Development and Performance Analysis of Continuously Variable Stiffness Dynamic Damper Simplified by Using Rolling Mechanism

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In recent years, the importance of torsional vibration reduction technology has been increased because reducing the number of cylinders of an engine leads to increasing the torque fluctuation from the engine and deterioration of the NV performance, and active research and development is under way. Among them, Dynamic damper has a large effect of reducing torsional vibration, but it effects in the narrow revolution range because the resonance point related to the stiffness is constant. So we have developed a variable dynamic damper (VDD) whose stiffness is continuously variable so that the resonance point follows the rotation speed. The structure has been simplified by using rolling mechanism. We also conducted a transient dynamo test assuming an actual vehicle and clarified its performance. Furthermore, a theoretical analysis model was constructed and compared with the experimental results to clarify its validity.

Fig. 1 shows the structure of VDD. The main components are a hub flange, centrifuges, outer rollers, inner rollers and an inertia ring. The number of the centrifuges and the rollers is six. The centrifuges are in contact with the hub flange, outer rollers, inner rollers. Outer rollers are in contact with the hub flange and inner rollers are in contact with the inertia ring. The centrifuges and rollers can roll and move between the hub flange and the inertia ring. The inertia ring can move in the direction of rotation, it effect as dynamic damper. The centrifuge is forced outside by rotation of the hub flange, and the force decides the stiffness of dynamic damper. Therefore, the stiffness of the inertia ring follows the speed of rotation and the natural frequency is continuously variable.

Fig. 2 shows the theoretical results of stiffness and natural frequency. In the figure, the horizontal axis shows the rotational speed [rpm], and the vertical axis shows the stiffness [Nm/rad] and natural frequency [Hz]. Fig. 2 shows the stiffness follow the rotational speed and natural frequency follows the target frequency.

Fig. 3 shows the theoretical analysis results and experimental results of damping performance. In the figure, the horizontal axis shows the rotational speed [rpm], and the vertical axis shows the fluctuation of rotational speed [rpm]. Both agree well and Fig. 2 shows VDD has a large effect of reducing torsional vibration in the full revolution range.

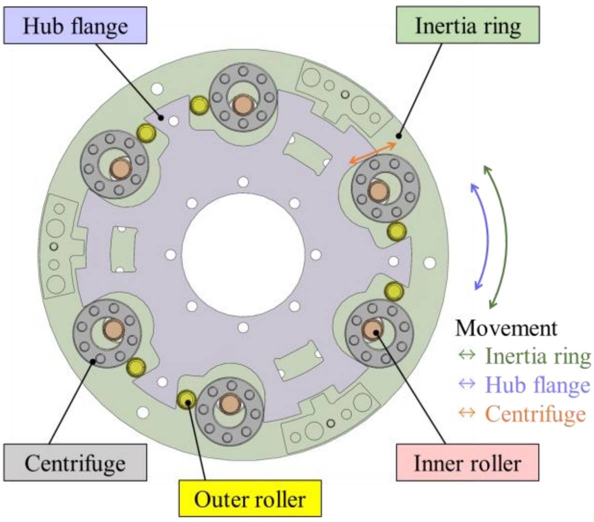
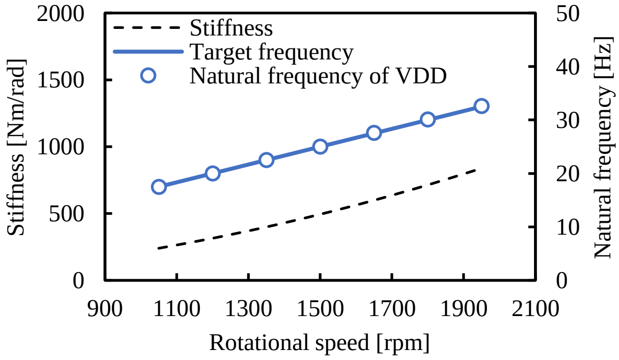
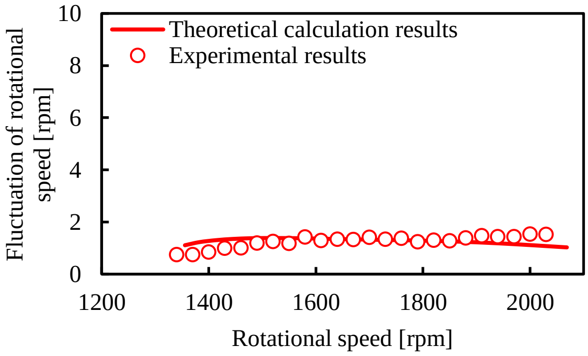


Fig.1 Structure of VDD



$\{h O\Omega = 5 \text{ [rpm]}\}$
Fig.2 Stiffness and natural frequency of VDD



{Input rotational fluctuation amplitude H=125 [rpm]}
Fig.3 Comparison of theoretical calculation results with experimental results of damping performance