

INFLUENCING FACTORS ON THE DECOUPLING OF INDUCED ROTATIONAL OSCILLATION BY WET-RUNNING MULTI-PLATE PACKAGES IN CONTROLLED SLIP MODE

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ABSTRACT

As a result of progressive mechatronization, modern clutch systems - for example, dual clutches or torque converter lock-up clutches - are increasingly controlled according to the situation and requirements. In order to improve controllability, they are operated in micro-slip. Additionally, it is possible, with appropriate adaptation and design, to implement a decoupling function of induced rotational oscillation at least partially aided by a specific slip operation [e.g. 1-3]. Slip operation has the decisive advantage that it can be regulated accurately according to the instantaneous requirements - until the clutch system is completely closed. This regulated slipping state has the consequence that the drive train is decoupled differently by the clutch system. These novel operating strategies lead to unknown phenomena which influence the dynamic behavior of the clutch system and the superordinate drive train. Wet-running multi-plate packages, as realized in dual clutches or torque converter lock-up clutches, are highly complex friction systems whose behavior is determined by the interactions of numerous influencing variables. Neglecting the masses or moments of inertia, stiffnesses and damping of the clutch system, the transfer behavior is determined solely by the multi-plate package and its tribosystems, wherein the greatest uncertainties lie. This is due to the lack of modelling and simulation approaches for tribological processes in such tribosystems at the current time as a result of a lacking holistic understanding of these systems.

The transfer behavior of the tribosystem depends on the structure of the tribosystem – e.g. friction pairing and lubricant as well as the input variables – e.g. kinematics, load and temperature in the tribological contact.

In addition to the validation, a targeted investigation of the complex tribological functional behavior is, therefore, necessary. This includes the interactions of the friction mechanisms in the tribosystem and the closed-loop interactions of the tribosystem with other components of the drive train. An innovative validation environment has been developed at IPEK - Institute of Product Engineering for a targeted investigation of these complex contexts. By the validation environment, all necessary input and output variables - torque and angular speed at the input and output of the multi-plate package - as well as state variables - clamping force applied to the multi-plate package and reaction force at the end of the multi-plate package, temperature of the steel plates, temperature of the

cooling oil at the inlet and outlet of the multi-plate package - for determining the dynamic transfer behavior and the system behavior can be determined with high resolution. At the same time, all relevant interactions at the input and output of the multi-plate package are simulated over a wide frequency range up to approximately 150 Hz. This makes it possible to investigate the dynamic transfer behavior of multi-plate packages in a targeted and regulated slip mode for vehicle application [4-7]. In addition, a further purposeful investigation of the complex processes in the multi-plate package as well as the interactions of the tribosystems in the multi-plate package with the superordinate supersystem can be carried out.

This paper presents results from experimental investigations. The goal was the identification of relevant influencing factors on the decoupling of induced rotational oscillation by multi-plate packages in the slip mode as well as the objectification of their influence on the decoupling. It was also developed how the decoupling behavior can be described quantitatively – e.g. analogue hysteresis of DMF. By varying the input variables and the tribosystem an empirical model was developed in order to describe the transfer behavior of the tribosystem. For this purpose, both the tribosystem - by friction materials and lubrication oil variant and the input variables, e.g. kinematics and load, were varied.

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