



DESIGN OF INNOVATIVE CLUTCHING MECHANISMS FOR HIGH EFFICIENCY AUTOMATIC TRANSMISSIONS



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INTRODUCTION

As hybrid vehicles are gaining popularity there is an increased demand for highly efficient automotive technologies. Current automatic transmissions are limited by hydraulic clutching technologies, which are a significant source of parasitic losses, as shown in Fig. 1.

There are two major energy sinks that are addressed in this project:

1. Open clutch drag: Spin losses from the open clutch due to oil churning around and between the plates of the clutch.
2. Hydraulic pump power: Fixed displacement pump power is the power used to provide the pressure to apply to the clutch plates to hold the elements of the planetary gear train.

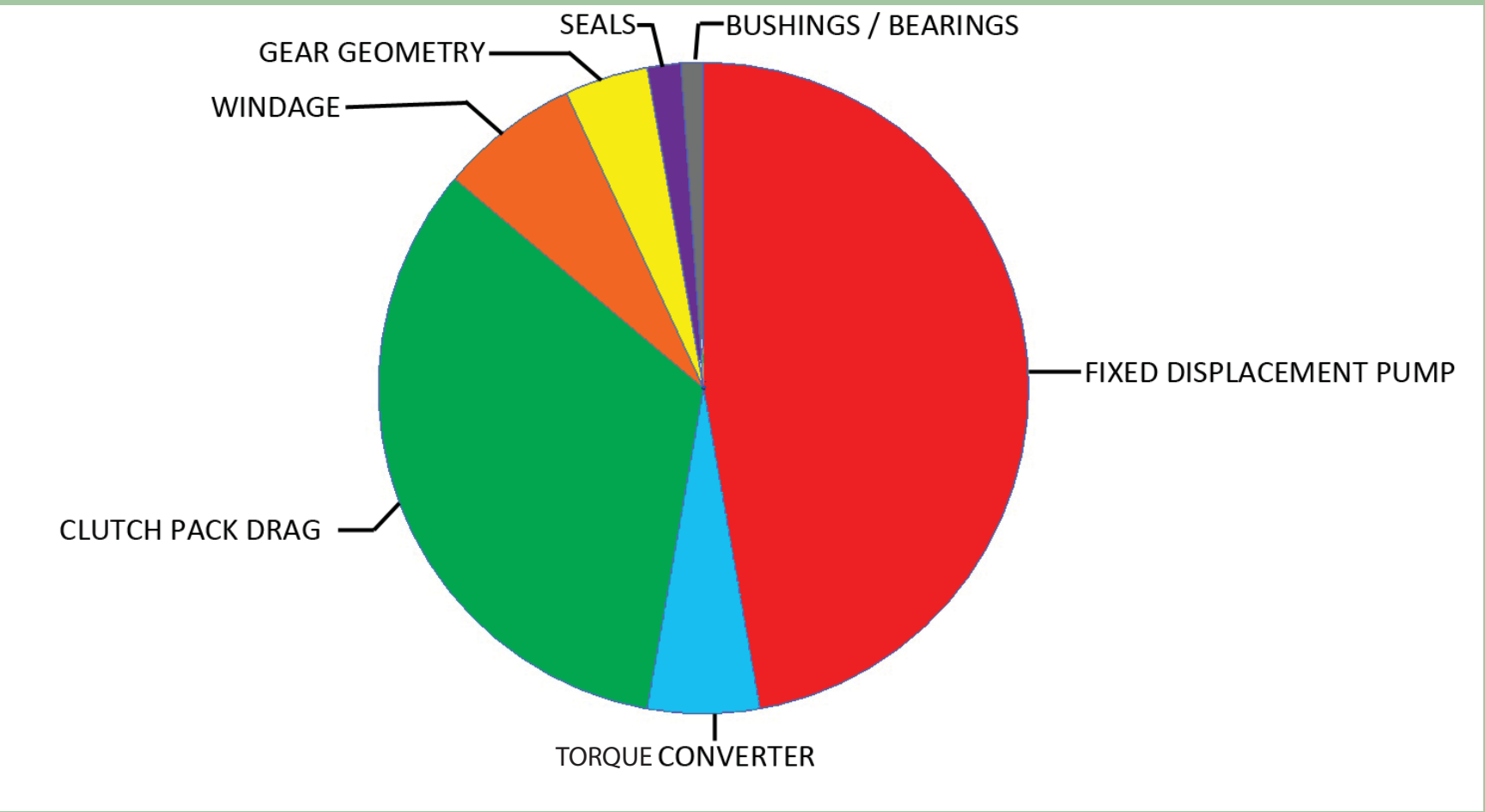


Figure 1: Automatic transmission parasitic loss distribution

PROJECT OBJECTIVES

The objective of the project is to design highly efficient clutching mechanisms suitable for use in hybrid automatic transmissions. Not only should the proposed mechanism match the performance of current wet multi-disk clutches; it should improve them by:

1. Changing actuation technology
2. Obviating the need for an external energy source during the operation of a clutch
3. Reducing clutch-pack drag losses stemming from fluid viscosity

CURRENT CLUTCHING TECHNOLOGIES

- The role of a clutch is to provide smooth engagement to synchronize the angular velocities of two shafts for either power transmission or braking.
- In a manual transmission clutches are used to disconnect the engine from the transmission to allow for gear shifting. In this application clutch engagement and disengagement are controlled by the driver.
- In modern automatic transmissions (Figs. 2 & 3), splined disks of steel and paper-based friction material are used as the main clutching interface. These disks are actuated hydraulically via servo pumps. Fluid pressure moves clutch pistons to clamp multiple disks together, thereby transmitting power.
- Range clutches (Fig. 4) are used to transmit power over specific ranges of gear ratios. Brake clutches (Fig. 5) are used to fix planetary gear elements to the transmission casing.

GM HYDRAMATIC 6T70 AUTOMATIC TRANSMISSION



Figure 2:
6T70 planetary gearset



Figure 4:
Range clutch assembly

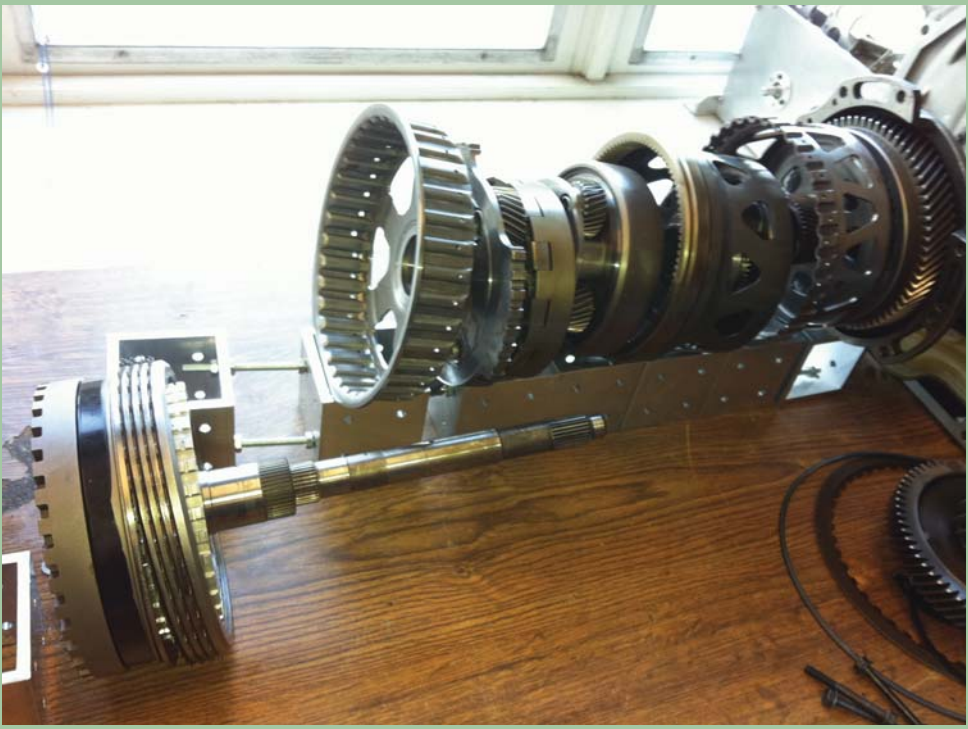


Figure 3:
Exploded view of planetary gearset



Figure 5:
Brake clutch assembly

ALTERNATIVE CLUTCHING MECHANISMS

1. MECHANICAL SYNCHRONIZERS

Mechanical synchronizers or dog clutches are widely used in manual transmissions. They transmit power by coupling transmission shafts, without the need for an external power source. An engaged dog clutch produces a rigid mechanical connection, thereby eliminating slip.

In a manual transmission the initial angular velocity synchronization is via conical surfaces that use frictional contact to match the angular velocities of the input and output. Any remaining slip and misalignment is eliminated by the sleeve engaging its dog teeth with those on the gear. Shown in Fig. 6 is a typical Borg-Warner style mechanical synchronizer.

Impact and contact stresses from this engagement lead to significant wear, which has kept them from being implemented in automatic transmissions.

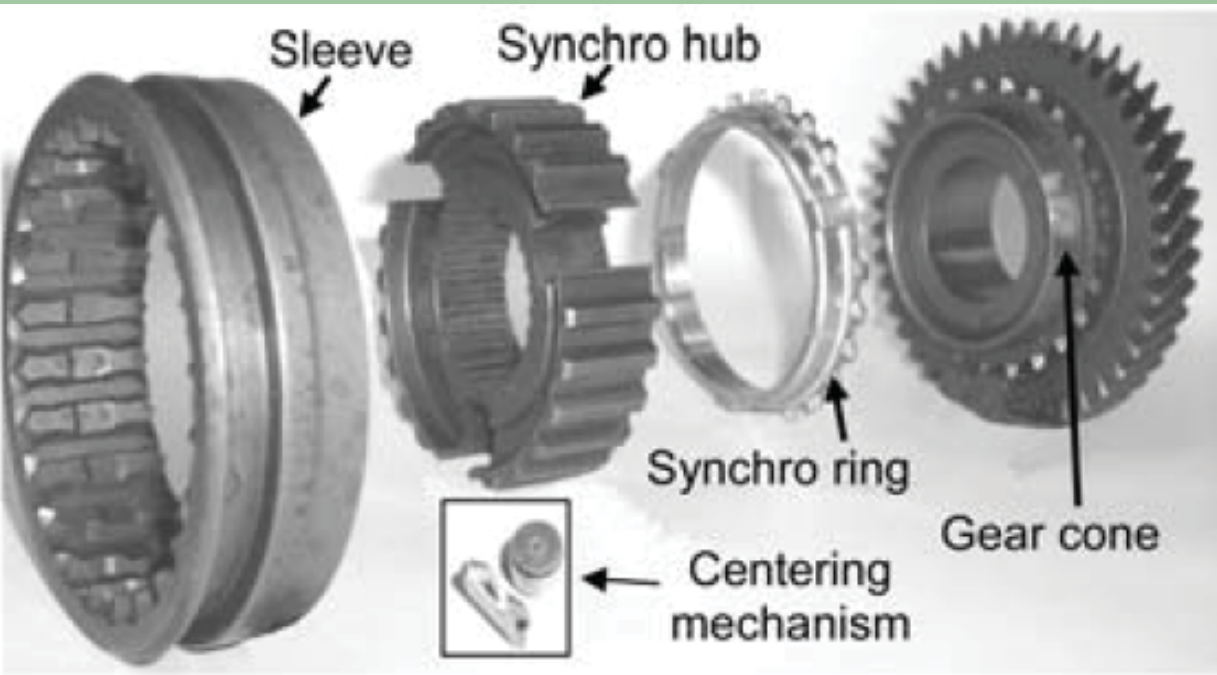


Figure 6: Borg-Warner mechanical synchronizer

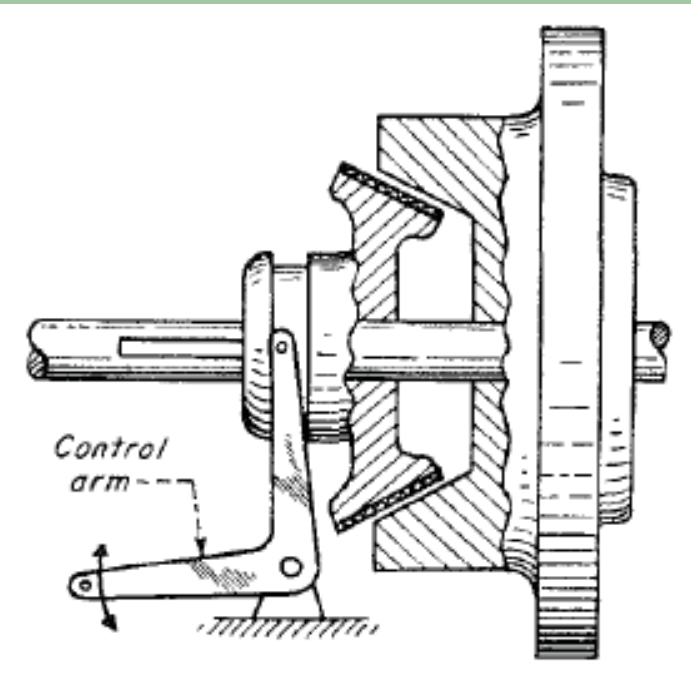


Figure 7: Cone clutch

2. CONE CLUTCHES

The angle of a cone clutch produces higher friction forces under a lower axial load. Advantages of cone clutches are that they can have fewer disks and greater clutch clearances. They can be used either as wet or dry clutches.

Cone clutches are generally used for synchronization in manual transmissions, motorsport and applications that demand rapid clutching. They can be used to replace the pack of splined clutch disks in a hydraulic transmission. An example cone clutch is shown in Fig. 7.

3. ELECTROMAGNETIC EDDY-CURRENT BRAKE SYSTEM

When a conductor moves through a magnetic field, it generates circulating surface currents called eddy-currents. These currents induce their own magnetic fields, which results in a braking force. Alternatively, should a conductor be subjected to a rotating field, it would cause the conductor to rotate (eg. induction machines).

Figure 8 shows a pie section layout of a radially polarized, permanent magnet eddy-current brake system. The copper-plated conductor is suspended in an air gap between the pairs of magnets. Figure 9 shows the resulting magnetic fields from a 2-D simulation of this system in Infolytica's MagNet, a commercial magnetic modelling software.

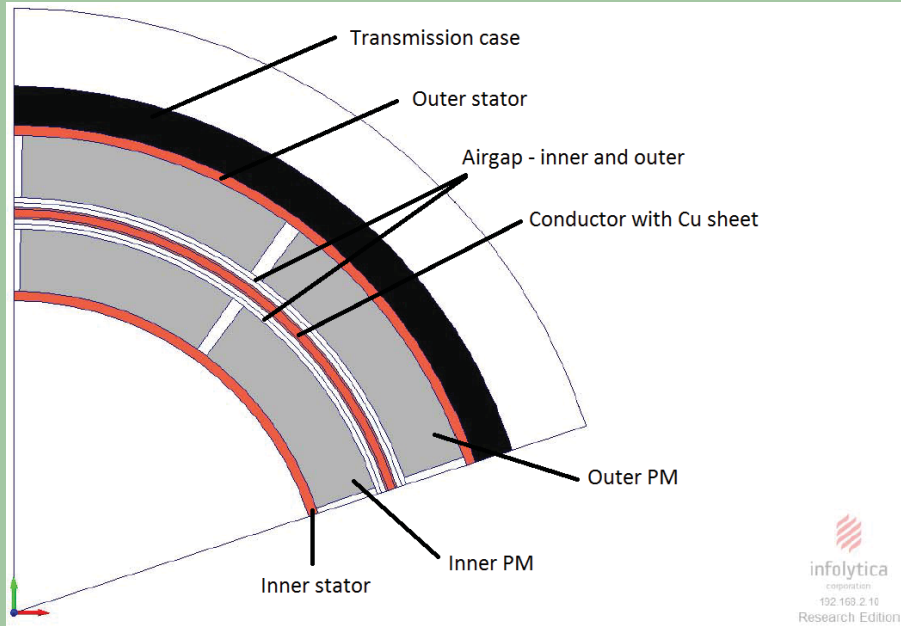


Figure 8: Permanent magnet
eddy-current brake layout

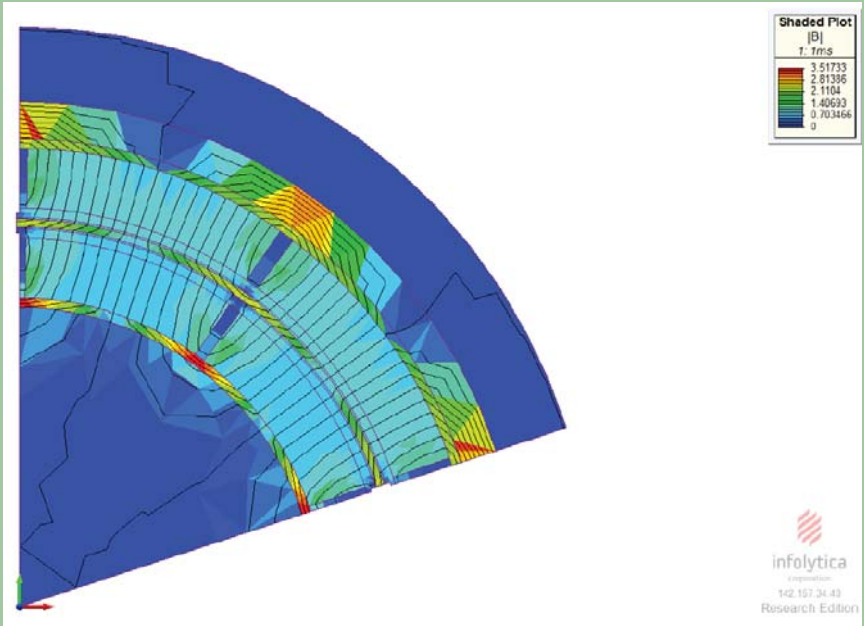


Figure 9: Magnetic fields from
MagNet simulation

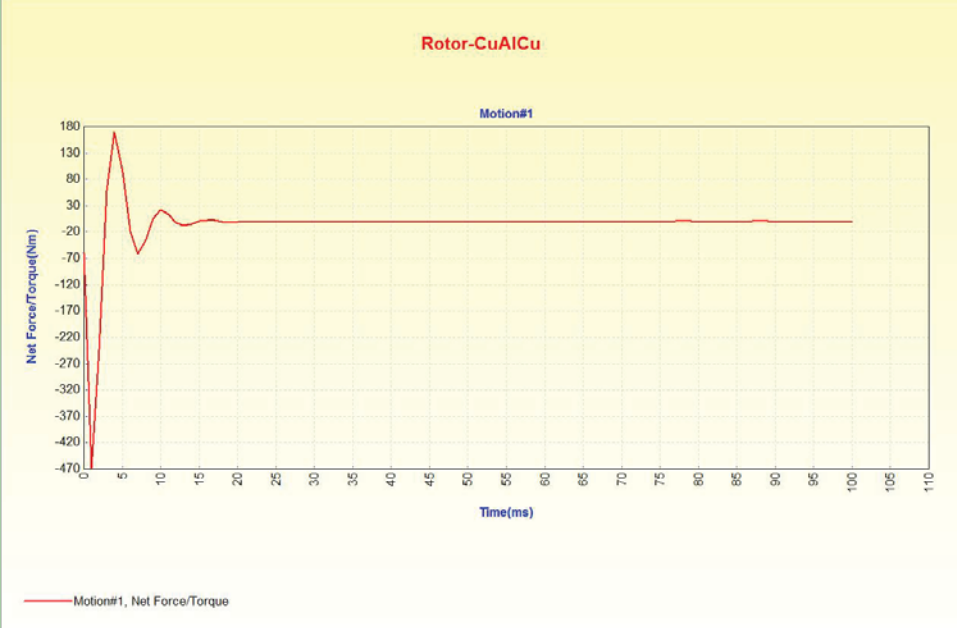


Figure 10: Net torque vs. time in
braking simulation

Figure 10 shows the response of the system to an initial torque of 300Nm. There is an initial excitation, a net torque that brakes the system. After 15ms the net torque is close to zero, and the rotation of the conductor has been retarded.

NEXT STEPS

The completion of simulation and optimization of proposed clutch variants. These clutches can then be fabricated and their performance validated through experimentation.

ACKNOWLEDGEMENTS

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