DRIVETRAIN

7.0 Introduction

Drivetrain is the assembly of all the components that are involved in the transmission of the power from the engine of the vehicle to its wheels.

7.1 Drivetrain configurations

The layout of the automotive drivetrain varies according to the position of the engine and the drive axle:

Drive configuration	Engine position	Driven axle
Standard rear-wheel drive	front	Rear-axle
Front-wheel drive	front. longit. or transverse	Front axle
All-wheel drive	front, occasionally rear or middle	Front-axle and rear-axle
Rear-wheel drive with rear-mounted engine	rear	Rear-axle

7.2 Drivetrain elements

The elements of the drive train must perform the following functions:

- remaining stationary even with the engine running,
- achieving the transition from a stationary to a mobile state,
- converting torque and rotational speed,
- providing for forward and reverse motion,
- compensating for wheel-speed variations in curves,
- ensuring that the power unit remains within a range on the operating curve commensurate with minimum fuel consumption and exhaust emissions.

7.3 Clutch Operation

Stationary idle, transition to motion and interruption of the power flow are all made possible by the clutch. The clutch slips to compensate for the difference in the rotational speeds of engine and drivetrain when the vehicle is being set in motion.

When different conditions demand a change of gear, the clutch disengages the engine from the transmission while the gear shift operation takes place. With automatic transmissions, the hydrodynamic torque converter is responsible for the take-up of power. The transmission (gearbox) modifies the engine's torque and revolution per minute to adapt them to the vehicle's momentary tractive requirements.

The overall conversion of the drivetrain is the product of the constant transmission ratio of the axle differential and the variable transmission ratio of the gearbox – assuming there are no other transmission stages involved. Gearboxes are almost always multiple fixed-ratio gearboxes though some are of the continuously variable ratio type. Gearboxes generally fall into one of two categories:(i) manual gearboxes with spur gears and a layshaft arrangement and (ii) load-actuated automatic transmissions with planetary gears. The transmission also allows the selection of different rotational directions for forward and reverse operation.

The differential allows laterally opposed axles and wheels to rotate at varying rates during cornering while providing uniform distribution of the driving forces. Limited-slip final drives respond to slippage at one of the wheels by limiting the differential effect, shifting additional power to the wheel at which traction is available.

Torsion dampers, hydrodynamic transmission elements, controlled-slip friction clutches or mass-suspension systems dissipate high vibration amplitudes, as well as protecting against overload and providing added ride comfort.

7.4 Power take-up elements

7.4.1 Dry-plate friction clutch

The friction clutch consists of a pressure plate, a clutch disk – featuring bonded or riveted friction surfaces – and the second friction surface represented by the engine-mounted flywheel. The flywheel and pressure plate provide the thermal absorption required for friction operation of the clutch; flywheel and pressure plate are connected directly to the engine, while the clutch disk is mounted on the transmission's input shaft.

A spring arrangement, frequently in the form of a central spring plate, applies the force which joins the flywheel, pressure plate and clutch disk for common rotation; in this state, the clutch is engaged for positive torque transfer. To disengage the clutch (e.g., for gear shifting), a mechanically or hydraulically actuated throw-out bearing applies force to the center of the pressure plate, thereby releasing the pressure at the periphery. The clutch is controlled either with a clutch pedal or with an electro-hydraulic, electro-pneumatic or electromechanical final-control element. A single- or multistage torsion damper, with or without a pre-damper, may be integrated in the clutch plate to absorb vibration.

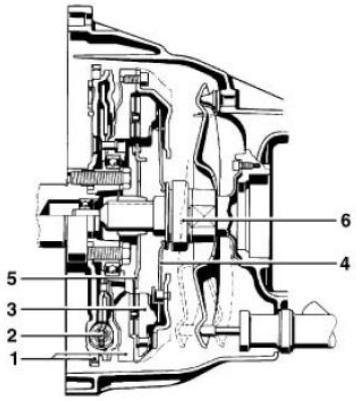

Figure 7.1: Clutch with dual-mass flywheel

1 Dual-mass flywheel, 2 Flexible element, 3 Pressure plate, 4 Spring plate, 5 Friction plate, 6 Thrust bearing.

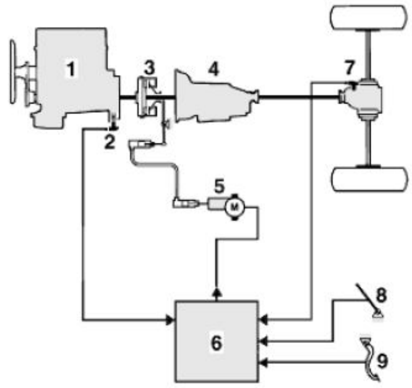

Figure 7.2: Automatic clutch, limited to clutch actuation

1 Engine, 2 Engine min^{-1} sensor, 3 Clutch, 4 Transmission, 5 Servomotor, 6 ECU, 7 Speed sensor, 8 Accelerator pedal, 9 Clutch pedal.

A two-section (dual-mass) flywheel featuring a flexible intermediate element can be installed forward of the clutch for maximum insulation against vibrations. The resonant frequency of this sprung mass system is below the exciter frequency (ignition frequency) of the engine at idling speed and therefore outside the operating speed range. It acts as a vibration insulating element between the engine and the other drive-train components (low-pass filter).

When used together with electronic control units, the automatic clutch can provide either gradual engagement for starting off, or it can be applied in conjunction with a servooperated shifting mechanism to form a fully-automatic transmission unit. Traction control and disengagement of power transmission during braking are also possible.

7.4.2 Wet-plate friction clutch

The wet-plate friction clutch has the advantage over the dry-plate version that its thermal performance is better as oil can be passed through to assist heat dissipation. However, its drag losses when disengaged are considerably higher than with a dry clutch. Use in combination with synchromesh gearboxes presents problems due to the increased synchronous load when changing gear. The wet clutch was introduced as a standard component on continuously variable car transmissions. It has space-saving advantages particularly when one or more friction-drive gear-shift components (multiplate clutch or clutch stop) that are present in any case can also be used for the power take-up process.

7.4.3 Hydrodynamic torque converter

The hydrodynamic torque converter consists of the impeller which is the driving component, the turbine which is the driven component and the stator which assists the torque converter function. The torque converter is filled with oil and transmits the engine torque by means of the viscosity of the oil. It compensates for the speed difference between the engine and the other drive-train components and is therefore ideally suited to a power take-up function. An impeller converts the mechanical energy into fluid energy; and a second transformation, back into mechanical energy, takes place at the blades within the turbine.

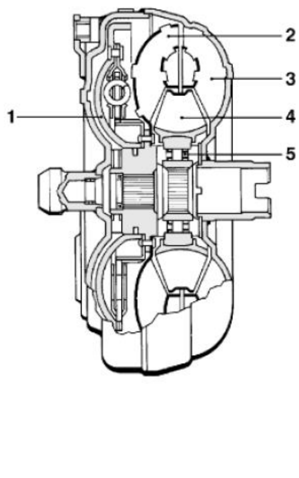

Figure 7.3: Hydrodynamic converter with lockup clutch

1 Lockup clutch, 2 Turbine, 3 Impeller, 4 Stator, 5 One-way clutch.

The hydrodynamic torque converter is a fully automatic infinitely variable transmission with virtually zero-wear characteristics; it eliminates vibration peaks and absorbs vibration highly effectively. However, its conversion range and efficiency, particularly at high levels of slip, are not sufficient for motor-vehicle applications so that the torque converter can only be usefully employed in combination with multi-speed or continuously variable gearboxes.

7.4.4 Converter lockup clutch

In order to improve efficiency, the impeller and turbine can be locked together by a converter lockup clutch once power take-up is complete. The converter lockup clutch consists of a plunger with friction surface, which is connected to the turbine hub. The transmission's valve body regulates the direction in which the fluid flows through the converter to regulate coupling engagement.

The converter lockup clutch normally requires additional means of vibration absorption such as

- a torsion damper,
- controlled-slip operation of the converter lockup clutch at critical vibration levels or
- both of the above in combination.

7.4 Multi-speed gearbox

Multi-speed gearboxes have become the established means of power transmission in motor vehicles. Good efficiency characteristics dependent upon the number of gears and engine torque characteristics, satisfactory to good adaptation to the traction hyperbola and easily mastered technology are the essential reasons for its success.

Gear shifting on multi-speed gearboxes is performed using either disengagement of power transmission (positively interlocking mechanism) or under load by a friction mechanism. The first group includes manual and semi-automatic gearboxes while the second group encompasses automatic transmissions.

The manually-shifted transmissions installed in passenger cars and in most heavy vehicles are dual-shaft units with main and countershaft (layshaft, idler gears). Transmissions in heavy commercial vehicles sometimes incorporate two or even three countershafts. In such cases, special design features are required in order to ensure that power is evenly distributed to all countershafts.

Automatic transmissions for cars and commercial vehicles are, in the majority of cases, planetary gear transmissions and only in rare cases are countershaft designs used. The planetary gears generally take the form of a planetary-gear link mechanism. They frequently involve the use of Ravigneaux or Simpson planetary gears.

7.4.1 Planetary-gear sets

The basic planetary-gear set consists of the sun gear, internal ring gear and the planet gears with carrier. Each element can act as input or output gear, or may be held stationary. The coaxial layout of the three elements makes this type of unit ideal for use with friction clutches and brake bands, which are employed for selective engagement or fixing of individual elements. The engagement pattern can be changed – and a different conversion ratio selected – without interrupting torque flow; this capability is of particular significance in automatic transmissions.

As several gear wheels mesh under load simultaneously, planetary-gear transmissions are very compact. They have no free bearing forces, permit high torque levels, power splitting or power combination, and feature very good efficiency levels.

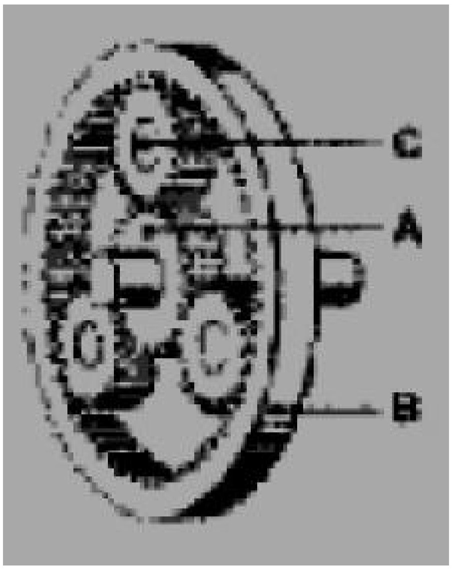

Figure 7.4: A planetary gear

A – Sun gear, B- internal ring gear, C-planetary gear with carrier.