TOPICS

Air Bearing for Automotive Turbocharger

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1. Introduction

The application of oil-free bearings such as air or magnetic types to automotive turbochargers is expected to realize a reduction in mechanical losses while eliminating oil consumption. As a result, engines fitted with oil-free turbochargers will offer an improved response and lower fuel consumption and exhaust emissions. We have designed compliant foil air bearings with uniquely shaped dampers for the journal and thrust bearings of small-sized turbochargers (**Figs. 1** and **2**).

2. Method

First, we undertook a rotational test of a prototype turbocharger with air bearings. The results of this test revealed the need to increase the load capacity of the thrust air bearing relative to that of the journal bearing. To solve this problem, we used 3D computational fluid dynamics to analyze the effects of the film thickness distribution between the bearing and runner surfaces of the thrust air bearing on the generated pressure distribution, so as to increase the load capacities of the bearing.

3. Results and conclusion

Numerical analyses revealed three effective methods of increasing the load capacity, namely, increasing the size of the fluid charge in the bearing, generating the maximum pressure at the center of the bearing surface, and preventing the leakage of the fluid in the radial direction of the bearing surface. To realize these three improvements, we devised a new thrust bearing design with a shallow squared groove leading from the leading edge to the center of the bearing surfaces of the topmost foil. **Figure 3** shows the calculated pressure distributions on the surfaces of the thrust bearings both with and without the groove. The grooved bearing allows fluid to enter the bearing surface over a wider area and increases the amount of fluid by 70% relative to that without the groove. Because the groove does not link the circumferential edges or interrupt the center of the bearing surface, there is basically no radial leakage of fluid in the groove and the maximum pressure is generated at the center of the bearing. Numerical analyses with the grooved foil bearing indicated a 1.5-times increase in the maximum pressure and a 2.5-times increase in the load capacity, relative to the conventional bearing. **Figure 4** shows a trial version of the improved bearing together with a conventional version, both of which were installed in a turbocharger and then evaluated experimentally. A turbocharger with the improved bearing has been run at a rotational speed up to 200,000 rpm.

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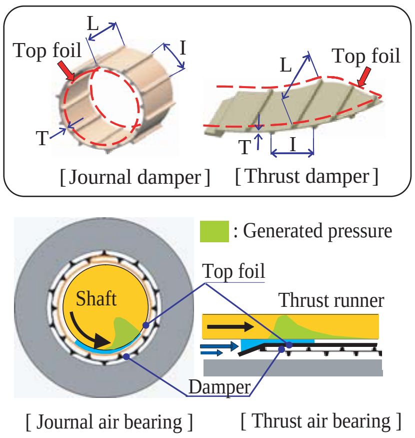

Fig. 1 Compliant foil bearings.

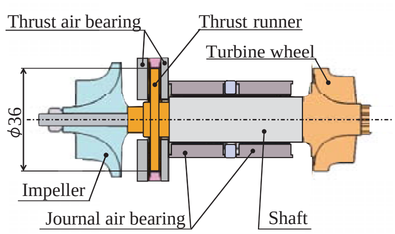

Fig. 2 Construction of air bearings for turbocharger.

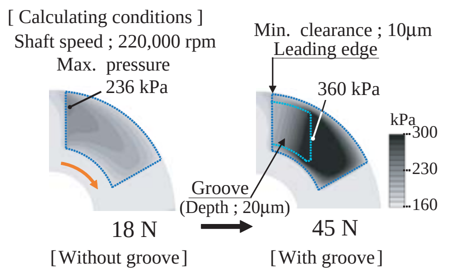

Fig. 3 Comparison of load capacity (calculated).

Fig. 4 Test peaces of compliant foil thrust bearing.