

Development of a Friction Evaluation Method under Actual Operating Conditions and Friction Reduction in the Crankshaft System

Kazunori Toida¹⁾ Takashi Koyama¹⁾ Makoto Okawa¹⁾ Teru Ogawa¹⁾

1) Toyota Motor Corporation

1 Toyota-Cho, Toyota, Aichi, 471-8572, Japan (E-mail: Kazunori_toida@mail.toyota.co.jp)

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In automotive internal combustion engines, the indicator diagram methodology is widely used to evaluate friction under in-cylinder pressure loading. However, its measurement often suffers from limited accuracy because the friction mean effective pressure (FMEP) is obtained from the difference between two large, measured quantities, IMEP and BMEP. In addition, measurement accuracy can be significantly affected by transient and long-term drift in the characteristics of in-cylinder pressure sensors caused by thermal exposure during combustion. To overcome these limitations, a boosted-motored methodology was developed by applying external boost pressure to the intake system while operating the engine without combustion (Fig. 1). This methodology enables the generation of in-cylinder pressures comparable to firing conditions while minimizing combustion-related measurement uncertainties.

Furthermore, friction reduction measures for a crankshaft system of an inline three-cylinder engine were investigated. Elastohydrodynamic lubrication (EHL) analysis predicted that compliance optimization of the crank journal cap (Fig. 2) could reduce bearing edge loading and boundary friction under high in-cylinder pressure conditions (Fig. 3). Friction measurements using the boosted motoring method confirmed the predicted trend, showing a reduction in FMEP at higher peak cylinder pressures. The experimental results were in good qualitative agreement with the EHL analysis (Fig. 4). The proposed boosted motoring method provides a practical and accurate tool for evaluating engine friction under cylinder-pressure loading conditions and is particularly useful for the development and validation of crankshaft-system friction reduction technology.

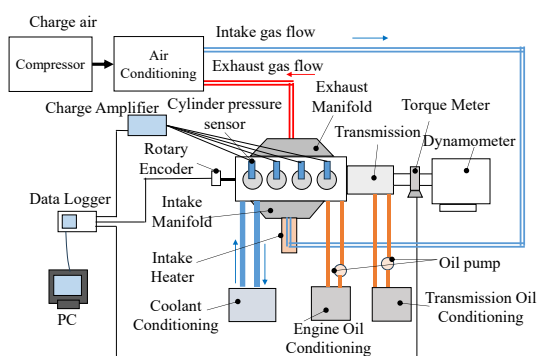


Fig. 1 Experimental setup for boosted-motored friction measurement

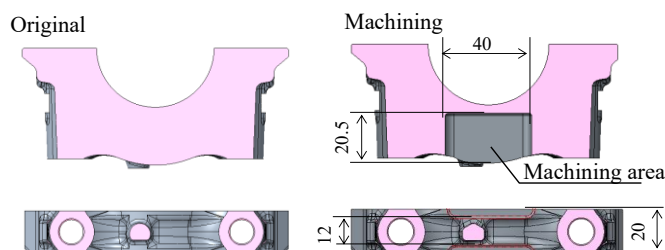


Fig. 2 Crankshaft journal cap design modification for compliance optimization

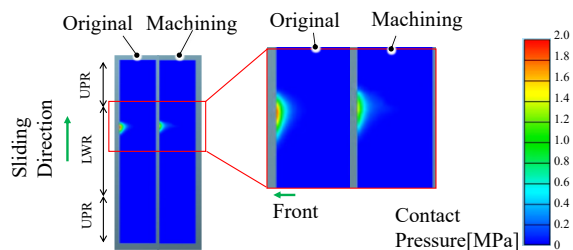


Fig. 3 Effect of journal cap machining on journal bearing contact pressure

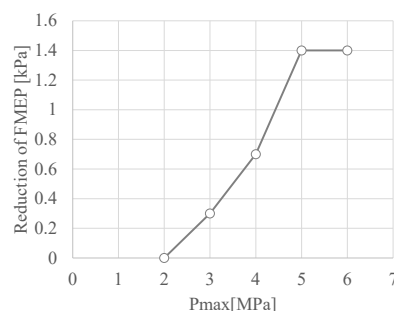


Fig. 4 Influence of maximum in-cylinder pressure on FMEP reduction