PLAINTIFF'S EXHIBIT
FD-720

Friction Materials (R-120 R)

1. 1975 Disc Brake Lining Development

Samples of our experimental organic linings were supplied to the Brake Department of Car Engineering for testing on a disc/drum Lincoln. The Docket 70-27 test has been completed, but the test data tapes have not yet been received. The lining met all Federal requirements except the final 100 mph stopping distance requirement. The lining did pass the first of the two 100 mph test sequences. Preliminary data indicates that the reason for the failure in the second 100 mph test was excessive fluid displacement. The test data will be reviewed when received to determine the cause of this problem. Lining wear or thermal mechanical properties could cause the fluid displacement problem. Formulation changes will be attempted to provide the required performance.

TMA (thermal mechanical analysis) tests of this formulation shows a greater thermal expansion and growth than the better production materials. Processing changes are being evaluated to reduce both.

Personnel: Anderson, Johnson
Weintraub (Chemical Engineering Department)

2. Dry Clutches

The Engine Controls, Tires and Fuel Systems Department of Car Engineering requested additional assistance in resolving some of the difficulties associated with implementing quality assurance testing of dry clutch facings. Borg-Warner selected and developed Q.C. tests, based on

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suggestions by SRS personnel. Attempts to duplicate these tests (DTA, TGA, and PGC) by the Product Development Materials Laboratory were unsuccessful. Based on discussions among SRS, Borg-Warner, and Product Development personnel most of the technical problems were resolved, except for repeatability of the PGC results. After visiting Borg-Warner laboratories and testing additional samples with various chromatographic columns, it was determined that Hewlett-Packard furnished two poorly coated chromatographic columns and an improperly calibrated pyrolysis probe to the Product Development Materials Laboratory. Various clutch facings were rerun using the Borg-Warner column and a SRS calibrated probe. The resulting pyrograms are in good agreement with those obtained by Borg-Warner. Work is continuing with the Product Development Laboratory. A detailed report will be issued as soon as the testing is completed.

Personnel: Anderson
Weintraub (Chemical Engineering Department)

Wear (R-110 R)

1. FT Truck Engine Cylinder Bore Wear

Analytical work to provide optimum piston ring face profile design curves is near completion. The engine is considered operating under full-load conditions for several values of the parameters of engine speed, crank-connecting rod ratio, and the oil viscosity distribution along the cylinder wall.

Personnel: Ting

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Bearings (R-110 R)

1. Light Truck Front Wheel Bearings

Fatigue tests on the new sample of production SKF/Tyson outer size slimline bearings have been completed in an attempt to assist Light Truck Engineering to qualify a second source. After the required minimum of 15 tests, the sample reached an L.C.L. of 18.3 hours, surpassing the minimum requirement of 11.9 hours specified in ES-DOAA-1200-B. The group met the minimum performance requirements by being very consistent in its failure behavior: all fifteen bearings failed, most of them after test times of less than 100 hours. As a result the group has a relatively steep Weibull slope of 2.4 and a correspondingly narrow 90 percent confidence band which enabled it to exceed the minimum L.C.L. requirement. A total of eight roller failures occurred in the tested bearings. Several of these were examined by the Process Research Department and found to be conventional fatigue spalls without any indications of seam defects. A summary report covering the test results has been distributed. A new sample of production SKF/Tyson inner size slimline bearings will be tested as soon as they are received from Light Truck Engineering.

Tests are also being conducted on Koyo slimline bearings, as an alternate attempt to qualify a second source. Six outer size and three inner size bearings have been tested thus far. Tests on Koyo bearings should be completed early in February.

Personnel: Carey, Janotik
Stickels (Process Research Department)

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2. 1974 Passenger Car Front Wheel Bearings

The front wheel bearing test procedure has been revised to incorporate testing of the new 1974 63 mm inner size bearing as well as new test conditions for the carry-over inner and outer size slimline bearings. The proposed new test procedure has been presented to Car Engineering and we are awaiting their approval of it. Revision of the bearing performance specification now in effect (ES-DOAA-1200-B) is expected to begin soon. As soon as the test procedure is finalized, tests will begin on 63 mm Timken bearings which have already been received. Case-hardened Koyo test bearings in the new 63 mm size have also been received for testing.

Personnel: Carey, Janotik

3. Truck Rear Wheel Bearings - 5,60 lb. Axle

In a meeting with Timken personnel, it was decided to continue tests on 1972 Timken bearings made in their Columbus Ohio Plant (gas furnace heated bearings) to obtain a homogeneous baseline for the Timken Gaffney (induction heated) bearings. Truck Engineering has agreed with this decision. The present baseline test group consists of two half-samples of 8 bearings each, which were from two different production years (1968 and 1972) and have widely differing fatigue life characteristics. Tests have resumed on the 1972 Columbus bearings. The baseline tests should be completed (a total of 15) by the end of January.

Seven tests on NTN bearings have also been completed, with an eighth test in progress. Tests will be continued, along with those on the Timken-Columbus bearings, however at a reduced pace due to a failure of one of the three test stations. Full operation will resume when repairs can be made.

Personnel: Carey, Janotik

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4. Passenger Car Rear Wheel Bearings

Our four spindle ball test machine, purchased recently from MRC has been installed in our laboratory. All necessary power and compressed air connections have been made. We have received a small number of balls from the Chassis Division, which will be used to run the first exploratory tests. The first major tests series is expected to begin late in January. It will compare the fatigue performance of the balls manufactured by our present ball vendor, Hartford, to that of balls made by a prospective vendor, the Hoover Ball Company. The 208-size bearing ball (17/32 in. dia.) will be used.

Tests requested by the Chassis Division on 208-size rear wheel bearings with Hoover balls are approaching completion. Six tests (12 bearings) have been completed, however only one ball failure occurred thus far (at 863.3 hours). The remaining two tests of the 8-test series are in progress. In the meantime, the Chassis Division has completed their eight tests on the same bearing group without ball failures. A Weibull analysis on the entire 32-bearing group will be performed after the conclusion of the last two tests.

Personnel: Carey, Janotik

Metal Cutting (R-130 R)

An investigation is in progress to determine the effect of cutting edge preparation (hone and camfer) on tool life for non-interrupted machining of steel. The effect on cutting forces and surface finish is also being studied. Tool life was observed to drop significantly as the amount of hone or chamfer is increased at a high cutting speed. Cemented titanium carbide and cemented

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tungsten carbide tools both showed a similar relative drop in tool life as the amount of hone or chamfer was increased at a cutting speed of 1000 sfpm. The effect of edge preparation on tool life was also observed to be dependent on cutting speed, the reduction in tool life appears to be much less at lower cutting speeds. This influence of cutting speed is being investigated further.

Edge preparation, such as a hone or chamfer, is usually employed on roughing tools to provide improved edge strength, and thus to provide increased life during interrupted cutting. An optimum or best compromise edge geometry may exist for combined non-interrupted and interrupted cutting. The influence of edge geometry during interrupted cutting of steel will be pursued through a research grant at the Technion, Israel. Our current facility is not suited for rough machining.

Personnel: Stauffer

Analytical Mechanics - Design (R-140 R)

1. Finite Element Analysis of Automatic Transmission Servo Piston and Cover

The stress analysis of the C4 automatic transmission servo piston and cover for the Transmission Division is nearly completed. This work is part of a feasibility study on the possible substitution of phenolic molded components for the current production aluminum alloy die castings. A meeting was held with personnel of the C4 Design Section of Transmission Division to discuss the results. Copies of the finite element model with indicated maximum stresses were distributed. We were asked to prepare additional copies of the complete computer

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results. This will be done for the various loading conditions and material properties.

Personnel: Bock

2. Automotic Transmission Band Failure Problem

Personnel of the C4 Design Section of the Transmission Division brought to our attention the breakage failure problem of bands used in the automatic transmission. This problem is evidently rather serious with warranty costs currently amounting to about a half million dollars annually. After some discussion of the problem and their attempts to solve it, several suggestions were made as follows which could alleviate these failures.

Since the bands break adjacent to the location where they are welded to the band end attachment, and there exists a severe discontinuity in bending rigidity there, it was suggested that the shape of the band end attachment be modified to include several fingers stretched out along the length of the band. This design would act to reduce the bending stresses in the band during engagement when the band is brought into conformity with the drum.

It was suggested that adhesive bonding be considered to replace the welding used to attach the band end attachment to the band. This would eliminate the loss in local material properties which accompanies the welding.

A thinner band was pointed out as one design modification which would reduce the bending strength. Transmission Division indicated that they

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are currently experimenting with this approach. They had recently tried thicker bands and discovered that this change aggravated the failure problem.

Personnel: Petrof

Reports

SR-72-143 H. Wu, A Study of Automotive Energy-Absorbing Bumpers.

John E. Mayer Jr.

John E. Mayer, Jr., Manager
Mechanical Research Department

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