

Study of Increase in Drag Torque at High Rotational Speed of Wet Multi-plate Clutch Part2.

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In the wet multi-plate clutch used in AT, one of the problem is the inefficiency due to the vibration of the clutch plate. In order to clarify the mechanism of the vibration phenomenon, the effect of pressure fluctuation due to the distance and inclination between the plates when the plates rotate relative to each other through the mixed fluid of lubricating oil and air is mainly numerical fluid dynamics. Report the result of study by CFD.

In this report, we investigated the vibration mechanism of the clutch plate in the high speed range, which has not been fully clarified so far.

First, the occurrence of periodic pressure fluctuations was confirmed by measurement when the clutch plates were tilted and rotated. In addition, based on the general knowledge of fluid vibration, we hypothesized that two resonance systems, caused by fluid vibration caused by pressure fluctuations on the plate due to tilting and elastic vibration of the plate, mutually excite coupled vibration.

Next, a CFD model of a flat plate was used to simulate the rotational motion of a tilted plate(Fig.1). From the calculation results, periodic pressure fluctuations similar to the actual measurements were confirmed. Furthermore, the relationship between the pressure distribution and the slope at different parts of the plate was calculated. And, from the calculation results of the CFD model, it was shown that the direction of the tilt and the direction of the moment due to the pressure are 90° perpendicular to each other, and the fluid vibration is in the rotational direction. Furthermore, we showed the relationship between the fluid vibration and the one-degree-of-freedom vibration system(Table1).

Finally, using 1D simulation, the possibility of coupled vibration due to the interaction between the fluid vibration system and the elastic vibration system of the plate was examined, and the validity of the hypothesis was verified(Fig.2, Fig.3).

From these results, it was suggested that the vibration mechanism of the clutch plate in the high speed range is caused by the coupled vibration of the fluid vibration system due to the plate pressure due to the inclination and the elastic vibration system of the plate.

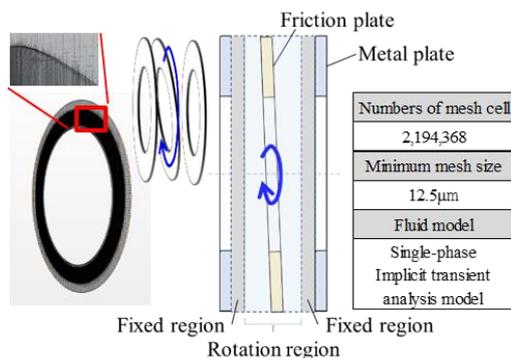


Fig.1 Motion of regions of CFD model

Table1 Resonance frequencies of fluid vibration

Clutch speed[rpm]	[deg]	3000rpm		6000rpm		
		0.043°	0.025°	0.043°	0.025°	0.043°
Plate tilt	[deg]	0.043°	0.025°	0.043°	0.025°	0.043°
Oil/Air ratio	[%]	1	1	1	1	0.5
Spring constant	[Nm/rad]	226	172	464	360	236
Natural frequency	[1/min]	6861	5982	9826	8662	7009

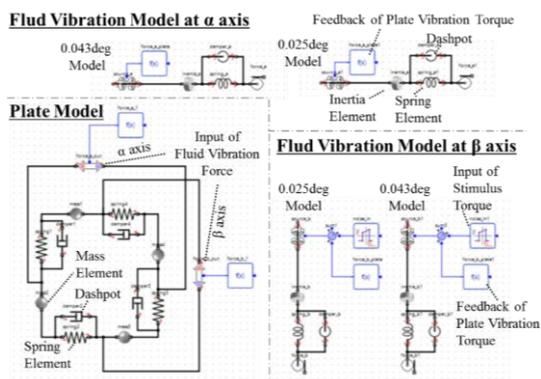


Fig.2 Plate elasticity model and fluid vibration model

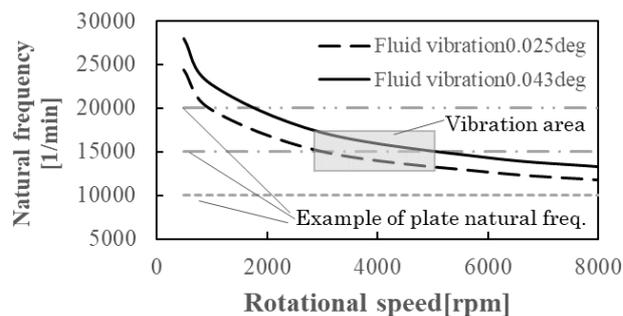


Fig.3 Relationship between fluid vibration and plate natural frequency