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A Study on the Measurement of Oil-Film Pressure in Engine Connecting Rod Bearing and Piston Pin-Boss by Thin-Film Sensor

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In order to measure the oil-film pressure in sliding surface of machinery, we have developed a piezo-resistive type thin-film pressure sensor. To reduce the measurement error due to temperature and strain, the constituent of the pressure sensitive alloy was optimized and a new sensor shape was devised. In this study, we present the measurement results of the oil-film pressure distribution in engine connecting rod big-end bearing and piston pin-bosses with 3 different pin-boss shapes using the newly developed thin-film pressure sensor.

Keywords : Oil-film pressure, Thin-film pressure sensor, Plain bearing, Piston pin-boss

1. INTRODUCTION

The optimal design of engine bearing and piston pin-boss requires a precise knowledge of the oil-film pressure distribution of internal combustion engine to solve the problem of emission and light weight of the engine. In this study, a thin-film pressure sensor was developed in order to measure the oil-film pressure distribution in those engine parts. We present this sensor and measurement result using actual engine and piston pin-boss fatigue tester.

2. THE STRUCTURE OF THIN-FILM SENSOR

Fig.1 shows the structure and shape of a thin-film pressure sensor. As seen in Fig.1(b), (1) is a substrate, such as bearing and piston-pin; (2) is a isolation film for isolating the sensitive part(3) from the substrate(1); (3)is the alloy of the sensitive part to sense the pressure and (4) is the protection film that protects the sensitive part(3). Fig.1(a) shows the sensor shape for this study. The sensor consists of two arcs and two semi-circles which serve as the lead film for connecting these two arcs.

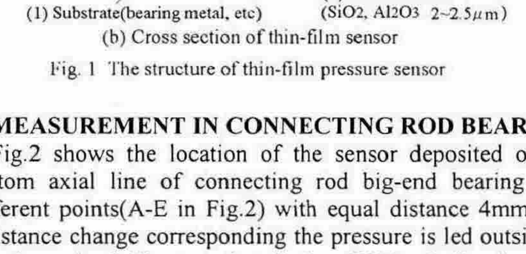


Fig. 1 The structure of thin-film pressure sensor

3. MEASUREMENT IN CONNECTING ROD BEARING

Fig.2 shows the location of the sensor deposited on the bottom axial line of connecting rod big-end bearing at 5 different points(A-E in Fig.2) with equal distance 4mm. The resistance change corresponding the pressure is led outside by aluminum lead films. A 4 cylinder, 5307cm3 diesel engine was run at full load and 2500rpm. Fig.3 shows a example of oil-film pressure measured at the bearing bottom center. The curve(1) in Fig.3 is the measured pressure. (2) is the bearing load calculated by simple method. (3) is the cylinder pressure. The tendency of oil-film pressure change was in good agreement with the calculated bearing load.

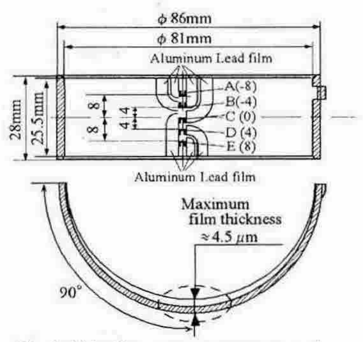


Fig. 2 Thin-film pressure sensor on engine connecting rod bearing (Total 5 sensors)

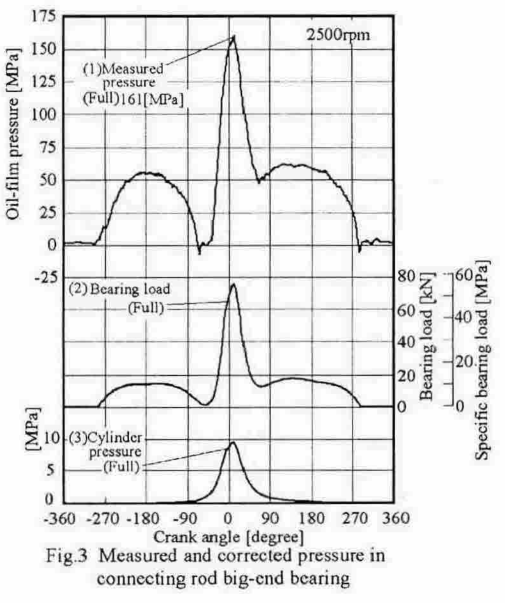


Fig.3 Measured and corrected pressure in connecting rod big-end bearing

4. MEASUREMENT IN PISTON PIN-BOSS

4.1 Test piston and measurement point

Fig.4 shows the thin-film pressure sensor deposited on the piston pin-boss. The sensitive part used in this experiment was also twin-arc type. The axial location of sensing part in piston pin-boss, measured from the R-edge shown in Fig.5(a), was varied from -0.6mm to 14.6mm by changing the length L of the lead part. Fig.6 shows the circumferential location of measurement in pin-boss. The top side in the pin-boss was defined as 0° with negative (thrust) and positive (anti-thrust) side. The pressure was measured at every 10° up to ±40°, then at ±60° and ±80°. Fig 5(b) shows 3 pin-boss shape of test pistons. The type (1) is a straight type piston pin-boss at the top, and it's length between the end of the snap ring groove and the R-edge inside the piston is 23.6mm. The type A and the type B are the same as that of straight type. However, they are tapered by 0.1° beginning from the points distant 20mm or 15mm from the snap ring groove. As the test rig for this experiment, a piston pin-boss fatigue tester was used.

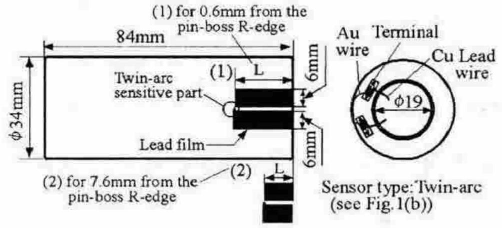


Fig. 4 Thin-film sensor deposited on the piston pin-boss

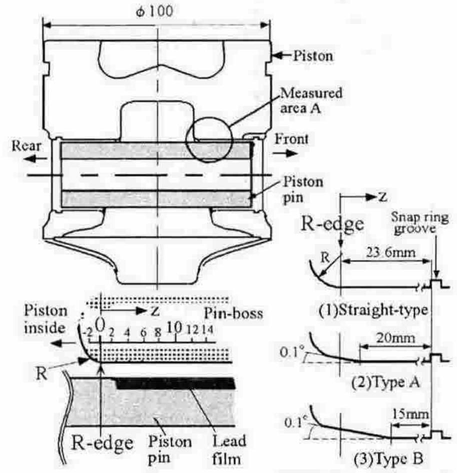


Figure 5 Measurement point in piston pin axial direction and pin-boss shape of test piston

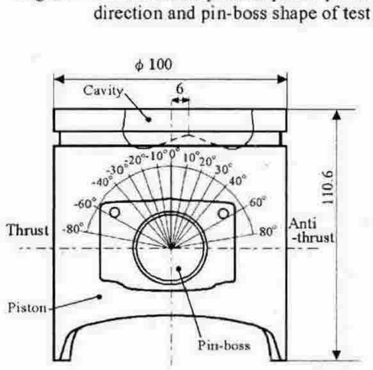


Fig. 6 Measurement position in circumference direction

4.2 Measurement result in axial direction

Fig.7 shows the axial distribution of the oil-film pressure along the top line of the inner surface of the piston pin-boss. When the maximum pressure Pmax=12MPa acted on the piston top, the maximum oil-film pressure measured in type(1),(2), and (3) was 195, 155 and 130MPa at the axial location 0.6, 1.6-3.6 and 3.6-5.6mm from the R-edge, respectively. Namely, the straight line type boss showed the highest oil-film pressure, followed by the typeA and typeB on the inner side of the boss.

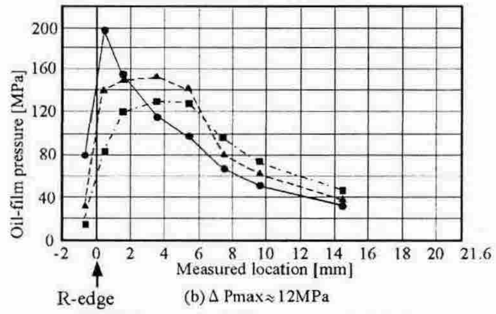
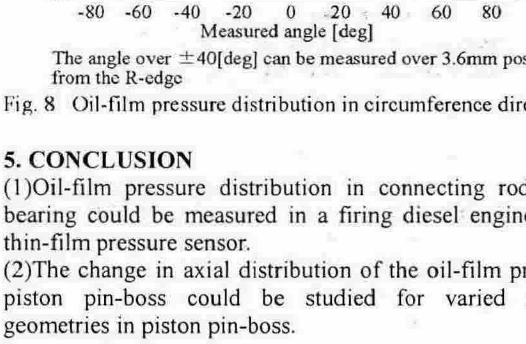


Fig.7 Measured oil-film pressure distribution in axial direction

4.3 Measurement result in circumference direction

Fig. 8 shows the oil-film pressure in circumference direction in piston pin-boss. The test piston used in this experiment is straight type shown in Fig.5(b)(1). At axial locations z=0.6mm and 1.6mm, the pressure could not be measured at ±60° and ±80° due to the pin-boss inner side shape. The pressure measured at all 4 axial locations was higher on anti-thrust side than on thrust side. This is because the cavity position of the piston crown was not symmetrical for pin-boss hole center. In Fig.8, the oil-film pressure on both sides(±60° and ±80°) is much lower than in the middle(0~±40°). Therefore, the elastic oval deformation of the hollow piston-pin under the "combustion" pressure could not be proved by this experimental results.



The angle over ±40[deg] can be measured over 3.6mm position from the R-edge

Fig. 8 Oil-film pressure distribution in circumference direction

5. CONCLUSION

(1)Oil-film pressure distribution in connecting rod big-end bearing could be measured in a firing diesel engine using a thin-film pressure sensor.

(2)The change in axial distribution of the oil-film pressure in piston pin-boss could be studied for varied clearance geometries in piston pin-boss.