

Rotating Clutch Temperature Model Development Using Rapid Prototype Controllers

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ABSTRACT

Due to the multitude of external design constraints, such as increasing fuel economy standards, and the increasing number of global vehicle programs, developers of automotive transmission controls have to cope with increasing levels of powertrain system complexity. Achieving these requirements while improving system quality, reducing development cost and improving time to market is a very challenging task. To achieve this goal, a rapid prototype controller was used to develop a new transmission clutch temperature model. This model is used to detect clutch surface overheating, improve design and enhance shift quality.

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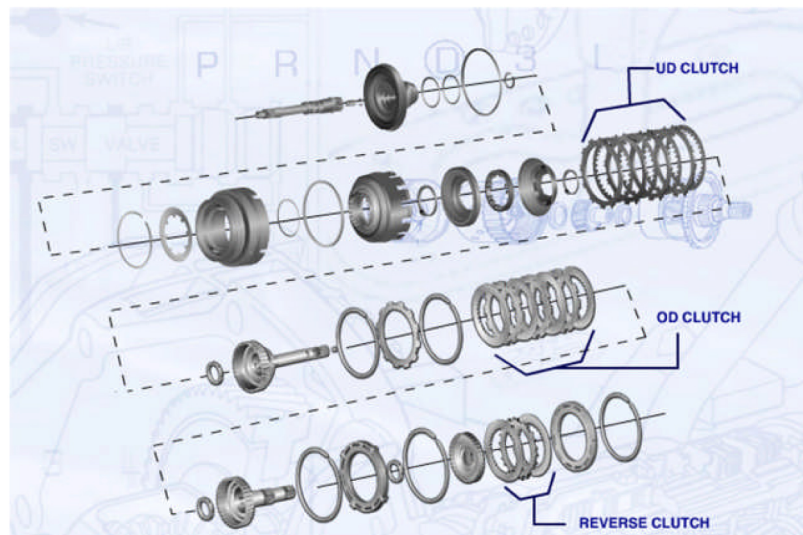


Figure 1. Clutch Assembly

INTRODUCTION

The automatic transmission has been using clutches to shift planetary geartrains for decades. The clutch assembly in an automatic transmission typically includes multiple separators, friction plates and other components as shown in Fig.1. The friction plate is made of a low carbon steel core plate with friction material bonded on each side. These plates are splined to the input shaft while the separator plates are lugged to the clutch housing. The clutch housing links to

either another shaft (rotating clutches) or to the transmission case (brake clutches).

Due to their desirable friction characteristics for shift quality and cost effectiveness, wet paper based friction materials have been primarily used as clutch facings for automatic transmissions in cars and brake materials for industrial vehicles. However, because of the lack of heat and chemical stability under extremely high temperature conditions, the paper-based cellulose fiber often breaks down.

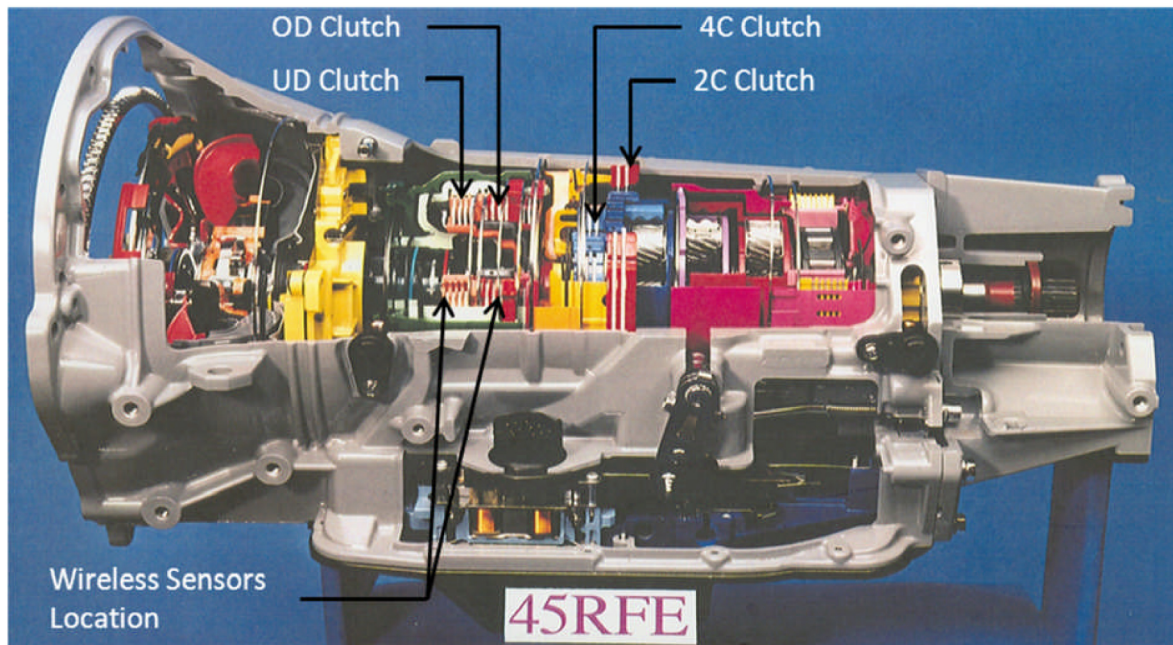


Figure 2. Wireless sensor locations in UD-OD Clutch of Chrysler 545RFE Transmission

This may cause material break-out, high friction lining thickness loss, and eventually loss of appropriate friction characteristics. Many researchers [1,2,3,4] have concluded that thermal degradation of the friction material due to high temperatures is the primary factor for determining the life cycle of wet clutches.

The thermal degradation mechanisms of the friction material due to high temperatures and the importance of clutch temperature tracking in evaluating the durability of the friction system has been comprehensively discussed in the previous work [5].

Considering it is very difficult to measure the maximum clutch temperature in production vehicles due to high cost or technical challenges, the practical way to track clutch temperature is the use of a real time clutch temperature model. However, to develop an accurate and robust model of clutch temperature for production purposes is not an easy task.

This paper illustrates how a calculated clutch temperature model of a rotating clutch using a rapid prototype controller is created, implemented, and validated.

INSTRUMENTATION SET UP & CLUTCH TEMPERATURE MEASUREMENTS

The Chrysler 545RFE transmission has UD, OD, 2C, 4C and reverse clutches as shown in Fig 2. Since both the 2C and 4C clutches are ground (fixed) clutches, routing of the thermocouples outside the transmission was relatively simple, requiring no telemetry and no major modifications. In the case of UD and OD, the clutches are rotating and wireless

sensing is required. Telemetric instrumentation allows remote measurement of the temperature sensors. Fig. 2 shows the installation of the wireless sensors in the UD, OD clutches. Wireless sensors reduce the complexities of the system integration process, and provide a cost-effective solution to developing the model.

Fig. 3 shows the instrumentation setup in dyno cell. This setup recorded the sensor data and model output data at the same time. In this application, the wireless sensors were integrated within the UD and OD clutch assembly. The sensor output voltage is a function of temperature; the sensors send signals to the IPS receiver mounted outside on transmission case. The ATI telemetry instrument allows tuning of the sensor output voltage between 0 to 5V. The signal conditioning box allows refinement of the sensor signal by using K-type thermocouple modules.

A Rapid Prototype Controller (RPC) was used to measure and collect the sensor data and implement the virtual temperature model. The model was implemented using Matlab/Simulink and tested using the setup shown in Fig 4. The RPC setup resulted in a very efficient way to develop the UD and OD clutch temperature model.

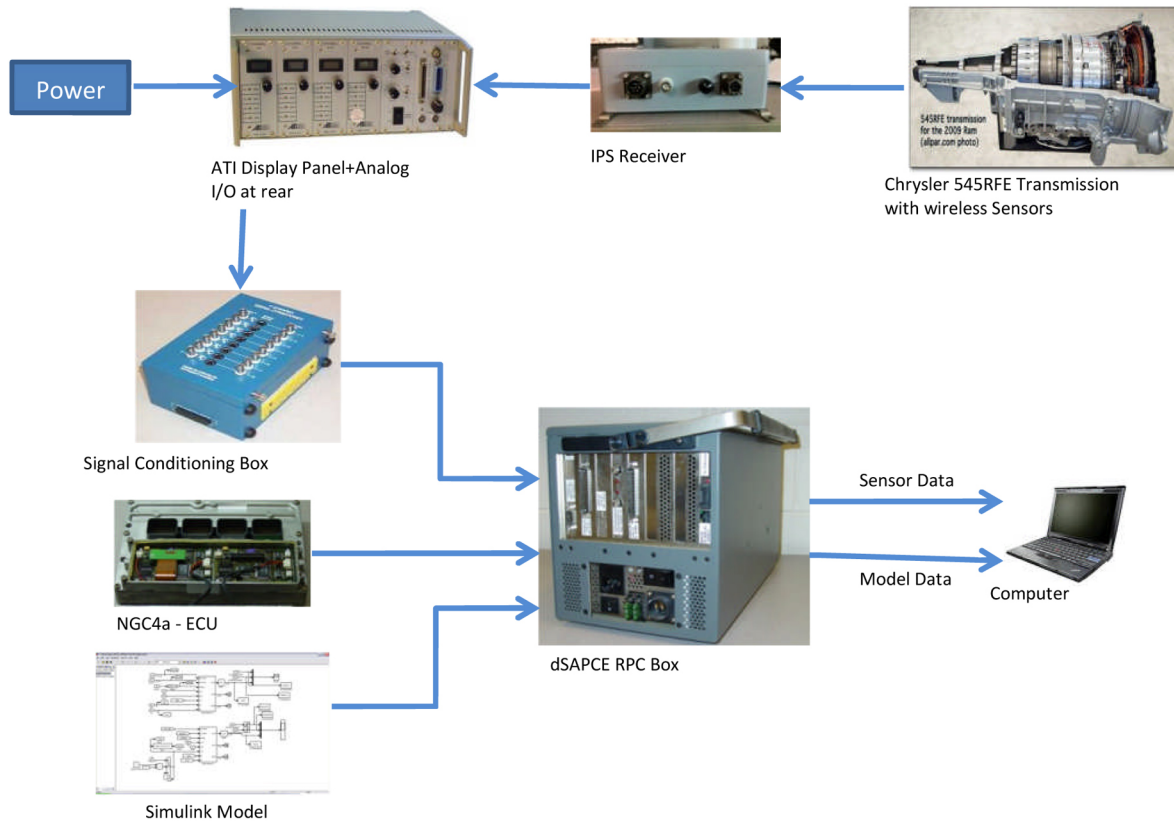


Figure 3. System architecture of UD/OD clutch temperature measurement

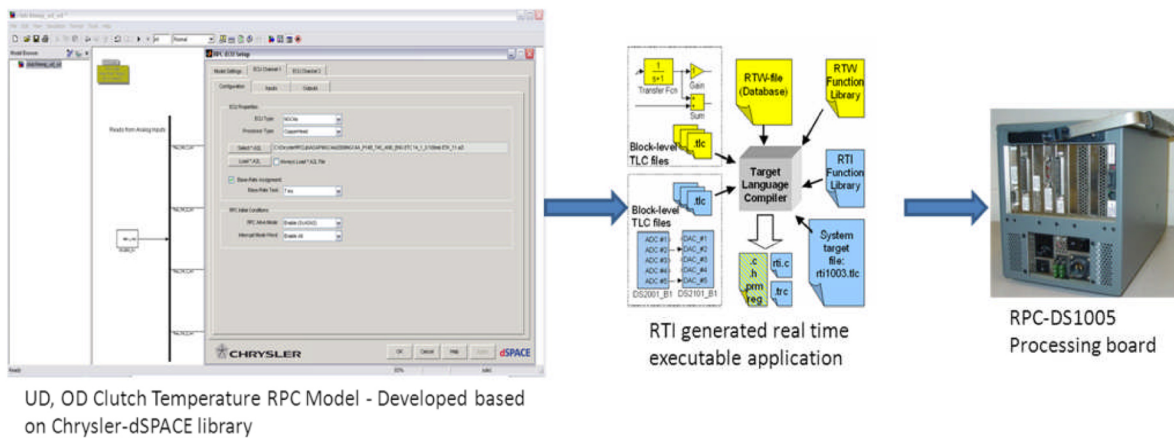


Figure 4. UD, OD clutch temperature model building process in RPC environment