Types of Clutches

Before you learn about the different types of clutches, answer a quick question to check your knowledge of what a clutch is.

Which of the following statements defines a clutch accurately?

1. A device used to engage or disengage power from a driving shaft to a driven shaft
2. A mechanical device that slows or stops a moving object by absorbing energy
3. A device that joins two or more objects mechanically to create non-permanent joints
4. A machine element that constrains relative motion to only the desired motion while reducing friction and handling stress

Correct answer: 1

When engaged, a clutch provides for power transmission from one component to another, especially from driving shaft to driven-shaft. The driven shaft may be stopped without stopping the driving shaft. Also power is transferred, the clutch can disengage, and the driven shaft can be stopped without stopping the driving.

In automobiles with manual transmissions, the power from the engine crankshaft flows to the drive wheels through a clutch located between the engine and the gear box.
Introduction to Clutches

**Introduction**
Clutches fulfil the necessity to engage or disengage a machine without starting or stopping the driving. Clutches may be dry or wet.

**What Clutches Do**
- Enable slower, smooth, and quick engagement and disengagement
- Protect from overload by limiting maximum torque loads
- Prevent accidental machine reversal

**Dry Vs. Wet Clutches**
- Dry clutches are typically air cooled.
- Wet clutches are immersed in oil or coolant, which helps dissipate heat when the clutch slips.

There are five types of clutches. In this document, you will learn about the first four types of clutches and their sub-types and applications.
Positive Contact Clutch

Introduction
A positive clutch has machine elements resembling jaws that interlock with each other to connect shafts. It allows no slippage while engaging or disengaging.

Elements
A standard jaw positive-contact clutch has two elements—one fixed and the other moving. These elements are illustrated here.

Types
Based on the use or application, you can choose from different types of jaw machine elements in a clutch. Let’s look at the features of the two positive clutches.

Square Jaw

Components
- An actuation lever with a pivot attached to a solid surface. The other end of the lever is moved to engage or disengage the clutch.
- A bearing assembly (throw-out bearing). The moving jaw is attached to the actuating lever through the throw-out bearing assembly and keyed to the shaft.
- The movable jaw is designed to slide freely on the shaft while its opposite end is locked in place just as a coupling half would be.

Engagement Speed
Should be engaged or disengaged only when stationary.
### Engaged Spiral Jaw Clutch

**Components**
- A locking device keeps it engaged.
- In some cases, the locking device may be spring loaded, allowing the spiral jaw clutch to become an overload mechanism.
- Depending on the amount of force applied by the spring, the clutch disengages automatically when its threshold torque is reached.

**Engagement Speed**
Should be engaged at low speed.

**Variation**
A taper-tooth design using the same mechanism serves as an overload device, regardless of the direction in which the clutch is turning.

### Application
Positive clutches have limited use. However, they may be used in applications where synchronous drive is required.
Friction Clutch

Introduction
Unlike positive contact clutches, frictional clutches can engage gradually. They can transfer power smoothly regardless of the loads and speeds.

Factors Affecting Effectiveness

Coefficient of Friction of the Mating Materials

- Coefficient of friction = Force pressing the objects together / Force that resists sliding
- The larger the value, the more the resistance to movement. However, clutch and brake liner material should be heat resistant.

Surface Area

- Increasing the surface area of the mating surfaces makes the clutch/brake proportionally more effective.
- Physical space requirements may limit the maximize size of a clutch/brake.

Amount of Force Used

- Greater force pressing the clutch or brake surfaces together increases their effectiveness.

Types
There are two key types of friction clutches: Radial and Axial.

Radial Friction Clutch
In radial clutches, contact pressure is applied to the peripheral of a drum or rim. Here are a few examples.

How It Works
The flexible friction band around a smooth drum helps achieve braking when the linkage tightens the band.

Band/Strap Brake

Advantages and Disadvantages

- Easy to manufacture and use with predictable performance
- Unable to dissipate heat efficiently
- Has uneven friction material wear
- Has an open construction
Centrifugal Clutch

The heavier the spring, the higher the speed at which the clutch engages.

**Capacity Determiners**
- Shoe contact area
- Weight of shoe
- Type of friction material used
- Weight of spring

**Advantages and Disadvantages**
- ✓ Provides a soft start.
- ✓ Under normal conditions and speeds, there is no slippage.
- ✗ Under overload conditions, some slippage may occur. Constant slippage can overheat the clutch and damage it.

Enough capacity to lock up under normal operating conditions.

Axial Friction Clutch

In axial friction clutches, contact pressure is applied perpendicular to a rotating shaft.

**Key Features**
- High horsepower capabilities due to larger surface area.
- May be designed to run dry or wet.
- Used to engage or disengage only, or they may act as torque limiters by slipping under excessive torque

**Key Components**
- One or more metal pressure plates and friction discs (the friction disc is free to move or float on the driven shaft by using keyways or splines).
- Spring-loaded pressure plate to engage and disengage friction disc.
- Throw-out bearing for support when clutch is disengaged.
Here are a few examples of types of axial friction clutches.

**Multiple-Disc Clutch**

A multiple-disc clutch is usually wet.

**Application**

Used in motorcycles to increase torque while minimizing space and weight requirements. Automatic transitions in modern automobiles may use three or more multiple-disc packs.

**How It Works**

Additional friction discs are sandwiched between metal plates to add to the surface area, thereby increasing torque capacity.

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**Mechanical Axial Brake**

**Advantages and Disadvantages**

✔ Low Maintenance and dependable.

✘ Requires larger force to brake than radial and drum brakes.

**Application**

- Automobiles may use power-assisted hydraulics to actuate disc brakes.
- In industrial application, disc brakes may be actuated by mechanical, pneumatic, hydraulic, or electric actuators.

Hollow discs with ribs and slots for air to flow between braking surfaces may be used to dissipate excessive heat.
Cone Clutch

Key Features
- Cone clutches are a combination of radial and axial type clutches.
- Due to the wedging action of the cone inside a matching drum, force required for activation is less than in purely radial or axial clutches.

Application
- High-speed application with lower horsepower requirements.

Fluid Clutch

Introduction
A fluid clutch uses liquid to transmit torque.

Elements
- An impeller rotates and imparts energy by centrifugal force to a viscous fluid.
- This fluid then imparts its motion to a runner attached to the output shaft.
- The impeller and runner vanes have a small clearance between them, allowing a little slippage, varying with the amount of fluid. The more the fluid, the less the slippage.

Variation
Another common industrial fluid clutch uses dry pellets called shot instead of oil or liquids as the fluid media. Physically, it looks the same as a fluid clutch. Take a look at how it works.
# Fluid Clutch Using Dry Pellets

## Key Components
- The motor or driver turns the clutch housing.
- A rotor attached to the driven shafts is inside the housing.
- Loose pellets, generally steel shot, are also used in the housing. The amount of shot used in this dry clutch is called flow charge.

## How It Works

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<thead>
<tr>
<th>Event</th>
<th>Description</th>
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<tbody>
<tr>
<td>As the speed increases,</td>
<td>Centrifugal force locks the shot into place.</td>
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<tr>
<td>The housing and rotor become locked together at the same speed.</td>
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<tr>
<td>When the clutch starts to rotate, the shot becomes evenly distributed.</td>
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<tr>
<td>When there is no rotation, the shot lies at the bottom of the housing.</td>
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</tr>
<tr>
<td>The rotor starts to turn because of the friction between the shot and the housing.</td>
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## Advantages
- Low maintenance
- Soft starts
- Overload and shock protection
- Efficiency usually lies between 97–99% in a well-designed system.

## Disadvantages
- Possible fluid leakage
- No positive lockup
- Need for an external cooling system for heat dissipation.

## Selection
- Correct selection of a fluid clutch allows for soft starts with less initial amperage draw, which can be critical with large electric-motor applications.
- Too much slip can shorten the clutch life as the shot used is highly abrasive and may wear out the rotor and housing quickly.

It should be sized lock up under normal operating conditions and slip under high overload conditions to prevent damage to equipment.

## Application
Dry fluid clutches constitute a simple, efficient, and economic solution for industrial applications needing soft start and overload protection.
Magnetic Clutch and Brake

Introduction

Similar to dry fluid clutches, magnetic-article clutches use electricity to activate a clutch or brake. They are used mainly for starting or stopping and are not suited for continuous slip operation. Their horsepower capabilities range from fractional to several hundred.

Elements

- A rotor is mounted in a sealed housing.
- The electromagnet is energized, and the metal particles lock into patterns formed by the magnetic flux lines and immobilize the rotor inside the housing.
- When the electromagnet is de-energized, the magnetic field is lost and the rotor returns to inside the housing.

Types

Two types of magnetic clutches are eddy current clutch and hysteresis clutch. Let’s take a look at their key features.

Eddy Current Clutch

Key Features

- Never locks completely and always has some slippage.
- Rotor speed never reaches the housing speed.
- Frequent overloads don’t harm the clutch or equipment.
- Poor choice for brakes because of the rotation speed required to produce the eddy currents that make these clutches operate.

Torque Adjustment

How It Works
- A non-contacting, non-ferrous rotor, usually made of copper or aluminium, is sandwiched between two magnetic discs mounted in a housing.
- The electric current induced in the rotor by the magnetic field causes the rotor to rotate.

The torque can be adjusted by misaligning the magnetic poles of the two magnetic discs on either side of the rotor.
- Max torque obtained by north-south magnetic-pole arrangement.
- Min torque obtained by north-north and south-south magnetic-pole arrangement.

**Application**
Eddy current clutches are used in industries where overloads frequently occur. They work well in applications that require constant torque but should never be used in applications where synchronization between input and output is required.

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**Hysteresis Clutch**

**Key Features**
- Like eddy current clutches, these clutches have no contact surface to wear. Therefore, clutch characteristics are stable over a long life.
- The performance and life depends on heat generation and dissipation.

**Torque Adjustment**
- Clutch input and output synchronize as long as the rated torque value is not exceeded.
- Torque is proportional to the coil current and can be adjusted.

**Application**
Hysteresis clutches are typically used in tensioning applications such as winding operations, conveyors, and rewinding. They also work well in any constant tension or torque applications.
Selecting a Magnetic Clutch

- Make sure that the heat generated by cycling and slip doesn’t exceed a value that would cause damage to the metal powder.
- Check with the manufacturer for temperature limitations of specific models of clutches/brakes.

Limitations

- Rotational speeds that exceed manufacturer’s recommendations will generate excessive centrifugal force, which causes the slip and torque to become erratic.
- In extreme cases, the clutch may even engage due to centrifugal force, locking the metal powder and rotor.

Application

- Manufactured in a wide range of configurations and sizes, these clutches and brakes may be integral to a motor or another piece of equipment or may be mounted separately.
- The lifespan of a carefully selected and sized clutch is excellent, without much maintenance required.
- These clutches are used in applications where rapid cycling is required.
- This clutch forms a good choice for automated production processes as its lock-and-unlock torque characteristics are consistent and predictable.