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Analysis and simulation of a torque assist automated manual transmission

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ABSTRACT

The paper presents the kinematic and dynamic analysis of a power-shift automated manual transmission (AMT) characterised by a wet clutch, called assist clutch (ACL), replacing the fifth gear synchroniser. This torque assist mechanism becomes a torque transfer path during gearshifts, in order to overcome a typical dynamic problem of the AMTs, that is the driving force interruption.

The mean power contributions during gearshifts are computed for different engine and ACL interventions, thus allowing to draw considerations useful for developing the control algorithms.

The simulation results prove the advantages in terms of gearshift quality and ride comfort of the analysed transmission.

1. Introduction

One of the most challenging issues for the automotive world in recent years has been the improvement of vehicles both in terms of fuel efficiency and longitudinal behaviour. Since transmissions play a fundamental role for energy saving and drivability, many researches have focused on enhancing the performance of existing systems and on developing new technologies [1–6].

Among the several types of transmissions currently available, manual transmissions (MT) show the highest efficiency value for any type of transmission (96%), while current production automatics (AT) have been improved to provide an efficiency of about 86% and belt type continuously variable transmissions (CVT) have an overall efficiency of 85%, but their major advantage consists in allowing the engine to operate most fuel efficiently (see e.g. [7,5,8]).

A recently developed power-shift automated transmission, i.e. the Dual Clutch Transmission, aims at optimising the advantages of MT and AT (see e.g. Kulkarni et al. [3]), offering high efficiency and excellent shifting quality.

Automated manual transmissions (AMT) are generally constituted by a dry clutch and a multi-speed gearbox, both equipped with electro-mechanical or electro-hydraulic actuators, which are driven by an Electronic Control Unit (ECU) [9]. In order to overcome the driving torque interruption that leads to undesired vehicle jerks during gear changes [6], different devices called torque gap fillers (TGF) can be integrated in AMT driveline architectures. A solution has been developed by Magneti Marelli Powertrain [10]: it mainly consists of an epicyclic gear-set to be added to a conventional AMT allowing to transfer power from the engine to the secondary shaft during gearshifts.

Recently Hitachi Group [4] has proposed an alternative solution, consisting of a friction clutch mechanism – called assist clutch (ACL) – that replaces the fifth gear synchroniser on traditional AMTs. The modulation of the assist clutch

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