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Benchtop Screening of Wet Clutch Materials

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Abstract

To decrease development time, bench-top screening tests are often used to rank materials prior to selection for standardized full-scale component test rigs, in-service vehicle tests, or system field testing. This paper describes the results from screening tests of four different paper-based clutch materials using a small scale bench-top test rig. Tests were conducted in automatic transmission fluid (ATF), with the primary aim of identifying test conditions which rank materials in the same manner they are ranked when full-scale clutches are tested using the SAE #2 friction test machine, or per the JASO M348-2012 test standard. Identical conditions for sliding speeds, contact pressures and test temperatures based on the full-scale test were used in the bench-top test, conducted on a Bruker UMT-TL. Preliminary data from tests conducted at room temperature as well as at 120° C show good correlation with the full-scale standard test ranking using a series of speed-slip tests at velocities ranging from 0.007 m/s to 1.65 m/s. Sliding and static friction values, computed from torque measurements, show the coefficient of friction (COF) ranged from 0.12 to 0.18 under the test conditions imposed. Further, the materials showed either positive or negative COF trends as a function of sliding speed, which is related to stick-slip behavior, and therefore important to clutch noise (shudder and judder). As a second part of the investigation, the effect of the fluid type was also investigated, and a strong effect of the fully-formulated ATF additive package was observed for the same clutch materials. In the base oil, without any additive package, the COF varied more widely, being much higher at low slip velocities, ranging from 0.15 to 0.23, and lower at high slip velocities, as low as 0.09 for one of the materials. Most importantly, in the unformulated base oil the clutch materials showed a strong negative gradient and a stronger static/breakaway COF in nearly every case, demonstrating the critical role of the additive package in the fully-formulated ATF.

Keywords: Bench-top tests, Clutch testing, Wet clutch COF.

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1. INTRODUCTION and MOTIVATION

Testing of automatic transmission clutch systems using full-scale test rigs is commonly done prior to on-vehicle tests. Continuous improvement and changes in such tests over the years has resulted in more accurate simulations of in-vehicle clutch performance, with industry consensus leading to the development of a cyclic test (SAE No. 2) to supplement the previously used steady-state test (SAE No. 1) [1]. Further improvement in clutch performance prediction accuracy has also been reported by changing the dynamic engagement conditions within the SAE No.2 tester [2]. Even with the improvement in predicting on-vehicle performance, both laboratory full-scale tests as well as on-vehicle testing are time, cost and material-intensive methods. As such, modelling efforts are being implemented as more efficient means for exploring the effect of material, design, or actuation changes. Effort has also been applied to provide modelling data through pin-on-disk tests [3], as well as attempting to correlate a pin-on-disc test with the SAE No. 2 friction test [4]. Improved clutch performance, i.e. “smoothness” of operation, has been explored through adding neural networks to the modelling process [5], but the focus of that effort was on clutch actuation and not materials development or testing. From the Tribosystem materials perspective, the effect of automatic transmission fluid (ATF) chemistry (anti-wear boundary, EP and VI-modifier additives) on the COF has been investigated on sintered copper friction materials [6], as well as the effect of paper porosity on friction characteristics [7].