

08A012 Automatic Transmission

DEPARTMENT ELECTIVE - DESIGN ENGINEERING

- 1. INTRODUCTION**
- 2. CENTRIFUGAL CLUTCHES AND FLUID COUPLING**
- 3. AUTOMATIC OVER DRIVES**
- 4. HYDRODYNAMIC TORQUE CONVERTERS**
- 5. HYDROSTATIC DRIVES**
- 6. TYPICAL AUTOMATIC TRANSMISSION SYSTEMS**
- 7. ELECTRIC DRIVES**

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TEXT BOOKS:

1. Jack Erjavec, "Automatic Transmissions", Delmar Publishers, 1st edition, 2005.
2. Tom Birch and Chnck Rockmood, "Automatic Transmissions and Transaxles", Prentice Hall, 1st edition, 2002.

REFERENCES:

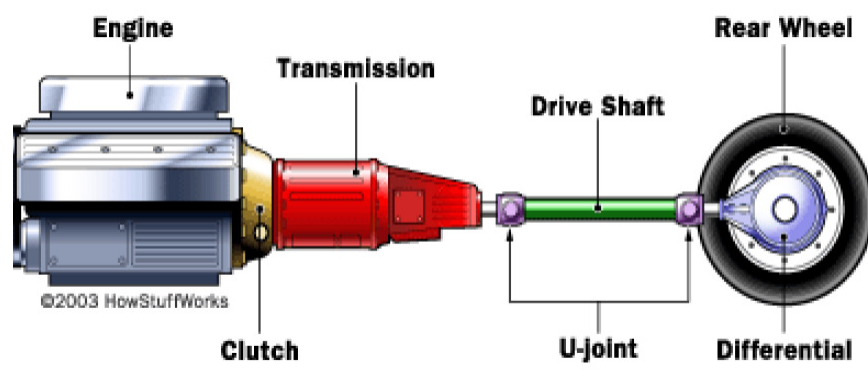
1. William Turney, "Automatic Transmissions and Transaxles", Chek Chart Publishers, 1997.
2. Tucker H F, "Automatic Transmission", Van Nostrand Reinhold Company, 1980.
3. Mathias F Brejeha, "Automatic Transmission", Prentice Hall, 1998.

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INTRODUCTION:

- Principles of Automatic Transmission
- Advantages, Limitations
- Main components of Automatic Transmission
- Hydraulic Control System
- Pumps
- Automatic variable delivery pump.

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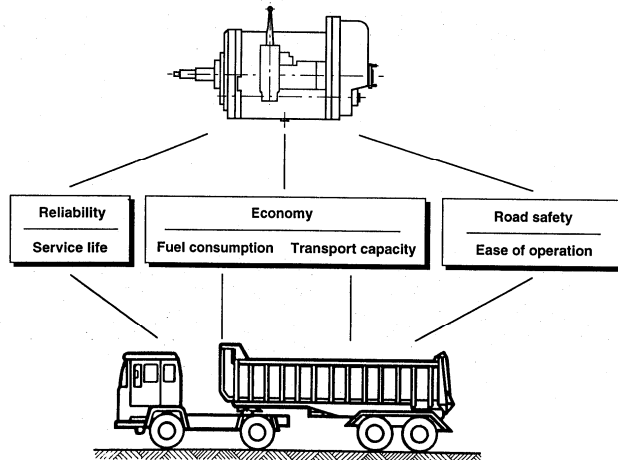


Figure 1.3. Effect of the transmission on key features of the vehicle

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TYPES:

Semi Automatic: Clutch is operated automatically, But driver still has to select the gears.

Fully Automatic: Modern Cars-Gears also changed automatically- Control Mechanism actuated by accelerator pedal only

Cars with fully automatic transmission - Two pedals one for Braking & another for Accelerating

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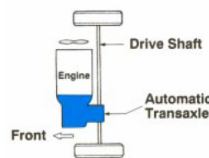
Transmission types									
z-speed-transmissions. (geared transmissions with z speeds)						Continuously variable transmissions			
Constant-mesh transmission	Synchromesh transmission	Semi-automatic constant-mesh or synchromesh transmission	Fully automatic constant-mesh or synchromesh transmission	Conventional automatic transm.	Twin-clutch transmission	Pulley transmission	Toroidal transmission (friction gear)	Hydrostatic transmission	Electric transmission
With power interruption				Without power interruption (powershift)					
Moving off and disengagement with foot-operated clutch			Automatic continuously variable moving off						
Manual gearshift	Semi-automatic gearshift	Automatic gearshift			Automatic torque and speed conversion				

Figure 1.2. Systematic classification of vehicle transmissions

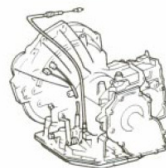
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Automatic Transmission Types

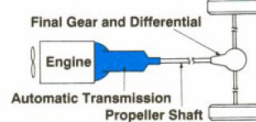
- FWD – More Compact



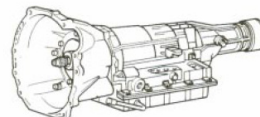
Front-Wheel Drive



- Transaxle
- Differential – Integral part



Rear-Wheel Drive



- RWD – Less Compact

- Differential – External

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1.Torque Converter:

- Transfer the power from the engine to input shaft of transmission
- Automatic clutch to engage engine torque to the transmission
- Provides a Smooth & automatic take up of the drive & at same time multiplies the output torque from Engine

2.Epicyclic Gear Box:

- Gears are permanently in mesh – Wet Clutch , Brake Bands actuate the engagement & disengagement of the various gear ratios.

3.Multiplate Clutches, Brake Bands

- Holding devices which hold members of planetary gear set

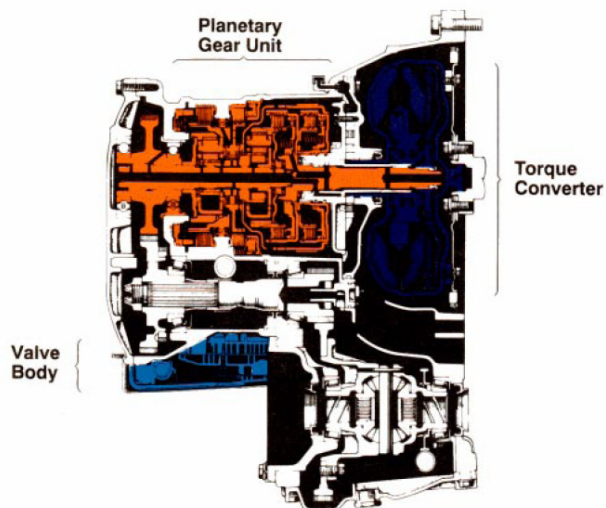
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Major Transmission Components

Torque Converter
- Transfers engine torque..

Planetary Gear
- Multiple gear ratios.

Valve Body
- Hydraulic control unit



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4. Hydraulic Control Unit:

- Automatic Selection of Gear Ratio
- Monitors the Driving Load & speed Conditions
- Directs the various **hydraulic servo units** to actuate the appropriate clutch & Brake Bands – necessary gear ratio changes take place to match the engine's output capability & the road resistance at any one time.

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Main components of Automatic transmission:

- **Planetary Gear sets** provide various forward gear ratios as well as reverse.
- **Hydraulic system** sends fluid to control Clutches and Bands to control Planetary Gear sets.
- **Seals and Gaskets** keep the oil where it is to be and prevent it from leaking out.
- **Torque Converter** provides continuously variable torque ratio to a max of 1:2.5
- **The Governor & Modulator** or Throttle cable monitor speed & throttle position to determine when to shift.
- **A large gear pump** to move transmission fluid around

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AUTOMATIC TRANSMISSION

- Manual Transmission locks & unlocks gear sets to output shaft for different gear ratios.
- In Automatic Transmission same set of gears produce different gear ratios

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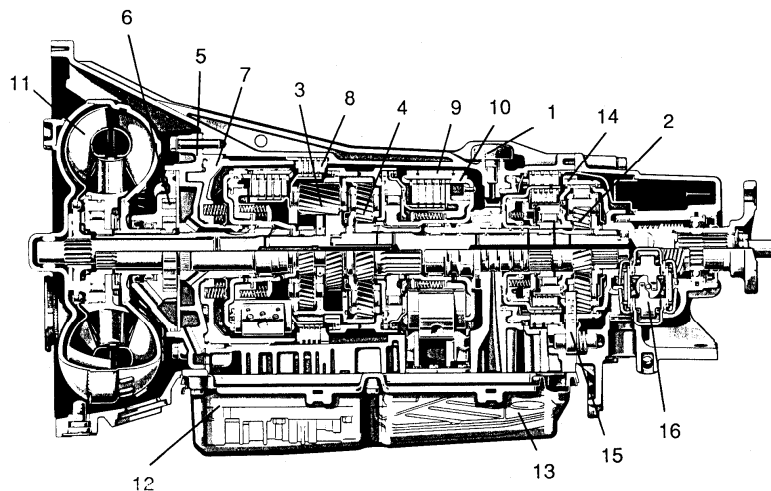
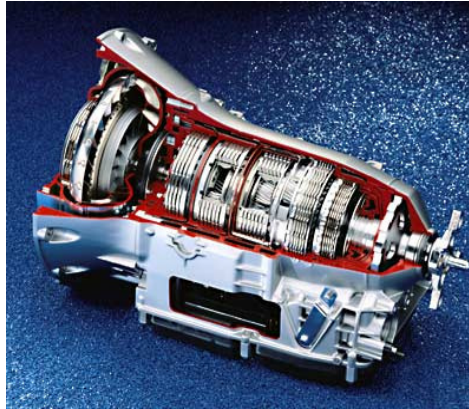


Figure 12.12. Mercedes-Benz W5A 030 5-speed automatic gearbox.
1/ Breather unit; 2 and 4/ Planetary gear-set; 3/ Ravigneaux set; 5/ Cover; 6/ Primary oil pump; 7/ Actuator piston; 8/ Multi-disc brake; 9/ Belt brake; 10/ Clutch disc carrier; 11/ Torque converter; 12/ Control plate; 13/ Sump; 14/ Parking interlock gear; 15/ Parking lock detent; 16/ Centrifugal governor

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- AT- operates – by controlling Vehicle Speed & Engine Load
- Increasing Vehicle Speed – Needs Changing Gears Upwards
- Increasing Engine Load- Change from Higher to lower Gear

***Mercedes-Benz
Automatic
Transmission, cut
away model***



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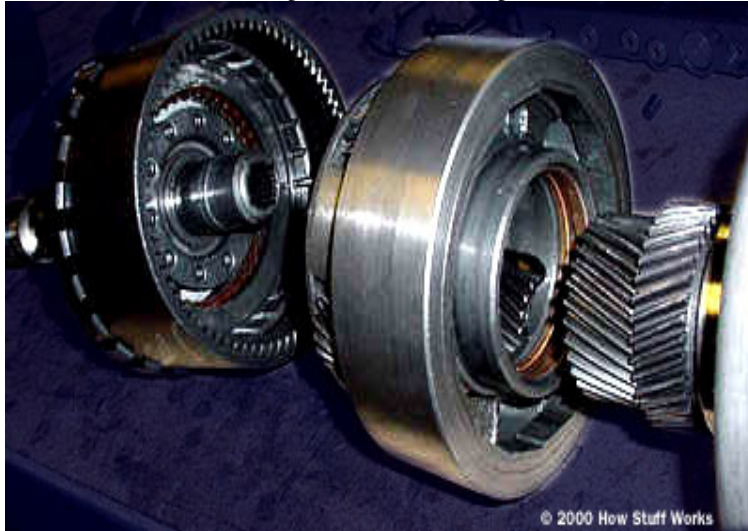
Planetary Gear Sets

Main parts of a Planetary gear set are:

- A Planetary gear set.
- A set of bands to lock parts of a gear set.
- A set of three wet-plate clutches to lock other parts of the gear set.
- A hydraulic system to control clutches & bands.
- A gear pump to move transmission fluid.

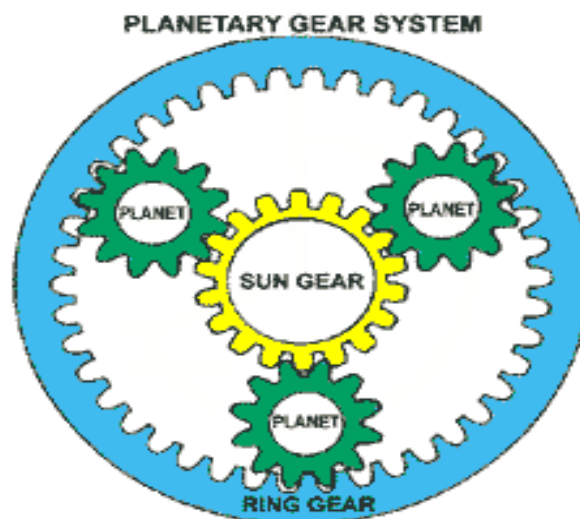
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Planetary Gear System



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Planetary Gear System



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Planetary Gear System

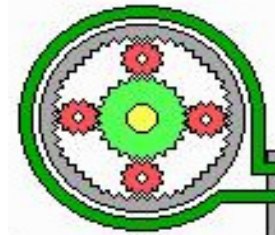
Planetary gear set consists of:

- A Sun gear,
- A Ring gear,
- Three planet pinions-connected to a common carrier.
- Each of these three components can be the input, the output or can be held stationary.
- Choosing which piece plays which role determines the gear ratio for the gearset

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Epicyclic Single Stage Gear Train

- Internally Toothed Annulus Ring Gear (A) with a Band encircling it.
- Centre – Sun Gear
- Planet (Pinion) Gears bridges the space between the Sun gear & Ring gear
- Planet Gears are mounted on a Planet Carrier
- For Torque Transmission - Either Ring Gear ,sun gear or planet carrier must be fixed to provide a reaction torque – other two members become either i/p or output drives

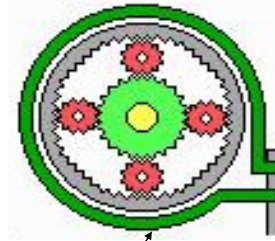


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Epicyclic Single Stage Gear Train

First Gear

- Annulus Gear or Ring Gear is fixed by brake band – input sun gear is driven
- Planet Gears rotate about their own axes & at same time revolve around the inside of the annulus gear or ring gear
- Planet Carrier which supports the planet gear axes connected to o/p shaft made to rotate but at a speed lower than that of the i/p shaft.



Ring Gear –
Fixed by brake
band

I/p Shaft – Sun
Gear

O/p Shaft –
planet carrier

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Epicyclic Single Stage Gear Train

- S = Sun Gear Diameter
- P = Planet Gear Diameter
- A = Annulus Gear Diameter = $S + 2P$
- N_s = Rotational Speed of the Sun Gear
- N_a = Rotational Speed of the Annulus gear
- N_c = Rotational Speed of the Carrier
- C_p = Pitch Circle diameter of carrier = $S + P$
- V_s = Peripheral Speed of the Contact Point between S & P
($\pi S.N_s$)
- V_c = Linear Speed of Planet Carrier – half of $V_s = \frac{1}{2} \pi S.N_s$

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Epicyclic Single Stage Gear Train

• But $V_c = \pi C_p \cdot N_c = \pi (S+P) \cdot N_c$

$$GR = \frac{I/P}{O/P} = \frac{N_s}{N_c} = \frac{2(S+P)}{S}$$

$V_a = 0$ ie Peripheral Speed of the Contact Point between A & P

Forward Under Drive with S i/p, Cp o/p & A fixed

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Epicyclic Single Stage Gear Train

Reverse Under Drive with S i/p, A o/p & Cp fixed

$$GR = \frac{I/P}{O/P} \times \frac{I/P}{O/P} = \frac{\pi S N_s}{\pi P N_p} \times \frac{\pi P N_p}{\pi A N_a} = \frac{S N_s}{A N_a}$$

$$\frac{N_s}{N_a} = \frac{A}{S} = \frac{S+2P}{S} = GR$$

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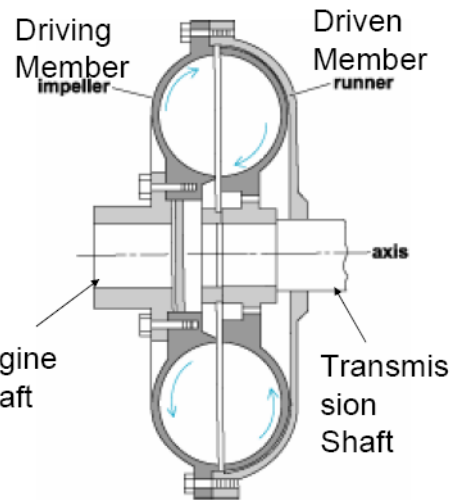
Fluid Coupling/Fluid Flywheel

- Hydraulic Coupling used in cars employing automatic transmissions

- Driving Member – Engine Flywheel

- Driven Member – Transmission Shaft

- 2 members don't have any direct contact with each other



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Fluid Coupling/Fluid Flywheel

- FC – Connects the Automatic transmission(AT) to Engine

- TC – Connects & Multiplies the torque

- Wind Mill – Example of FC, Where Fluid is Air

TURBINE:

- i/p shaft of AT (Turbine Shaft) – Splined – fit the hub of a turbine

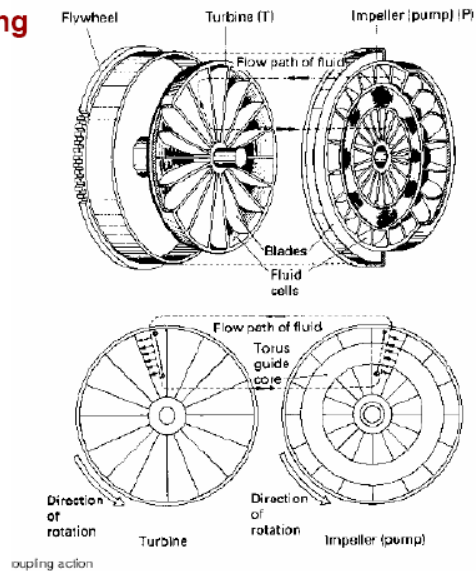
- Turbine supported by a bearing in the housing and it is free to turn

- Turbine Blades – Vanes

- Force of Transmission Fluid pushes the vanes – rotates the turbine and input shaft of transmission.

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Fluid Coupling



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Fluid Coupling/Fluid Flywheel

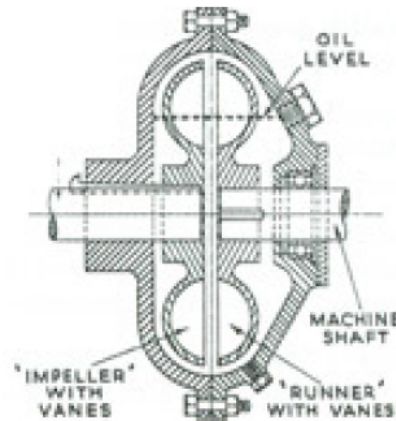
IMPELLER & HOUSING:

- Force the Fluid – Vanes are attached to housing - Housing turns with Engine, Impeller act as pump.
- FC – Fluid is forced back to impeller against the direction of rotation of impeller and Engine.
- Reduces the amount of work that is performed
- It can't multiply torque.

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Fluid Coupling/Fluid Flywheel

- 2 rotors are always filled with fluid of suitable viscosity
- Provided with radial Ribs to form a no of passages which avoid formation of eddies & also guide the fluid to flow in the desired direction



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Fluid Coupling/Fluid Flywheel

IMPELLER & HOUSING:

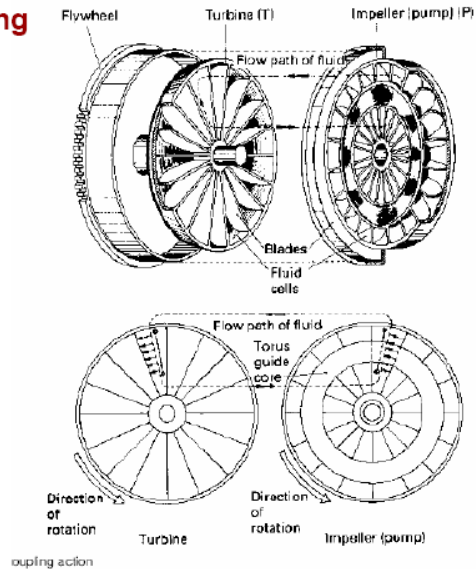
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- FC – Fluid is forced back to impeller against the direction of rotation of impeller and Engine.
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GUIDE RING

- Guide the Fluid to Flow b/w the vanes of impeller ,turbine, stator and finally back to the impeller

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Fluid Coupling



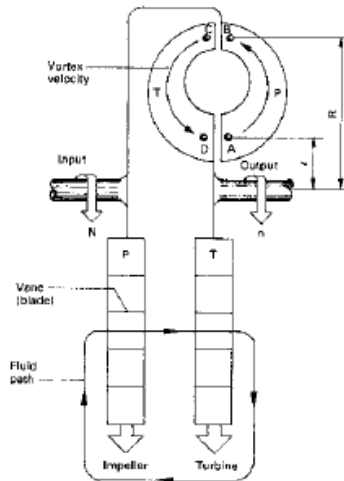
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Fluid Coupling/Fluid Flywheel

- Engine Started – Impeller Rotates – Fluid trapped in impeller cells rotate- Fc & Pressurized – Radially outwards
- Small particle of Fluid circulating b/w one set of impeller and turbine vanes at various points A,B,C,D.
- A to B – Radially outward centrifugal force – 'r to R'
- B to C – at B max KE – impeller cell to turbine cell – KE imparted to turbine wheel – turbine start rotating
- C to D - Radially inward centrifugal force – 'R to r' – at D min KE

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Fluid Coupling/Fluid Flywheel



V_i = Impeller exit velocity
 V_r = Relative linear velocity of both pump and turbine
 V_e = Resultant effective velocity and direction of fluid

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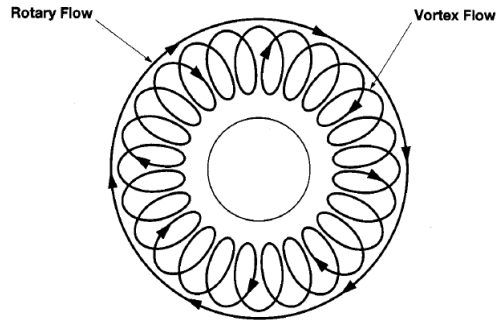
Fluid Coupling/Fluid Flywheel

- Vehicle is at Rest – Turbine is stationary – No Fc transfer
- Engine Rotates the Impeller - Fc transfer - Turbine rotates
- **Rotary Flow** - Fluid is circulated by the impeller around its axis
- **Vortex Flow** – Circulates round the cells in a Vortex Motion
- I/p Impeller gives KE to Fluid which in turn gives it to o/p turbine
- Transfer of Energy from I/p Impeller to o/p turbine but no TM

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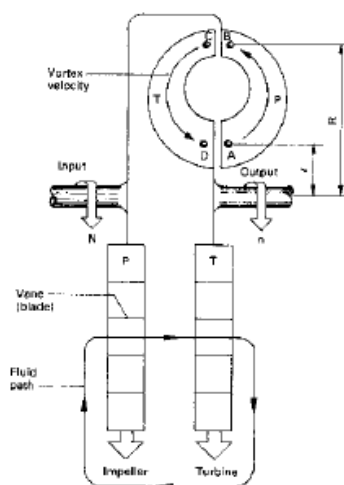
Converter Fluid Flow

Vortex flow is strongest when the difference in impeller and turbine speed is the greatest



- **High Vortex** – Vehicle is accelerating – During TM – Spiral Like Flow of Fluid
- **Cruising Speed** – No VF – as difference in speed b/w impeller and Turbine is less – **only Rotary Flow** - Fluid Flows around the circumference of FC

08A012 Automatic Transmission Fluid Coupling/Fluid Flywheel



- V_i = Impeller exit velocity
- V_r = Relative linear velocity of both pump and turbine
- V_e = Resultant effective velocity and direction of fluid

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Fluid Coupling/Fluid Flywheel

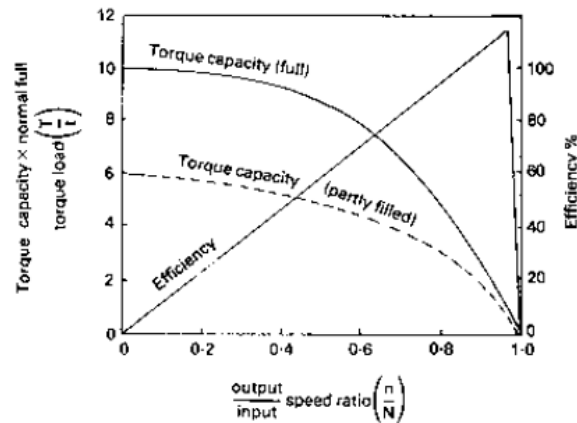


Fig. 4.4 Relationship of torque capacity efficiency and speed ratio for fluid couplings

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Fluid Coupling/Fluid Flywheel

- Coupling Efficiency = Power Available at Turbine / Power Supplied to the impeller
- Power Loss – Fluid Shock, Friction ,Heat – Relative Slip b/w two members

$$\% \text{ slip} = \left(\frac{N - n}{N} \right) \times 100$$

- % Slip - Influenced by Engine Speed & Output Turbine Load
- % Slip – Must Exist to create a sufficient rate of vortex circulation - to impart energy from impeller to the turbine.
- Coupling Efficiency = 98% - Considerably reduced as turbine output load is increased or impeller speed is lowered.
- More % Slip – Increase the Vortex Circulation Velocity

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Fluid Coupling/Fluid Flywheel

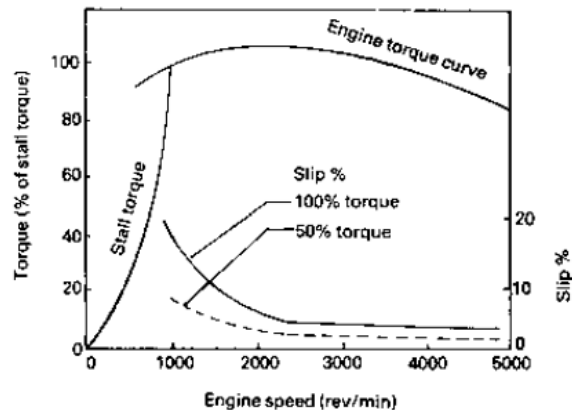


Fig. 4.5 Relationship of engine speed, torque and slip for a fluid coupling

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Fluid Coupling/Fluid Flywheel

$$\text{i.e. } T \propto D^5 N^2$$

where D = impeller diameter

N = impeller speed (rev/min)

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FLUID COUPLING/FLUID FLYWHEEL

- % Slip = $(N1 - N2) / N1 * 100$
- N1= Speed of driving member , N2 = Speed of driven Member
- % Slip – Loss of Energy & Increased Fuel Consumption
- N1<500 rpm = 100 % Slip, Clutch is fully Engaged
- N1= 1000 rpm = Slip falls rapidly to 10%
- N1= 3000 rpm = Slip falls rapidly to 2%
- Engine Should not be allowed to run at a speed between approximately 500 & 1000 rpm
- Advantages:**
 - No wear, No Maintenance, No Adjustment, Simple Design
 - No Jerk on transmission when gear engages, No Skill Required

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FLUID COUPLING/FLUID FLYWHEEL

Disadvantages:

- Even % slip is 100 = drag on GB shaft
- Gear changing difficult – ordinary Gear Box
- It can be Only employed with Epicyclic Gear Box.

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AUTOMATIC TRANSMISSION- WORKING FLUID REQUIREMENTS/FUNCTIONS/PROPERTIES

- Transmits Engine Torque
- Controls Hydraulic System
- Applies Clutches and Brakes
- Lubricates Moving Parts
- Removes Heat From Internal Parts
- Seal the parts & Cleans

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AUTOMATIC TRANSMISSION- WORKING FLUID

- **Natural or Synthetic oil** because oil is capable of transmitting power, is a lubricant, and is able to absorb and dissipate heat.
- **Water** as the fluid in fluid couplings, but sealing problems (keeping water out of the bearings and oil out of the water) and corrosion occurs.
- **Motor Oil** –used as Transmission Fluid
- ATF – **high grade petroleum product – Special Chemical Additives**
- Transmission **oil pump** pressurize it – fed in to TC –Transmits the torque generated by engine to transmission
- Pressurized ATF flows through the passages and valves to operate the clutches and brakes
- Cools , Cleans and lubricates all moving parts

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AUTOMATIC TRANSMISSION- WORKING FLUID- TYPES

- Dexron , Dexron II – GM, Chrysler - Dyed Red
- Type F – Ford Motor Company – Dyed Red
- CJ Fluid – Amber Orange Color
- Fluids with appropriate coefficient of friction must be chosen based on type of lining used for clutches, bands.

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AUTOMATIC TRANSMISSION- WORKING FLUID- TYPES

ATF Used by Toyota

- Type "T"
All-Trac Transaxles A241H & A540H
- Dexron II
All Toyota Automatic Transmissions since 1984
(except All-Trac)
Prior to 1984 — A55 (1983), A41, & A140
- Type "F"
All Toyota Automatic Transmissions prior to 1984
- Type T – Latest Type – All Transaxles

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AUTOMATIC TRANSMISSION- WORKING FLUID- ADDITIVES

Viscosity Index Improvers:

- Oil become thin at high temperatures and thick at low temperatures.
- High Viscosity Index will stay at a more constant viscosity.

Pour Point Depressants:

Oil become too thick to pour at low temperatures- helps the oil to flow at lower temperatures

Oxidation Inhibitors:

When clutch or Band applied – temp is as high as 600 F- oil combines with O₂ –oxidation – form gum and varnish

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AUTOMATIC TRANSMISSION- WORKING FLUID- ADDITIVES

Foam Inhibitors:

- Gear train of a transmission – air into fluid forming foam – **aeration** – undesirable – air can be compressed – would keep the clutches or bands from locking up – incorrect fluid level cause aeration

Detergents - Depressants:

- Clean the Parts and valves , clean sludge ,varnish

Corrosion and Rust Inhibitors:

- At high temp, water, oxygen and oil will form **acids** - form rust and corrode parts. CI – neutralize the acids, RI – prevent water from damaging the transmission parts

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AUTOMATIC TRANSMISSION- WORKING FLUID- ADDITIVES

Extreme Pressure Agents:

- Work Chemically with Metal Parts to form a **strong, tough surface film** – prevents metal to metal contact

Friction Modifiers:

- Adjust the **Coeff of friction** of mineral oil which is low to match up with clutch and band facings.

Fluidity Modifiers:

- ATF should flow readily thru small openings in valve body.

Corrosion and Rust Inhibitors:

- At high temp, water, oxygen and oil will form acids - form rust and corrode parts. CI – neutralize the acids, RI – prevent water from damaging the transmission parts

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TORQUE CONVERTER



Housing

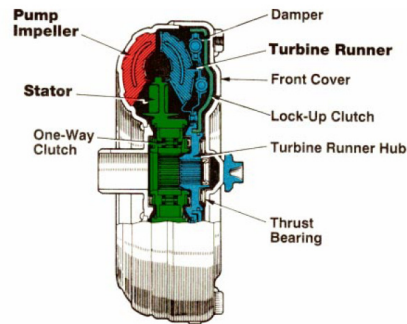


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TORQUE CONVERTER

Torque Converter

Transmits engine torque to the transmission input shaft.



- Torque Converter is mounted on input side of the transmission gear train and connected to a drive plate.
- Drive Plate is used to connect the converter to crankshaft flywheel flange of the engine.
- Ring Gear is attached to the drive plate

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TORQUE CONVERTER

Impeller

• The impeller is driven by the engine, through the torque converter housing.

• The impeller has many thin metal fins or blades similar to a fan.

• These fins spin around in Automatic Transmission Fluid and force it away from the impeller like air from a fan.

• Fluid from the impeller is directed to the blades of the turbine which is splined to the input shaft of the transmission.



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TORQUE CONVERTER

Turbine

- The turbine is splined to the input shaft of the transmission.

- The turbine receives fluid directed from the impeller.

- As the fluid hits the blades of the turbine, it forces the turbine to rotate.

- The input shaft which is splined to the turbine, rotates at the same time.



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TORQUE CONVERTER

Stator

- The stator is located between the impeller and the turbine.

- The stator helps to redirect the fluid from the turbine back to the impeller so that the process can begin all over again.

- The stator is mounted on a one way clutch, so that it can't fight the correct flow of fluid inside the converter.

- The stator helps to achieve **vortex flow** of fluid inside the transmission which is where torque multiplication occurs.



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TORQUE CONVERTER

Torque Converter Clutch

•The torque converter clutch forms a mechanical link between the transmission input shaft and the engine.

•Fluid coupling from the converter is only about 90% efficient at best.

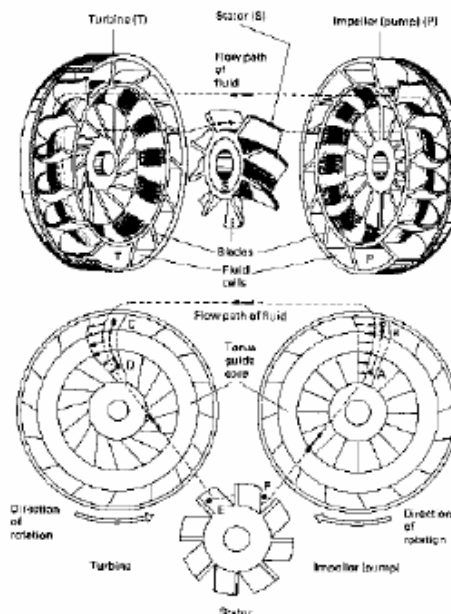
•When the vehicle is at cruise and the torque converter is in coupling phase, there is an inherent 10% slip between the TC and the engine.

•A TCC is inside the TC housing and can be forced against the housing to remove the 10% slip rate.



08A012 Automatic Transmission Torque Converter

- Impeller – 26 Blades
- Turbine - 23 Blades
- Both- Low Carbon Steel Pressings
- Stator - Aluminum alloy Casting – 15 Blades



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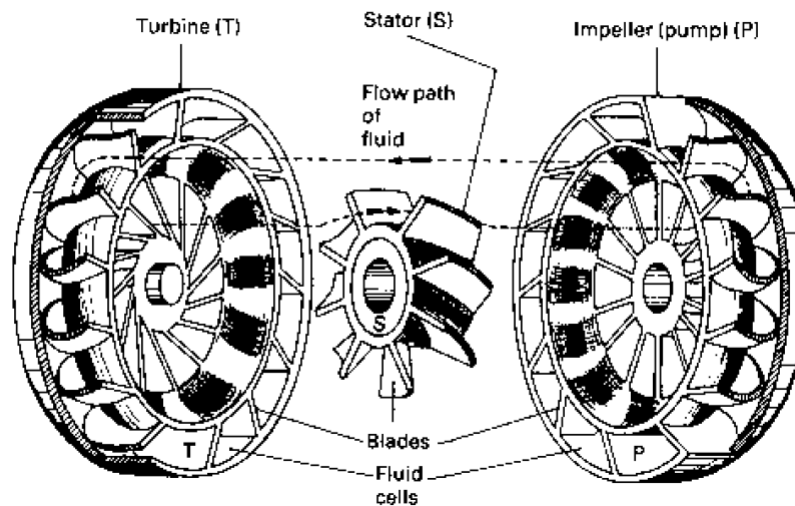
TORQUE CONVERTER

Role of the torque converter:

- Multiplies torque generated by the engine.
- Serves as an automatic clutch which transmits engine torque to the transmission.
- Absorbs torsional vibration of the engine and drivetrain.
- Smoothes out engine rotation.
- Drives the oil pump of the hydraulic control system.

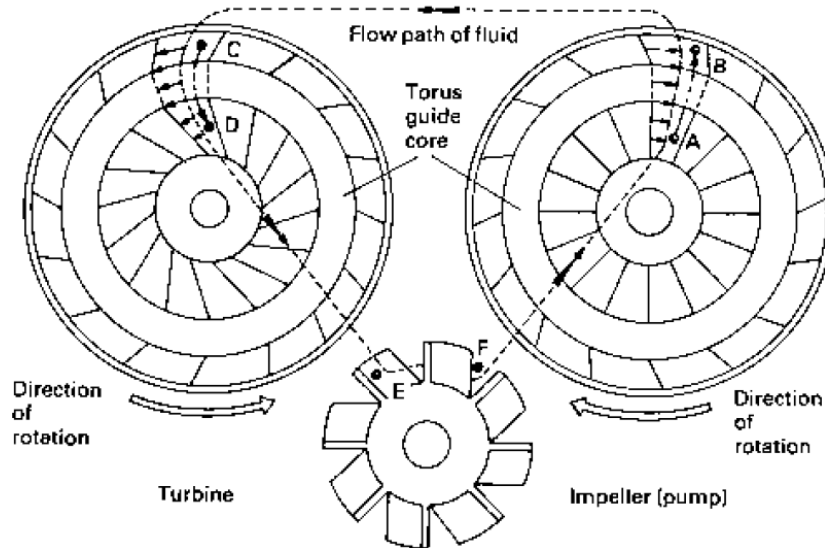
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TORQUE CONVERTER



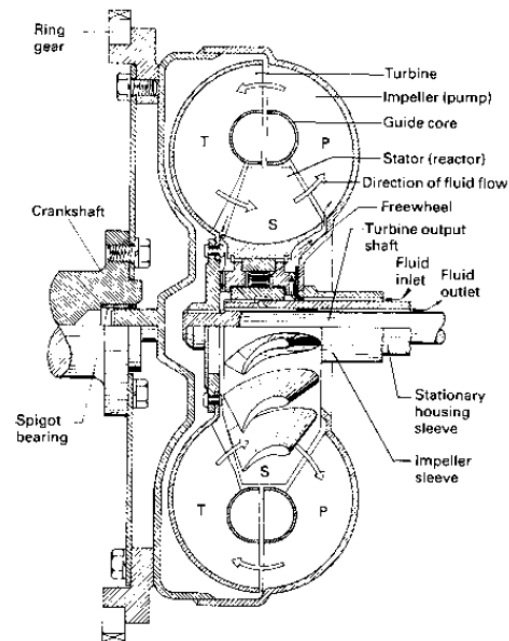
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TORQUE CONVERTER



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TORQUE CONVERTER



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Torque Converter

- Additional Stationary Member – **Stator or Reaction Member**
- All Members have **blades or vanes** of specific shape
- Increases the torque in a ratio of about **2:1 to 3:1**
- Torque Output Variation is Continuous unlike GB in finite no of steps
- η τ_c -High – only within narrow limits of speed

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NEED FOR STATOR IN FLUID COUPLING

- In 1930's - Provided a means of transferring torque from engine to the transmission – Vehicle can be stopped in gear while the engine runs at idle.
- **Poor Acceleration** – Vanes on the impeller and turbine are curved in the opposite direction to one another
- Fluid coming off the turbine is thrust against the impeller in a direction opposite to engine rotation.
- Power is consumed to overcome the force of fluid coming from the turbine. – Stator is provided to prevent this – Increase the torque to the impeller.

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Torque Converter

- 3 Main Parts
- Impeller or the Driving Member or Pump – Engine
- Turbine or Driven Member – connected to road wheels through the transmission shaft
- Stator Fixed to a frame through a free wheel/one way clutch
- Transmission oil pump- Which keeps the converter full of oil under pressure
- **Cavitation:** During rotation – Centrifugal forces pushes oil in outward direction – air pockets near the center of the converter due to low pressure
- Converter is kept between 200 KPa to 1200 KPa Pressure to avoid Cavitation

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Torque Converter Operation

- As Engine is Started – Impeller starts rotating- oil from impeller is pushed to the turbine due to high F_c at the impeller as turbine is stationary
- Oil leaving Impeller have high kinetic energy – strike the outer edge of the turbine – turbine rotates due to the oil force
- F_c increases with Engine Speed.
- Force is sufficient – turbine starts rotating & vehicle moves
- Turbine blade angle is set – to change the direction of oil flow- fluid from turbine-fluid from turbine strike a stationary member stator

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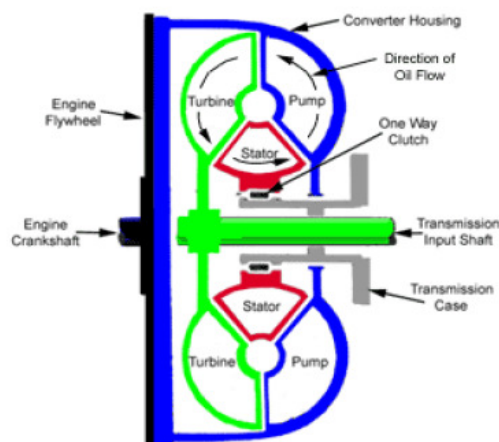
TORQUE CONVERTER

- After imparting torque to the turbine member ,fluid in turbine cell passages moves inwards to the turbine exit.
- Then it is compelled to flow between the fixed stator blades.
- Reaction of Fluid's Momentum is absorbed by casing to which stator is held - & redirected towards the impeller entrance
- Acts on Drive side of the vanes – imparts torque equal to stator reaction in direction of rotation.

$$\begin{array}{l} \text{Engine} \\ \text{Torque} \\ \text{Delivered to} \\ \text{the impeller} \end{array} + \begin{array}{l} \text{Reaction Torque} \\ \text{Transferred by} \\ \text{fluid to the} \\ \text{impeller} \end{array} = \begin{array}{l} \text{Transmitted to} \\ \text{output turbine or} \\ \text{Output Turbine} \\ \text{Torque} \end{array}$$

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Torque Converter – Sectional view



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Torque Converter Operation

- Stator (reactor) takes the reaction-change the oil direction suitable – it strikes the impeller in a direction in which impeller is rotating
- Impeller throws the oil back in to the turbine at the outer edge. This goes on continuously
- Repeated Pushing of the turbine blades – increases the torque on the turbine – Torque Multiplication (TM)
- TM occurs when turbine speed ($\propto$ Vehicle Speed) < impeller Speed (Engine Speed)
- TM is max (2.1 to 2.6) –when Turbine is stationary –Impeller is running fast at the engine speed –**STALL**-

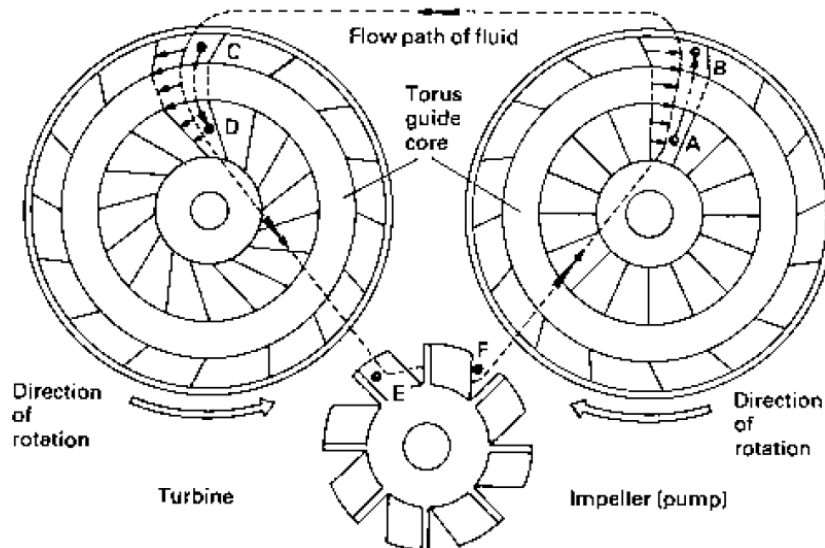
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Torque Converter Operation

- When the Vehicle begins to move – Turbine Speed Start to increase- Decrease in TM (difference between Impeller & Turbine Speed)
- TM =1 ,Turbine Speed = Impeller Speed ----- Direct Gear
- Need for one Way Clutch:**
- When Turbine Speed increases to **85% of the impeller speed-Coupling Point is reached-oil** from turbine hits back the back of stator blade-interrupt the flow of fluid from the turbine to impeller.
- To avoid Stator is mounted on **Free Wheel Clutch (one way Clutch)**- allows it to rotate in the direction of turbine or impeller & doesn't interrupt the fluid flow

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TORQUE CONVERTER



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TORQUE CONVERTER

Engine Running - Impeller Centrifugal Pump – Engine power to Hydrokinetic Energy

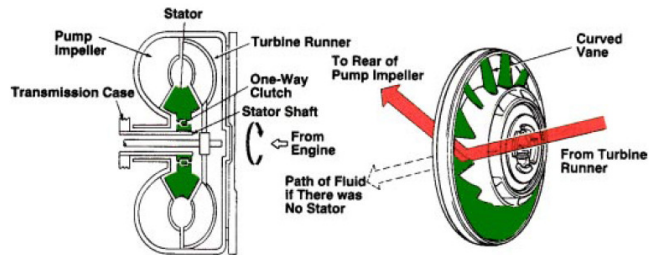
- Fluid Particle 'A' in impeller - 'B' in impeller –FC outwards
- Fluid Particle 'C' in turbine - 'D' in turbine –FC inwards
- P_r generated in impeller will be far greater than turbine as impeller speed is more.
- Fluid particle possessing KE at turbine exit, moves to stator blade entrance side to point E. It is guided by curvature of blades to exit point F
- From the fixed stator blade the fluid particle is again directed to impeller entrance point impart its KE to impeller

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TORQUE CONVERTER

Torque Converter - Stator

The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller



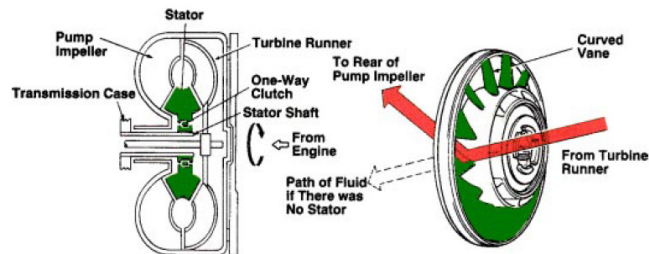
- Stator is mounted on stator reaction shaft – fixed to transmission case.
- Stator vanes catch the fluid from turbine runner and redirects it to strike the back of vanes

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TORQUE CONVERTER

Torque Converter - Stator

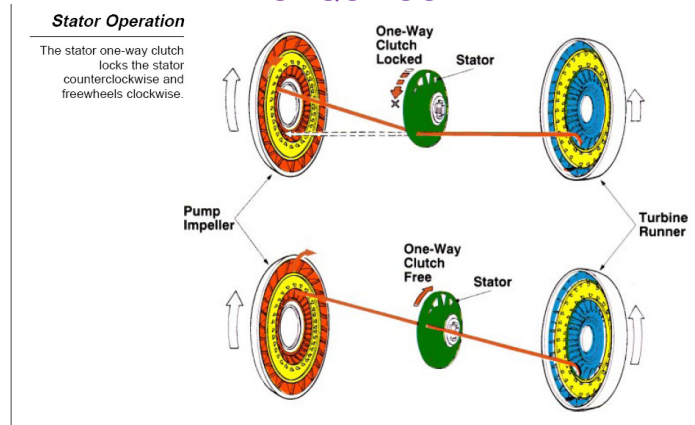
The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller



- **One Way Clutch** – allows stator to rotate in same direction as Engine Crankshaft
- If stator attempts to rotate in opposite direction, One Way Clutch locks the stator to prevent it from rotating.
- **Stator is Rotated or Locked** depending on the direction from which the fluid strikes against the vanes.

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TORQUE CONVERTER

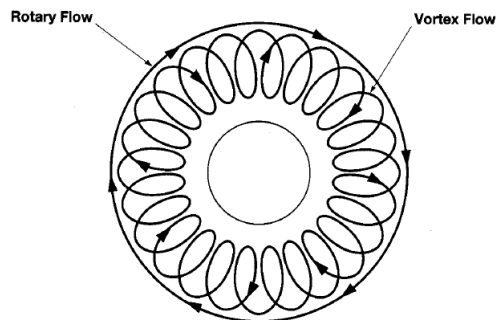


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TORQUE CONVERTER

Converter Fluid Flow

Vortex flow is strongest when the difference in impeller and turbine speed is the greatest



- High Vortex – Vehicle is accelerating
- Fluid Flow leaving the turbine strikes the front of stator vanes & locks it on stator reaction shaft preventing it from rotating in CCW
- Fluid from the stator strikes the back of the vanes of impeller – increase in torque
- No stator – returning fluid would interfere with normal impeller rotation

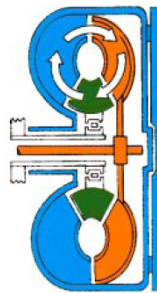
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TORQUE CONVERTER

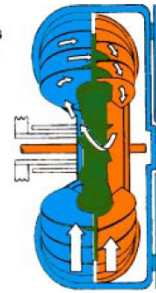
TORQUE CO

Fluid Flow While Vehicle is Accelerating

Impeller turning much
faster than turbine.



Centrifugal
Force Causes
Circular Flow



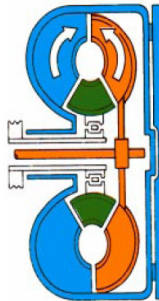
Stator
Changes
Direction
of Flow
to Multiply
Torque

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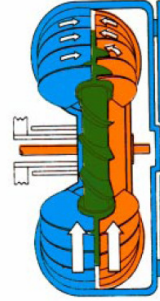
TORQUE CONVERTER

Fluid Flow While Vehicle is Cruising

Impeller and Turbine at
almost same speed



Opposing
Centrifugal
Forces Stop
Circular Fluid
Flow



Stator
Freewheels-
No Torque
Multiplication

08A012 Automatic Transmission

Torque Converter – Construction Function

Torque Converter consists of:

- Impeller or Pump – connected to engine.
- Rotor or Turbine – Connected to transmission input shaft.
- Reaction member or Stator – fixed to frame.
- Stator is responsible for torque multiplication.

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Torque Converter

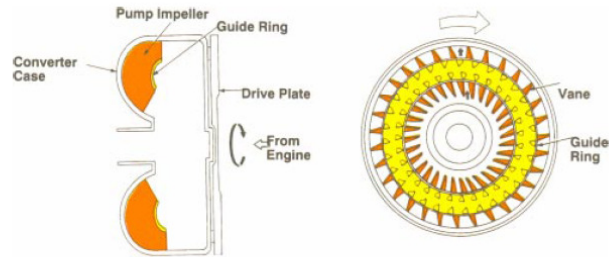
- Torque Converter functions like a Gear Box
- i.e. It increases the torque while reducing the speed
- It provides a continuous variation of ratio from the lowest to the highest.

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TORQUE CONVERTER

Torque Converter - Impeller

The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller.

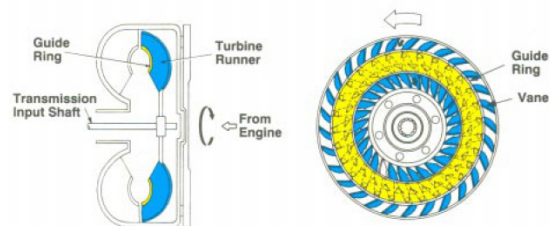


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TORQUE CONVERTER

Torque Converter - Turbine

Fluid is caught in the cupped vanes of the turbine and torque is transferred to the input shaft.

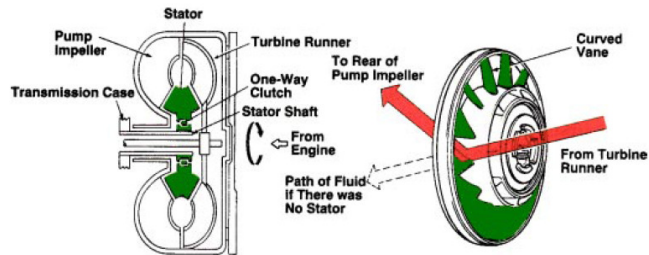


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TORQUE CONVERTER

Torque Converter - Stator

The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller



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TORQUE CONVERTER

Torque Converter Stall

- Torque converter stall is when the impeller is spinning while the turbine is held stationary.
- It's good to have stall in the TCC because without it, your vehicle would die every time you came to a stop.
- Stall speed is the highest rpm the impeller can move before the turbine must move.

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TORQUE CONVERTER

Coupling Phase

- When the speed of the turbine is nearly equal to the speed of the impeller
- The motion of the fluid during the coupling phase is called rotary flow.
- During rotary flow efficiency approaches 90% and slipping is held to a minimum.

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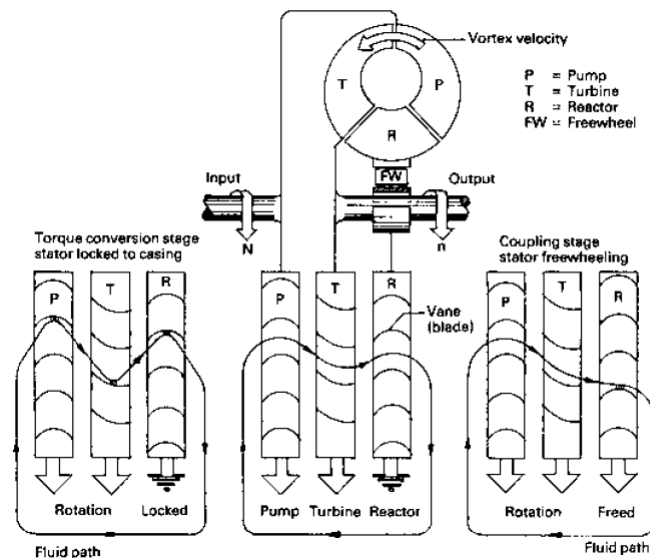
TORQUE CONVERTER

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- <http://www.youtube.com/watch?v=LEFWO3M4XOA>. March 2010
- <http://www.youtube.com/watch?v=MvLoX0z9qoY>. March 2010

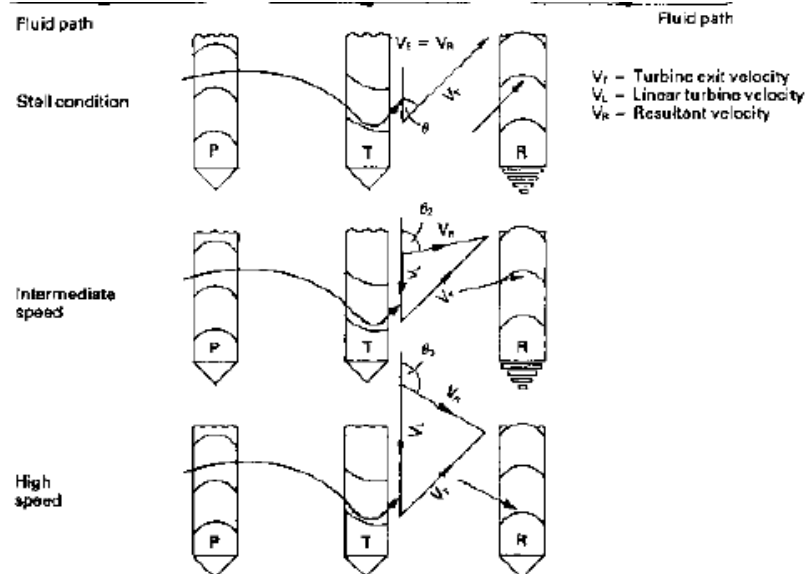
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TORQUE CONVERTER



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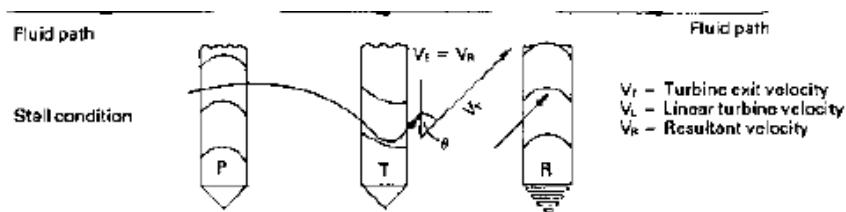
TORQUE CONVERTER



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TORQUE CONVERTER

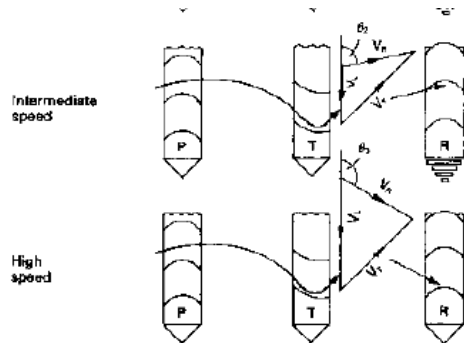
- Fluid Direction Entering the Stator Blades - Tangential Exit Velocity – Vortex Circulating Speed & Linear Velocity due to rotating turbine member
- Stall Condition – Fluid Direction Leaving the Impeller det by curvature and shape of turbine vanes.
- Fluid Direction move deep into concave side of stator blades where it reacts & flow towards the impeller in a direction which provides the maximum thrust



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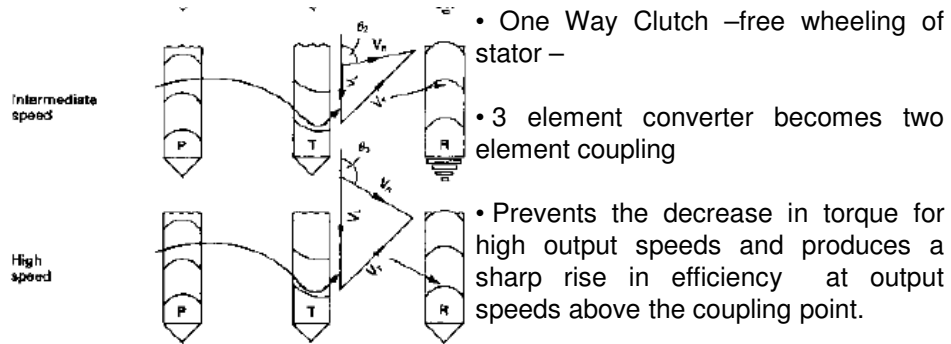
TORQUE CONVERTER

- As Turbine begins to rotate - Fluid will have Linear velocity – reduced reaction to stator
- Less Fluid Momentum
- Once Turbine Speed rises, Fluid linear forward velocity will also increase, Turbine Tangential Exit Velocity doesn't alter – now acts on convex back side of stator blades
- Stator reaction torque act in opposite sense and redirect the fluid.
- Resultant Fluid Direction will hinder impeller motion –cancel some of Engine's Input torque



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TORQUE CONVERTER



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TORQUE CONVERTER CHARACTERISTICS

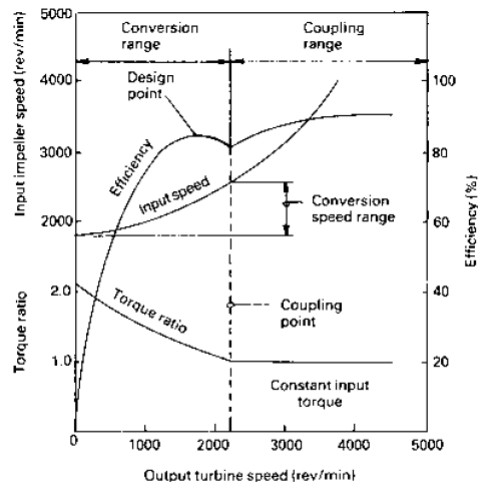


Fig. 4.11 Characteristic performance curves for a three element converted coupling

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TORQUE CONVERTER CHARACTERISTICS

- TM – max (diff b/w impeller speed and turbine speed is max)
- Torque o/p to input ratio of about 2:1 occurs (TR) – STALL – Vortex rate is max – Max Hydrokinetic energy transfer occurs
- Turbine output speed increases relative to impeller speed, the efficiency rises and vortex velocity decrease
- Torque o/p to input ratio comes to about 1:1, coupling point is reached – reaction torque is zero – above this speed stator is freewheeled – Improvement in coupling efficiency
- Under Load, Turbine output speed drop, increase in fluid circulation, rise in TM, coupling efficiency drop (more slip) – TR increases
- Load Reduces, Turbine output speed increases, coupling efficiency increases (less slip) – TR Reduces

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TORQUE CONVERTER CHARACTERISTICS

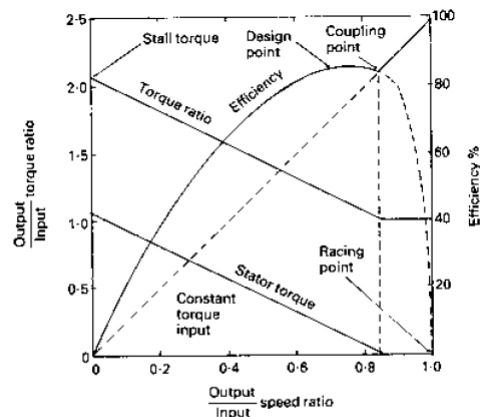


Fig. 4.12 Characteristic performance curves for a converter coupling plotted to a base of output (turbine speed) to input (impeller speed)

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TORQUE CONVERTER CHARACTERISTICS

- **Fluid Drive Efficiency:**

$$\text{Efficiency} = \frac{\text{Output work done}}{\text{Input work done}} \times 100$$

- **Speed Ratio:**

occur. This is normally defined in terms of a speed ratio of output (turbine) speed N_2 to the input (impeller) speed N_1 .

$$\text{i.e. Speed ratio} = \frac{N_2}{N_1}$$

- **Torque Ratio:**

more conveniently expressed in terms of a torque ratio of output (turbine) torque T_2 to the input (impeller) torque T_1 .

$$\text{i.e. Torque ratio} = \frac{T_2}{T_1}$$

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TORQUE CONVERTER CHARACTERISTICS

- **Stall Speed:** This is the maximum speed which the engine reaches when the accelerator pedal is fully down, the transmission in drive and the foot brake is fully applied. Under such conditions there is the greatest

- **Design Point:**

Torque converters are so designed that their internal passages formed by the vanes are shaped so as to make the fluid circulate with the minimum of resistance as it passes from one member to another member at definite impeller to turbine speed ratio, known as the *design point*. A typical value might be 0.8:1.

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TORQUE CONVERTER CHARACTERISTICS

- **Design Point:** • Above or Below this optimum speed ratio, change in fluid direction, flow will not be parallel to surfaces of the vanes – strike the sides of passenger vanes – momentum losses – efficiency decreases as speed ratio move away on either side.

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TORQUE CONVERTER CHARACTERISTICS

Coupling Point:

As the turbine speed approaches or exceeds that of the impeller, the effective direction of fluid entering the passages between the stator blades changes from pushing against the concave face to being redirected towards the convex (back) side of the blades. At this point, torque conversion due to fluid transfer from the fixed stator to the rotating impeller, ceases. The turbine speed when the direction of the stator reaction is reversed is known as the *coupling point* and is normally between 80 and 90% of the impeller speed. At this point the stator is

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TORQUE CONVERTER CHARACTERISTICS

Racing or Run- Away Point:

- Stator Not Functioning – fluid direction against impeller rotation – Vortex flow declines – Torque capacity of the converter approaches zero – Turbine speed catches up with that of impeller
- Accelerator Pedal fully down – very little load – impeller and turbine rotate at same speed, vortex circulation ceases(fluid resistance)

fluid resistance, racing will tend to begin slightly before a 1:1 speed ratio (a typical value might be 0.95:1).