MECHANICAL PART

SEMESTER:-5TH

BRANCH:-AUTOMOBILE AND MECHANICAL ENGINEERING

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SEMESTER 5TH

MECHATRONICS (TH 4)

Unit 3.1

ACTUATORS-MECHANICAL

1. Define Actuator.

- ✓ An actuator is a component of a machine that is responsible for moving and controlling a mechanism or system, for example by opening a valve.

2. What is Mechanical Actuators?

- ✓ A mechanical actuator is a device designed to remotely control or move a secondary mechanism via an external power source, which may include electric current and high pressure oil or gas. The internal mechanisms used to convert the input power to a working motion differ according to the intended output orientation and the specific power source used.

3. Define Machine.

- ✓ A machine is a physical system using power to apply forces and control movement to perform an action.

4. What is link?

- ✓ A link is defined as a single part which can be a resistant body or a combination of resistant bodies having inflexible connections and having a relative motion with respect to other parts of the machine. A link is also known as kinematic link or element.

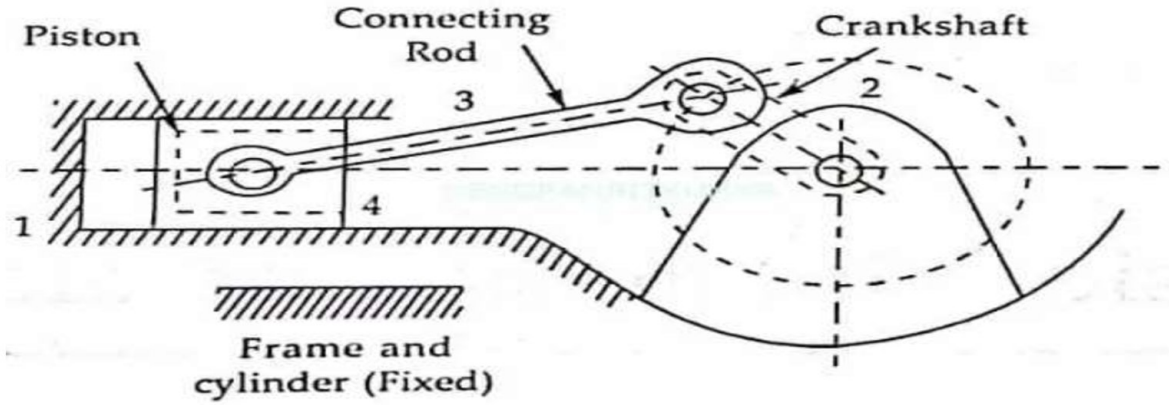
5. Define and explain about kinematic link.

- ✓ A kinematic link or element or link is a resistant body that constitutes part of the machine, connecting other parts which have motion relative to it.

Example Kinematic Link:

Piston, piston rod and crosshead of a steam engine constitutes one unit and hence called one link shown in the below figure.

In this figure, the various links are designated as 1,2,3,4, etc.



Link 1 is a fixed link that includes frame and all other stationery parts like cylinder, crankshaft bearing, camshaft bearing, etc.

Link 2 is the crankshaft, flywheel, etc all having rotation motion with respect to a fixed axis.

Link 3 is the connecting rod and

Link 4 is the piston which is having reciprocating motion. hence this is called a 4 bar mechanism.

Link need not be a rigid body but must be a resistant body. Hence link must have the following two characteristics:

1. It must be a resistant body.
2. It must have relative motion.

Types of Kinematics Link:

There are basically 4 types of the link which are:

- *Rigid Link*
- *Flexible Link*
- *Fluid Link*
- *Floating Link*

1. Rigid link:

A rigid link is one that does not undergo any deformation while transmitting motion. Links, in general, are elastic in nature. They are considered rigid if they do not undergo appreciable deformation while transmitting motion.

For Example, crank and connecting rod.

2. Flexible link:

A flexible link is one which while transmitting motion is partly deformed in a manner not to affect the transmission of motion.

For Example, spring, Chain, Rope, Belt, etc.

3. Fluid link:

A fluid link is one that is deformed by having fluid in a closed vessel and the motion is transmitted through the fluid by pressure.

For Example, hydraulic press and hydraulic jack.

4. Floating link:

A floating link is one that is not connected with the frame.

A link can also be classified based upon its number and end vertices:

1. *Binary* Link
2. *Ternary* Link
3. *Quaternary Link.*

Binary link:

It having two vertices.

Ternary link:

This is having three vertices.

Quaternary link:

This having four vertices.

6. What is Kinematic Link?

- ✓ Each part of a machine, which moves relative to some other part, is known as a kinematic link or element. A link may consist of several parts, which are rigidly fastened together, so that they do not move relative to one another.

7. What is pair?

- ✓ Pair is defined as the two links or elements of a machine when in contact with each other are said to form a pair.

8. What is kinematic pair?

- ✓ Kinematic pair is defined as the two links or elements of a machine when in contact with each other are said to form a pair. If the relative motion between them is completely or successfully constrained in a definite direction, the pair is known as the Kinematic pair.

9. What is Kinematic Pair?

Kinematic pair is defined as the two links or elements of a machine when in contact with each other are said to form a pair. If the relative motion between them is completely or successfully constrained in a definite direction, the pair is known as the Kinematic pair.

According to the following consideration, Kinematic Pair has been classified into three types:

1. Types of relative motion
2. Contact and
3. Types of mechanical constraint or Type of closure.

1. According to types relative motion:

Relative Motion types categorized into 5 parts which are,

1. Sliding,
2. Turning,
3. Rolling,
4. Screw and
5. Spherical Pair.

Sliding Pair:

This consists of two elements connected in such a manner that one is constrained to have a sliding motion relative to another.

Example:

- Rectangular bar in a rectangular hole
- Square bar in the square hole
- Piston and cylinder of an Ic engine.
- Tail-stock and lathe bed, etc.

Turning Pair:

This consists of two elements connected in such a manner that one is constrained to turn or revolve about a fixed axis of another element.

Example:

- Shaft with a collar at both ends revolving in a circular hole.
- The crankshaft of an I.C engine turning in a bearing.
- Cycle wheel revolving about their axles.

Rolling Pair:

This consists of two elements connected in such a manner that one is constrained to roll in another element which is fixed.

Example:

- Ball and roller bearings.

- Wheel rolling on a flat surface.
- Marble rolling on a flat surface.

Screw Pair:

This consists of two elements connected in such a manner that one element turns about the other element by means of threads. The motion, in this case, is a combination of sliding and turning.

Example:

- The lead screw of a lathe and nut.
- Nut and bolt combination
- Screw with nut of screw jack.

Spherical Pair:

This consists of two elements connected in such a manner that one element in the form of a sphere turns about the other fixed element.

- Ball and socket joint.
- Pen stand
- Minor attachment of vehicles.

2. According to the type of contact:

Types of contact classified as

1. Lower pair and
2. Higher Pair.

Lower pair:

When the two elements of a pair have surface contact when relative motion takes place and the surface of one element slides over the surface of another element, the pair formed as lower pair.

Example:

- All sliding, Turning and Screw pairs are lower pair.

- Nut turning in a screw.
- shaft rotating in a bearing.
- Universal joint
- All pairs of slider-crank mechanism.

Higher Pair:

When the two elements of a pair have line contact or point contact when relative motion takes place and the motion between the two elements is partly turning, sliding then the pair is known as higher pair.

Example:

- Toothed gearing
- Belt and rope drives
- Ball and roller bearings
- Cam and follower.

3. According to the type of Mechanical constraint / Types of closure:

Types of Mechanical Constraint classified into two types,

1. Self closed pair and
2. Force closed pair.

These are further classified as Self closed pair or closed pair and Force closed pair or Un-closed pair.

Self closed pair or closed pair:

whenever two elements of pair are held together mechanically in such a way that only required the type of relative motion occurs called Self closed pair or closed pair.

Example: All lower pairs.

Force closed pair or Unclosed pair:

whenever two elements of pair are not held together mechanically but are kept in contact by the action of external forces the pair is said to be Force closed pair or Un-closed pair.

Example: Cam and spring-loaded follower pair.

10. What is mechanism?

- ✓ A mechanism is a group of links connected to each other by joints, to form a kinematic chain with one link fixed, to transmit force and motion.

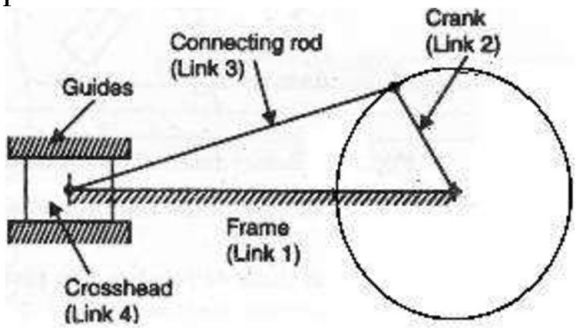
11. What is Slider crank Mechanism?

- ✓ Slider-crank mechanism, arrangement of mechanical parts designed to convert straight-line motion to rotary motion, as in a reciprocating piston engine, or to convert rotary motion to straight-line motion, as in a reciprocating piston pump.

12. Explain the types slider crank mechanism.

- ✓ **Single Slider Crank Chain**

A single slider crank chain is a modification of the basic four-bar chain. It consist of one sliding pair and three turning pairs. It is, usually, found in reciprocating steam engine mechanism. This type of mechanism converts rotary motion into reciprocating motion and vice versa. In a single slider crank chain, as shown the links 1 and 2, links 2 and 3, and links 3 and 4 form three turning pairs while the links 4 and 1 form a sliding pair.



Single Slide mechanism

Link 1 corresponds to the frame of the engine, which is fixed. The link 2 corresponds to the crank; link 3 corresponds to the connecting rod and link 4 corresponds to cross-head. As the crank rotates, the cross-head reciprocates in the guides and thus the piston reciprocates in the cylinder.

INVERSION:

We have already discussed that when one of the links is fixed in a kinematic chain, it is called a mechanism. So we can obtain as many mechanisms as the number of links in a kinematic chain by fixing, in turn, different links in a kinematic chain. This method of obtaining different mechanisms by fixing different links in a kinematic chain is known as inversion of the mechanism.

Inversion Definition :

When one of the links is fixed in a kinematic chain, it is called a mechanism. So we can obtain as many mechanisms as the number of links in a kinematic chain by fixing, in turn, different links in a kinematic chain. This method of obtaining different mechanisms by fixing different links in a kinematic chain is known as inversion of the mechanism.

Or

A Mechanism is a Kinematic Chain with one Fixed Link. The Fixed Link is called Frame. Different Mechanism is obtained by fixing different link in a kinematic chain. The process of choosing the different links in a kinematic chain for the frame is known as Inversion. Thus by fixing one by one links of the mechanism, we can obtain the inversion.

It may be noted that the relative motions between the various links are not changed in any manner through the process of inversion, but their absolute motions (those measured concerning the fixed link) may be changed drastically.

Types of inversion

1. Four bar chain or quadric cycle chain

- Beam engine
- Coupling rod of locomotive
- Watt's indicator mechanism

2. Single slider crank chain

- Bull engine or pendulum engine
- Oscillating cylinder engine
- Rotary engine
- Crank & slotted quick return mechanism

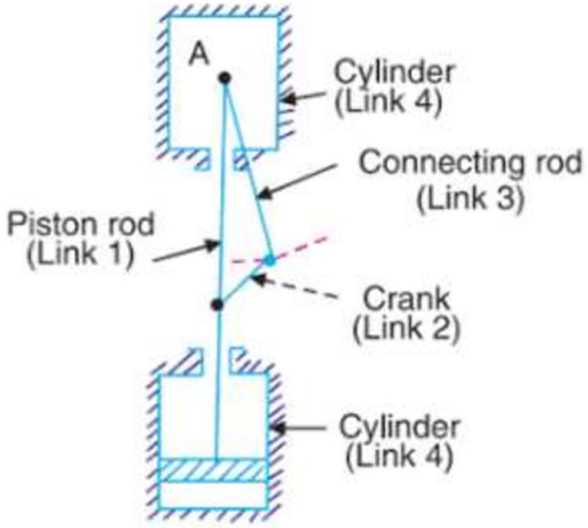
- Whitworth quick return mechanism

3. Double slider crank

- Elliptical trammels
- Scotch yoke mechanism
- Oldham's coupling

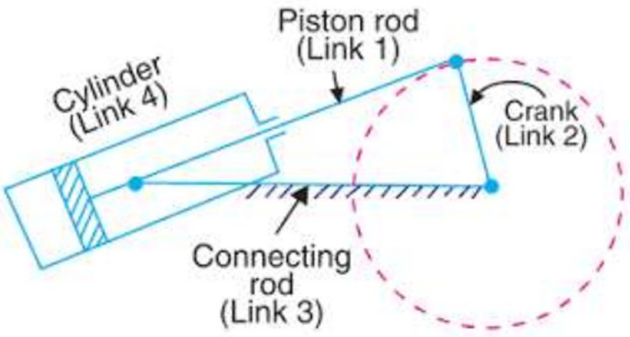
1) Bull engine or pendulum engine:

In this mechanism, the inversion is obtained by fixing the cylinder or link 4 (i.e. sliding pair), as shown in Fig. In this case, when the crank (link 2) rotates, the connecting rod (link 3) oscillates about a pin pivoted to the fixed link 4 at A and the piston attached to the piston rod (link 1) reciprocates. The duplex pump which is used to supply feed water to boilers have two pistons attached to link 1, as shown in Fig.



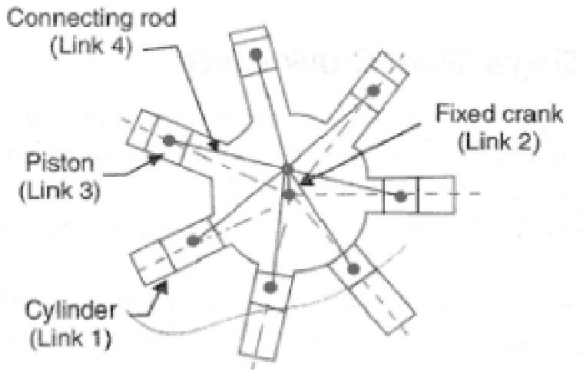
2) Oscillating Cylinder Engine;

The arrangement of oscillating cylinder engine mechanism, as shown in Fig. is used to convert reciprocating motion into rotary motion. In this mechanism, the link 3 forming the turning pair is fixed. Link 3 corresponds to the connecting rod of a reciprocating steam engine mechanism. When the crank (link 2) rotates, the piston attached to the piston rod (link 1) reciprocates and the cylinder (link 4) oscillates about a pin pivoted to the fixed link at A.



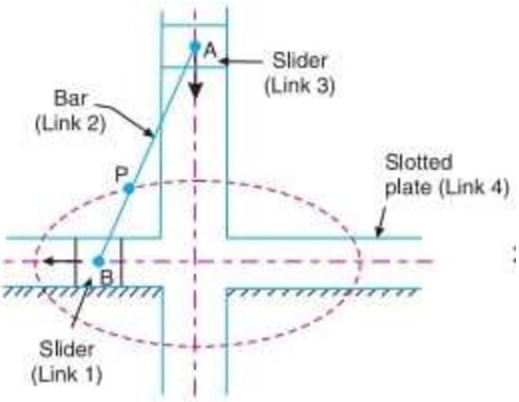
3) Rotary Engine :

Sometimes back, rotary internal combustion engines were used in aviation. But nowadays gas turbines are used in its place. It consists of seven cylinders in one plane and all revolves about fixed center D, as shown in Fig. while the crank (link 2) is fixed. In this mechanism, when the connecting rod (link 4) rotates, the piston (link 3) reciprocates inside the cylinders forming link 1.



4) Elliptical trammels:

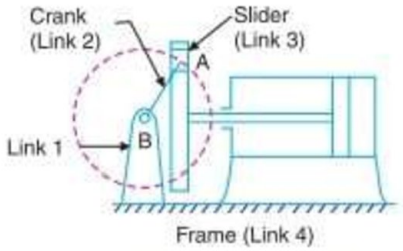
It is an instrument used for drawing ellipses. This inversion is obtained by fixing the slotted plate (link 4). The fixed plate or link 4 has two straight grooves cut in it, at right angles to each other. The link 1 and link 3, are known as sliders and form sliding pairs with link 4. The link A B (link 2) is a bar that forms a turning pair with links 1 and 3.



Elliptical trammels.

5) Scotch yoke mechanism:

This mechanism is used for converting rotary motion into a reciprocating motion. The inversion is obtained by fixing either the link 1 or link 3. In this, link 1 is fixed. When the link 2 (which corresponds to crank) rotates about B as center, the link 4 (which corresponds to a frame) reciprocates. The fixed link 1 guides the frame.



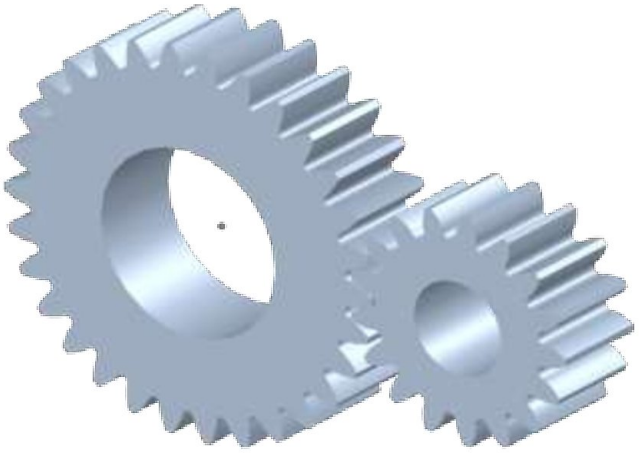
Scotch yoke mechanism.

13. What is a Gear?

- ✓ A Gear is a machine component, which is used to transmit mechanical power from one shaft to the other by successively engaging its teeth. Power transmission by the gears has almost 100% efficiency.

14. Define Spur gear?

- ✓ Spur gears are a cylindrical shaped toothed component used in industrial equipment to transfer mechanical motion as well as control speed, power, and torque.



15. Define Bevel gear.

- ✓ Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel

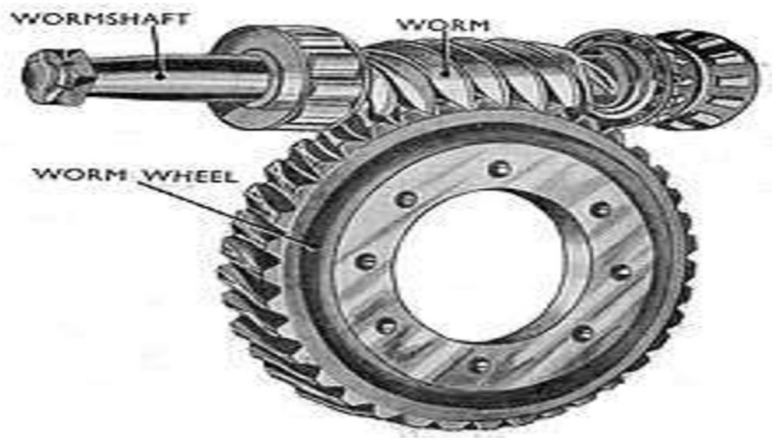
gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone.

16. Define helical gear.

- ✓ Helical gears are cylindrical gears with teeth that are at an angle to the axis of rotation of the gear wheel.

17. Define worm gear.

- ✓ A worm drive is a gear arrangement in which a worm (which is a gear in the form of a screw) meshes with a worm wheel (which is similar in appearance to a spur gear). The two elements are also called the worm screw and worm gear.



18. Explain the different types of Gearbox.

- ✓ A gearbox, also known as a gear drive, has three main functions: to increase torque from the driving equipment (motor) to the driven equipment, to reduce the speed generated by the motor, and/or to change the direction of the rotating shafts. The connection of this equipment to the gearbox can be accomplished using couplings, belts, chains, or hollow shaft connections.

  Speed and torque are inversely and proportionately related when power is held constant. Therefore, as speed decreases, torque increases at the same ratio.

  The heart of a gear drive is the gears within it. Gears operate in pairs, engaging one another to transmit power. Read on to learn the different types of gear and the applications and industries that utilizes them.

Spur Gear

Spur gears transmit power through shafts that are parallel. The teeth of the spur gears are parallel to the shaft axis. This causes the gears to produce radial reaction loads on the shaft, but not axial loads. Spur gears tend to be noisier than helical gears because they operate with a single line of contact between teeth. While the teeth are rolling through mesh, they roll off of contact with one tooth and accelerate to contact with the next tooth. This is different than helical gears, which have more than one tooth in contact and transmit torque more smoothly.

Helical Gear

Helical gears have teeth that are oriented at an angle to the shaft, unlike spur gears which are parallel. This causes more than one tooth to be in contact during operation and helical gears can carry more load than spur gears. Due to the load sharing between teeth, this arrangement also allows helical gears to operate smoother and quieter than spur gears. Helical gears produce a thrust load during operation which needs to be considered when they are used. Most enclosed gear drives use helical gears.

Double Helical Gear

Double helical gears are a variation of helical gears in which two helical faces are placed next to each other with a gap separating them. Each face has identical, but opposite, helix angles. Employing a double helical set of gears eliminates thrust loads and offers the possibility of even greater tooth overlap and smoother operation. Like the helical gear, double helical gears are commonly used in enclosed gear drives.

Herringbone Gear

Herringbone gears are very similar to the double helical gear, but they do not have a gap separating the two helical faces. Herringbone gears are typically smaller than the comparable double helical and are ideally suited for high shock and vibration applications. Herringbone gearing is not used very often due to their manufacturing difficulties and high cost.

Bevel Gear

Bevel gears are most commonly used to transmit power between shafts that intersect at a 90 degree angle. They are used in applications where a right angle gear drive is required. Bevel gears are generally more costly and are not able to transmit as much torque, per size, as a parallel shaft arrangement.

Worm Gear

Worm gears transmit power through right angles on non-intersecting shafts. Worm gears produce thrust load and are good for high shock load applications but offer very low efficiency in comparison to the other gears. Due to this low efficiency, they are often used in lower horsepower applications.

Hypoid Gear

Hypoid gears look very much like a spiral bevel gear, but unlike spiral bevel gears, they operate on shafts which do not intersect. In the hypoid arrangement because the pinion is set on a different plane than the gear, the shafts are supported by the bearings on either end of the shaft.

	Industries	**Applications**	**Rexnord Products**
Spur Gear	Food Beverage Automotive Forest Energy Unit handling	Small conveyors Package handling equipment Farm machinery Planetary gear sets Automotive	Planet gear
Helical Gear	Cement Food Beverage Mining Marine Energy Forest Bulk material handling	Medium to large conveyors Mixers Large pumps Water treatment Crushers	V-Class Quad drive Ultra Max Ultra mite
Double Helical Gear	Mining Marine Heavy industry	Milling Steam turbines Ship propulsion	
Herringbone Gear	Mining Marine Heavy industry	Milling Steam turbines Ship propulsion	

Bevel Gear	Cement Food Beverage Mining Energy Bulk material handling	Medium to large conveyors Mixers Crushers Water treatment	V-Class Ultramite
Worm Gear	Food Beverage Automotive Forest Energy Unit handling	Small conveyors Package handling equipment Farm machinery	Ultramite Omnibox
Hypoid Gear	Cement Food Beverage Mining Energy Bulk material handling	Small to medium conveyors Small mixers Crushers Water treatment	

19. Define Belt.

- ✓ A belt is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. Belts may be used as a source of motion, to transmit power efficiently or to track relative movement.

20. Define Belt drive.

- ✓ Belt Drives are a type of frictional drives used for transmitting powers from one shaft to another by means of pulleys which rotate at the same speed or at the different speed.

21. Write the different types of belts.

- ✓ Types of Belts

There are three commonly used types of belts are:

1. Flat belt
2. V belt
3. Circular

Flat belt: This belt has a rectangular cross-section. These belts are capable of transmitting power over long distances between pulley centres. The efficiency of this drive is around 98% and produces little noise.
V-belts: v-belts also used with grooved pulleys, V-belts are trapezoidal in cross-section. These belts permit large speed ration and can transmit higher power. Multiple drives are possible.

Circular: This type of belt has a circular cross-section and is used with the grooved pulleys.

22. Explain the the difference types of belts.

- ✓ **Belt Drives**

Belt Drives are a type of frictional drives used for transmitting powers from one shaft to another by means of pulleys which rotate at the same speed or at the different speed.

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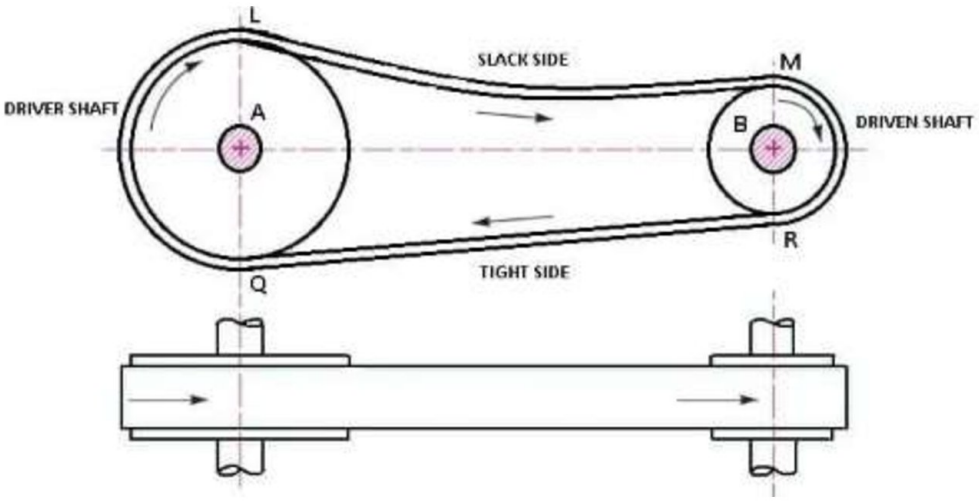
Circular: This type of belt has a circular cross-section and is used with the grooved pulleys.

Types of Belt Drives

The following are the **5 main types of Belt Drives:**

1. Open belt drive.
2. Crossbelt drive.
3. Stepped cone pulley or speed cone drive.
4. Fast and loose pulleys.
5. Jockey pulley drive.

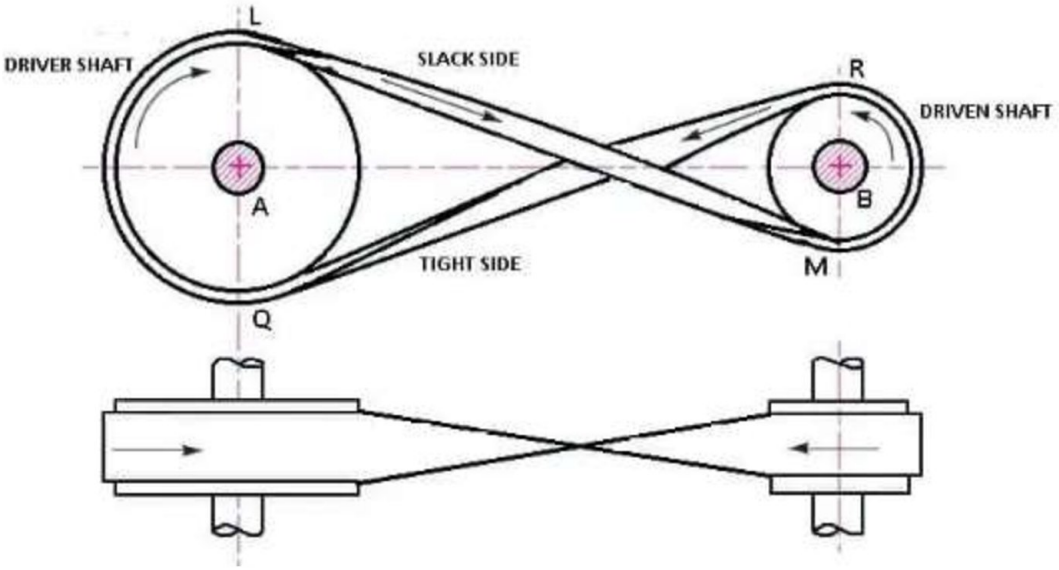
1. Open Belt Drive



- In these **types of belt drive,** the belt is employing when the two parallel shafts have to rotate in the same direction.
- When the shafts are far apart, the lower side of the belt should be the tight side and the upper side must be the slack side.

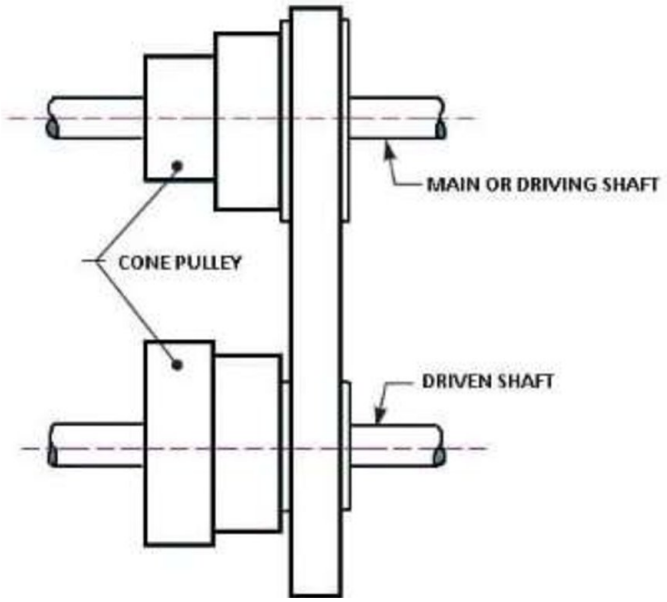
- This is because, when the upper side becomes the slack side, it will sag due to its own weight and thus increase the arc of contact.

2. Cross Belt Drive



- This types of belt drives, the belt is employing when two parallel shafts have to rotate in the opposite direction. At the junction where the belts cross, it rubs against itself and wears off.
- To avoid excessive wear, the shafts must be placed at a maximum distance from each other and operated at very low speeds.

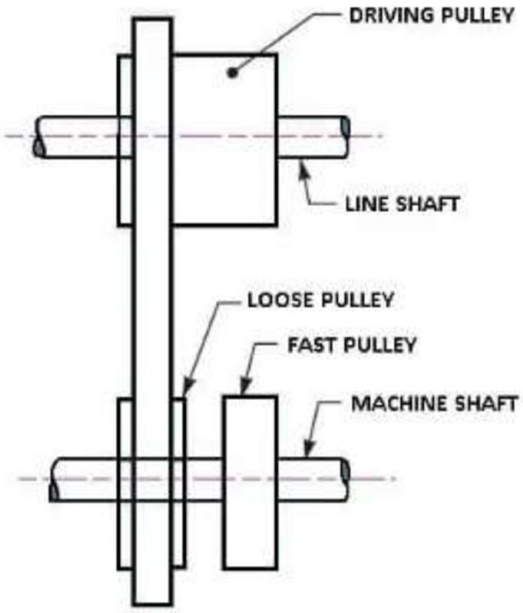
3.Stepped Cone Pulley or Speed Cone Drive



A stepped cone pulley also known for a speed cone is showing in the fig.

- This types of belt drives are used when the speed of the driven shaft is to be changed very frequently as in the case of machine tools such as lathe, drilling machine, etc.
- A stepped cone pulley is an integral casting having three or number of pulleys of different sizes one adjacent to the other as shown in fig.
- One set of stepped cone pulley is mounted in reverse on the driven shaft. An endless belt will be wrapped around one pair of pulleys.
- By shifting the belt from one pair of pulleys to the other, the speed of the driven shaft can be varied.
- The diameter of the driving and driven pulleys is such that the same belt will operate when shifted on different pairs of pulleys.

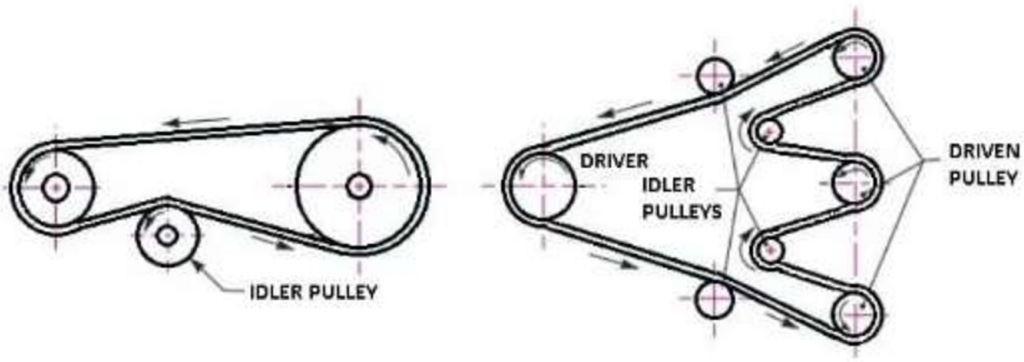
4. Fast and Loose Pulley Drive



A fast and loose pulley drive is showing in fig.

- This types of belt drives are used when the driven or machine shaft is to be started or stopped whenever desired without interfering with the driving shaft.
- A pulley which is keyed to the machine shaft is called a fast pulley and run at the same speed as that of the machine shaft.
- A loose pulley runs freely over the machine shaft and is incapable of transmitting any power.
- When the driven shaft is required to be stopped, the belt is pushed on to the loose pulley by means of a sliding bar having belt forks.

5.Jockey Pulley Drive



- In an open belt drive arrangement, if the center distance is small, or if the driven pulleys are very small, then the arc of contact of the belt with the driven pulley will be very small, which reduces the tensions in the belt, or if the required tension of the belt cannot be obtained by other means, an idler pulley, called jockey pulley is placed on the slack side of the belt as shown in fig.
- Which increases the arc of contact and thus the tension which results in increased power transmission?

Materials Used For Belts

The materials used for belts must be strong, flexible and durable. It should have a high coefficient of friction. The various material used are:

1. Leather
2. Fabric
3. Rubber
4. Balata

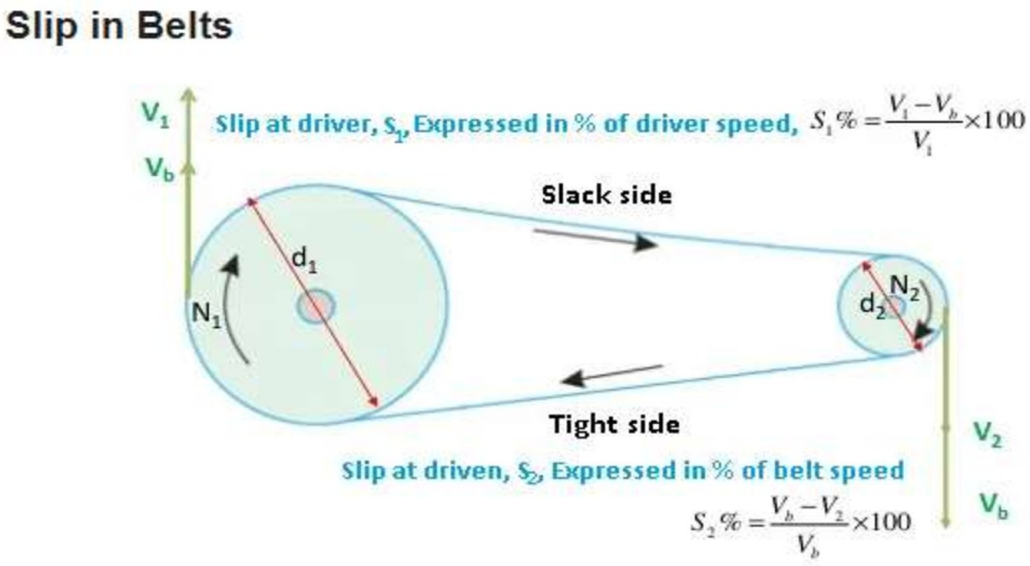
Leather: The leather may be oak-tanned or mineral salt tanned ex: Chrome tanned. When the thickness of the belt required is more than, two or more strips are cemented together. Leather belts require periodic cleaning.

Fabric: Fabric belts are made by folding canvas or cotton ducks is a layer (depending on the required thickness) and stitching together.

Rubber: The belts are made of Fabric with a rubber layer. These are used in sawmills, paper mills, etc.

Balata: The belts are made out of these materials are similar to rubber belts expect that balata gym is used instead of rubber. The belts of these materials are acid and waterproof but cannot be used where the temperature is above 45°.

Slip And Creep In Belt Drive

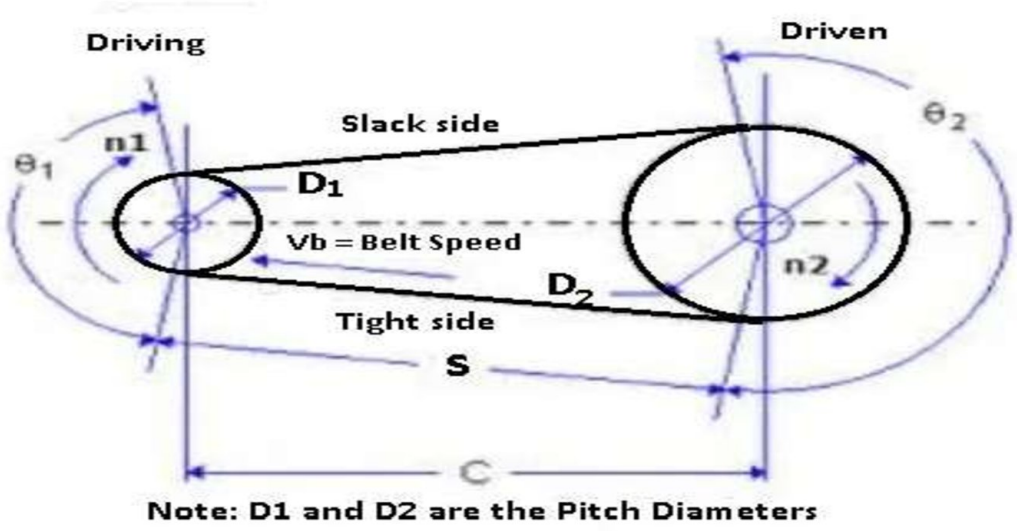


Consider an open belt drive rotating in a clockwise direction, this rotating of the belt over the pulleys is assumed to be due to firm frictional grip between the belt and the pulleys.

When this frictional grip becomes insufficient, there is a possibility of forwarding motion of driver without pulley with it, this is known as **the slip in a belt**.

Therefore slip may be defined as the relative motion between the pulley and the belt in it. This reduces the velocity ratio and usually expressed in % and it is denoted by S.

Creep in Belts



Note: D1 and D2 are the Pitch Diameters

Consider as an open belt drive rotating in the clockwise direction. The portion of the belt leaving the driven and entering the driver is known as the tight side and a portion of the belt leaving the driver and entering the is known as the slack side.

During rotation, there is an expansion of a belt on a tight side and contraction of the belt on the slack side.

Due to this uneven expansion and contraction of the belt over the pulleys, there will be a relative movement (motion) of the belt over the pulleys this phenomenon is known as **Creep in a belt.**

Advantages and Disadvantages of Flat Belts

The following are the advantages and disadvantage of belts drive.

Advantages

1. Flexible, simple in construction, smooth operations.
2. Efficient at high speeds and protects against overload.
3. Running and maintenance cost is low.
4. Relatively long life and easy to work with.

Disadvantages

1. Loss of power sues to slip and creep in turn results in low efficiency.
2. Not preferred for short-centre distances.
3. because of the endlessness of the belt, joints reduce the life of the belt.
4. Not a positive drive.

Selection of Belt Drive

The following factors are considered in the selection of belt drives.

- The speed of the driver and driven pulleys
- Speed reduction ratio
- Power to be transmitted
- Center distance between the shaft
- Shaft layout
- Positive drive requirements

23. Write the types of Belt Drives.

✓ The following are the 5 main types of Belt Drives:

1. Open belt drive.
2. Cross belt drive.
3. Stepped cone pulley or speed cone drive.
4. Fast and loose pulleys.
5. Jockey pulley drive.

24. Define Bearing.

✓ A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts.

25. Write the different types of Bearing.

✓ **1)Plain Bearings**

Plain bearings are the simplest type of bearing and are composed of just the bearing surface with no rolling elements. They have a high load-carrying capacity,

are generally the least expensive and, depending on the materials, have much longer lives than other types.

2) Rolling Element Bearings

Rolling element bearings place balls or rollers between two rings – or "races" – that allows motion with little rolling resistance and sliding. These bearings include ball bearings and roller bearings.

Ball bearings are the most common type of rolling element bearing.

These bearings can handle both radial and thrust loads but are usually used where the load is relatively small. Because of its structure, there is not a lot of contact with the balls on the inner and outer races. If the bearing is overloaded the balls would deform and ruin the bearing. Roller bearings are able to handle a much heavier, radial load, like conveyor belts, because they don't use balls. Instead, they have cylinders allowing more contact between the races, spreading the load out over a larger area. However this type of bearing is not designed to handle much thrust loading.

3) Jewel Bearings

Jewel bearings are plain bearings with a metal spindle that turns in a jewel-lined pivot hole. They carry loads by rolling the axle slightly off-center and are usually used in mechanical watches or clocks. This is due to their low and predictable friction that improves watch accuracy.

4) Fluid Bearings

Fluid bearings support their load using a thin layer of gas or liquid and can be classified into two types: fluid-dynamic bearings and hydrostatic bearings. Fluid-dynamic bearings use rotation to form the liquid into a lubricating wedge against the inner surface. In hydrostatic bearings, the fluids – usually oil, water, or air – rely on an external pump.

Fluid bearings are used in high load, high speed or high precision applications that ordinary ball bearings either couldn't handle or would suffer from increased vibration and noise.

5) Magnetic Bearing

support moving parts without physical contact, instead relying on magnetic fields to carry the loads. They require continuous power input to keep the load stable, thus requiring a back-up bearing in the case of power or control system failure.
Magnetic bearings have very low and predictable friction and the ability to run without lubrication or in a vacuum. They are increasingly used in industrial machines like turbines, motors, and generators.

6) Flexure Bearing

A typical flexure bearing is one part joining two others, like a hinge, in which motion is supported by a load element that bends. These bearings require repeated bending, so material selection is key. Some materials fail after repeated bending, even at low loads, but with the right materials and bearing design the flexure bearing can have an indefinite life. Another notable characteristic of this bearing is its resistance to fatigue. Many other bearings that rely on balls or rollers can fatigue as the rolling elements flatten against each other.

SEMESTER 5TH

MECHATRONICS (TH 4)

5.0 ELEMENTS OF CNC MACHINES

1. Define NC machine.

- ✓ Numerical control is defined as the form of programmable automation, in which the process is controlled by the number, letters, and symbols.

2. Define CNC.

- ✓ Computer numerical control (CNC) is a method for automating control of machine tools through the use of software embedded in a microcomputer attached to the tool. It is commonly used in manufacturing for machining metal and plastic parts.

3. Define CAD.

- ✓ Computer-aided design is the use of computers to aid in the creation, modification, analysis, or optimization of a design. This software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing.

4. Define CAM.

- ✓ Computer-aided manufacturing also known as Computer-aided Modeling or Computer-aided Machining is the use of software to control machine tools and related ones in the manufacturing of work pieces.

5. Define CIM.

- ✓ Computer-integrated manufacturing is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each part. Manufacturing can be faster and less error-prone by the integration of computers.

6. Function of CAD.

- ✓ Used by engineers, architects, and construction managers, CAD has replaced manual drafting. It helps users creating designs in either 2D or 3D so that they can visualize the construction. CAD enables the development, modification, and optimization of the design process.

7. Function of CAM.

- ✓ Cam, in its simplest definition, is a mechanical link that converts rotational motion into linear motion, or vice versa. The cams on a camshaft achieve this displacement by the rotation of a radial pattern, and a follower which moves perpendicular to the rotational axis.

8. What are the software used in CAD?

- ✓ **A)TinkerCAD**

TinkerCAD an online 3D design app geared towards complete beginners coming from Autodesk. The software features an intuitive block-building concept, allowing you to develop models from a set of basic shapes. The online software comes with a library of millions of files that users can use to find shapes that suit them best and manipulate them as they wish. It also has a direct interaction with third party printing services. It is quite a simplistic program and will have limitations for some designs. However, it is aimed mostly at people with no experience whatsoever with 3D modeling.

B) FreeCAD

FreeCAD is a completely free parametric 3D modeling tool that is open-source and enables you to design real-life objects of any size. The parametric component makes editing easier. You can go to your model's history and change the parameters to get a different model. This software is not designed for professional purposes but is a good training tool. The options it offers are quite basic but a good starting point when you have no experience.

C) BlocksCAD

This 3D software is specifically created for educational purposes, its development is done so that anyone can later use OpenSCAD, a more professional CAD software. The commands for the development of the objects and their

transformations are represented by colour blocks, reminiscent of the well-known construction toys, LEGO. BlocksCAD's code is fully compatible with Open SCAD's so you can give your models the last touch up on there. Export formats can be Open SCAD or STL. To make sure that anyone can learn to use the software, Blocks CAD has a you tube channel with different tutorials on 3D modeling.

D) Creo

Creo CAD software is one of the market leaders in product design, developed by Parametric Technology Corporation more than 30 years ago. It integrates many functionalities such as thermal, structural, motion, parametric and freestyle surface generation and direct modeling. It is a complete tool, ideal for additive manufacturing, that will allow you to perform all your dimensioning calculations while modelling your final idea. The latest Creo 5.0 version was released in 2018 and features an improved user interface, redesigned for a better handling. A 30-day trial version is available free of charge.

E) Fusion 360°

Fusion 360 is a cloud-based 3D CAD program. It's unique in the sense that it uses the power of the could to bring together design teams to collaborate on complex projects. An advantage of the Fusion 360° platform is it stores the entire history of the model including all the changes. It contains numerous design options, including freeform, solid and mesh modeling. It operates on a monthly payment subscription basis. The developers also regularly update the features, making it better as new installments come along. It runs on multiple platforms and allows users to access their information wherever they want. In immaterialism's poll in 2017, they noticed a jump in the program's popularity in the last two years. Many people have praised the software's professional capabilities and user-friendly interface and workflow.

F) Solid works

Published by assault Systems, it is often used by professional 3D designers. It is a parametric featured-based model. The software includes a wide range of features such as design validation tools, or reverse engineering. It tends to be used for industrial objects. It is quite practical and detailed. One of its special features is that unlike many other software that mimic curves through gently inclining flat structures, Solid works uses a system of NURBS. This system allows to create very detailed curvatures. Also, instead of polygonal modeling, it uses dimensional sketching so that resizing becomes far less of a hassle. One disadvantage that is often brought up by users of the software is the limited ability to import .STL files.

If you wish to download and edit .STL files, a secondary program will most likely be necessary. The file format is very much an output file format and not intended for post-design processing.

G) AutoCAD

AutoCAD software from Autodesk was one of the first CAD software to be released on the market in 1982, making it a very established CAD software across industries. Even though AutoCAD is popular and widely used, in the 3D printing community its popularity has decreased lately according to i.materialise's poll. Many users cite that although it is ideal for 2D drafting, it is not the easiest to use for 3D modeling. Indeed, the learning curve to master macros and scripts is steep for moving beyond simple parts. The software is aimed at professionals with experience in programming models algorithmically. If you have that skill, there is little you can't do with AutoCAD. The 3D models can readily be converted to STL files for 3D printing. Since 2010, AutoCAD was released on a mobile and web-app as well, called AutoCAD 360.

H) CATIA

The CATIA CAD solution has historically been developed for Dassault Aviation's own needs. It is more than a simple CAD Software, as it is also a multi-platform software suite for CAD, CAM (Computer Aided Manufacturing), CAE (Computer Aided Engineering) and more. It is powered by Dassault Systèmes' 3DEXPERIENCE platform. CATIA innovates product design and experience by integrating various approaches in product design and development, enabling multiple disciplines to leverage their existing tools throughout the stages of product development process. Therefore, the software is very useful for industrial and creative designers, mechanical engineers, and systems architects. CATIA provides a 3D design environment that enables online people and stakeholders to share product designs and collaborate on product modeling.

I) OpenSCAD

OpenSCAD is a free, open-source CAD software aimed at making solid 3D models. It is suitable for experienced users seeking a platform for an elaborated project. Also, given its Constructive Solid Geometry (CSG) and the Extrusion of 2D outlines, this software is intuitive for coders/programmers. It is great for simple shapes that are already parametrically defined. Since it is completely based on description language, the program will not be intuitive for everyone at all.

J) Rhino

The company behind this software markets it as the world's most versatile 3D-modeler. It is a commercial 3D computer graphics and CAD software. The program uses a precise and mathematical model known as NURB which allows to manipulate points, curves, meshes, surfaces, solids and more in all sorts of ways. Rhino3D's strong point is its wide range of design features. It offers great versatility in creating complex 3D models. Many users have reported however that the software is difficult to learn and will take a lot of practice to master. It is also reportedly not the most accurate software at capturing user intent. The software is available for download in a variety of bundles on their website at various prices.

9. Write the Hardware of CAD.

- ✓ The hardware for a typical CAD system consists of the following components:

(1) one or more design workstations,

(2) digital computer,

(3) plotters, printers and other output devices.

Design Workstations. The workstation is the interface between computer and user in the CAD system.

10. What are Function of CAD and CAM ?

- ✓ CAD/CAM applications are used to both design a product and program manufacturing processes, specifically, CNC machining. CAM software uses the models and assemblies created in CAD software, like Fusion 360, to generate tool-paths that drive machine tools to turn designs into physical parts.

11.Write the application of CAD and CAM system.

- ✓ CAD/CAM applications are used to both design a product and program manufacturing processes, specifically, CNC machining. CAM software uses the models and assemblies created in CAD software, like Fusion 360, to generate tool paths that drive machine tools to turn designs into physical parts.

12.What is guide-ways /slide-ways in CNC ?

- ✓ Guide-ways (slide ways) are linear bearings for translatory motion between two members of a machine tool such as carriage and bed in lathe. Guide-ways are used in machine tools to Control the direction or line of action of the carriage or the table on which a tool or a work-piece is held.

13. Write the types of Guide-ways used in CNC.

- ✓ TYPES OF GUIDEWAYS

The guide-ways are mainly classified according to the nature of friction between contacting surfaces of the operative element:
(a) Guide-ways with sliding friction
(b) Guide-ways with rolling friction

The most commonly used shapes of guiding elements of slide-ways are:

(i) V-type

(ii) Flat type

(iii) Dovetail type

(iv) Circular or cylindrical type.

14. What are the guide-ways are used in CNC machining?

- ✓ **Introduction to Guide-ways**

A guideway is one of the important elements of the machine tool. The main function of the guideway is to make sure that the cutting tool or machine tool operative element moves along a predetermined path. The machine tool operative element carries a work-piece along with it. The motion is generally circular for boring mills, vertical lathe, etc. while it is a straight line for lathe, drilling, boring machines, etc.

The purpose of the guideway (or slide-way) is to accommodate the axial movement of the machine slides, worktables, and spindles. The guideway also provides the geometric alignment (parallelism, perpendicularity, roll, pitch, and yaw) for the axis. The surface must support the static and dynamic loads (including

machining forces) with as little friction as possible, but at the same time dampen the effect of a movable joint on the machine.

The design of machine tool elements is critical in tool engineering. They must withstand against an applied external load. Requirements, functions, and types of guide-ways are also explained.

Functions of guide-ways

i. To have low friction as compared to slide-ways
ii. Should have uniformity of motion even at slow speeds.
iii. Should have high stiffness if the rolling members are preloaded.
iv. Possibility of using the high velocity of motion.

Requirements of guide-ways

i. It should be strong
ii. It should process sufficient stiffness
iii. There should be less wear
iv. The pressure distribution should be uniform.
v. It should provide good guidance
vi. There should be less friction.

Standard Guideway Geometries

The guideway configurations or geometries most commonly used are:

1. Round – Limited used on surface grinders as well as feeding spindle bars (e.g. boring mill).

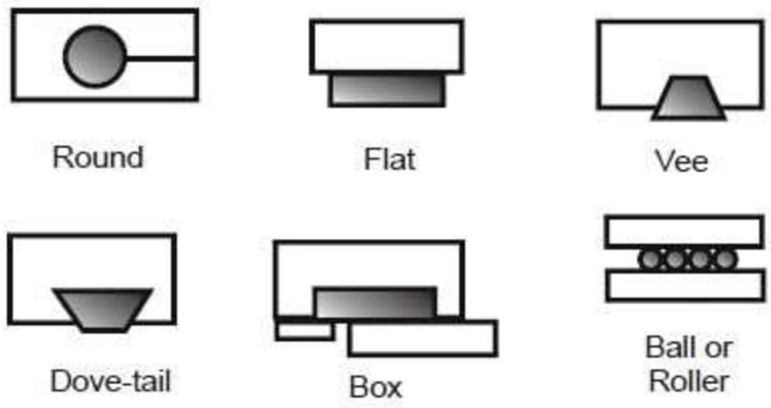
2. Flat – This guideway is used for alignment only – normally outboard from the machine's spindle. Found on a wide range of machines including grinding machines.

3. Vee – Cylindrical grinders may have vee ways. They are outboard from the grinding wheel and are used primarily for alignment.

4. Dovetail – This guideway is seldom seen on today's machine tools. However, it has some applications in tool slides (e.g. gang tool slide on a Swiss-type turning machine). It features extremely good rigidity and alignment characteristics. It is an expensive guideway to produce.

5. Box (square/rectangular) – This is a common guideway on machining centers and lathes. It is used in heavy machining (e.g. milling) applications. The box can either be a bolted-on steel rail or an integral part of the machine's casting. When they are integral, the cast-iron surface is flame or induction heat-treated and then ground and/or hand scraped.

6. Ball or roller – Prepackaged ball and roller packs can be purchased in a variety of sizes and ratings for general application on a wide range of machine guideways.



Common Guideway Geometries (Courtesy Decision Technology, Inc.)

TYPES OF GUIDEWAYS

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(b) Guide-ways with rolling friction

The most commonly used shapes of guiding elements of slide-ways are:

(i) V-type

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(iv) Circular or cylindrical type.

Vee- or Inverted Vee - Guide-ways:

- These are widely used on machine tools, especially on lathe beds.
- The advantage of this is that parallel alignment-of the guideway with the spindle axis is not affected by wear. There is a closing action as the upper member settles on the lower member, and this automatically maintains the alignment.
- Jibs are, therefore, not required with the vee guideway to take up the clearance caused by the wear.

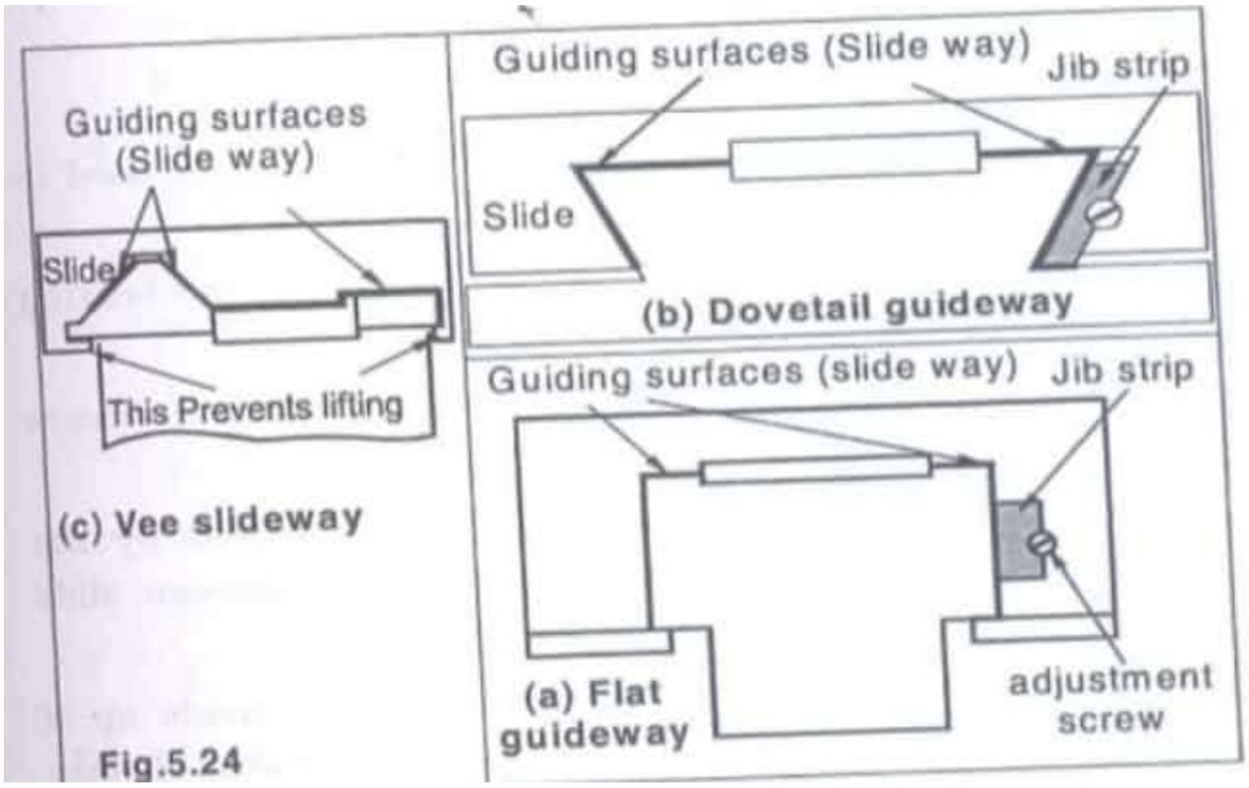


Fig.5.24

Flat and Dovetail Guide-ways:

- Flat or dovetail forms are used on CNC machine tools.
- The flat guide-ways have better load- bearing capabilities than the other guide-ways.
- After a period of use, wearing may occur owing to the sliding of the surfaces over each other. Jibs are used to ensure accurate fitting of the slide to both the flat and dovetail guide-ways.
- The jibs are tapered and can be adjusted to reduce excessive clearance caused by wear.
- The metal-to-metal contact on the vee, flat, and dovetail types of the guideway is normally cast iron to cast iron.
- The cast iron may be heat-treated to increase its hardness, and the surface ground to obtain the required accuracy.

Cylindrical guide-ways:

- In cylindrical guide-ways, the bore in the carriage housing provides support all around the guideway.
- For relatively short traverses and light loads, cylindrical guide-ways are very efficient.
- A limitation on the use of these guide-ways for long traverses is that if the guide bar is supported only at each end, it may sag or bend in the center of the span under a load.

Antifriction Linear Motion (LM) Guide-ways:

Antifriction linear motion guide-ways are used on CNC machine tools to:

(a) Reduce the amount of wear
(b) Improve the smoothness of the movement
(c) Reduce friction
(d) Reduce heat generation.

- They use rolling elements between the moving and the stationary elements of the machine.

These are Guide-ways with Rolling Friction.

Advantages over conventional guide-ways.

1. Low friction as compared to slide-ways
2. Uniformity of motion even at slow speeds due to the virtual absence of the stick-slip phenomenon.
3. High stiffness if the rolling members are preloaded, and
4. Possibility of using high velocities of motion.

- The main disadvantage of these guide-ways as compared to friction guide-ways is their lower damping capacity.

Stick-slip phenomena in machine tool guide-ways

- In a machine tool either the table holding the work-piece or the saddle holding the cutting tool moves very slowly over suitable guides and at the same time is subjected to heavy forces caused by cutting and clamping. In such sliding cases often a time-dependent intermittent motion is noted which causes consecutive sticking and slipping of the slide at regular intervals. This regularly repeated motion is known as stick-slip motion.
- This stick-slip motion when exits is found to worsen surface finish and dimensional accuracy of the product and also reduces the overall life of the machine tool and the cutting tools.
- Therefore for satisfactory machining performance, it is essential to eliminate or reduce the stick-slip motion. This requires being acquainted with the stick-slip characteristics and the role of various parameters on it.
- The principle agents which are responsible for stick-slip motion under low speed and large forces are the elasticity of the sliding elements and the frictional characteristics at the sliding surfaces.

Advantages of Linear Motion Guide-ways :

Following are the advantages of LM Guide-ways due to which their demand for high precision work is increasing:

1. High Positional Accuracy – When a load is driven by an LM guideway, the frictional contact between load and bed desk is rolling contact. The coefficient of friction is only 1/50 of traditional contact.

2. Long Life with high motion Accuracy – With a traditional slide, errors in accuracy are caused by the counter flow of oil film. Insufficient lubrication causes wear between the contact surfaces. In contrast, rolling contact has little wear, therefore machines can achieve a long life with motion accuracy.

3. High-speed motion is possible with the low driving force LM Guide-ways have little frictional resistance, only a small force is required to move a load.
4. Equal loading capacity in all directions LM Guide-ways can take the load in either vertical or horizontal directions.
5. Easy Installation – Installing a Linear Guideway is quite easy. Grinding or Milling the machine surface, following the recommended installation procedure, and tightening the bolts to the required torque can achieve highly accurate linear motion.
6. Easy Lubrication
7. Interchangeability

Applications Of Guide-ways:

Following are few Applications of LM Guide-ways:

1. Used in CNC machining Centre Fig. shows a CNC machining center in which Linear Motion Guide-ways are been used for getting high accuracy & Precision Motion.

2. The application of the linear guide-ways is very extensive, such as automation equipment, heavy-duty carry equipment, heavy-cut machining tool, CNC grinding machine,

3. large-scale planning machine and machining center with the demand of high rigidity and heavy load.

4. Injection Moulding Machine.

5. CNC Lathe.

6. Industrial Robots

7. Semiconductor Machines- PCB Driller

8. Other Machines- Measuring Machine, Transporting Machine, Welding Machine, Medical equipment, Test equipment, etc.

9. It can also be used in Aluminum Extrusion Press.

10. Various Manufacturing Catalogues are available for a selection of LM Guide-way for a particular Machine tool.

15. What are the Factors required for design of guide-ways ?

- ✓ Requirements of guide-ways are :

(a) Guide-way should have high rigidity.

(b) The surface of guide-ways must have greater accuracy and surface finish.

(c) Guide-ways should have high accuracy of travel.

16. What is spindle drive?

- ✓ Spindle drives convert the power generated by the motor into feed velocity and feed force. The integrated axial bearing can take extremely high axial loads.

17. what is feed drive in CNC?

- ✓ The feed drive is one of the most important parts of every CNC machine tool.The feed drive main purpose is to move the working parts of machine tool (working table, tool unit, spindle unit etc.) through machine axes. A separate feed drive is necessary for every machine axis.

18. What Is a CNC Spindle & How Does It Function?

- ✓ CNC spindles play a crucial role in machining. These components are fundamental to a fast and efficient process, while also ensuring that produced elements are as precise as possible. The team at Superior Spindle

Service is committed to helping their clients understand these components. Keep reading to learn more about spindles and their overall function in your CNC machine.

A machine spindle is a critical component, and is needed in a wide array of industries, including the automotive and aerospace sectors. Spindles are electrically or air-powered devices that come in numerous sizes.
Typically, there is a shaft that holds the tool together, a motor, and a taper used to control various tools. Then, the spindle rotates on an axis. The axis is controlled by commands coming from either a person or a computer. As the machine rotates the tool, the spindle cuts, slices, refines, and more.

Types of High-Speed Spindles

CNC spindles come in many shapes and forms, but they are typically divided into two categories, each of which has its own set of benefits.

- Integral Motor Spindle: This device comes with an internal motor that can reach a maximum speed of 60,000 RPMs. Because this machine can spin so quickly, it can be used in a variety of applications. On the other hand, because it rotates so quickly, it also burns out quickly. Its power and torque might be limited depending on the motor housing.
- Belt-Driven Spindle: This machine spindle can rotate up to 15,000 RPMs. Although it is not as quick as an integral motor spindle, it has an external motor that allows it to deliver more power and torque. It is also not as expensive as an internal motor spindle. If you have a limited budget, this could be the better option for you.

The Benefits of Using High-Speed Spindles

High-speed spindles offer a number of benefits, including:

- Accuracy: High-speed spindles are some of the most accurate machines available.
- Versatility: These tools operate well at any temperature, and can withstand most changes in temperature.
- Durability: High-speed machine spindles can handle routine wear-and-tear without breaking down quickly.
- Cost-Effective: The precision of high-speed spindles will help you save money down the road.
- Low Maintenance: Although you do have to take care of spindles, they are not costly to maintain.

What To Consider When Choosing a Machine Spindle

The most common question among CNC enthusiasts and businesses using this technology for the first time is “how do CNC machines work?” The most straightforward answer is through computer programming. CNC machines operate

by numerical coding, allowing the user to preprogram machine functions. These functions are determined by the design of your system: open loop or closed loop. If you are looking for a spindle for your CNC machine, there are many options available. When choosing a spindle, there are some factors that are important to consider, including its application, what type of CNC machine you have, and what types of materials you are working with.

Spindle Application Use by Industry

Machine spindles have a multitude of uses across many different industries. This includes equipment that's integral to agriculture, automotive, mold manufacturing, and even aerospace applications. In terms of the machine process, spindles play an important role in a fast production space.

For instance, metal lathes are used to cut hard materials. Along with metals, these machines can also cut plastics, as well as sturdy composite materials. Lathes can be used for milling, which uses rotary cutters to trim away at a piece until it reaches the desired shape. CNC machines containing spindles can also be used in woodworking, electrical component creation, and manufacturing parts for computers.

If you're not sure which type of spindle is best for your industry, reach out to the experts at Superior Spindle Services.

Spindles by CNC Machine Type

You should also think about the type of CNC machine that you have. Some of the most common types include:

- CNC Mills: Based on a three-axis system, CNC mills utilize G-code or other unique languages, and are heavily used in the manufacturing industry.
- CNC Lathes: These machines are often used for complex and intricate cutting and require high velocity.
- CNC Plasma Cutters: Using a combination of compressed-air gas and electrical arcs to produce adequate heat, plasma cutters are used heavily in metal fabrication shops. The plasma torch is controlled along an axis, and is capable of performing accurate and clean cuts repetitively.
- EDM: Also called electric discharge machines, these machines are used in the process of molding pieces with the use of electrical sparks.
- CNC Water Jets: While often found in metal shops, water jets are also useful in the cutting and shaping of granite. These tools force water through a series of narrowing tubes, increasing its pressure and velocity as it is sprayed against and through a hard substance.

There are countless CNC machines out there, and you need to make sure you find the right machine that meets your needs.

Spindles by Material Use

Finally, you also need to think about the materials you work with on a regular basis. CNC spindles are designed to work with all types of materials, including embroidery, foam, wood, glass, plastic, and more. Whether your business offers 3D printing, wood routing, or glass cutting services, machine spindles can help you streamline your production processes.

The type of CNC machine spindle you need depends on the materials that you are working with. If you need help finding the right spindle, contact the professionals at Superior Spindle Services.

How Superior Spindle Services Can Help You

To get the most out of your CNC machine, you need to be vigilant about maintenance, and you should understand the basis of computer programming responsible for executing your objectives. Unfortunately, most issues with machine spindles arise out of human error. That's why it's important to work with spindle specialists.

Superior Spindle Services has a tremendous amount of experience in the field; their specialists can help you identify the right machine spindle. They can also help you maintain your equipment for years to come with their exceptional spindle repair services.

CNC Spindle Repairs

Over time, it's likely that your spindles will break down due to gradual wear. If your machine spindles are not functioning properly, it's important to repair or replace them to prevent disruptions to your operation.

Repairing or rebuilding a CNC spindle is a rigorous process that should only be undertaken by highly experienced professionals. For example, reassembling new spindle components must take place in a sterilized environment to prevent dirt and debris from coming in contact with the component. This speeds up degradation and greatly shortens the lifespan of your spindle.

If something has gone wrong with the spindle in your CNC machine, turn to Superior Spindle Services. They offer a full line of spindle repair services includes vibration analyses, bearing repairs, full replacements, and rebuilds. Their experienced technicians will work closely with you to help you find the most cost-effective and long-lasting solution.

19.What are the different types of spindle bearings are used in CNC?

✓ 4 Types of Bearings Used in Machine Tool Spindles

In the machine tool industry, spindles are a critical component used to shape materials through the use of high-speed rotation and pressure. As modern machinery advances, machining equipment is required to be faster, more precise, and more durable than ever before. Bearings are crucial parts that direct and enhance spindle movement. The use of high quality bearings, improves the efficiency and reliability of machine tool spindles, thereby increasing production and reducing wear and tear on machinery.

AFBM Std 20-1977	**DIN 620**	
ABEC 1-3	PN	Standard precision level for majority of applications
ABEC 5	P5	Increased Precision Class for high operating accuracy, high speed, quiet running
ABEC 7	P4	Higher than ABEC 5/P5
ABEC 9	P2	Higher than ABEC 7/P4

The Demand for Bearings in the Machine Tool Industry

With the advent of CNC technology, machine tools are expected to be more accurate, efficient, and reliable than ever. To remain competitive, machining companies are investing in high quality bearings that ensure top equipment performance. The overall purpose of a spindle bearing is to enhance and streamline spindle movement to ensure optimal machine speed and accuracy. Bearings affect the speed, rotation, vibration, precision, and

temperature of the machine tool, which in turn alters the quality of the final product.

Bearings are typically composed of a ring or series of rings with a ball or other rolling element that streamlines the motion of the spindle in the desired direction. Depending on the equipment and desired motion, bearings can be engineered to facilitate the movement of spindles on both lateral and radial axes. They must be able to withstand the load pressure, temperature, and high speed of machine tool spindles.

4 Types of Bearings for Machine Tool Applications

There are four separate categories for bearings used in machine tool spindles. Each bearing design has characteristics that make it useful for certain applications, and it's essential to know how each works so you choose the best bearing for your equipment.

Angular-Contact Ball Bearings

Angular-contact ball bearings are the most common spindle bearing. They are rolling bearings and consist of one or more rows of rolling balls between concentric grooved rings. They are useful for both radial and axial loads in one direction, and their axial load carrying capacity is determined by the angle at which the load contacts the bearing. The greater the angle, the higher the load capacity.

Radial or Deep-Groove Bearings

Popular in industrial machinery, radial bearings are rolling bearings primarily used for load bearing on the radial axis. Like angular-contact bearings, they are composed of an inner and outer ring with rolling balls between them; however, radial bearings can carry loads in both axial directions, making them more versatile than their angular-contact counterparts.

Roller Bearings

Roller bearings enhance motion through the use of rolling cylinders instead of balls. They are used to support primarily radial loads and axial loads parallel to the axis in one direction. They are useful in moderate to high-speed applications to reduce friction and enhance equipment speeds.

Thrust Ball Bearings

Engineered to specifically support heavy, high precision thrust loads, thrust ball bearings offer exceptionally precise axial support parallel to the drive shaft, but little to no radial support. The rolling element may be a ball, roller, or needle, depending on the application. They are particularly useful for applications such as propeller engines, which support free and easy movement of heavy loads parallel to the shaft.

SEMESTER 5TH

MECHATRONICS (TH 4)

6.0 ROBOTICS

1. Define Robot.

- ✓ Robot, any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner. By extension, robotics is the engineering discipline dealing with the design, construction, and operation of robots.

2.What are the function of a Robot?

- ✓ They may recognize people or objects, talk, provide companionship, monitor environmental quality, respond to alarms, pick up supplies and perform other useful tasks. General-purpose robots may perform a variety of functions simultaneously or they may take on different roles at different times of day.

3.Write the laws of robotics.

- ✓ There are three laws for a robot I.e.

First Law

A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Second Law

A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

Third Law

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

4.Write the types of industrial robots.

- ✓ **Articulated robots**

Articulated robots are the most common industrial robots. They look like a human arm, which is why they are also called robotic arm or manipulator arm. Their articulations with several degrees of freedom allow the articulated arms a wide range of movements.

Cartesian coordinate robots

Cartesian robots, also called rectilinear, gantry robots, and x-y-z robots have three prismatic joints for the movement of the tool and three rotary joints for its orientation in space.

To be able to move and orient the effectors organ in all directions, such a robot needs 6 axes (or degrees of freedom). In a 2-dimensional environment, three axes are sufficient, two for displacement and one for orientation.

Cylindrical coordinate robots

The cylindrical coordinate robots are characterized by their rotary joint at the base and at least one prismatic joint connecting its links. They can move vertically and horizontally by sliding. The compact effectors design allows the robot to reach tight workspaces without any loss of speed.

Spherical coordinate robots

Spherical coordinate robots only have rotary joints. They are one of the first robots to have been used in industrial applications. They are commonly used for machine tending in die-casting, plastic injection and extrusion, and for welding.

SCARA robots

SCARA is an acronym for Selective Compliance Assembly Robot Arm. SCARA robots are recognized by their two parallel joints which provide movement in the X-Y plane. Rotating shafts are positioned vertically at the effectors.

SCARA robots are used for jobs that require precise lateral movements. They are ideal for assembly applications.

Delta robots

Delta robots are also referred to as parallel link robots. They consist of parallel links connected to a common base. Delta robots are particularly useful for direct control tasks and high maneuvering operations (such as quick pick-and-place tasks). Delta robots take advantage of four-bar or parallelogram linkage systems.

6.Define Robotic systems.

- ✓ Robotic systems can be roughly defined as "systems that provide intelligent services and information by interacting with their environment, including human beings, via the use of various sensors, actuators and human interfaces".

7.What are the basic parts of a robot?

- ✓ **Manipulator:**

Just like the human arm, the robot consists of what is called a manipulator having several joints and links.

2. Endeffector:

The base of the manipulator is fixed to base support and at its other free end, the Endeffector is attached.

The Endeffector is expected to perform tasks normally performed by the palm and finger arrangements of the human arm.

3. The Locomotion Device:

In the case of Human Beings the power for the movement of the arm, the palm and fingers is provided by muscles. For the robot the power for the movement (locomotion) is provided by the motors. The motors used for providing locomotion in robots are of three types depending on the source of energy: Electric, Hydraulic or Pneumatic.

4. The Controller:

The digital computer (both the hardware and the software) acts as a controller to the robot. The controller functions in a manner analogous to the human brain. With the help of this controller, the robot is able to carry out the assigned tasks. The

controller directs and controls the movement of the Manipulator and the Endeffector. In other words, the controller controls the robot.

5. The Sensors:

Without the data supplied by the sense organs, the brain would be incapable of intelligence. In other words the controller (the computer) of the robot cannot do any meaningful task, if the robot is not with a component analogous to the sense organs of the human body. Thus, the fifth and the most important component of the robot is the set of sensors. Sensors are nothing but measuring instruments which measures quantities such as position, velocity, force, torque, proximity, temperature, etc.

8.What are the advantages and disadvantages of Robot?

ADVANTAGES OF ROBOT

- ✓ Increased efficiency
- ✓ Higher quality
- ✓ Improved working environment
- ✓ Increased profitability
- ✓ Longer working hour
- ✓ Time saving

The Disadvantages of Robots

- ✓ They Need Constant Power.
- ✓ They're Restricted to their Programming
- ✓ The Perform Relatively Few Tasks
- ✓ They Have No Emotions
- ✓ They Require Expertise to Set Them Up
- ✓ They're Expensive to Install and Run

(OR)

Advantages Of Robotics:- There are several advantages of Robotics and some particular advantages are mentioned below,

- **Increase efficiency :-** Robots can complete certain tasks faster and more efficiently than humans as they are designed and built to perform them with higher accuracy. In fact, if you are producing two to three items in the industry a day, with a robot, you can manufacture 50 to 100 items a day more accurately. This

combined with the fact they are used to automate processes which previously might have taken significantly more time and resource results in the use of industrial robots to increase the efficiency of production lines.

- **Long Working Hours:-** You can employ robots in places where it is risky for humans to handle jobs. They can work continuously for months together without a break, maintenance and are considered to be more productive than people. Humans go nuts and their brains stop working when they work without a break and sleep. However, robots can work without sleep and break.
- **Respective and dangerous tasks:-** Some tasks are deemed as too dangerous or laborious and repetitive for humans to carry out and so instead robots can perform these tasks instead. Working conditions, therefore, can be vastly improved as well as the safety within factories and production plants by introducing industrial robots.
- **New Jobs:-** With its progression, it churns out new jobs as people need to design and fix the issues in robots as well. Robots can work round the clock without getting tired. This is one of the advantages of robotics.

Disadvantages of Robotics:- There are several disadvantages of Robotics and some particular disadvantages are mentioned below,

- **Higher Cost & Continues supply power:-** This is one of the disadvantages of robotics. Robots consume a lot of power to function. Robots need to be maintained continuously to keep them in good condition. You would need to invest a huge amount of money to buy robots. On top of this, to develop software to make it function as per your needs would cost even more also implementing industrial robots can incur a high capital as well.
- **Unemployment:-** If robotics comes into trend, then many skillful workers would also lose their jobs and would be on roads, which is one of the disadvantages of robotics. Many daily wage workers would lose their jobs, which are actually the bread and butter of their families.
- **Dangerous:-** Robots can also be dangerous to humans when they malfunction or designed to work for warfare and some of the countries have already started using robots in wars in various forms.
- **Emotionless:-** Robots can never interact like humans, as they lack empathy, which is one of the disadvantages of robotics. If Robotics comes in to the force them in various parts of the personalized services human touch will be always missing.

9. What are the joints used in Robots?

- ✓ Types of joints used in robots

The Robot Joints is the important element in a robot which helps the links to travel in different kind of movements. There are five major types of joints such as:

- Rotational joint
- Linear joint
- Twisting joint
- Orthogonal joint
- Revolving joint

Rotational Joint: Rotational joint can also be represented as R –Joint. This type will allow the joints to move in a rotary motion along the axis, which is vertical to the arm axes.

Linear Joint: Linear joint can be indicated by the letter L –Joint. This type of joints can perform both translational and sliding movements. These motions will be attained by several ways such as telescoping mechanism and piston. The two links should be in parallel axes for achieving the linear movement.

Twisting Joint: Twisting joint will be referred as V –Joint. This joint makes twisting motion among the output and input link. During this process, the output link axis will be vertical to the rotational axis. The output link rotates in relation to the input link.

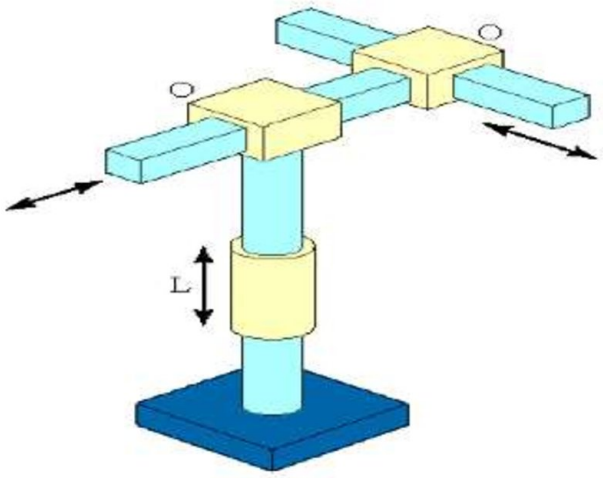
Orthogonal Joint: The O –joint is a symbol that is denoted for the orthogonal joint. This joint is somewhat similar to the linear joint. The only difference is that the output and input links will be moving at the right angles.

Revolving Joint: Revolving joint is generally known as V –Joint. Here, the output link axis is perpendicular to the rotational axis, and the input link is parallel to the rotational axes. As like twisting joint, the output link spins about the input link.

10.What are the basic coordinate systems in industrial robots.

- ✓ **Cartesian coordinate system**

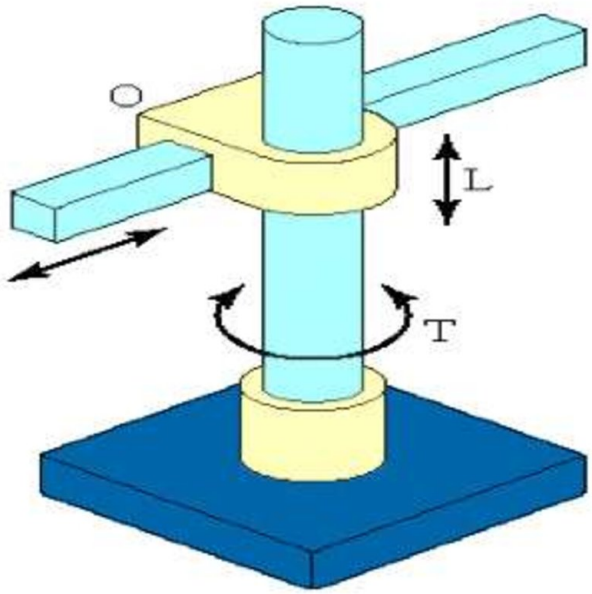
Cartesian coordinate robot- x-y-z- robot consists of three sliding joints. Main application area loading, palletizing, transporting, simple works



Cartesian robots are also called rectilinear or gantry robots and have a rectangular configuration. These types of industrial robots have three prismatic joints to deliver linear motion by sliding on its three perpendicular axes (X, Y and Z). They might also have an attached wrist to allow rotational movement. Cartesian robots are used in majority of industrial applications as they offer flexibility in their configuration which make them suitable for specific application needs.

Cylindrical coordinate system

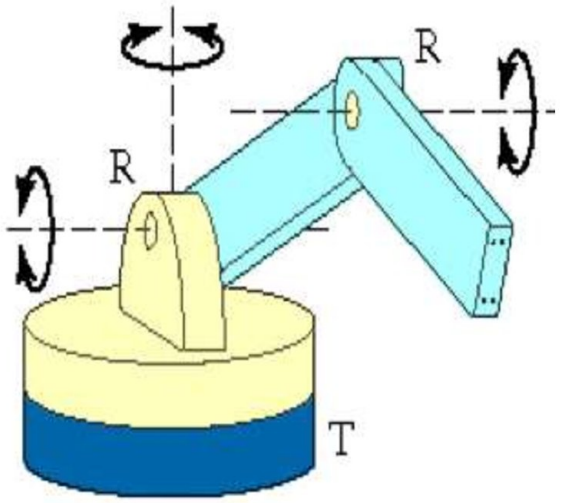
Cylindrical configuration consists of a vertical column, relative to which an arm assembly is moved in and out relative to the axis of the column. Common configuration is to use a T-joint to rotate the column about it axes. An L joint is used to move the arm assembly vertically along the column, while O joint is used to achieve radial movement of the arm. Typically used for loading- unloading operations of different machine tools.



Robots with a cylindrical coordinate system have a relatively simple structure, where one twisting joint (T) is added to two typical linear coordinates (L). Such type of robots are used for loading-unloading operations, for packing, palletizing, etc. in cases where the robot's task is to move between different objects in the workplace. Flexibility for the robot can be added with coordinates of the wrist assembly system.

Spherical coordinate system

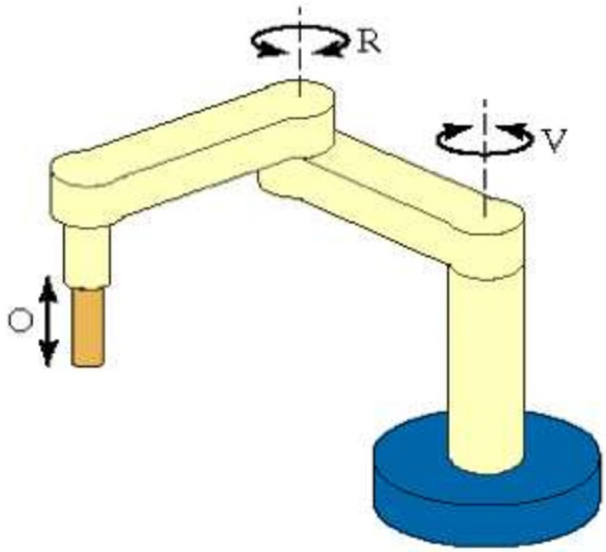
Jointed-arm robot- general configuration of a human arm. This consists of a vertical column that swivels about the base using T joint. At the top of the column is a shoulder joint (an R joint), output of an elbow joint (another R joint). Robot is very flexible and suits for different applications. Could be used as working robot (welding, painting, assembly, machining, etc) or servicing robot (loading – unloading of different equipment). For transport applications not the best solution.



Articulated robot (spherical coordinate system) is one of the most common types of industrial robots. It resembles a human arm in its mechanical configuration. The arm is connected to the base with a twisting joint (T). The number of rotary joints (R) connecting the links in the arm can range from two joints to ten joints and each joint provides an additional degree of freedom. The joints can be parallel or orthogonal to each other. Articulated robots having six degrees of freedom are the most commonly used industrial robots as the design offers maximum flexibility.

SCARA type robot

SCARA type robot is used for assembly operations. Similar in construction to the jointer-arm-robot, expect that the shoulder and elbow rotational axes are vertical, which means that the arm is very rigid in the vertical direction, but compliant in the horizontal direction. As name, used mainly in assembly works.



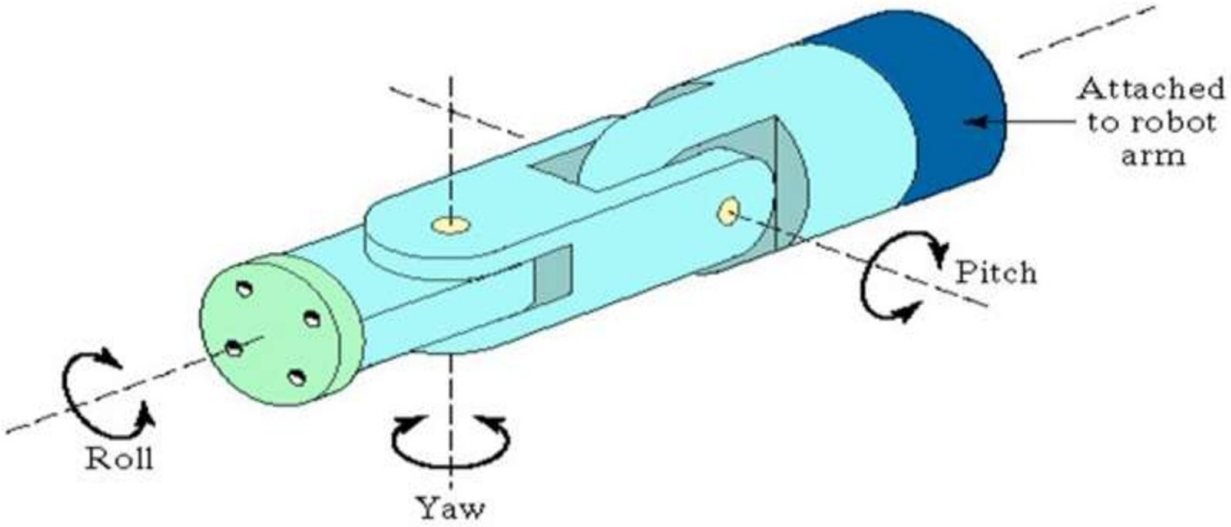
Wrist coordinate system

Wrist assembly is attached to end-of-arm

End effectors is attached to wrist assembly

Function of wrist assembly is to orient end effectors

Body-and-arm determines global position of end effectors



Robot basic construction

There are two basic parts of the robot manipulator:

- a body-and-arm assembly, with three degrees of freedom
- a wrist assembly, with two or three degrees of freedom

REFERANCE:-

- ✓ R.K Rajput
- ✓ INTERNET