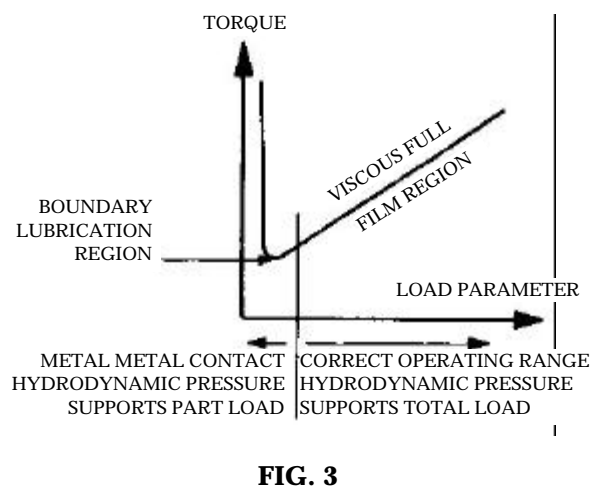
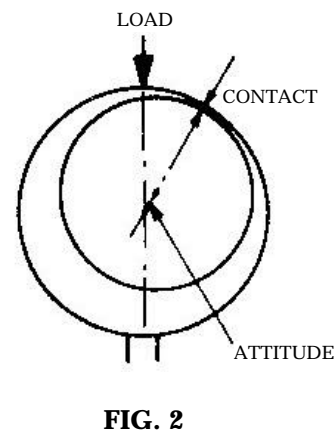
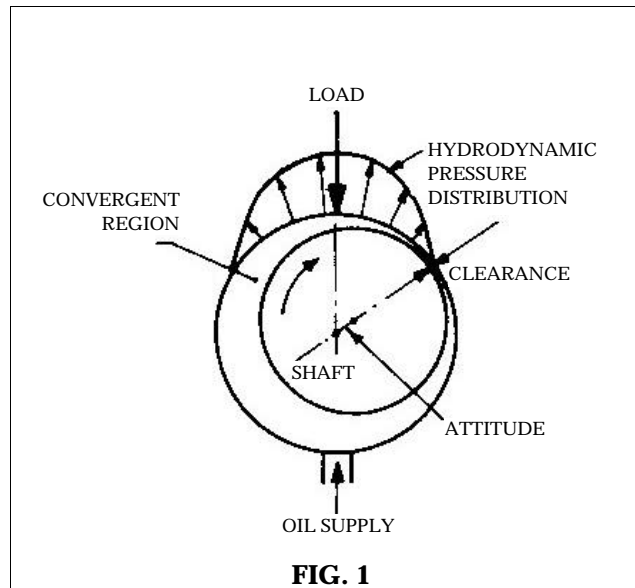
When a journal bearing which has an adequate supply of lubricant is carrying a load it normally runs with the geometric centres of the shaft and housing displaced so that a region of convergent flow is established. In this region large hydrodynamic pressures are set up within the oil film and these pressures when summated over the total bearing surface are found to completely support the load.

If bearing conditions change; for instance the load may vary, the displacement or "attitude" of the centres changes so that the new pressure distribution is sufficient to support the new load. Fig. 1 illustrates the basic principles.

Various non-dimensional load parameters are used to assess the performance of a bearing. The parameters are formed from terms such as the oil viscosity and the load and speed of the bearing. For a given bearing it is found that there is a critical value of load parameter at which the convergent film is unable to support the total bearing load and the surfaces touch. Under these conditions the friction torque suddenly starts to rise and boundary lubrication occurs in the region of minimum film thickness. Figs. 2 and 3 illustrate these phenomena.

SUGGESTED EXPERIMENTS AND DEMONSTRATIONS

- 1) Friction Torque in a Journal Bearing (with P5013)
 - (a) Running-in.
 - (b) The preparation of torque-load parameter curves under different conditions of speed, load, bearing width and clearance and including the boundary lubrication region.
 - (c) The comparison of the friction torque with that predicted by the Petroff equation.



2) Pressure Distribution in a Journal Bearing (with P5013 and P5014)

- (a) Simple Demonstration.
- (b) Comparison of summated pressures with applied load under different conditions of load and clearance including that where limited boundary lubrication is allowed.
- (c) Repetition of 2(a) and 2(b) at different speeds.

3) Bearing Attitude (with P5013 and P5015)

- (a) The measurement of approximate running-in wear.
- (b) The measurement of bearing attitude for different conditions of load, speed, bearing width and clearance.

NOTE: In all cases viscosity can be changed by changing the oil.

Typical experimental results with the Cussons apparatus are shown opposite.

HYDRODYNAMIC LUBRICATION UNIT

Specification of items of apparatus comprising the unit

P5013 JOURNAL FRICTION APPARATUS

Cussons Journal Friction Apparatus comprising steel frame and instrument panel with ball bearing mounted countershaft carrying overhung mandrel with variable speed drive by DC motor and AC solid state control unit, journal shaft assembly with hardened steel sleeves (3), split journal bearing assembly with a set of thin wall bearing shells, hydrostatic pad, mass hanger and masses (total 50 kg), pressurised oil supply with pump and reservoir, ammeter, electrical resistance meter, sensitive torque meter and tachometer (analogue). For electrical supply 220/240 volt, single phase, 50 or 60Hz. Other voltages to special order. Requires compressed air supply at pressure not less than 6 bar (851b/in²).

Overall dimensions 1.6m high x 0.84m wide x 0.75m deep (63" high x 33" wide x 30" deep)

Weight 210 kg.

P5014 PRESSURE DISTRIBUTION APPARATUS

Equipment for use in conjunction with P5013 comprising journal bearing assembly with multiple pressure tappings and supplied complete with pressure probe fitted bourdon gauge and with blanking plugs.

P5015 BEARING ATTITUDE APPARATUS

Equipment for use in conjunction with P5013 comprising a pair of air gauging nozzles, standard test pressure gauges (2) with reducing valve and fittings for connection to air circuit of P5013. Supplied together with separate calibration fixture with micrometer head.

P5016 AIR COMPRESSOR

A reciprocating air compressor driven by a single phase electric motor and supplied with air receiver and filter regulator. Capacity 77.9 /min. Working pressure 8.5 bar.

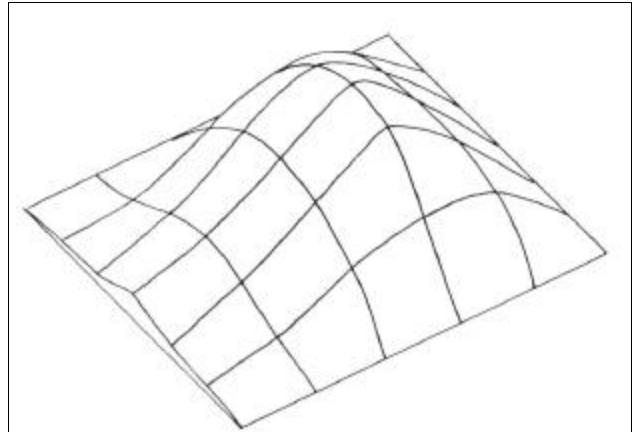


FIG. 4 A typical pressure distribution in the journal bearing (P5013 and P5014)

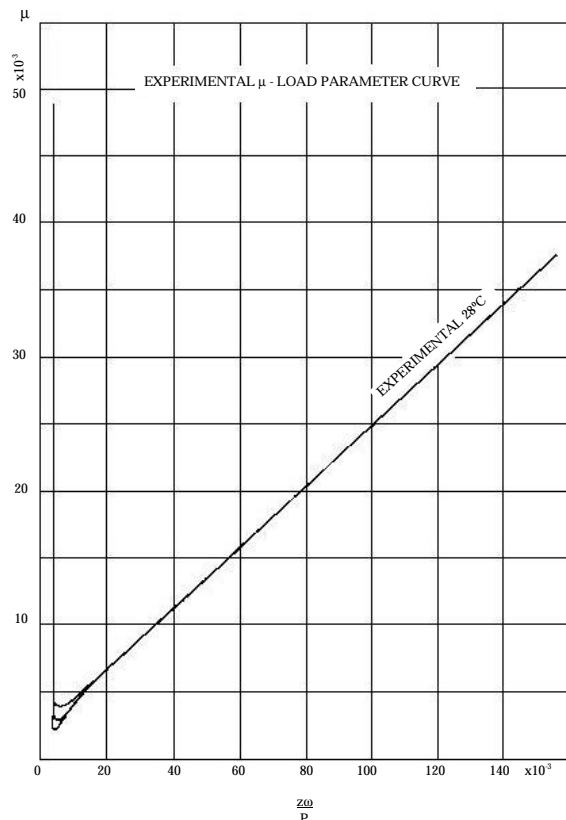


FIG. 5 Experiment results from P5013 unit

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