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Consideration on Lubrication of High-Speed Rotating Gear (Fourth Report)

- Parametric Study of Side Clearance and Discharge Hole Diameter -

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As electrification advances, powertrains are required to operate at increasingly higher rotational speeds. Under such conditions, windage loss and churning loss become dominant. Conventional oil bath and oil jet lubrication methods therefore face difficulties in supplying sufficient lubricating oil to gear tooth surfaces due to the formation of an air curtain around the rotating gear.
In this study, a passive lubrication concept utilizing airflow phenomena generated during high-speed gear rotations is investigated.

1. Evaluation of Power Loss
The proposed lubrication device supplies lubricating oil to the gear tooth surface by utilizing negative pressure generated by gear rotation, without requiring high-pressure oil injection.

Power loss measurements, defined as the difference between lubricated and dry conditions, show that the proposed lubrication method achieves lower power loss compared to oil jet lubrication and churning lubrication, even under equivalent oil flow rate condition, as shown in Fig.1.

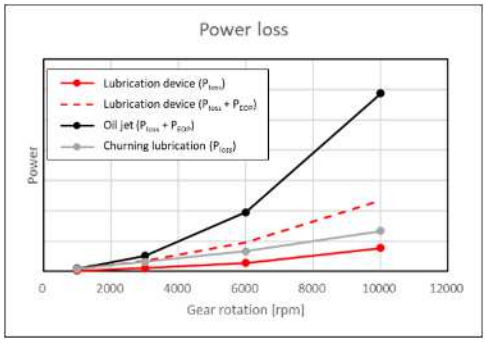

Fig.1 Power loss results

2. Design Parameters and Evaluation Method
To evaluate applicability for mass production, key design parameters of the lubrication device were investigated. Two dominant parameters were selected: the side clearance between the gear and the device, which affects negative pressure generation, and the discharge hole diameter, which governs the oil suction flow rate. Lubrication devices with different parameter combinations were fabricated, and the oil suction flow rate was evaluated from the oil level decrease in the reservoir during gear rotation. The configuration of the lubrication device and the definition of the design parameters are shown in Fig.2.

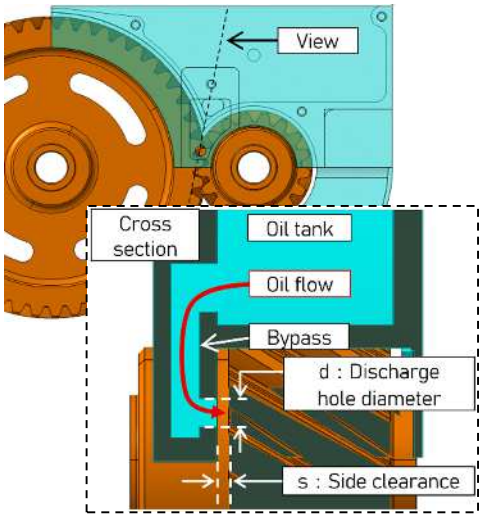

Fig.2 Device parameters

3. Results of the Parametric Study
The parametric study revealed that reducing the side clearance increases negative pressure and consequently enhances the lubrication oil suction flow rate. In contrast, the discharge hole diameter mainly affects the oil flow rate, while its influence on the negative pressure itself is relatively small. These trends are summarized in Fig.3, demonstrating that the proposed lubrication method enables stable oil supply with low power loss through appropriate selection of design parameters.

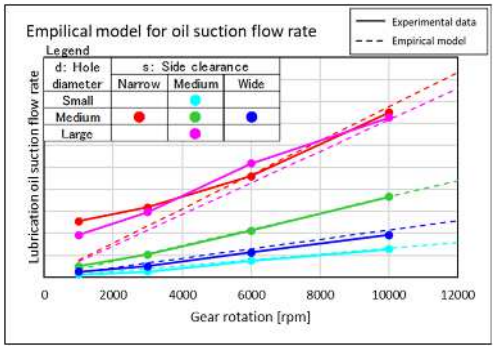

Fig.3 Empirical model validation for oil suction flow rate

4. Conclusion
This study demonstrates the effectiveness of a passive lubrication device for high-speed rotating gears and clarifies the influence of key design parameters on negative pressure generation and lubrication oil suction flow rate. In particular, it was shown that the negative pressure follows an inverse power-law dependence on the side clearance, and an empirical correlation was proposed.
The obtained results provide useful design guidelines for achieving stable lubrication with low power loss, contributing to the development of compact and high-efficiency gear reduction systems.