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

- Relationship between the behavior of lubricating oil and air flow on the tooth surface -

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The injection oil flow toward the gear tooth surface and the oil behavior on the tooth surface have been reported in a number of literature. However,in previous studies,the experiments were conducted under conditions different from the rotational speed required by the e-Axle due to limitations of those of the visualization technology and the analysis technology at that time. In this study,it is attempted to visualize the flow of air and oil around the gear during high-speed rotation as experiments under conditions as close to the actual environment as possible. By collilating the observed results with the contents of CAE analysis,the purpose is to discover new notices and to achieve future lubrication optimization.

This study confirmed the following:

1. Behavior of the injection oil flow onto the rotating gear tooth surface.
Oil adhering to the tooth surface is classified into three major states. Those adhering to the surface of the tooth; hitting the tip of the tooth and scattered circumferentially; almost scattered away from the gear. Scattering varies depending on the circumferential speed.

2. Correlation between actual measurement and analysis of airflow generated on the gear tooth tip periphery.
On the periphery near the gear tooth tip,airflow generated by the gear tooth profile during high-speed rotation occurs like wrapping along the direction of gear rotation at the wind speed equivalent to the gear circumferential speed, and under the condition of the higher the circumferential speed,the thicker the high-speed airflow becomes. In addition,The MPS-FVM analysis and the measured PIV values approximate and are consistent,so it can be said that the MPS-FVM analysis can predict the airflow.

3. Behavior of airflow generated at the gear engagement
The airflow generated at the gear engagement is different from that at the start of engagement and at the end of engagement. At the start of engagement,the airflow flows in the blowout direction,and at the end of engagement,the air flow in the suction direction.
These airflows are interlocked with the gear circumferential speed, and the faster the circumferential speed,the faster the wind speed. The injection is also characteristic,with wind speed is higher from near the center of the tooth width to the range of the end of meshing than the vicinity from the start of engagement to the center of the tooth width.

From the above results, it is considered that the knowledge leads to the optimum lubrication method was obtained by devising the injection direction, position, and injection speed of the lubricating oil. It is also confirmed the effectiveness of PIV and MPS-FVM analysis as an efficient development method.

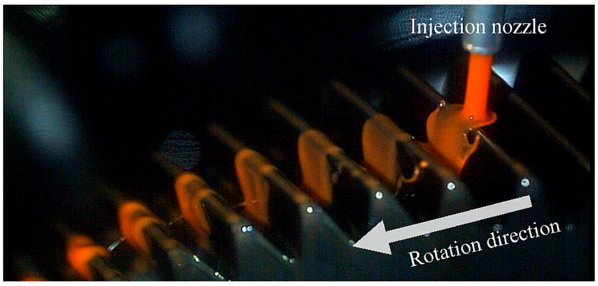

Fig. 1 Gear tooth surface lubrication condition. (On 2-axis gear)

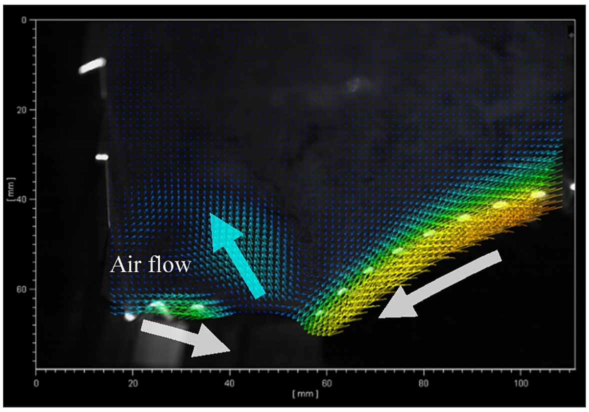

Fig. 2 Airflow conditions on the starting side of engagement.

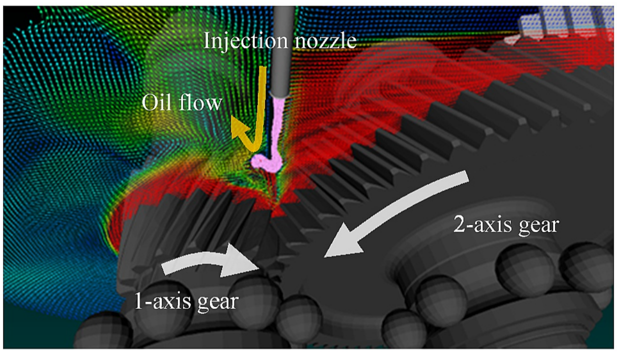

Fig. 3 Airflow and oil conditions at the starting side of engagement.