
Kshitij 2014
Industrial
Design
Problem
TUTORIAL

Contents:

The Problem Statement

To Design a CVT system for following design requirement.

Power output: 1 MW, Turbine Rotor Speed: 9 - 17 RPM, Generator speed: 1800 RPM, 4 pole Generator.
Generator can be permanent magnet synchronous or Squirrel cage induction generator.

Design for Extreme Torque, which can be upto 3 times the nominal Torque.

Weight Restriction: Conventional gear box weighs approximately ~10t for similar design. CVT design should be 25% lower weight.

Continuously Variable Transmission

A **continuously variable transmission** (**CVT**) is a transmission that can change seamlessly through an infinite number of effective gear ratios between maximum and minimum values. This contrasts with other mechanical transmissions that offer a fixed number of gear ratios.

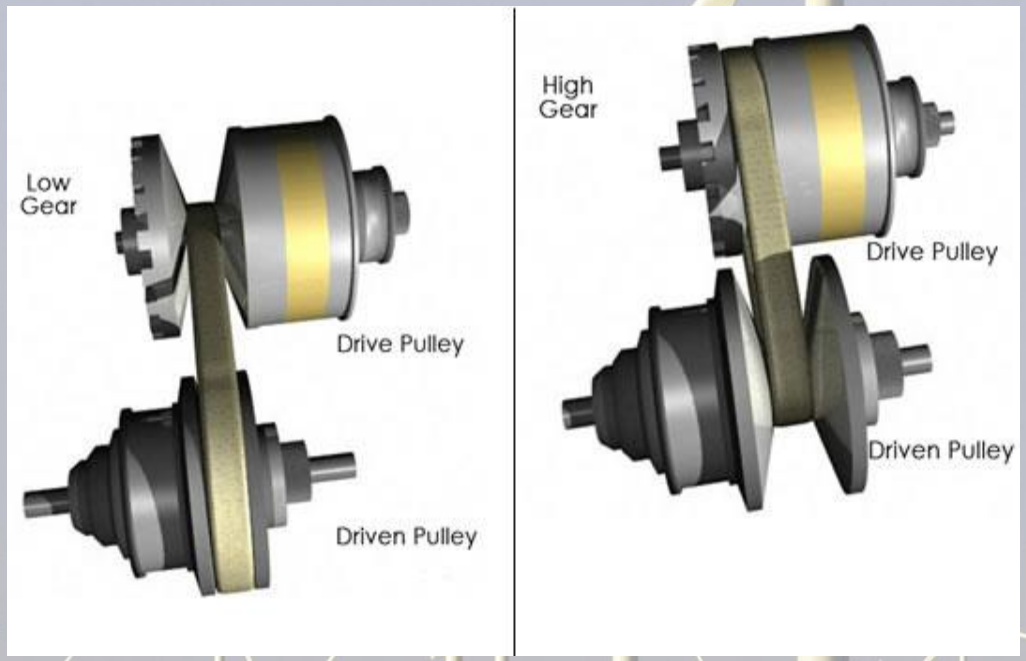
Main Types of CVTs:

- Metal Push Belt CVTs
- Toroidal Drive CVTs
- Hydrostatic CVTs

Metal Push Belt CVTs

Three Components:

- High-power metal or rubber belt
- A variable input “drive” pulley
- An output “driven” pulley

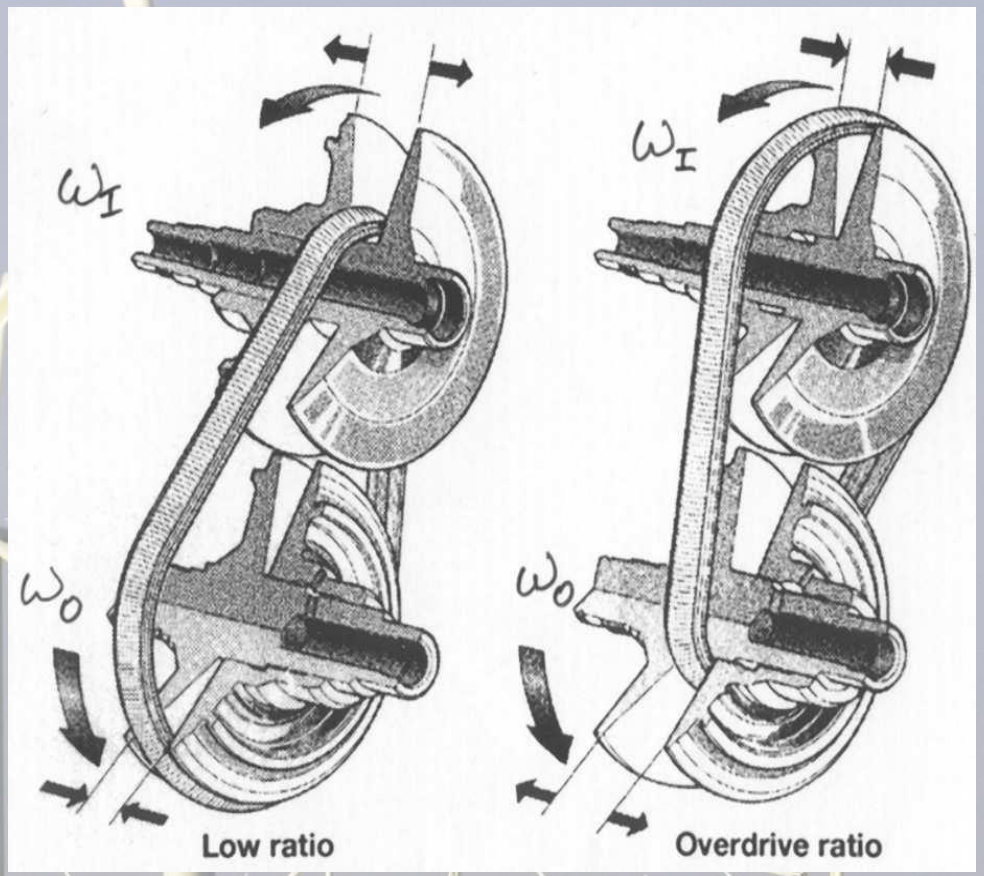


The distance between the centre of the pulleys to where the belt makes contact in the groove is known as the **pitch radius**. The ratio of the pitch radius on the driving pulley to the pitch radius on the driven pulley determines the **gear.**

Working of Metal Push Belt CVT

The belt rides lower or higher along the walls of the pulley, depending on driving conditions, thereby changing the gear ratio.

$$Gear\_ratio = \frac{r_o}{r_i} = \frac{\omega_o}{\omega_i}$$

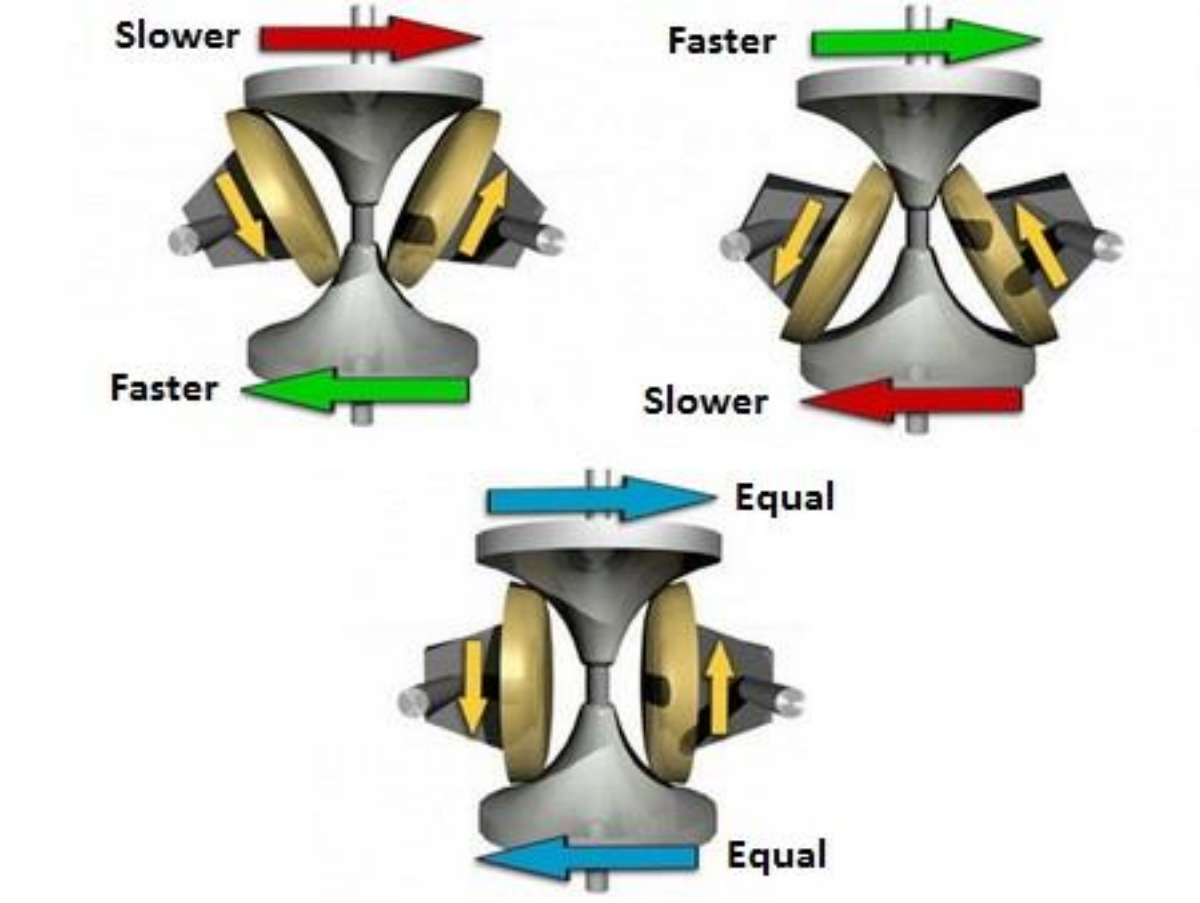


Toroidal CVTs

Toroidal CVTs replaces belts and pulleys with discs and rollers.

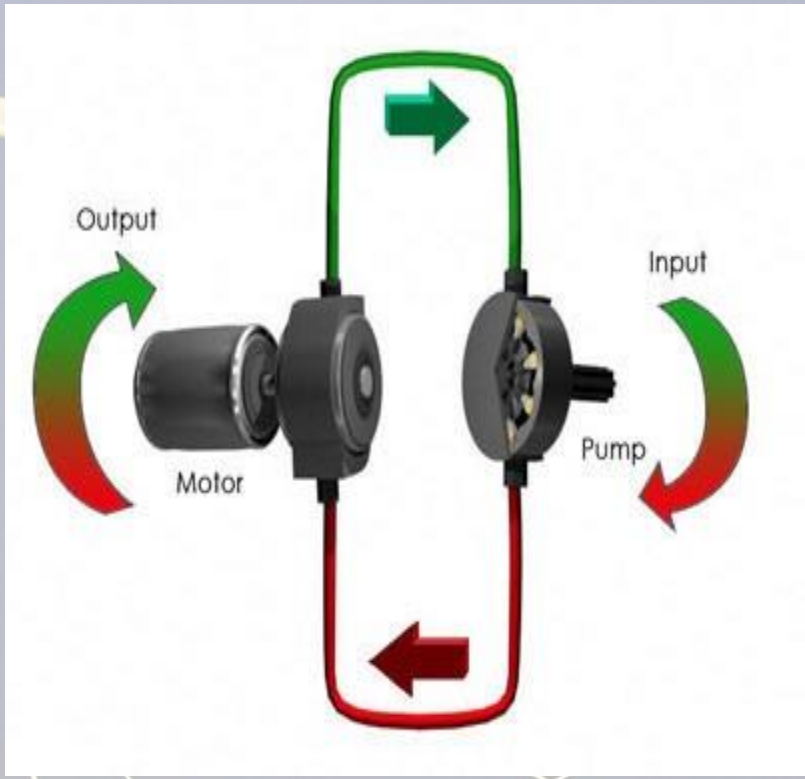
- A viscous fluid with high shear strength properties is fundamental in transmitting torque between rollers and discs.
- Rollers and discs never touch.
- The angle of the rollers changes relative to shaft position resulting in a change in gear ratio.
- The change in angle by a roller must be mirrored by the opposing roller.

Working of Toroidal CVT



Hydrostatic CVT

A hydrostatic CVT uses **variable-displacement pumps** to vary the fluid flow into hydrostatic motors. In this type of transmission, the rotational motion of the engine operates a hydrostatic pump on the driving side. The pump converts rotational motion into fluid flow. Then, with a hydrostatic motor located on the driven side, the fluid flow is converted back into rotational motion.



Advantages of CVT

- ✓ *Decreases engine fatigue*
- ✓ *Allows for an "infinite" number of gear ratios, maintaining the engine in its optimum power range*
- ✓ *More mechanically efficient than Automatic transmissions.*
- ✓ *Greater fuel efficiency than both manual and automatic transmissions.(Fuel savings of more than 17% have been achieved).*
- ✓ *Cheaper and lighter than Automatic trans.*
- ✓ *Smooth, responsive and quiet to drive*
- ✓ *Newer CVT's have a "manual" option, giving the driver more control, simulating a MT.*
- ✓ *CPU can be configured to suit a wide range of driving modes and styles.*

CVT in Cars

When you step on the gas pedal of a car with a continuously variable transmission, you notice the difference immediately.

- The engine revs up toward the rpm at which it produces the most power, and then it stays there. But the car doesn't react immediately.
- Then, a moment later, the transmission kicks in, accelerating the car slowly, steadily and without any shifts.
- In theory, a car with a CVT should reach 60 mph (100 km/hr) 25-percent faster than the same car with the same engine and a manual transmission. That's because the CVT converts every point on the engine's operating curve to a corresponding point on its own operating curve.
- CVTs are equally efficient on hills. There is no "gear hunting," because the CVT cycles without steps down to a gear ratio appropriate for the driving conditions. A conventional automatic transmission shifts back and forth trying to find the right gear, which is far less efficient.
- A CVT does not strictly require the presence of a clutch, allowing its dismissal.

Have a look at the video Nissan CVT explained

Principle Elements of a CVT in Cars:

- Primary clutch
- Secondary clutch
- Belt

The **primary clutch** is an advanced form of centrifugal clutch and is typically mounted to the output end of the engine crankshaft. The clutch has two sheave faces; one that is laterally fixed (stationary sheave), and one that can move in and out to engage the belt (moveable sheave). In most systems, at idle the sheave surfaces are spread at their widest spacing, the belt is riding on the post or shaft at the smallest diameter of the clutch, and the belt is not pinched by the sheave faces. This provides a “neutral” position that allows the engine to idle without transmitting power to the wheels.

- The **secondary clutch** is mounted to the input shaft of the transmission, transaxle, or the like. In modern CVT systems such as those used in recreational vehicles, the secondary clutch has two functions: as a “slave” to the primary clutch and to provide a torque sensing element.

clutch in a CVT http://www.youtube.com/watch?v=6TlCXoMi3VQ

Future of CVT

- The internal combustion (IC) engine is nearing both perfection and obsolescence; advancements in fuel economy and emissions have effectively stalled.
- CVTs could potentially allow IC vehicles to meet the first wave of new fuel regulations
- As CVT development continues, costs will be reduced further and performance will continue to increase.
- This cycle of improvement will ultimately give CVTs a solid foundation in the world's automotive infrastructure.