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Application of Torque Capacity Prediction Technology during Operating Conditions for Automatic Transmission Clutches

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ABSTRACT - Increases in engine power have led to demands for automatic transmissions (AT) that display high torque capacity while remaining lightweight and compact. One feature of Honda AT is a compact design that positions a multiple plate clutch for each speed on three or four parallel shafts. The design of the clutch unit has generally been studied on the desk using a simple equation to calculate torque capacity. However, this equation was formulated for conditions of uniform contact pressure distribution on each disk and an identical coefficient of friction at all points on the surfaces of the disks during clutch engagement.

It was also known from experience that a variety of factors that were not considered in the equation used to calculate the torque capacity of the clutch unit, including the misalignment of the drive gears and flexibility of the shafts, might affect the torque capacity of a clutch actually fitted in AT. However, the extent of these effects varied significantly depending on the layout, friction properties and operating conditions of the AT, among other factors, and quantitative study on the desk therefore represented a challenge.

This paper focused on the torque transmission characteristics of facing materials in order to enable desktop prediction of the torque capacity of the multiple plate clutches used in AT. The amount of torque transmitted by the facing materials themselves was affected by the temperature, contact pressure and sliding velocity of the friction surfaces. An analytic model of a test apparatus was therefore constructed, and the friction properties of the facing material were identified from the amount of torque transmitted. Next, a torque capacity prediction model, able to simulate the flow of torque transmission in the AT, was constructed. This enables torque capacity in an operating AT to be predicted for the first time with high accuracy to within $\pm 5\%$ of measured values. In addition, an examination of the friction force vectors of the clutch disks shows that torque capacity is affected not only by friction force components acting in the direction of rotation, but also by simultaneously produced friction force components acting in a radial direction. This paper also shows that the developed method of predicting torque capacity is effective for the other AT with differing clutch layouts.