Predicting the launch feel of automatic and dual clutch transmissions

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Recent developments of the Powertrain Dynamics (PTDynamics) Library [1] are presented and these are used to model the initial launch response of two vehicles. The developments discussed are the introduction of a dynamic torque converter model, the addition of a new wet clutch model that accounts for temperature effects and aggregated shafts.

In automatic transmissions the engine and gearbox are coupled by a torque converter. This is typically modelled using the steady state performance curves for the torque converter that relate speed ratio, torque ratio and capacity factor (k-factor, MPC2000, or c-factor). The problem is that models based on these curves cannot capture the transient behaviour of the torque converter. During large transient events such as initial launch, gear shifting and driver tip-in and tip-out events the transient response of the torque converter has an impact on the vehicle response and the perception of performance experienced by the driver.

A dynamic torque converter model has been implemented to overcome this problem and enable the torque converters fluid inertia and stator dynamic behaviour to be included in simulations. The model is based on the nonlinear lumped parameter model derived in Hrovat and Tobler [2] that describes the converter dynamics. An example vehicle model is used to illustrate the different results achieved during the initial launch of a car using the steady state and dynamic torque converter models.

Wet clutches are key components in both automatic and dual-clutch transmissions and a new model for predicting the torque response of a wet clutch pack has been developed. The torque across a wet clutch is a direct function of automatic transmission fluid (ATF) film thickness, pressure distribution and asperity pressure at the interface. The model calculates the total torque across the wet clutch as the sum of the hydrodynamic torque and asperity torque.

Initial torque generation is known to be heavily influenced by the presence of the lubricating oil and its properties [3] requiring accurate clutch pressure control for smooth engagement. By accounting for the hydrodynamic and friction torque from asperity contact separately, the Wet Clutch models within the PTDynamics library were used to study the torque engagement profile under cold and warm conditions. Results show a need for controller calibration during cold starting conditions to achieve a smooth pull-away from standstill.

References

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