



MACHINE ELEMENTS

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INTRODUCTION

- Machine- an assembly of a number of smaller components.
- Mechanical systems/devices are designed to transmit power and accomplish specific patterns of motion.

Some such functions and components are listed below.

Function	Component
To hold two components together	Nuts & bolts, screws, pins, couplings, keys etc.
To transmit power of motion	Shafts, gears, pulleys, sprockets, chains, belts, clutches, breaks etc
To give support to other components	Bearings, brackets, axles etc.



SHAFTS

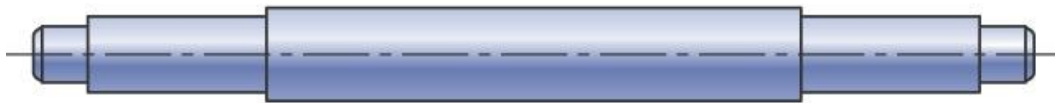
- Rotating member which transmits power from one point to another.
- Different types of shafts are as follows:
 - **Transmission shafts** used to transmit power from the source to the machine which absorbs the power.
 - Shaft subjected to torque, bending moment and/or axial forces.
 - Transmission shafts support transmission elements like gears, pulleys, sprockets
 - **Spindle** is a short shaft used to give motion to a cutting tool/workpiece on a machine tool.
 - **Axle** is a non rotating machine element that supports rotating elements like pulleys etc. It does not transmit power.



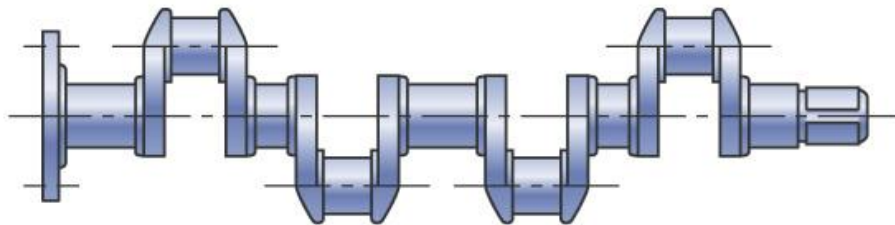
COMMON SHAFT TYPES



(a)



(b)

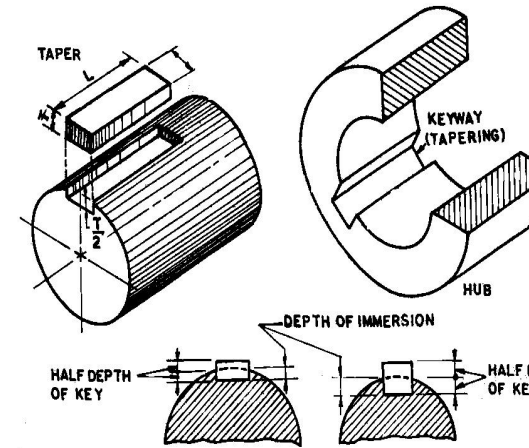


(c)

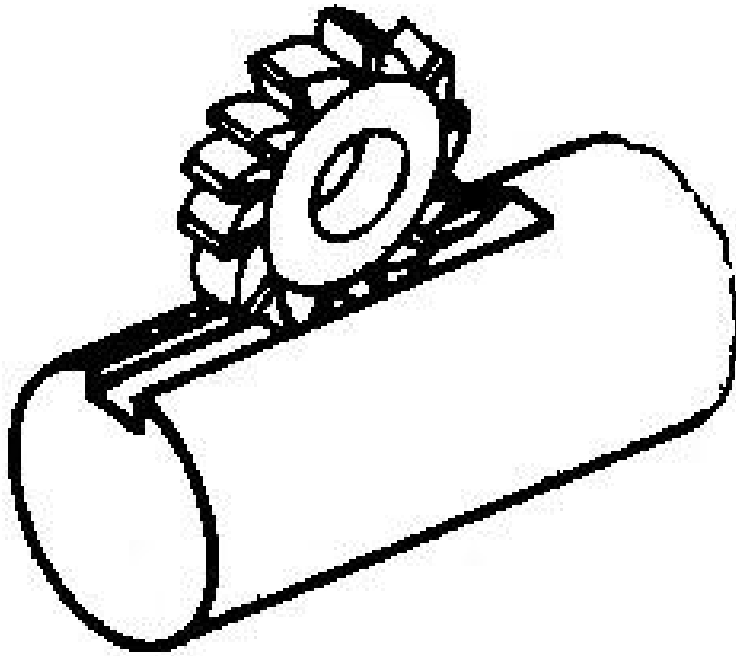


KEYS

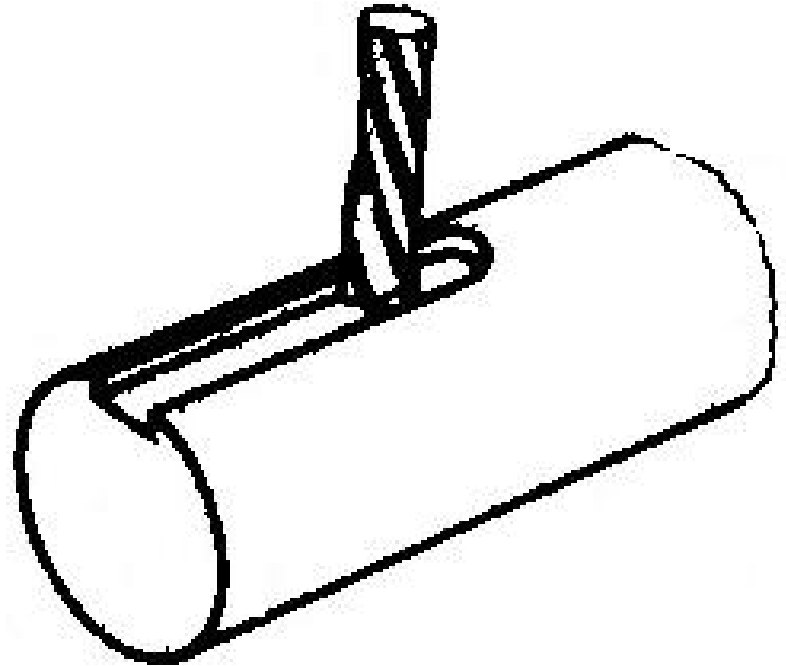
- Element used on shafts to secure the rotating elements like gears, pulleys, sprockets etc. and prevent relative motion between the two..
- May allow sliding movement along the shaft if required.
- **Keyway** is a slot/recess in a shaft and hub of the rotating element to accommodate a key.
- **Functions of Key**
 - To prevent the relative motion between the shaft and the hub of the rotating element like gear, pulley etc.
 - To transmit the torque from the shaft to the rotating element or vice-versa.



KEYWAYS MILLED



horizontally



vertically

Keys are made up of plain carbon steels and alloy steels. Generally, material used for key is of lesser strength than the shaft material so that if at all there is a failure the key should fail instead of shaft.

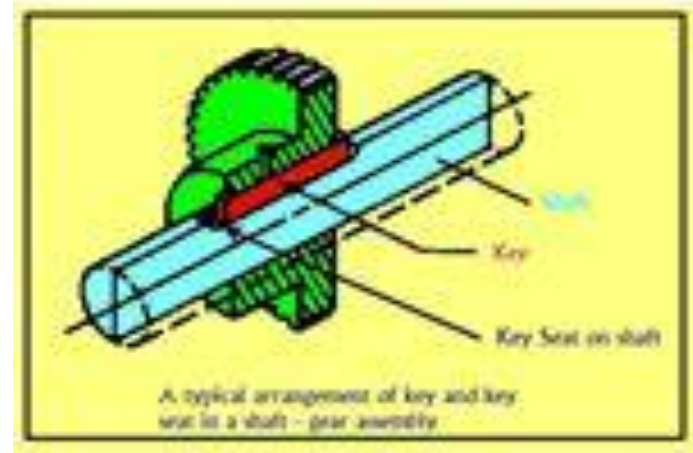
- There are two basic types of key:
- (a) *Sunk keys* which are sunk into the shaft and into the hub for half their thickness in each. These keys are suitable for heavy duty applications.
 - Taper sunk keys
 - Parallel sunk keys
 - Feather keys
- b) *Saddle keys* which are sunk into the hub only. Suitable only for light duty applications.
 - Hollow saddle key
 - Flat saddle key



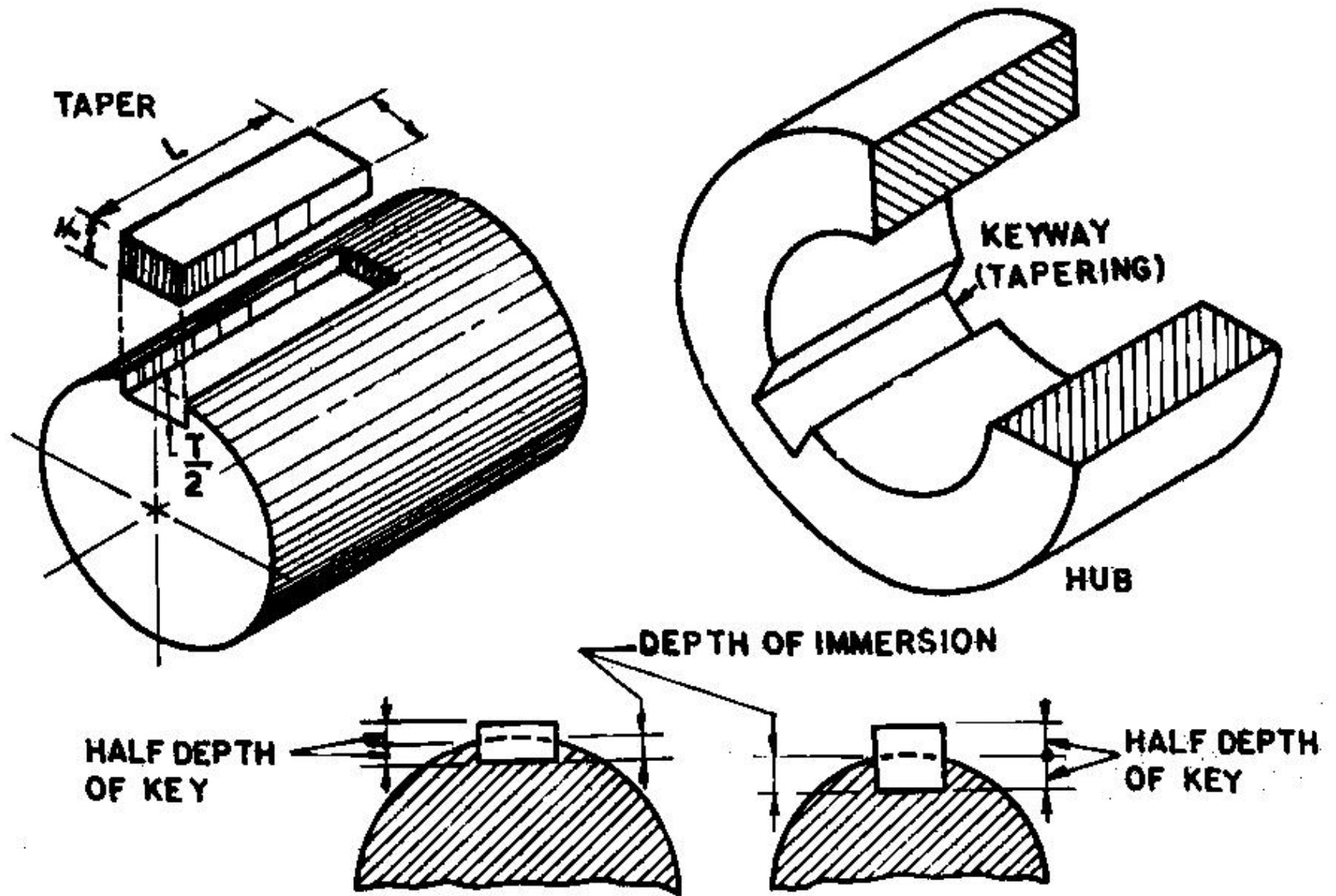
SUNK KEYS

- Sunk keys are sunk in the shaft and the hub. These keys are suitable for heavy duty since they rely on positive drive.
- Taper sunk keys:

This is the standard form of the key and may be either of rectangular or square cross-section. The key is sunk in the shaft to a depth of half its nominal thickness when measured at the side.



SUNK TAPER KEY

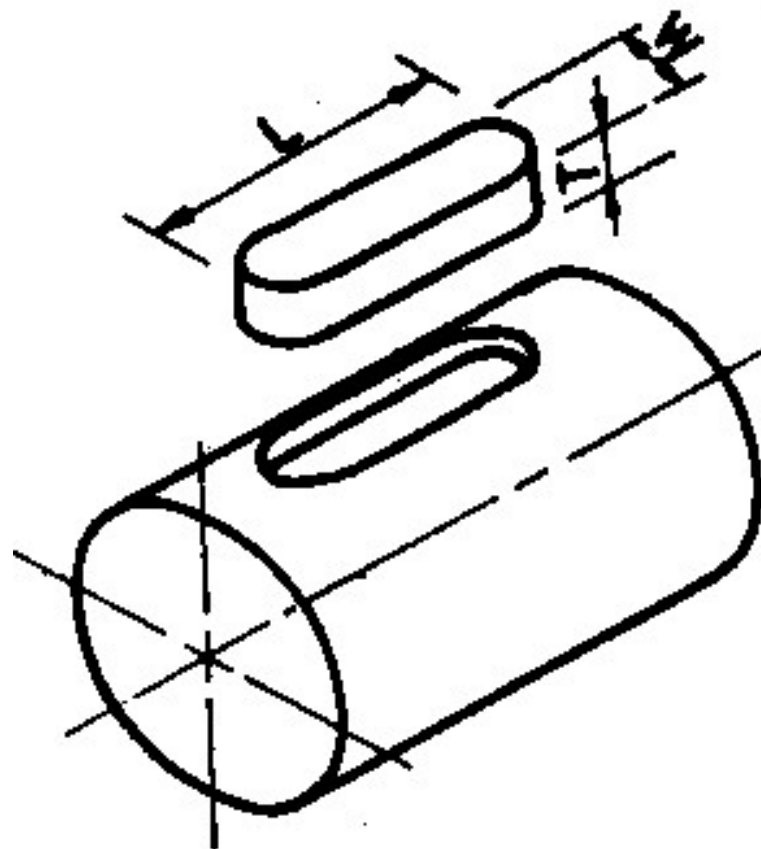


PARALLEL SUNK KEY

It is uniform in width and thickness throughout.

It is thus taper less and is used where the pulley or other mating piece is required to slide along the shaft.

It may be rectangular or square cross-section and their ends may be squared or rounded.

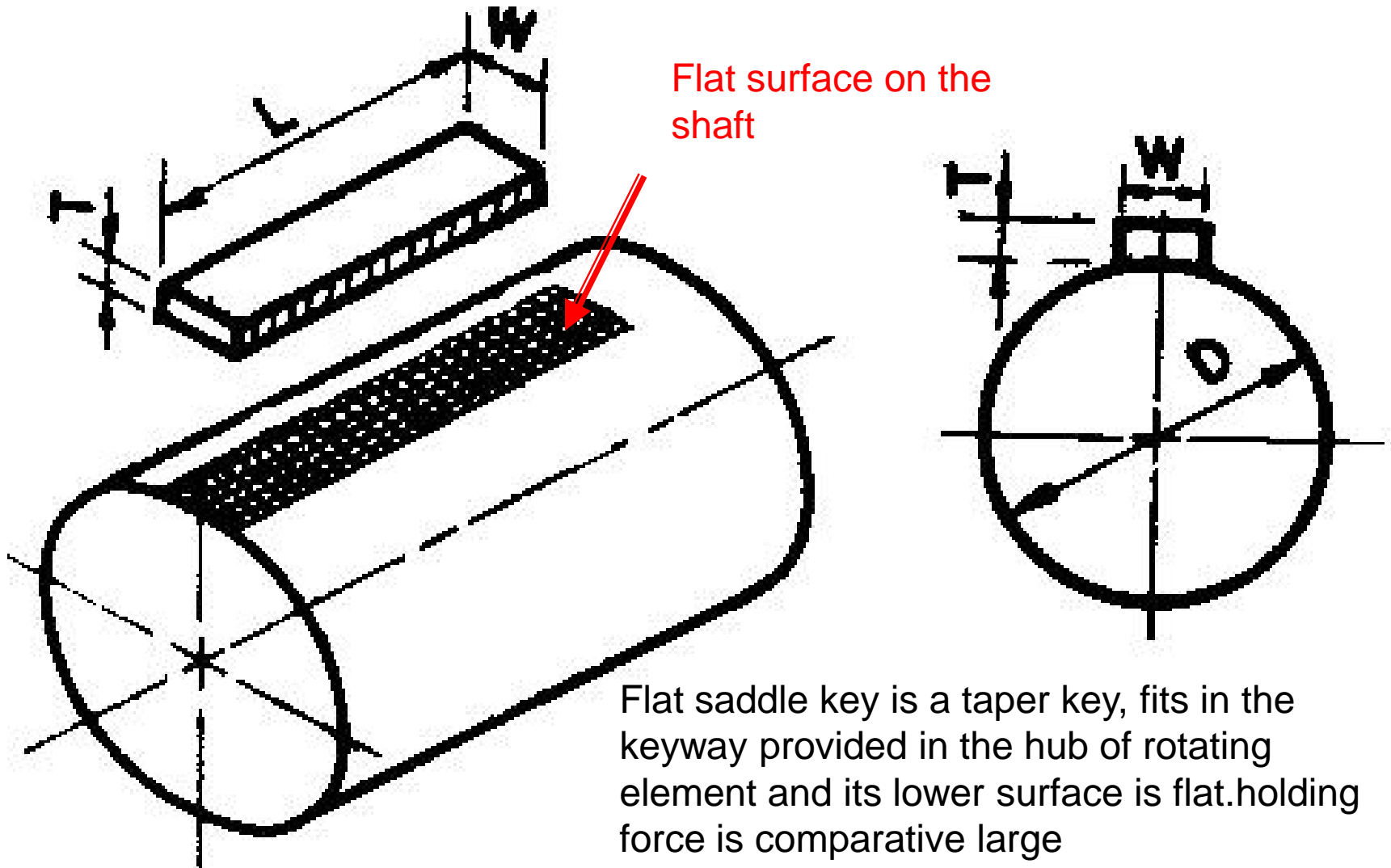


SADDLE KEYS

- Saddle key are taper keys which completely fits in the keyway provided in the hub of rotating element.
- Taper prevents axial movement along the shaft.
- Saddle key is suitable for light duty, since they rely on a friction drive alone. Torque transmitted due to friction between the key and the shaft and are liable to slip on the shaft under load.



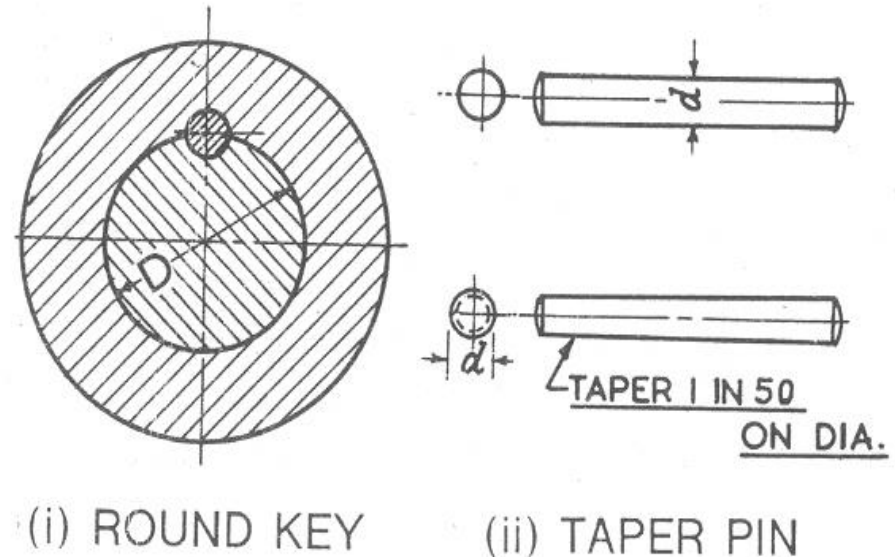
FLAT SADDLE KEY



Flat surface on the shaft

Flat saddle key is a taper key, fits in the keyway provided in the hub of rotating element and its lower surface is flat. holding force is comparative large than the hollow saddle key

Round key or Pin Key:



- It is a straight pin of circular cross section, fitted into a common hole drilled at the interface of the shaft and hub.
- A taper pin is a pin of circular cross section, fitted into a common hole drilled through the hub and shaft, which is perpendicular to the axis of the shaft.
- Commonly used for low power drives.



Couplings



Coupling is a device used to connect two shafts permanently so that necessary torque and power can be transmitted.

Clutch is also a connecting element. Clutch permits rapid connection and disconnection of driving and driven shafts as and when driver desires.



(a) Assembled coupling

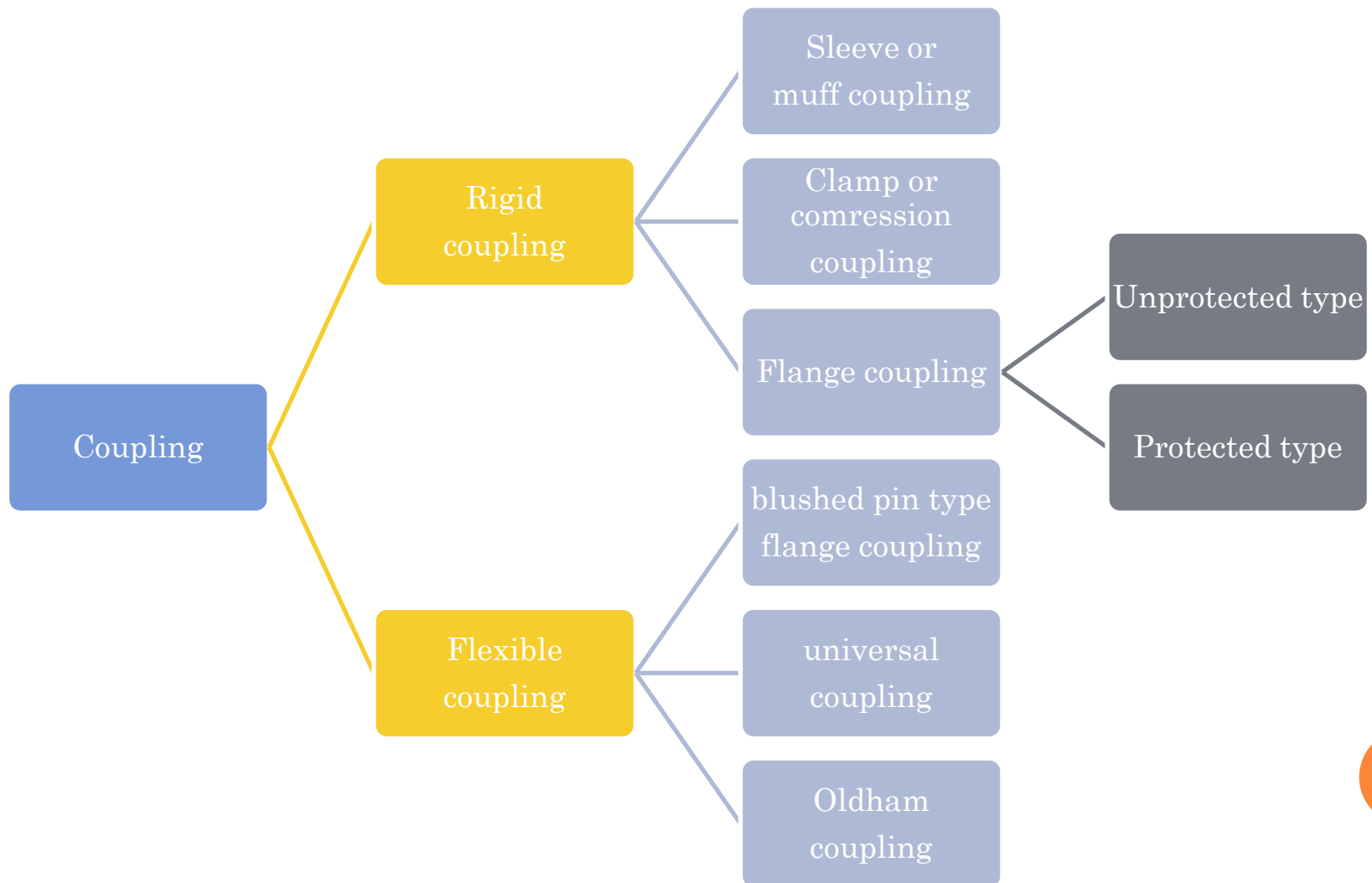
Requirements of a good coupler are:

- Must transmit full power of the driving shaft
- Easy connection/disconnection of coupling
- Must keep the shaft in perfect alignment
- Shock free transmission of power

Shafts are mostly available up to 7 meters length due to transport difficulty. To get a greater length , it is necessary to joint two or more pieces of the shaft using coupling.



TYPES OF COUPLINGS

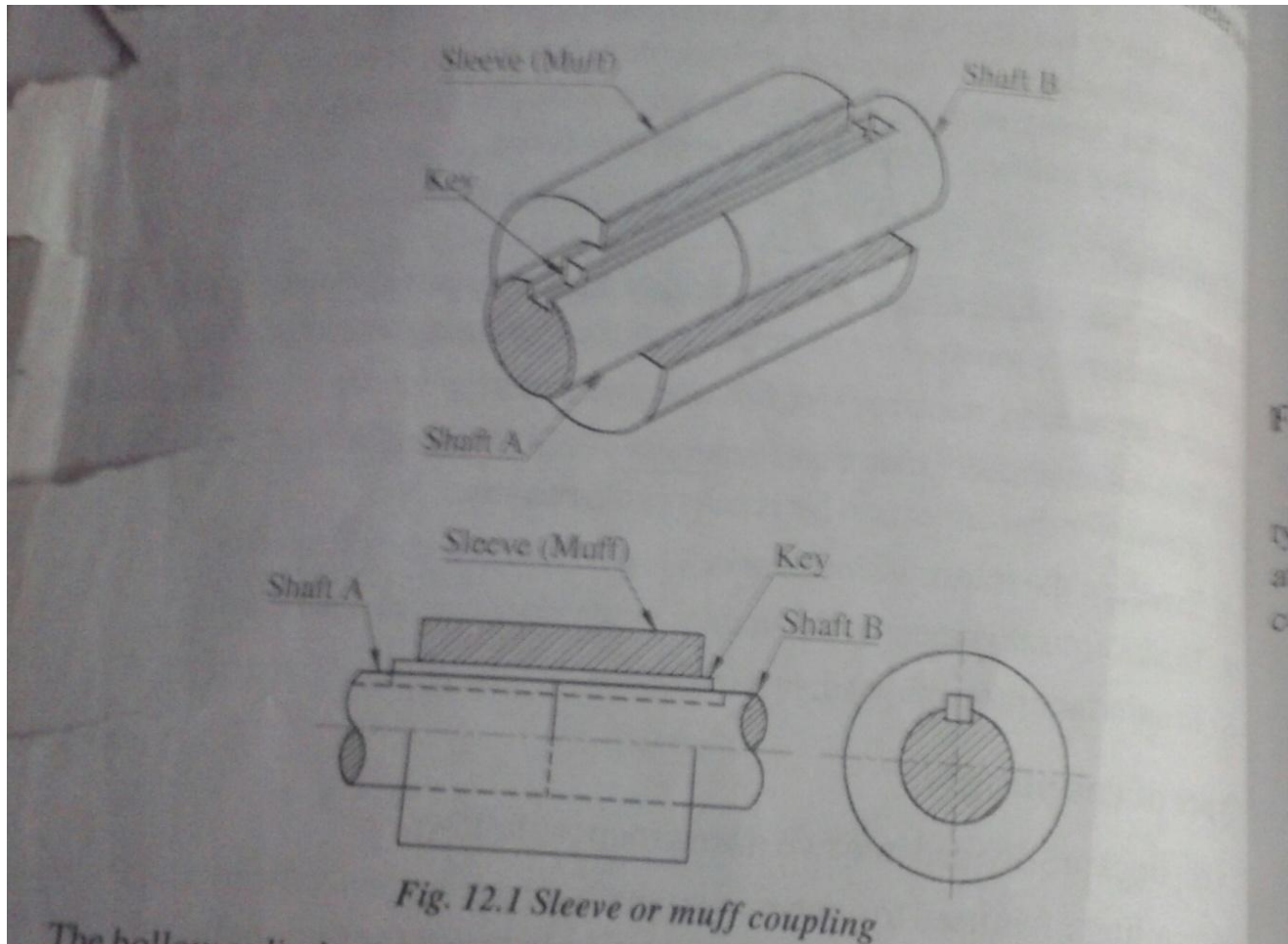


RIGID COUPLING-SLEEVE/MUFF COUPLING

- It is made from cast iron and very simple to design and manufacture.
- It consists of a hollow cylinder whose inner diameter is the same as diameter of the shaft.
- The hollow cylinder is fitted over the end of the two shafts with the help of taper sunk key.
- A key and sleeve useful to transmit power from one shaft to the other shaft.
- The main disadvantage of this coupling is that it is difficult to assemble when there is no perfect alignment between shafts.

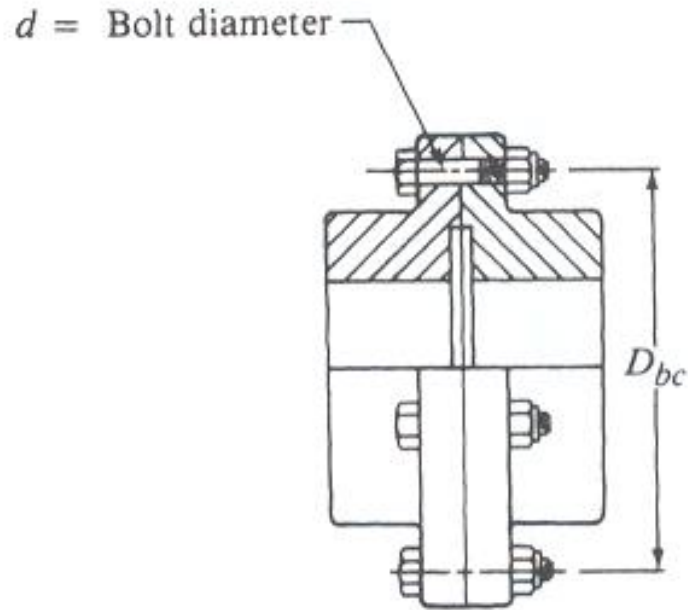


Sleeve or muff coupling



RIGID COUPLINGS-

FLANGE COUPLING



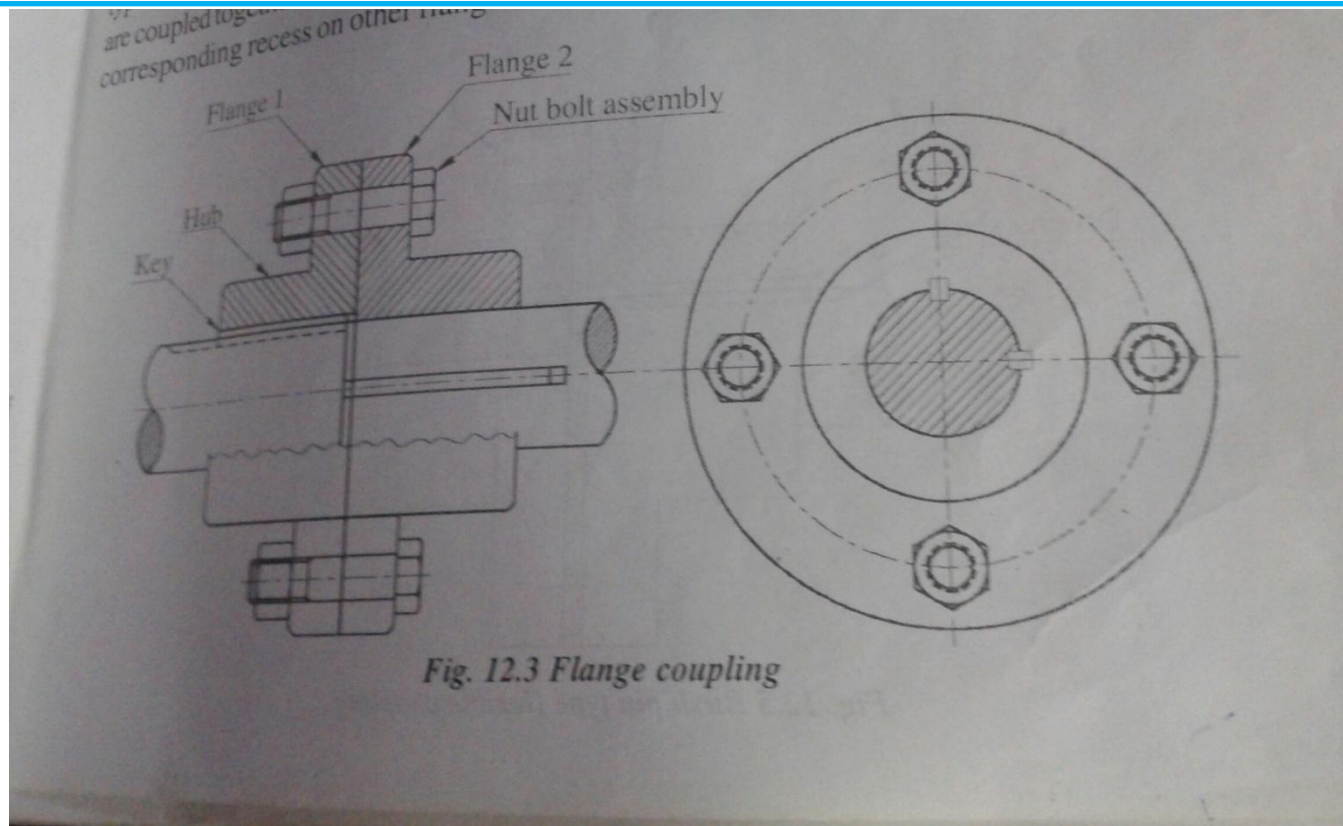
Cutaway view

No relative motion between the shafts.

Precise alignment of the shafts



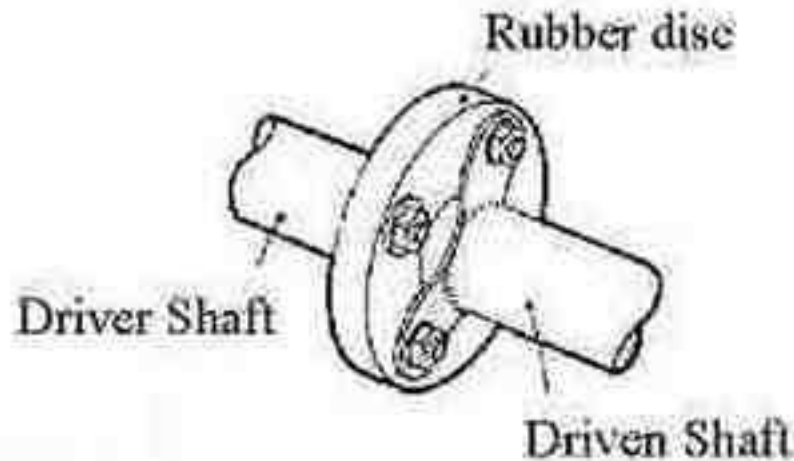
Flange coupling



In flange couplings, Flanges are provided at the end of the shaft. They are fastened together by bolts and nuts.



FLEXIBLE COUPLING

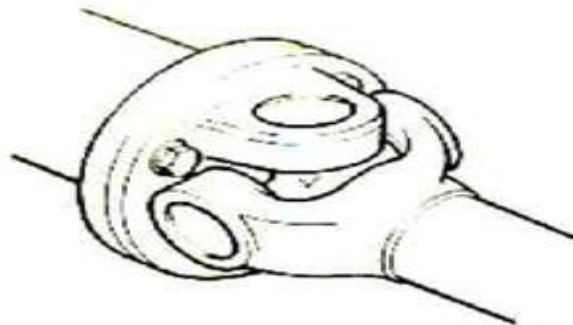


- Both shafts are bolted to a rubber disc. Power transmitted through the flexible rubber bushes which takes care of misalignment of shafts. The flexibility of the disc compensates for the change in angle.
- Can handle approximately 1 to 12 mm of misalignment depending on the size of the coupling.



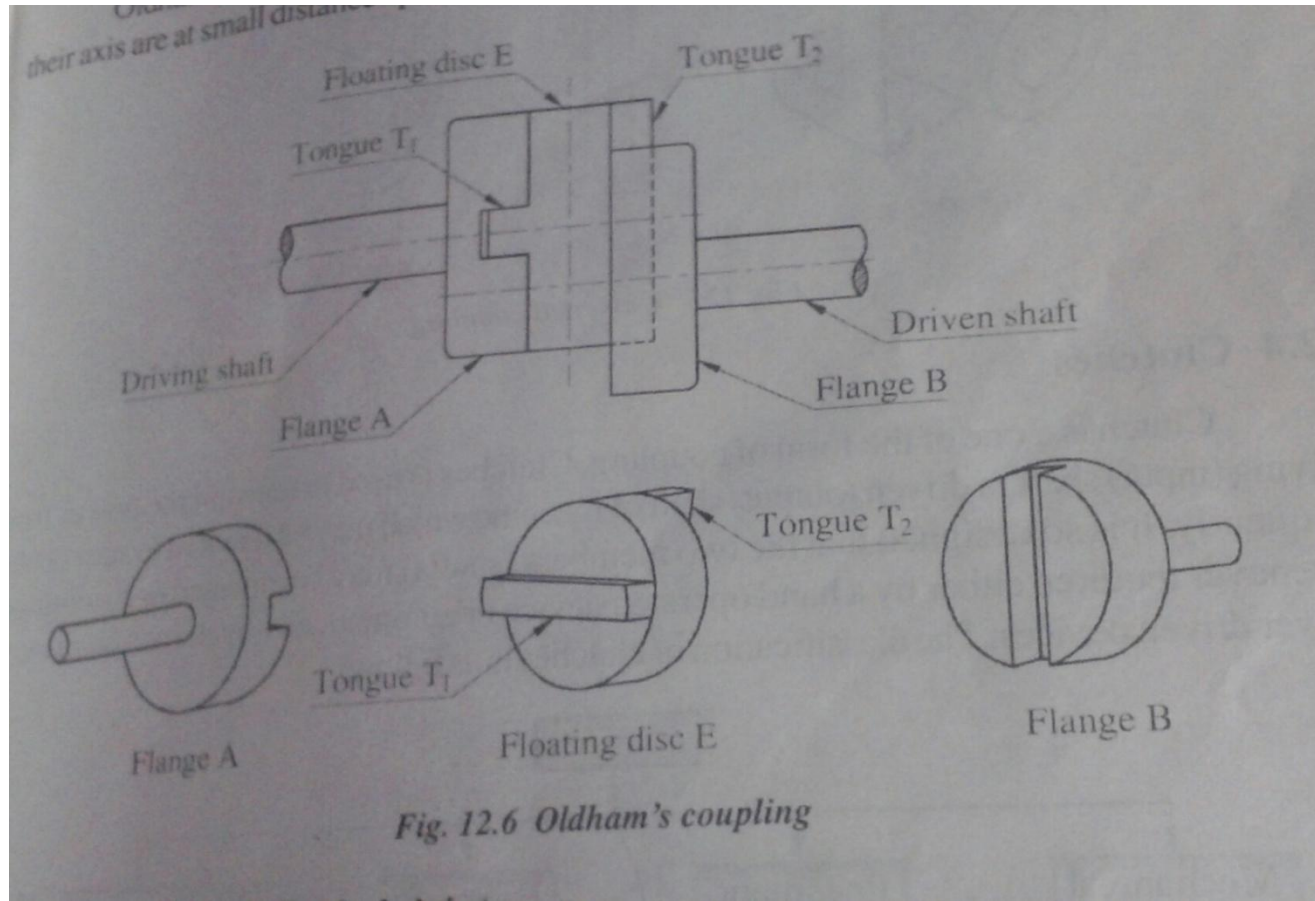
UNIVERSAL COUPLING/HOOK'S JOINT

- Universal coupling consists of two similar forks keyed on the ends of the two shafts.
- This coupling is used to connect/transmit motion and power to two intersecting shafts.
- Also in the cases of shafts having angular misalignment.
- It is widely used in automobile power transmission.
- To transmit motion to adjustable shafts like spindles of drilling machines and other machine tools.




OLDHAM'S COUPLING

- It consists of two flanges and a central floating disc.
- This coupling is used in connecting two parallel shafts but not in alignment, and their axes are at a small distance apart.



FUNCTION OF A BEARING

- It is a machine element that supports a sliding or rotating member of a machine and confines its motion.
 - It needs a good support to ensure stability and frictionless rotation. The support for the shaft is known as “bearing”.
 - All bearings are provided some lubrication arrangement to reduce friction between shaft and bearing.
- 

CLASSIFICATION OF BEARINGS

- Sliding Contact Bearing: They support the revolving component under the condition of relative sliding motion of shaft surface over the bearing surface separated by a thick film of lubrication.
- Roller Contact bearing: To support rotating shafts. It facilitates rolling motion between the mating members with the help of cylindrical or spherical balls.



SLIDING CONTACT BEARINGS



- Solid Journal bearing:
- Hollow cast iron cylindrical block to receive a shaft.
- Extension in the form of base plate with holes to bolt the bearing with the frame of the machine.



SLIDING CONTACT BEARINGS CONTD..



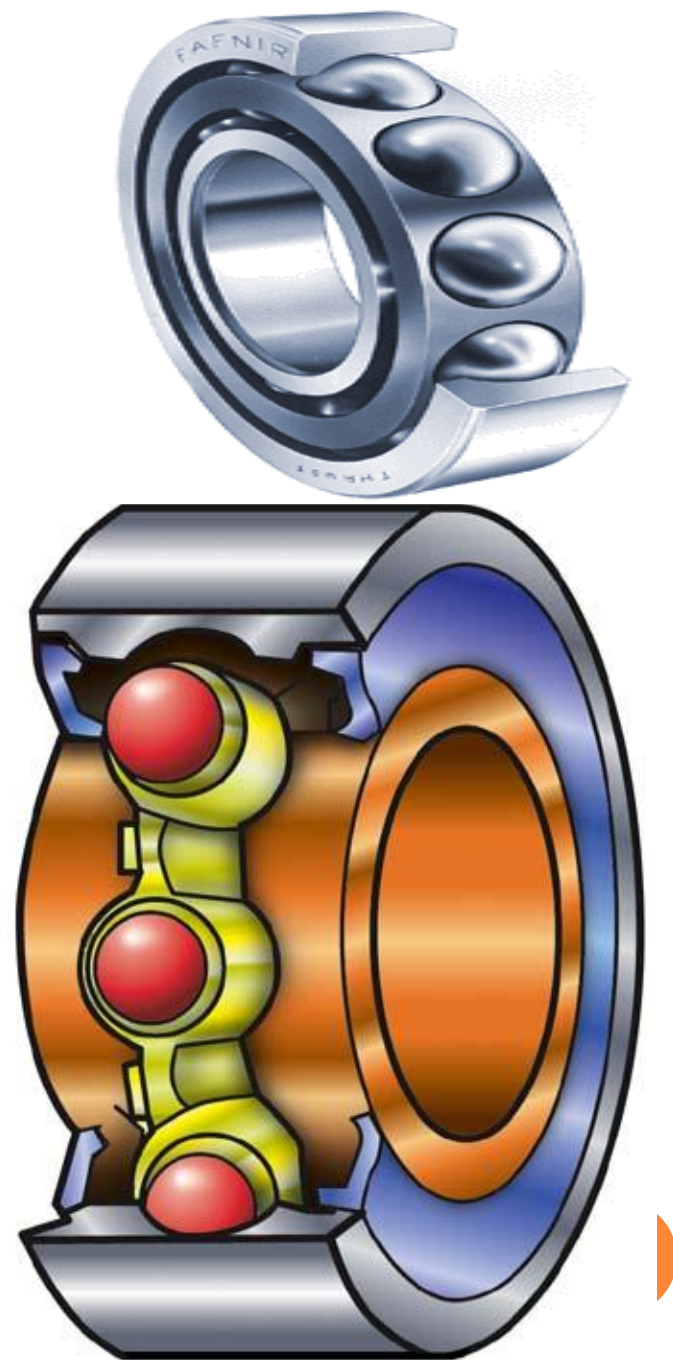
- Bush bearing:
- A solid bush (made of brass/bronze/Al alloy) is inserted in the hole provided in the cast iron body of the bearing.
- Worn out bush can be replaced by another bush instead of discarding the whole bearing.
- Used for Centrifugal pumps, motors, generators etc.



ROLLER CONTACT BEARINGS

○ Ball Bearing

- Incorporates hardened steel balls
- Steel balls geometrically contact inner and outer race at a point, which helps it spin very smoothly
- But this creates high stresses locally, so if bearing overloaded, the balls can deform, damaging the bearing.
- Ball bearings have good capacity to withstand radial and axial loads.



ROLLER BEARINGS

○ Roller Bearings

- Hardened steel cylindrical rollers
- Line contact deforms into areas larger than ball bearings
- Capable of carrying higher radial loads
- Long life
- Selected when maximum load capacity is required in a given space.
- Also suitable under impact and shock loads.



TYPES OF ROLLER BEARINGS

○ Cylindrical Roller bearings

- Cylindrical rollers in guide ways.
- They have line contact instead of point contact as in ball bearings. So larger contact area. Load distributed over a larger area. Hence increased load carrying capacity.



TYPES OF ROLLER BEARINGS CONTD...

○ Spherical Roller Bearings

- Spherical rollers in spherical guideways.
- Can carry both radial and thrust loads and permits a small amount of angular misalignment of shaft.



TYPES OF ROLLER BEARINGS CONTD...

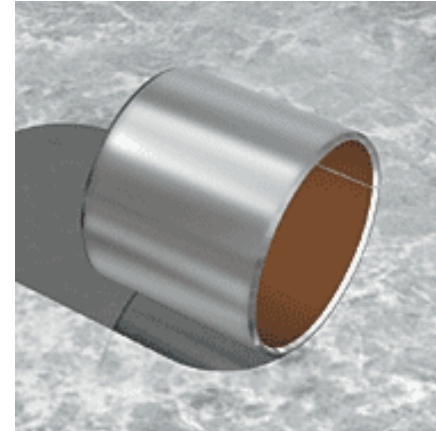
○ Tapered Roller Bearing

- Support high thrust loads (wheel bearing)
- Supports radial load (car weight) while supporting thrust loads (cornering)



OTHER TYPES OF BEARINGS

- Self Lubricating Bearings
 - Low Friction
 - No lubrication needed



Elastomeric Bearings



○ Bearing Materials:

- Material should have high compressive strength, wear resistance, high thermal conductivity and high corrosion resistance.
- Metals like aluminium alloys, brass, bronze
- Non metals like plastics(Nylon, teflon), graphite, rubber etc.



POWER TRANSMISSION



INTRODUCTION

- The system that is used to transmit power from one mechanical element to another mechanical element.
- Rotating elements which possess mechanical energy has to be utilized at required place by transmitting.
 - From prime mover to machine
 - From one shaft to another

TYPES OF DRIVES

○ Types of drives extensively used are

- (1) Belt drives
- (2) Rope drives
- (3) Chain drives
- (4) Gear drive

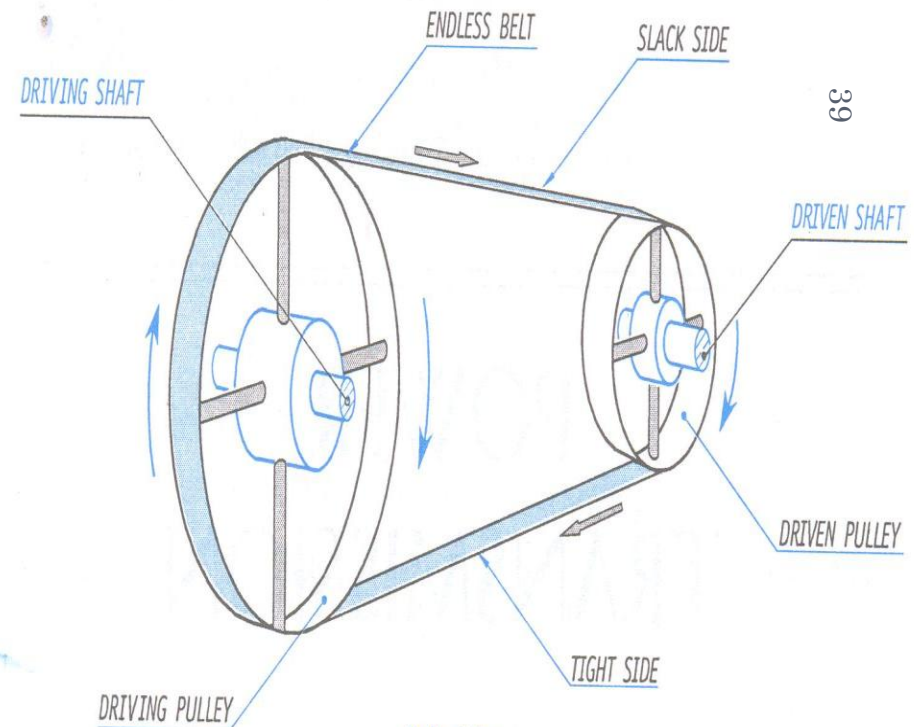
Reasons for applying drives in machines are:

- Required speeds of motion of operating members not coinciding with rated speeds of electric motor power the machine
- To obtain variable speeds (like automobiles)
- To convert rotary motion to linear motion

- Motor can't be directly linked to the operating mechanisms because of overall size of the machine.
- Factors to select transmission system
 - Distance between driver and driven pulley shaft.
 - Operational speed.
 - Power to be transmitted

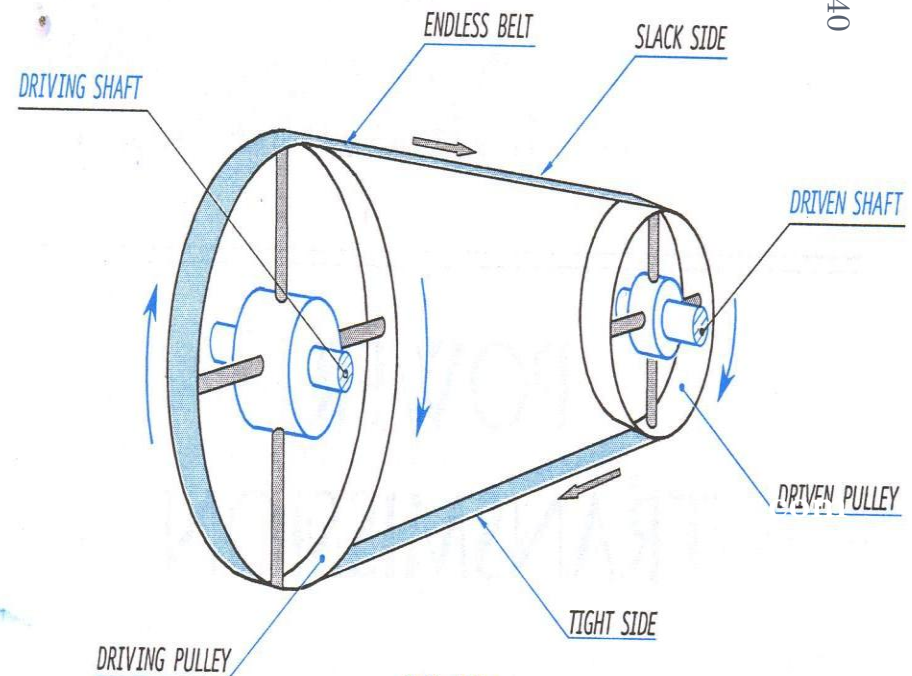
BELT DRIVE

- Power is to be transmitted between the parallel shafts.
- Consists of two pulleys over which an endless belt is passed encircling the both.
- Rotary motion is transmitted from driving pulley to driven pulley.



Belt Drive
Fig. 9.1

- Friction is a helpful agent.
- Tension in one side of the belt
 - Portion of the belt having less tension is called slack side.
 - Portion of the belt having high tension is called tight side.



Belt Drive
Fig. 9.1

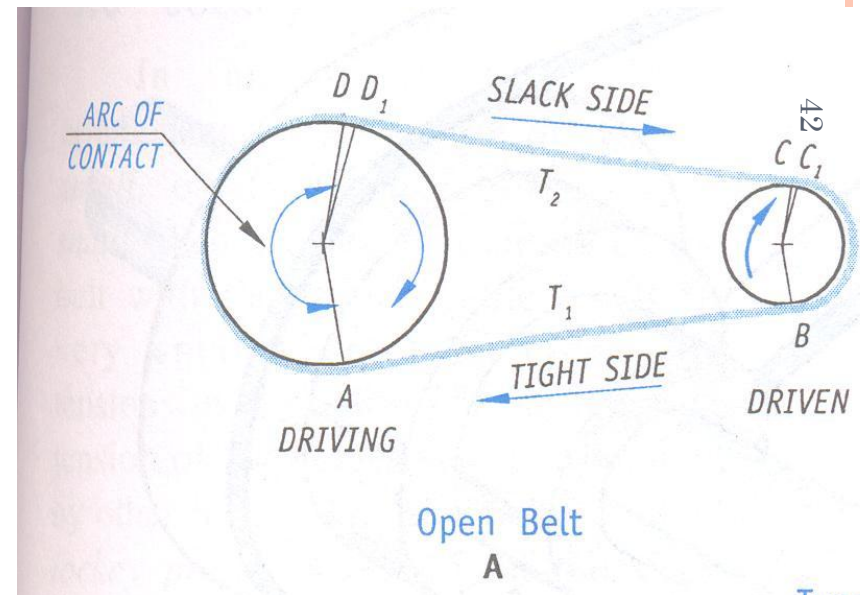
TERMINOLOGY OF A BELT DRIVE

- Driver : in a transmission system the one which drives or supplies power to other mechanical element.
- Driven : in a transmission system the one which follows the driver or receives power from driver.
- Tight side : the portion of the belt in maximum tension. Denoted by T_1 Newton.
- Slack side : the portion of the belt in minimum tension. Denoted by T_2 Newton.

CLASSIFICATION OF BELT DRIVES

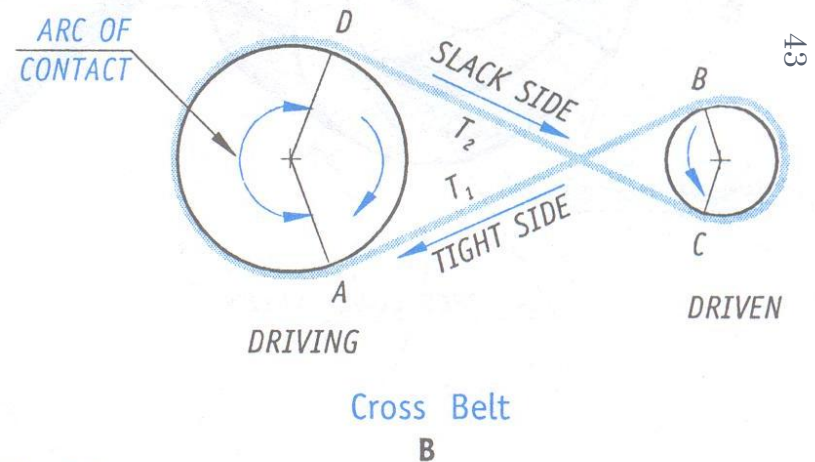
OPEN BELT DRIVE

- Both driver and driven pulley rotate in same direction.
- Belt is passed over driver and driven.
- Driver pulley pulls the belt from one side and delivers to other side.
- Tension is more in lower side than upper side.



CROSS BELT DRIVE

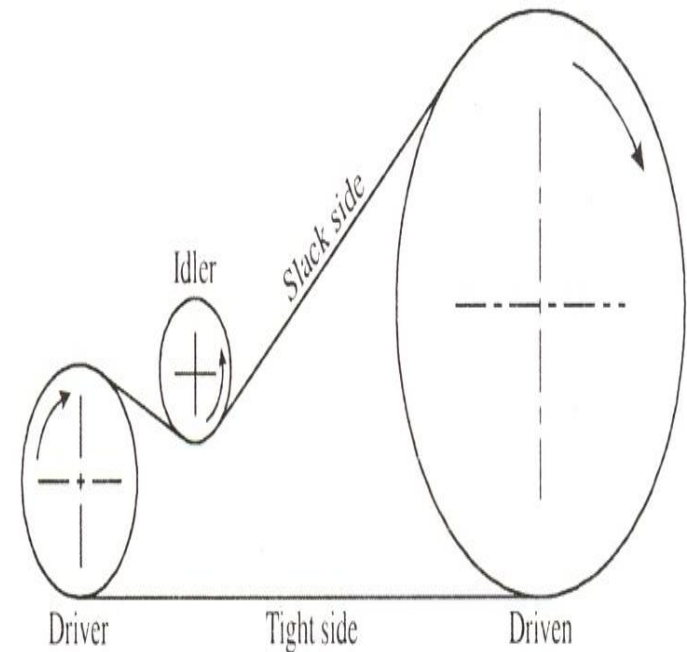
- Driven rotates in opposite direction to that of driver.
- At the point where the belt crosses it rubs against each other and there will be wear.
- To avoid this, speed of belt should be less than 15 m/s.



of Belt Drives
Fig. 9.2

USE OF IDLER PULLEY

- In an open belt drive, if the centre distance is small or if one of the pulleys is very small, then the arc of contact of the belt with the driven pulley will be very small, which reduces the tension in the belt. Hence an idler pulley is placed on the slack side to increase the arc of contact and thus tensions to increase the power transmission.



FLAT BELT DRIVES

○ Advantages

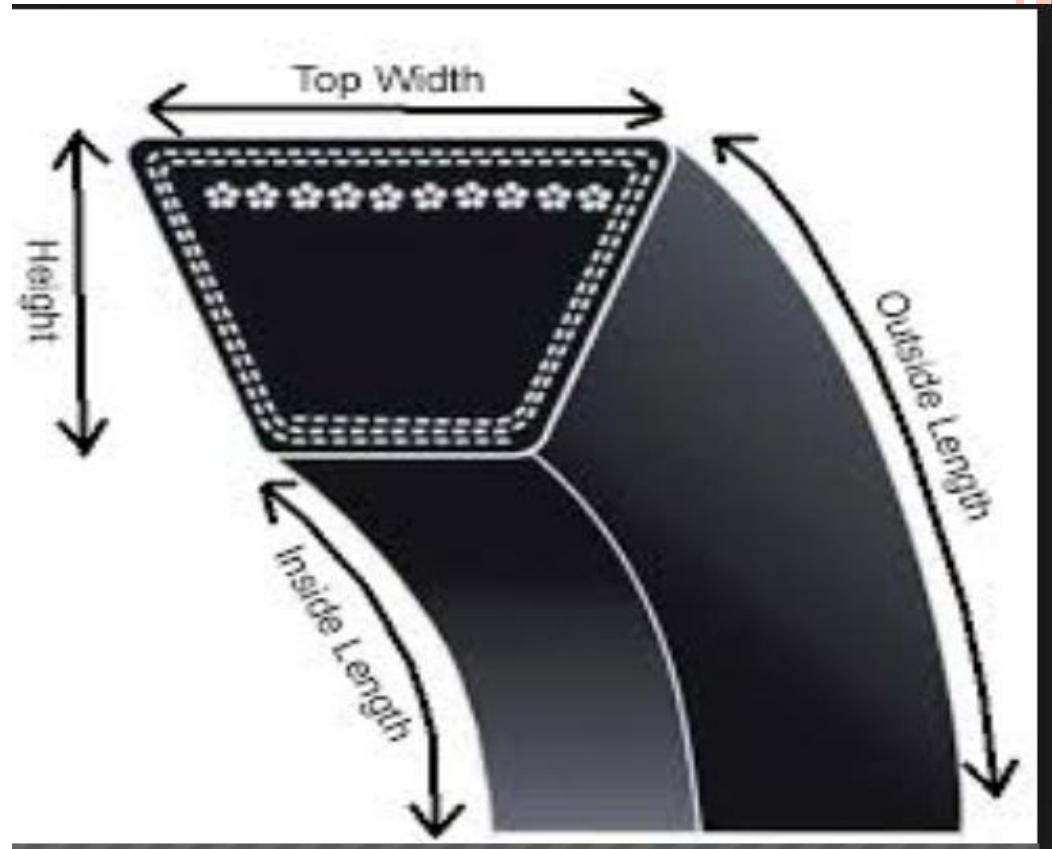
- Simplicity and low Running and maintenance cost
- Smooth operation, ability to absorb shocks due to elasticity of belt.
- Possibility to transmit power over a moderately long distance.

○ Disadvantages

- Not preferred for short centre distance.
- Belt joints reduces the life of the belt.
- Loss of power due to slip and creep.

V- BELTS

- Trapezoidal cross section
- They run over pulleys with grooves of similar cross section as of belt.
- Due to the wedging action, the grip of V belt is high on pulleys, therefore they have a higher pulling capacity as compared to the flat belts.



- Flat belt drive

- Suitable for more moderate power transmission for medium distances

- Requires large space due to large centre distance

- Less frictional grip, may slip over the pulley

- V belt drive

- Suitable for high power transmission when the distance between the shafts is small

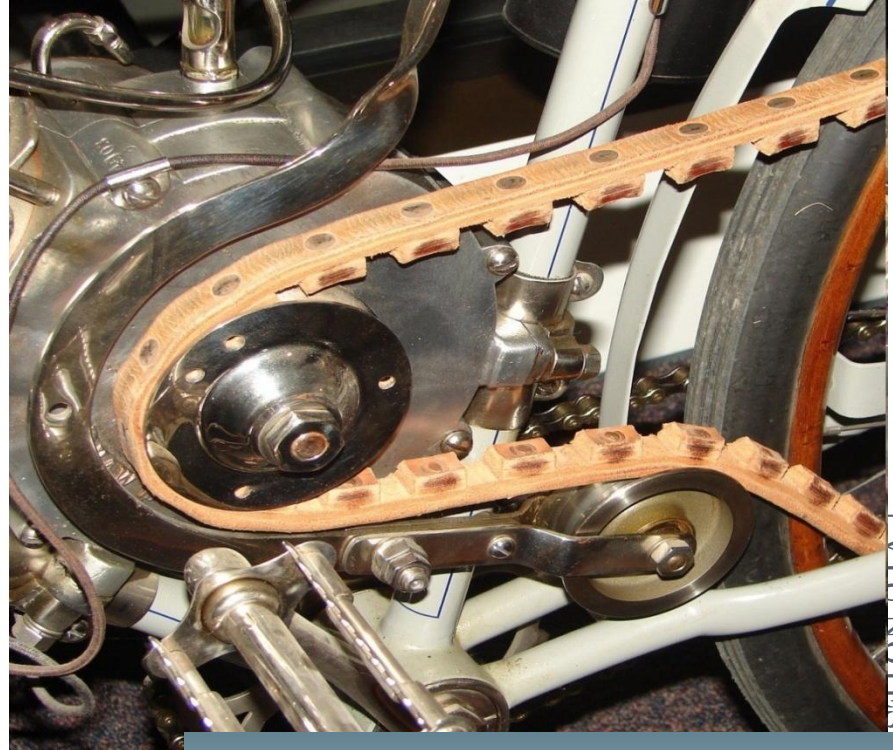
- Compact due to small distance between the shafts

- Due to grooves, more frictional grip and less tendency to slip over the pulley.



BELT MATERIALS

- Rubber
- Leather
- Canvas
- Cotton
- Steel



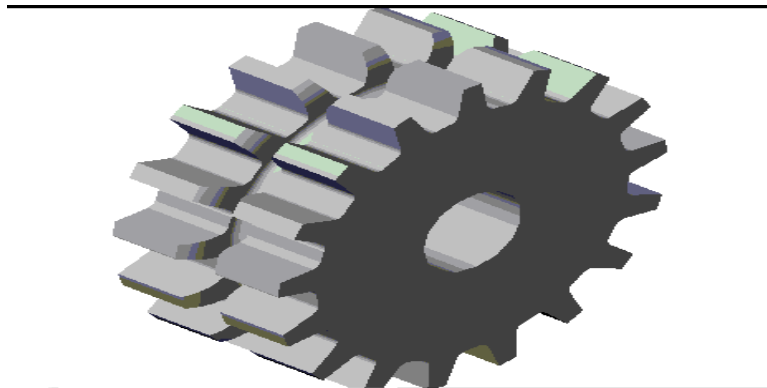
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VTU NOTES





CHAIN DRIVES

- A chain drive consists of driving and driven chain sprocket wheels and a chain which runs over the sprockets and meshes with their teeth.
- Used in automobiles, conveyor drives, machine tools, concrete mixers etc.



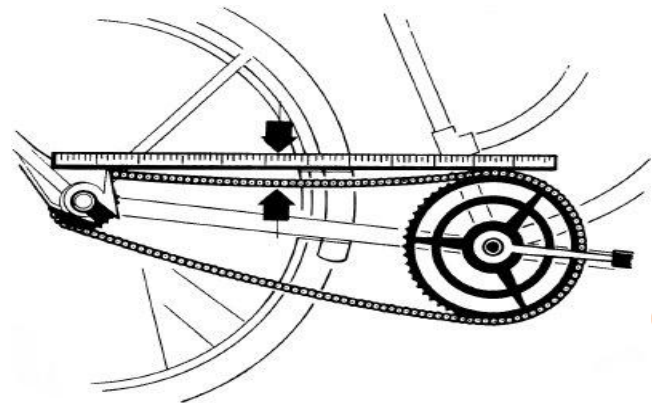
CHAIN DRIVES

○ Advantages of Chain Drives

- Do not slip
- Maintain constant and precise speed.
- Good service life
- Easy to install and repair

○ Disadvantages of Chain Drives

- Noisy
- Need lubrication
- Weight of the chain



GEAR DRIVES

- Gear drives are preferred when considerable power has to be transmitted over a short centre distance.
- A gear is a toothed wheel with the teeth cut either on a cylindrical or a conical surface.
- Gears are mounted and keyed to shafts.
- Two gears mounted one each on driving and driven shafts are arranged so that the teeth of one will mesh with the teeth of the other.
- The turning of one will cause turning of the other.



SPUR GEAR

- Used when axes of driving and driven shafts are parallel and co planar.
- Widely used in machine tools, automobile gear box etc



HELICAL GEARS

- Similar to spur gear
- Teeth are cut in the form of the helix around the gear
- Used for transmitting power between two parallel shafts and also between non-parallel non-intersecting shafts.
- Not as noisy as spur gear because of the more gradual engagement of the teeth during meshing.
- Used in automobile power transmission



BEVEL GEARS

- Used when axes of two shafts inclined to one another(usually angle 90 deg)
- Teeth of bevel gear cut on conical surfaces.
- Ex: differential gear box in truck



WORM AND WORM WHEEL

- Used for shafts at right angle and non coplanar.
- Consists of a worm and a worm wheel.
- Employed in machine tools like lathe, milling, drilling machine tools etc. to get large speed reduction.



RACK AND PINION

- Used when rotary motion is to be converted into linear motion.
- Rack is a rectangular bar with a series of straight teeth cut on it.
- Application in machine tools,

