Measurement of oil-film pressure distribution in engine sliding surfaces using thin-film sensor

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1. Introduction

In order to reduce CO₂ emissions and fuel consumption, the reduction of mechanical friction loss is very important technologies. To reduce such friction loss, understanding the lubrication conditions of engine sliding surfaces are very important. In order to investigate their conditions and to validate the CAE (Computer aided engineering), the author has developed a thin-film pressure, strain, temperature and also thin-film gap sensor and measured the distributions of oil-film condition in main bearings, piston skirts, pin-bosses and gear tooth surfaces. In this paper, the structure and form of thin-film sensor especially for piston skirts, plain bearings and gears were discussed and provided a measurement example.

2. Example structure of thin film pressure sensor

The sensor structure for a piston skirt is shown in Fig.1(b). The sensor consists of (1) substrate (piston skirt), (2) insulation film which obtains high electric insulation resistance between the substrate and sensing layer ((3a) and (3b)), and (4) protection film to improve the durability of sensing layer due to contact with cylinder liner. Total film thickness is from 3μm to 6μm. The shape of the sensor is shown in Fig.1(a). The sensor has a line of 20μm in width and two semi-arcs connected by two semicircles in the center. Fig.2(a) shows the sensor location on the plain bearing surface and Fig.2(b) shows the detail form of the sensor and lead film. Fig.3(a) is an overview of 5-point sensor sputtered on a spur gear tooth. The outer diameter of the spur gear is 91.4mm with a module of 3. As shown in Fig.3(b), five sensors P1 through P5 are put on the pitch circle and along the 30 mm long tooth flank. The total film thickness of the sensor is approximately 6μm.

3. Measurement results of engine bearing

Fig.4 shows a result of oil-film pressure measurement in engine main bearing using four cylinder turbo charged diesel engine (5307cm³). As for an increase of combustion pressure under half load, oil film pressure obtained the maximum pressure of 43MPa and obtained 36MPa with no load. Using sputtering technique, new types of thin-film sensors are developed with success to measure oil-film pressure of the surface of engine bearings in actual condition.

4. Summary

(1) Using sputtering technique, new types of thin-film sensors are developed with success to measure oil-film pressure of the surface of engine bearings.
(2) Due to thin and small sizes, these sensors scarcely disturb the test object and possess high spatial resolution and response.
(3) The distribution of the measured oil-film pressure gave the clear evidence of elastic deformation of sliding parts (EHL)