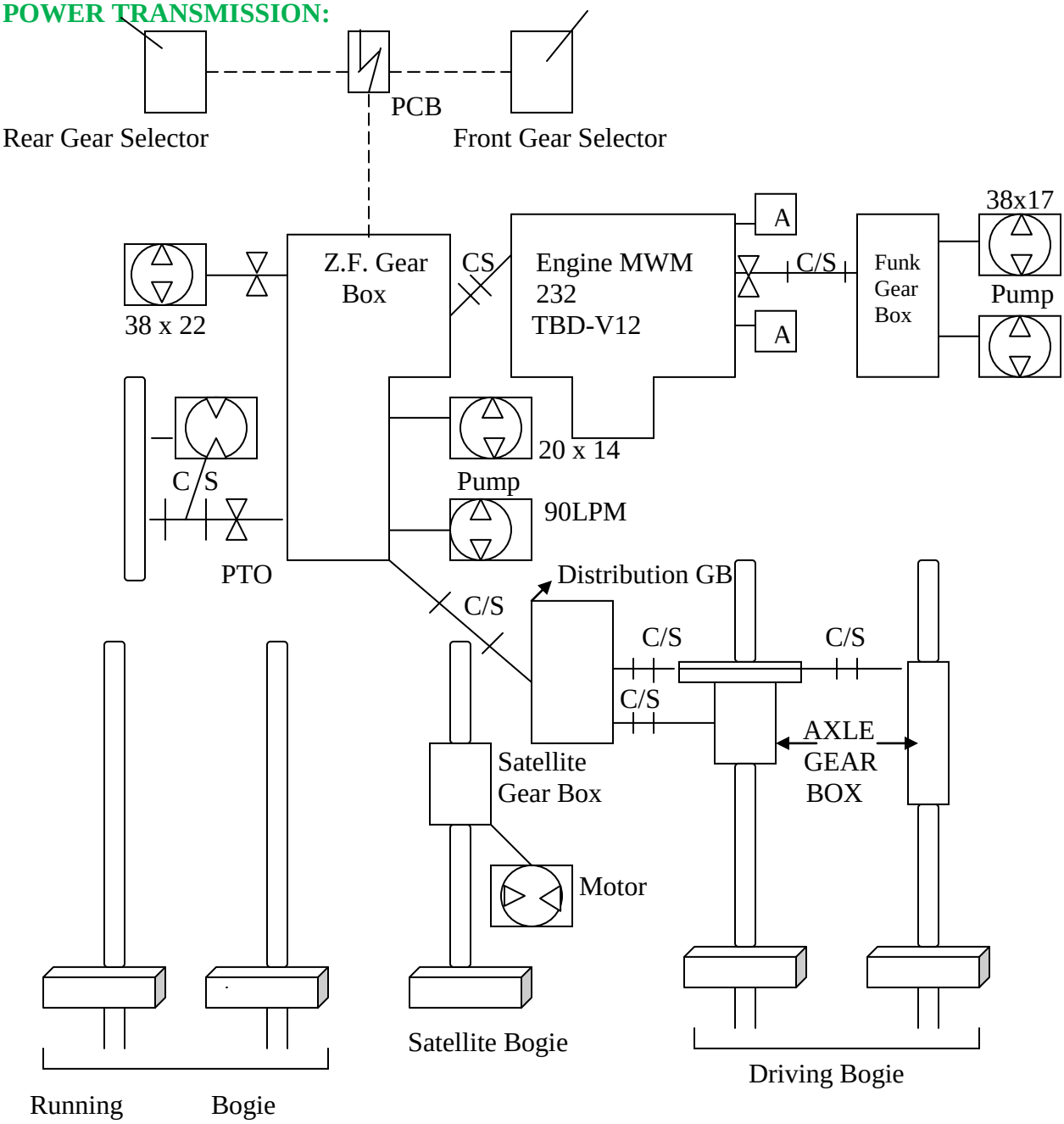
SUB: HYDRAULICS, PNEUMATICS & MECHANICAL
Duration: 74 Sessions = 148 Periods
Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)
Lesson-I: Power Transmission **Session-1:** Block Diagram, Types of Power Transmission, Mechanical Transmission, 'V' belt, Chain, Pulley, Cardon Shaft.

INTRODUCTION:

We cannot imagine a world without power expect for the power of human or animal muscles, It would be a world without homes as we know them, without factories, electric lights, modern medicine, automobiles, adequate food and clothing.

Man's ability to produce and utilize power has helped to shape our modern civilization. A numerous types of power have been developed in industrial application. Such as mechanical, electrical, pneumatic, hydraulics, electrical, electronics.etc.

POWER TRANSMISSION:



POWER TRANSMISSION:

In mechanical Engineering, the word power transmission is widely used term in all types of transmission applicable involved mechanical arrangement. The following are the various mechanical power transmissions generally available in day to day working which are given as under:

'V' Belt transmission (Belt transmission)
Chain drive transmission
Pulley drive transmission
Gear drive transmission

INTRODUCTION TO BELT DRIVES

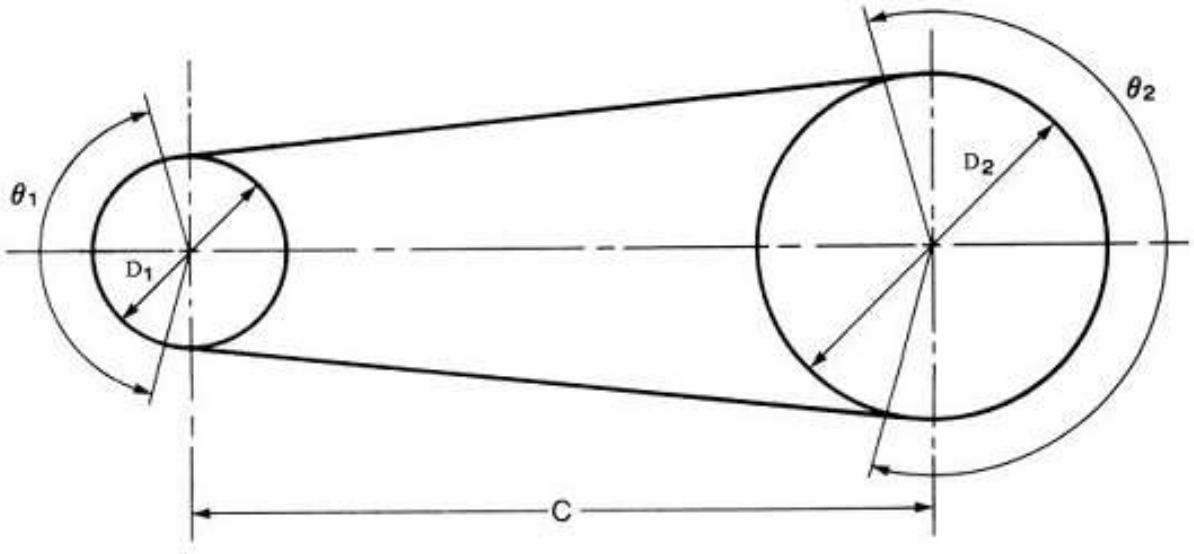
A belt drive consists of driving and driven pulleys and the belt , which is mounted on the pulleys. Drives may have two or more driven pulleys. When installing, the belts are tightened on the pulleys, there are pressures between belts and pulleys because of the initial pulls. When the drivers rotate, the follower will rotate in the same direction by friction forces.

Geometric relationships in belt drives

By using the geometry of the pulley drive, the total length of the belt can be calculated by using the relation:

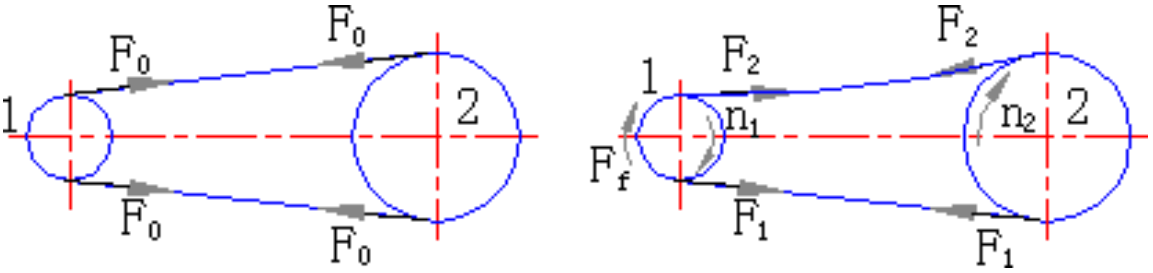
Length of the belt, $L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{(D_2 - D_1)^2}{4C}$

Where C= Center distance between two pulleys
D_1= Diameter of the smaller pulley
D_2= Diameter of the larger pulley



Tension in belts

Belts are mounted on the pulleys with a certain amount of (initial) tension F_0. Before drives operate, the forces acting on the two sides of belts are equal. When belts operate, the forces are different owing to the action of the force of friction between the belt and the pulley. In clockwise rotation of the driver, the driver pulls belt from lower side and delivers it to the upper side. Thus the tension in the lower side belt, F_1 will be more than that of the upper side belt F_2. Hence the lower side is called as tight side and upper side is called as slack side.



a) When it does not work b) Working

If the length of an endless belt is constant, when drives operate, according to deformation relation,

$$F_1 - F_0 = F_0 - F_2$$

$$F_0 = \frac{F_1 + F_2}{2}$$

Also, the peripheral force acting on the pulleys or useful load of a belt is:

$$F_e = F_1 - F_2$$

The relationship of the peripheral force, the belt speed and the transmitted power is:

$$P = \frac{F_e v}{1000} \text{ KW}$$

Where v= velocity of belt in m/s

Fe=peripheral force in N

The relationship between the minimum tension F_2 and maximum tension F_1 is:

$$\frac{F_1}{F_2} = e^{\mu\theta}$$

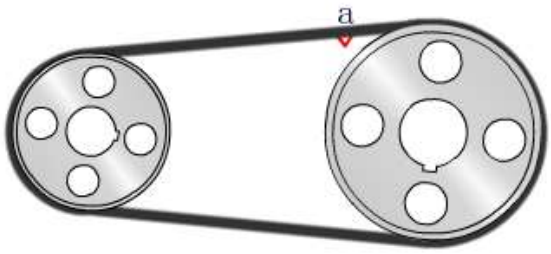
Where μ =coefficient of friction between pulley and belt

θ = angle of contact of the smaller pulley

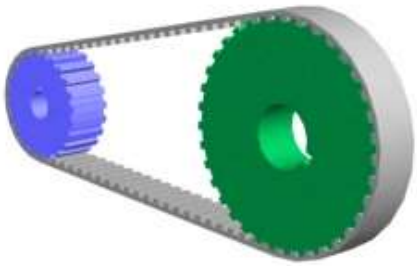
$$= 180° - \frac{D_2 - D_1}{C} \times 57.5°$$

Types of transmission

Belt drives have two types of transmission, friction and meshing. The former transmits power by friction force produced between the belts and the pulleys and the latter by meshing between the teeth in the belt and the grooves cut on the periphery of the pulley.

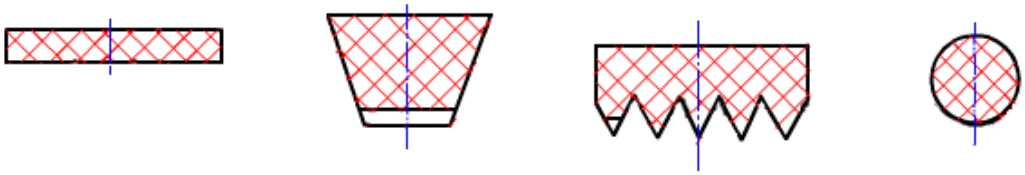


by friction



by meshing

Cross section of belts

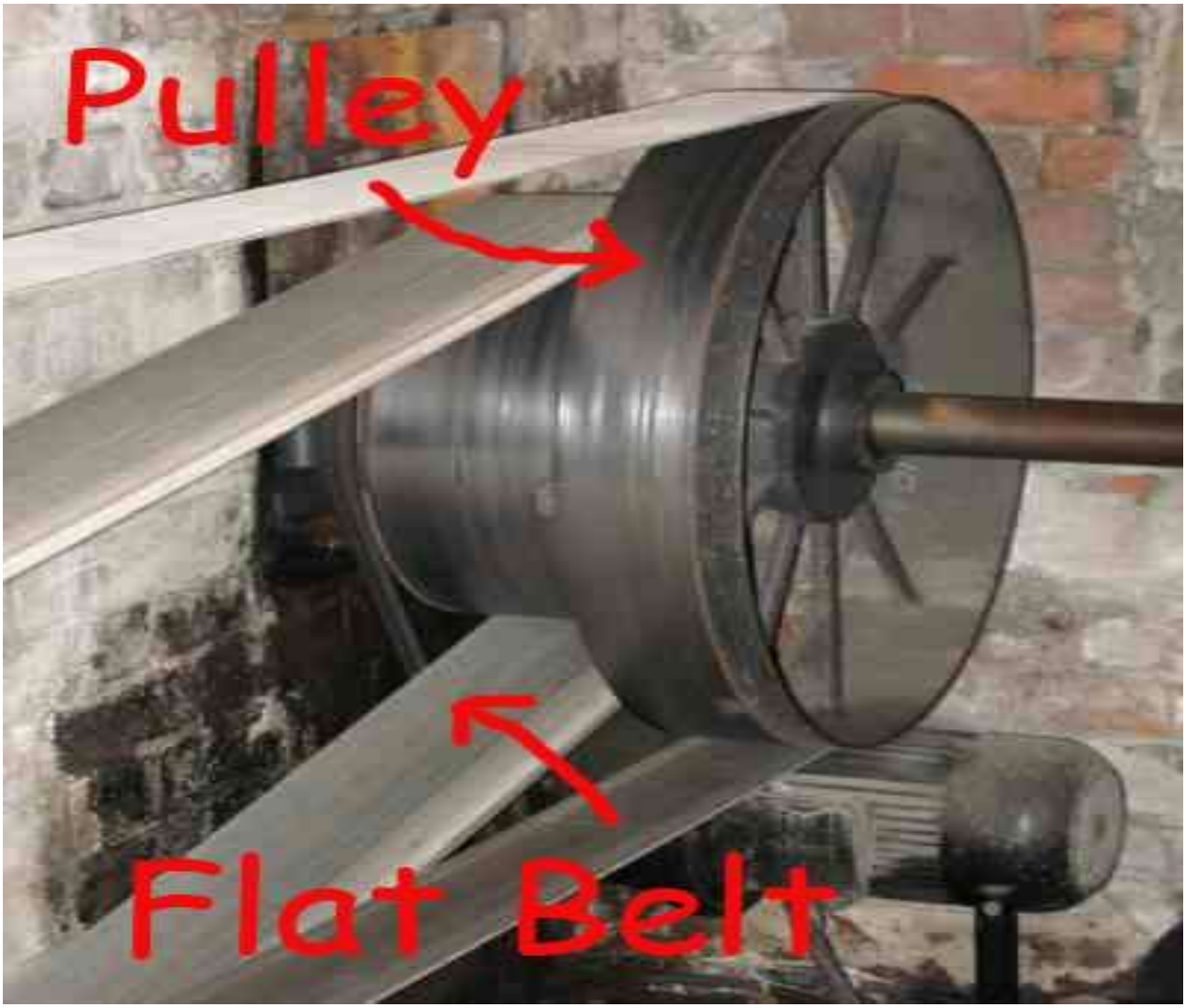


Flat belt V-belt multiple V-belt round belt

Types of belt drive

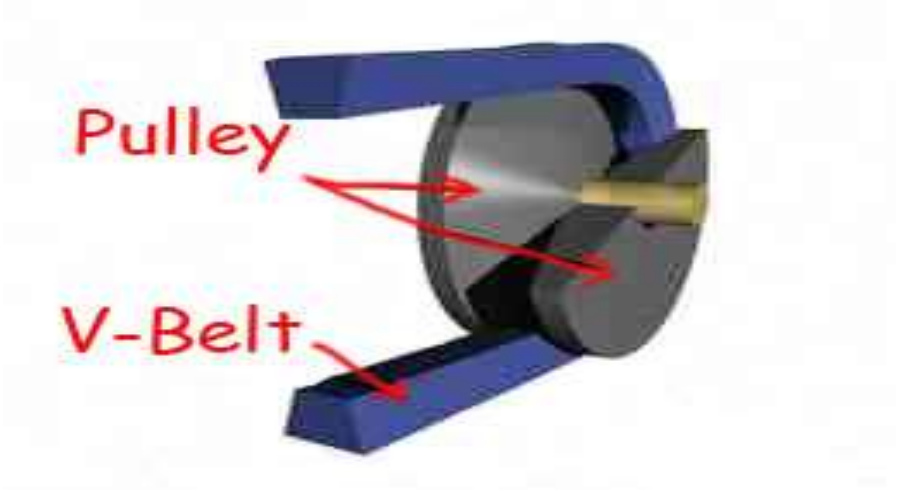
1. Flat belt

Flat belt transfers torque by friction of the belt over a pulley. Flat belt drives are mostly used for low power and high speed applications. These are also used for conveyance applications. Best drives result from belts with high flexibility, low mass, and with surfaces engineered to provide a high coefficient of friction.



2. V-Belt

V-belts are also known as wedge rope. This provides the best combination of traction, speed of movement, long of the bearings, and long service life. Better torque transfer possible compared to flat belt. With a flat belt drive only one belt is used, with a v- belt drive a number of belts are used.V- Belt Drives achieve drive efficiencies of about 95%.

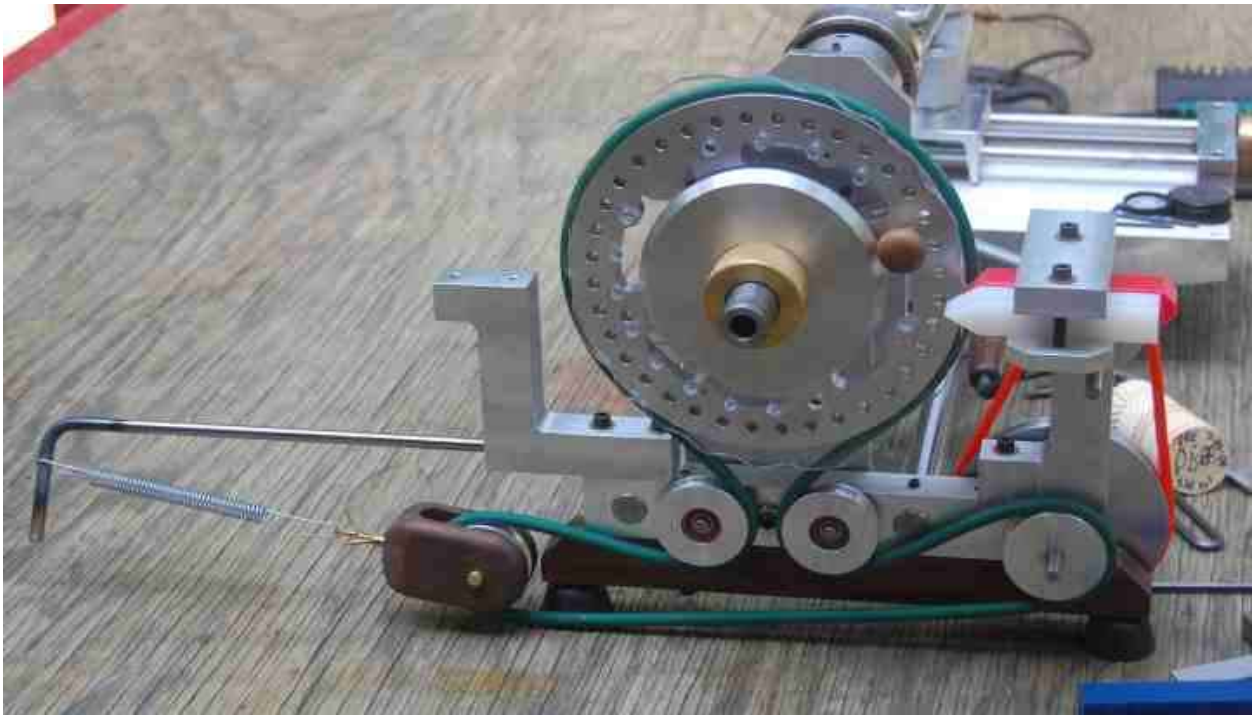


3. Timing belt

These belts are used for power transfer and for synchronized drives to ensure that the driven pulley is always rotating at a fixed speed ratio to the driving pulley. Belt toothed on the inside driving via grooved pulleys. This has limited power capacity compared to chain and V- belt derivatives and does not require lubrication.

4. Round belt

Round belts have circular cross section designed to run in a pulley with a circular (or near circular) groove. They are for use in low torque situations.

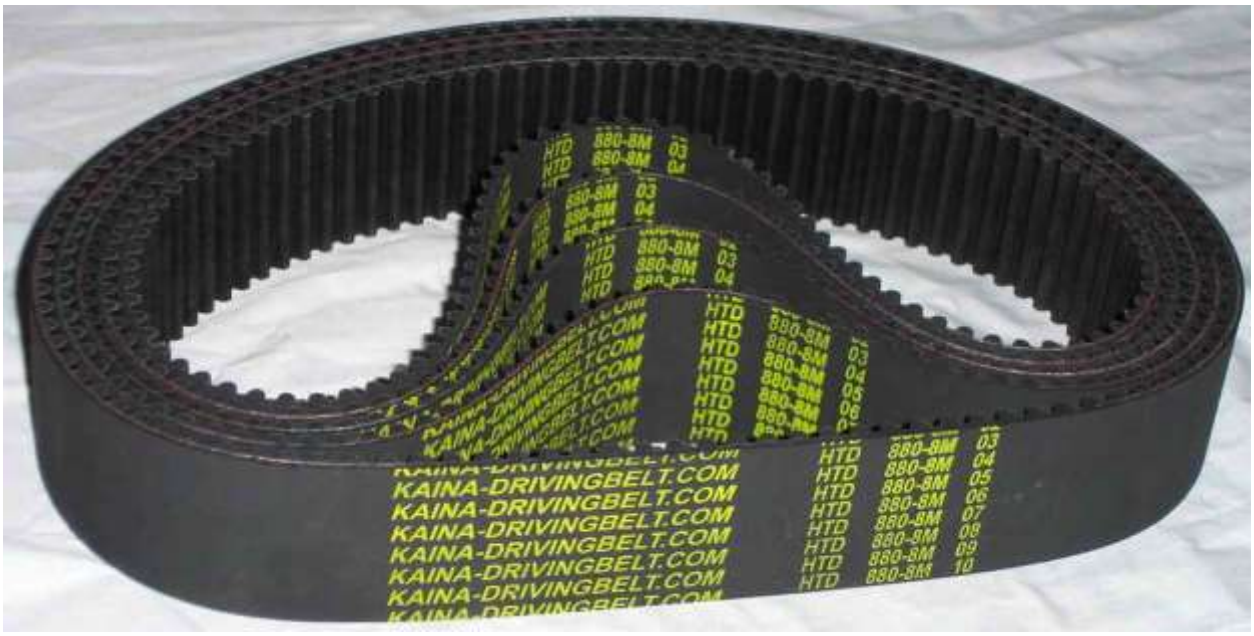


5. Other types

(a) Multi-groove/ Polygroove belts: These are made up of 5 or 6 “V” shape belt alongside each other. The added flexibility offers an improved efficiency.

(b) Ribbed belt

It is a power transmission belt featuring lengthwise grooves.



(c) Speciality belt

This type of belt transmits power on the tension side of the loop, designed for continuously variable transmission.

Of the various belt types, V-belts are the most popular. V-belts are belts of trapezoidal cross section with two sides wording surface and run over pulleys with grooves of the corresponding cross section.

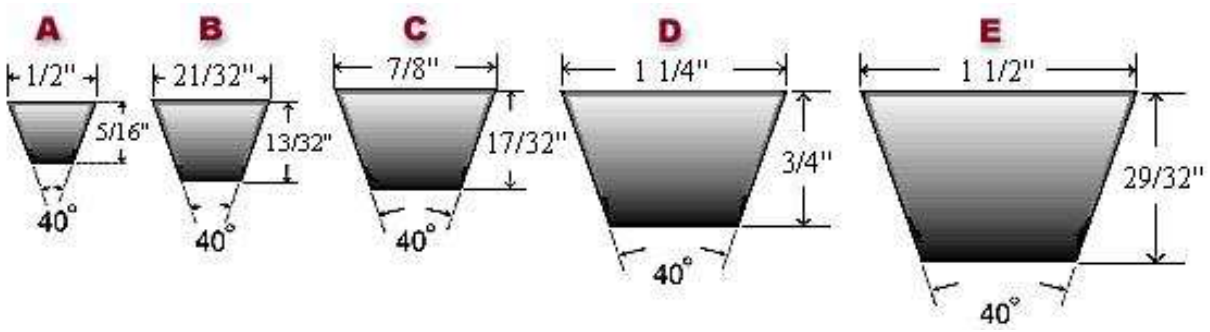
VEE BELTS:

V-belt drives are by far the most widely used of any of the belt drives in an industrial plant. Because of this large usage, V-belts have progressed from the one or two simple types originally furnished to at least a dozen different types. Most types of belts having similar cross-sections are interchangeable, and can be used to operate related pieces of equipment. The particular choice of for using a certain type of belt over others that are almost identical is based on the experience of the equipment manufacturer, plant engineer or the maintenance department.

V-Belt construction

1. Cover
2. Insulating Compound
3. Tension members
4. Compression area

Generally, V-belts are broken down in to three separate groups, identifiable by the size and shape of the belts. In the standard group belt sizes are currently designated by the letters A,B,C,D,and E as shown in the fig. Each of the different lettered belts has specific size limitations indicated by the dimensions. Some manufactures sizes vary slightly from those shown. Belts are made in specific length, although they are occasionally purchased as a single strand and spliced to the desired length. The standard belts are still the most commonly used in industry.



Slip and Creep of belt drives

Slip may be defined as an actual movement (or sliding) of the belt relative to the pulley. Creep, however, is a different phenomenon. When the speed of the belt exceeds the peripheral speed of the pulley, relative slip takes place between the belt and the pulley. Such relative slip is known as belt creep.

'V' BELT TRANSMISSION:

This is the Mechanical Power Transmission method in which 'V' belts are used and the power is transmitted from one end to the another. In this method power transmission is affected on account of wear and tear and slippage etc. Generally following are the different categories of belts used in transmission in machines, A-33, A-34, A-41 & A-42 etc.

The second group of V- Belts is classed as high capacity belts. These are used where standard belts may not perform well because of high horsepower or loading conditions. Also heat, moisture, or other similar conditions may require special belt. Sometimes, there isn't room for a standard drive, and the reduced section of the high capacity belts allows it to fit in to the smaller space.

The standard and high capacity belts, there are a number of smaller belts used for lighter duty and with smaller drive pulleys, the two types commonly used are shown in fig. The 2L through 5L belts are similar in cross-section to standard belts, and are used most often.

V-Belt Drives:

In belt drives, power is transmitted by friction. The amount of power transmitted by friction.

The amount of power transmitted is dependent upon the coefficient of friction between the belt and the pulley. The coefficient of friction depends on the materials in contact, their condition the arc of contact between the belt and the pulley, or sheave, and the velocity at which the belt operates.

To make the drives efficient, there are several different sizes of belts available for industrial applications. The size of a belt is determined by its cross-sectional area. Standard duty belts with large cross- sections are used for heavy duty or high horsepower drives while small

cross-section belts are used for light duty or small horse-power drives. There are many cases where two or more small belts can provide the proper amount of belt cross-section more economically than one large one. However, if small belts are used on a heavy drive, a large number would probably be required because of low horsepower ratings per belt. In this case, one or two large belts would be more economical than many smaller ones. Exceptions to this are the high capacity belts which have a smaller cross section.

RUBBER BELTS:

Rubber belting is one of the important medium of transmission of mechanical power.
They are trapezoidal in X section.
The vee belts are designated by suffices letter A. B. C. & D with standard dimensions followed universally by all belt manufacturers.

(i) Installation & Maintenance:

1. Check pulley groves for damage, dent make, burs and excessive wear before mounting the belts.
2. Check drive and driven units for alignment.
3. Move the drive unit towards driven unit to mount the belts in groove.
4. Avoid excessive and un even tension.
5. All ways use pulley with larger dia.
6. Check for pulley groves angle and proper positioning of belt.
7. Check the belt tension daily.
8. If it is required to be change a belt in a multi belt drive unit, change all the belts with new set.
9. During storage, keep the belts hanging.
10. Store the vee belt in cool and dry place.

(ii) Chain Drive Transmission:

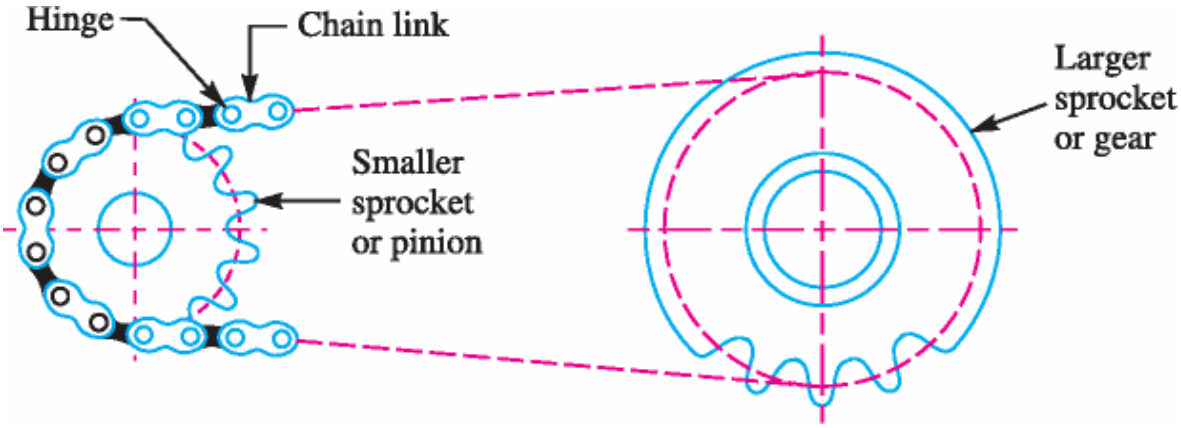
This is the method of power transmission in which chain is used for transmitting power from one end to another. In this method chain is interlinked and power transmission takes place. In track machines, following are the applications of chain drives such as simplex chain, duplex chain of PQRS machines, cutting chain of BCM etc.

Chain drive, unlike V-belts drives, do not use friction to aid in transmitting motion. Their means of transmitting motion is positive and similar to a gear tooth contact. Because of the positive transfer of motion, chain drives are approximately 98 percent efficient. The chain serves as a connection between the driver and the driven sprockets allowing them to be spaced some distance apart,

The chain , while flexible, can only be used to transmit motion in a straight line between the sprockets, it cannot make quarter turns or be reversed to form a figure V- belt can however chains have several advantages that V- belts do not.

One of these is the driving range of driving power that is available from the compact single strand chains, additional horse power can be accommodated by doubling or tripling the strands of chain as require. Also, the chain can be driven from either side without reversing the chain strand.

Furthermore, the chain weight forms its own take up on the loose or slack side of the drive this eliminates the adjustment that is required in a V- belt drive to maintain the proper friction contact. However, chain drives do stretch, and occasionally the take up has to be adjusted, or a link or two removed from the chain. Another important feature is that a chain drive can be positioned in any part of the driving machinery with only minor assembly or disassembly problems. This is accomplished by the link design which allows you to place the strand of chain in position and then couple it together.



CHAIN DEFINITIONS:

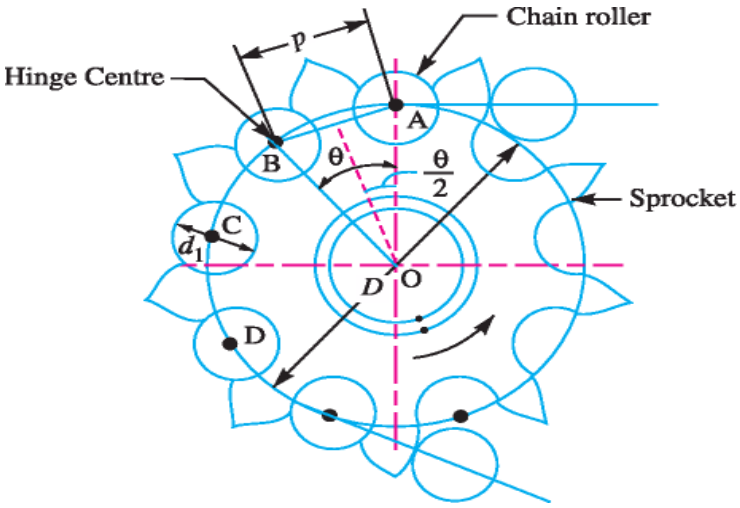
Like V- belts drives, chain drives also have specific terms describing their various components. Some of these are quite similar to the V- belt drives, while others are considerably different. We will only cover a few of the more common terms used.

DRIVER SPROCKET:
Usually the driver sprocket is the smaller of the two sprockets and the one having the highest RMP.

DRIVEN SPROCKET:
The driven sprocket is usually the larger of the two sprockets and the one having the slower RMP.

CHAIN PITCH:
This is the distance (in inches) from the center of one connecting pin to the center of the next, in chains having a solid bock link, the chain pitch is on alternate spacing

CENTER DISTANCE:
The center distance is the distance in inches between the centers of driver and driven shafts.



CHAIN LENGTH:

The chain length is the distance from the center line of the connecting pin at one end of the strand to the empty connecting hole at the opposite end. Chains can be measured in feet and inches, or in pitches.

CHAIN RATING:

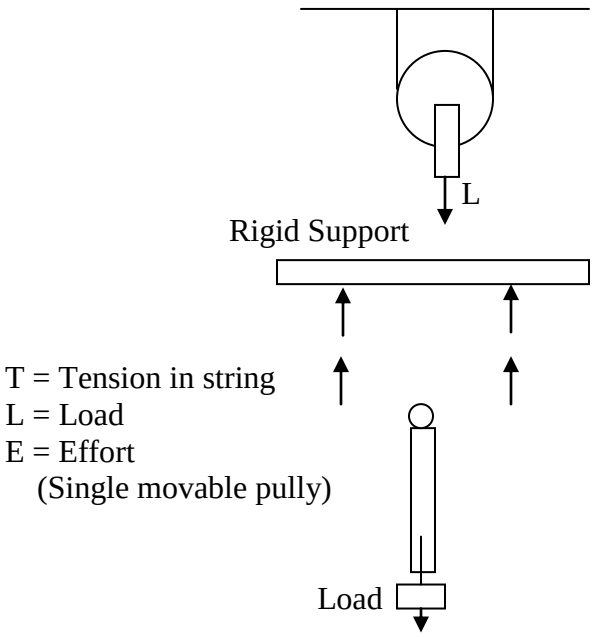
The chain rating, or recommended working load, is the load in pounds that the chain will satisfactorily handle over extended periods of time. Most manufacturers rate their chains in maximum or average working load.

UlTIMATE STRENGTH:

This is the strength of the chain before it will break. This is not a governing factor in the selection of the chain. However, it gives you the shock loading capacity of the chain.

(iii) Pulley Drive Transmission:

This is also a method of power transmission in pulleys is used and we get mechanical advantages by the fixed support following figure:



As per the figure: An inextensible Sting of negligible Mass-Passes around the grooved rim of the pulley. One end of the sting is tied to a hook ‘H’ at a rigid support and the effect ‘E’ is applied at its free end.
The tension ‘T’ acts on the string on both sides of pulley as shown in the above figure.
Load is balanced L = T+T = 2T and effort E = T.

$$\text{Mechanical advantage} = \frac{\text{Load L}}{\text{Effort E}}$$

$$\text{Therefore} \quad \text{Mechanical advantage} = \frac{2T}{T} = 2$$

So by applying an effort equal to half the load (in ideal situation) i.e. single movable pulley acts as a Force multi pliers) P

(iv) Gear Drive Transmission:

In this method of power transmission Gears are used for transfer of power from one point to another. More teeth of Gears are meshed to each other. There are two gears which are connected to each other one is drive gear and the another driven gear. Depending upon no. of teeth, Gear Ratio is decided. The arrangement of gears on drive and driven gear can be such that driven gear can rotate faster or slower.

GEAR

A toothed wheel that engages another toothed mechanism in order to change the speed or direction of transmitted motion.

A gear is a component within a transmission device that transmits rotational force to another gear or device. A gear is different from a pulley in that a gear is a round wheel which has linkages ("teeth" or "cogs") that mesh with other gear teeth, allowing force to be fully transferred without slippage. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. The most common situation is for a gear to mesh with another gear. Gear’s most important feature is that gears of unequal sizes (diameters) can be combined to produce a mechanical advantage, so that the rotational speed and torque of the second gear are different from that of the first. To overcome the problem of slippage as in belt drives, gears are used which produce positive drive with uniform angular velocity.

GEAR CLASSIFICATION

Gears or toothed wheels may be classified as follows:

1. According to the position of axes of the shafts.

The axes of the two shafts between which the motion is to be transmitted, may be

a. Parallel

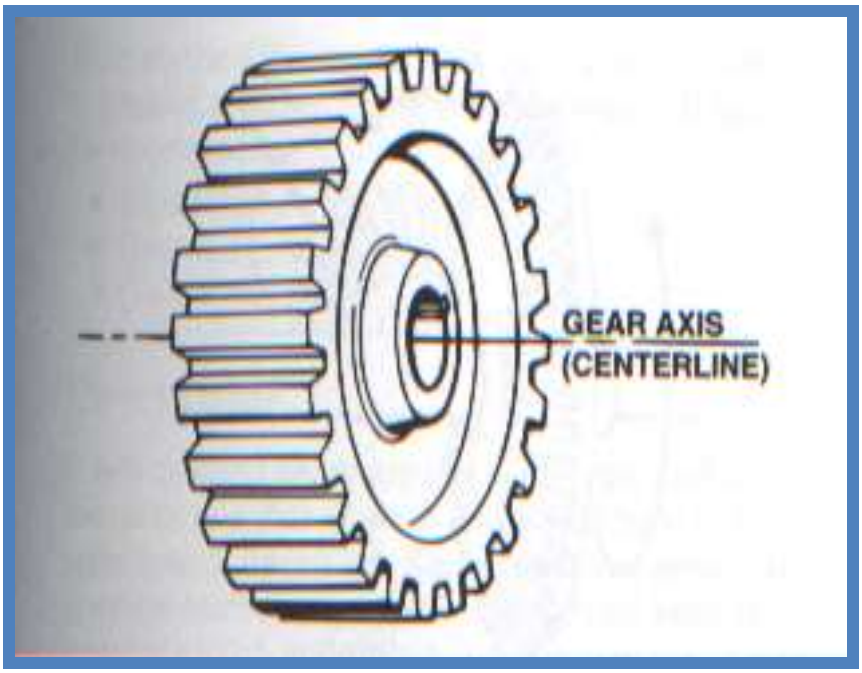
b. Intersecting

c. Non-intersecting and Non-parallel

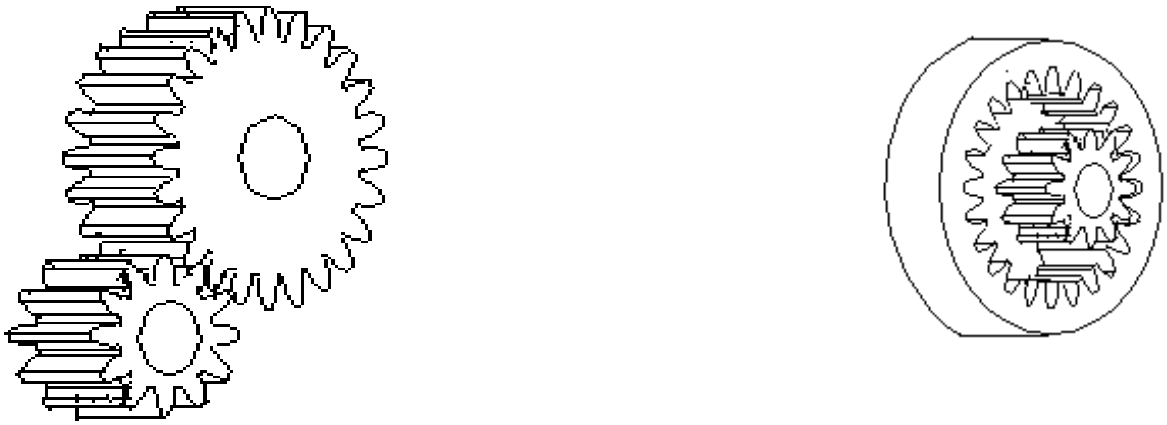
Gears for connecting parallel shafts

1. Spur Gear

Teeth is parallel to axis of rotation can transmit power from one shaft to another parallel shaft. Spur gears are the simplest and most common type of gear. Their general form is a cylinder or disk. The teeth project radially, and with these "straight-cut gears".



Spur gears are gears in the same plane that move opposite of each other because they are meshed together. Gear ‘A’ is called the ‘driver’ because this is turned by a motor. As gear ‘A’ turns it meshes with gear ‘B’ and it begins to turn as well. Gear ‘B’ is called the ‘driven’ gear.



EXTERNAL AND INTERNAL SPUR GEAR

External gear makes external contact, and the internal gear (right side pair) makes internal contact.

APPLICATIONS OF SPUR GEAR

Electric screwdriver, dancing monster, oscillating sprinkler, windup alarm clock, washing machine and clothes dryer

2. Parallel Helical Gear

The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement.

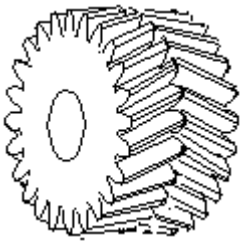
This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears. For this reason, helical gears are used in almost all car transmissions. Because of the angle of the teeth on helical gears, they create a thrust load on the gear when they mesh. Devices that use helical gears have bearings that can support this thrust load.

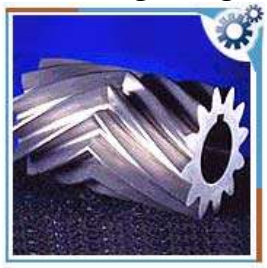
One interesting thing about helical gears is that if the angles of the gear teeth are correct, they can be mounted on perpendicular shafts, adjusting the rotation angle by 90 degrees.

CROSSED HELICAL GEAR

Herringbone gears:

To avoid axial thrust, two helical gears of opposite hand can be mounted side by side, to cancel resulting thrust forces. These are called double helical or herringbone gears





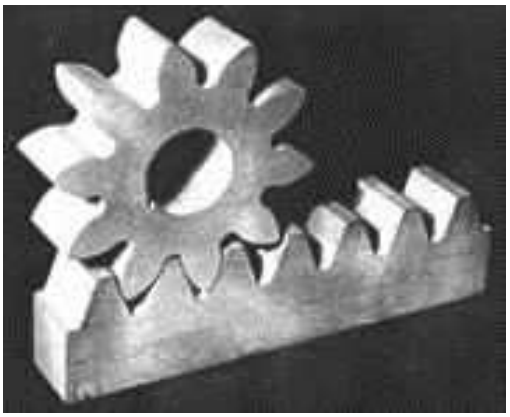
Herringbone gears (or double-helical gears)

Applications of Herringbone Gears

The most common application is in power transmission. They utilize curved teeth for efficient, high capacity power transmission. This offers reduced pulsation due to which they are highly used for extrusion and polymerization. Herringbone gears are mostly used on heavy machinery.

3. Rack and pinion

Rack and pinion gears are used to convert rotation (From the pinion) into linear motion (of the rack). A perfect example of this is the steering system on many cars. The steering wheel rotates a gear which engages the rack. As the gear turns, it slides the rack either to the right or left, depending on which way you turn the wheel. Rack and pinion gears are also used in some scales to turn the dial that displays your weight.



RACK AND PINION

GEARS FOR CONNECTING INTERSECTING SHAFTS

1. Straight Bevel Gear

Bevel gears are useful when the direction of a shaft's rotation needs to be changed. They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The teeth on bevel gears can be straight, spiral or hypoid. Straight bevel gear teeth actually have the same problem as straight spur gear teeth as each tooth engages, it impacts the corresponding tooth all at once.

BEVEL GEAR

Just like with spur gears, the solution to this problem is to curve the gear teeth. These spiral teeth engage just like helical teeth: the contact starts at one end of the gear and progressively spreads across the whole tooth.

SPIRAL BEVEL GEAR

On straight and spiral bevel gears, the shafts must be perpendicular to each other, but they must also be in the same plane. If you were to extend the two shafts past the gears, they would intersect

The bevel gear has many diverse applications such as locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

NON-INTERSECTING AND NON-PARALLEL

1. WORM AND WORM GEAR

Worm gears are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater.

Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm. This is because the angle on the worm is so shallow that when the gear tries to spin it, the friction between the gear and the worm holds the worm in place.

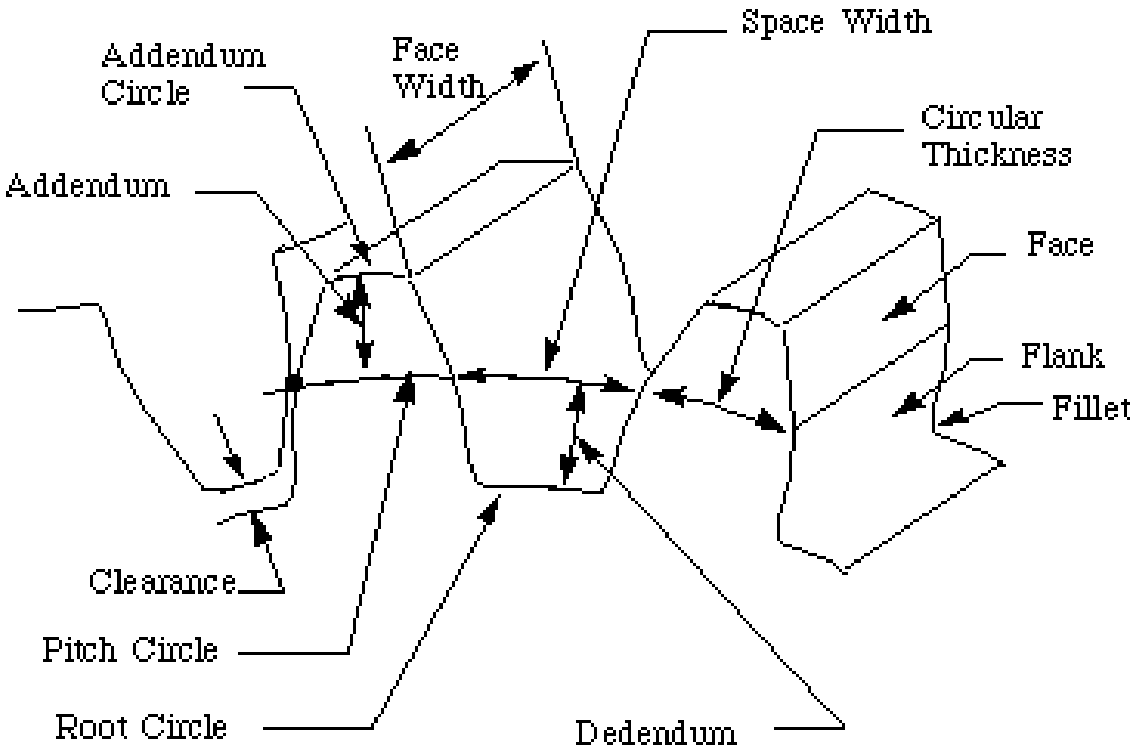
WORM AND WORM GEAR

This feature is useful for machines such as conveyor systems, in which the locking feature can act as a brake for the conveyor when the motor is not turning. One other very interesting usage of worm gears is in the Torsen differential, which is used on some high-performance cars and trucks. They are used in right-angle or skew shaft drives. The presence of sliding action in the system even though results in quieter operation, it gives rise to considerable frictional heat, hence they need good lubrication for heat dissipation and for improving the efficiency. High reductions are possible which results in compact drive.

APPLICATION OF WORM GEARS

Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc.

NOMENCLATURE OF SPUR GEARS



NOMENCLATURE OF SPUR GEAR

In the following section, we define many of the terms used in the analysis of spur gears.

- **Pitch surface**: The surface of the imaginary rolling cylinder (cone, etc.) that the toothed gear may be considered to replace.
- **Pitch circle**: A right section of the pitch surface.
- **Addendum circle**: A circle bounding the ends of the teeth, in a right section of the gear.
- **Root (or dedendum) circle**: The circle bounding the spaces between the teeth, in a right section of the gear.
- **Addendum**: The radial distance between the pitch circle and the addendum circle.
- **Dedendum**: The radial distance between the pitch circle and the root circle.
- **Clearance**: The difference between the dedendum of one gear and the addendum of the mating gear.
- **Face of a tooth**: That part of the tooth surface lying outside the pitch surface.
- **Flank of a tooth**: The part of the tooth surface lying inside the pitch surface.
- **Circular thickness** (also called the **tooth thickness**): The thickness of the tooth measured on the pitch circle. It is the length of an arc and not the length of a straight line.

- **Tooth space**: pitch diameter The distance between adjacent teeth measured on the pitch circle.
- **Backlash**: The difference between the circle thickness of one gear and the tooth space of the mating gear.
- **Circular pitch** (Pc) : The width of a tooth and a space, measured on the pitch circle.

$$P_c = \frac{\pi D}{N}$$

- **Diametral pitch (P_d)**: The number of teeth of a gear unit pitch diameter. A toothed gear must have an integral number of teeth. The circular pitch, therefore, equals the pitch circumference divided by the number of teeth. The diametral pitch is, by definition, the number of teeth divided by the pitch diameter. That is,

$$P_d = \frac{N}{D}$$

Where

Pc = circular pitch

P_d = diametral pitch

N = number of teeth

D = pitch diameter

- **Module** (m): Pitch diameter divided by number of teeth. The pitch diameter is usually specified in inches or millimeters; in the former case the module is the inverse of diametral pitch.

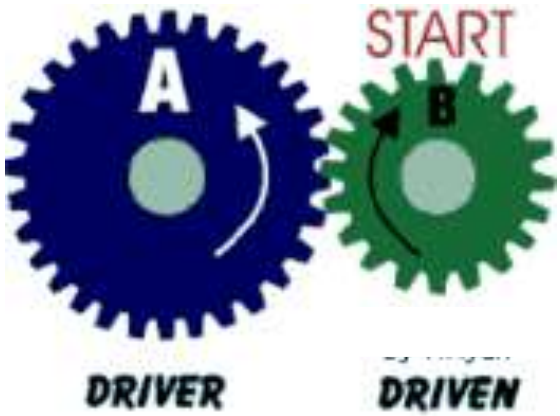
$$m = D/N$$

- **Fillet:** The small radius that connects the profile of a tooth to the root circle.
- **Pinion**: The smaller of any pair of mating gears. The larger of the pair is called simply the gear.
- **Velocity ratio**: The ratio of the number of revolutions of the driving (or input) gear to the number of revolutions of the driven (or output) gear, in a unit of time.
- **Pitch point**: The point of tangency of the pitch circles of a pair of mating gears.

- **Common tangent**: The line tangent to the pitch circle at the pitch point.
- **Line of action**: A line normal to a pair of mating tooth profiles at their point of contact.
- **Path of contact**: The path traced by the contact point of a pair of tooth profiles.
- **Pressure angle** (α): The angle between the common normal at the point of tooth contact and the common tangent to the pitch circles. It is also the angle between the line of action and the common tangent.
- **Base circle**: An imaginary circle used in involute gearing to generate the involutes that form the tooth profiles.

VELOCITY RATIO OF GEAR DRIVE

Velocity ratio is defined as the ratio of the speed of the driven shaft to the speed of the driver shaft.



One gear is a driver, which has d_1, N_1, ω_1 as diameter, speed and angular speed respectively. Another gear is driven connected to the driven shaft has d_2, N_2 , ω_2 as diameter, speed angular speed respectively.

Angular speeds of the two gears will be

$\omega_1 = 2\pi N_1$ $\omega_2 = 2\pi N_2$

The peripheral velocity of the driver and driven shafts for the meshing pair of gear is

equal and is given by $V_P = \omega_1 \frac{d_1}{2} = \pi d_1 N_1 = \omega_2 \frac{d_2}{2} = \pi d_2 N_2$

Hence velocity ratio (n) = $\frac{\omega_2}{\omega_1} = \frac{N_2}{N_1} = \frac{d_1}{d_2}$

T_1 and T_2 are the number of teeth on driver gear and driven gear, since the pair of gear

as the same module (m),then

$d_1 = mT_1$; $d_2 = mT_2$

and $n = \frac{N_2}{N_1} = \frac{d_1}{d_2} = \frac{T_1}{T_2}$

GEAR TRAINS

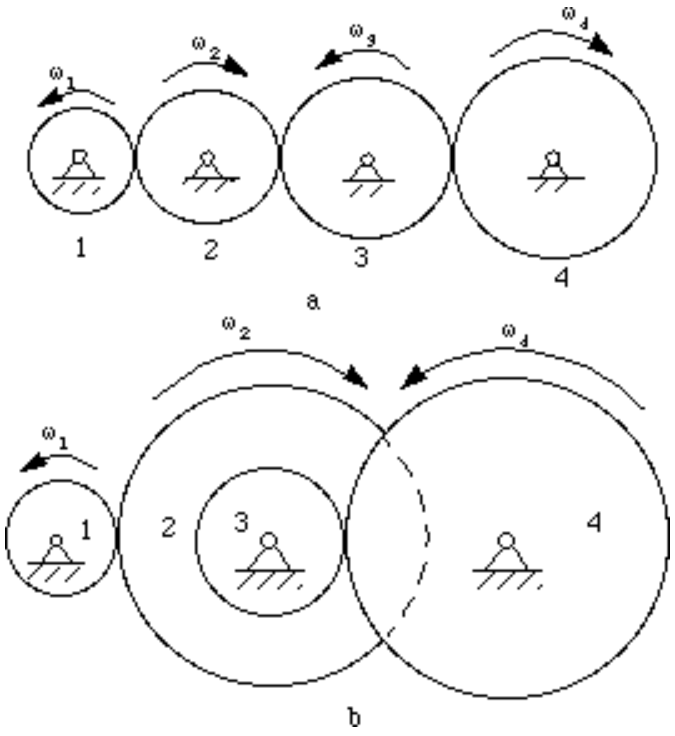
A gear train is two or more gear working together by meshing their teeth and turning each other in a system to generate power and speed. It reduces speed and increases torque. To create large gear ratio, gears are connected together to form gear trains. They often consist of multiple gears in the train. The smaller gears are one-fifth of the size of the larger gear. Electric motors are used with the gear systems to reduce the speed and increase the torque. Electric motor is connected to the driving end of each train and is mounted on the test platform. The output end of the gear train is connected to a large magnetic particle brake that is used to measure the output torque.

Types of gear trains

1. Simple gear train
2. Compound gear train
3. Planetary gear train

Simple Gear Train

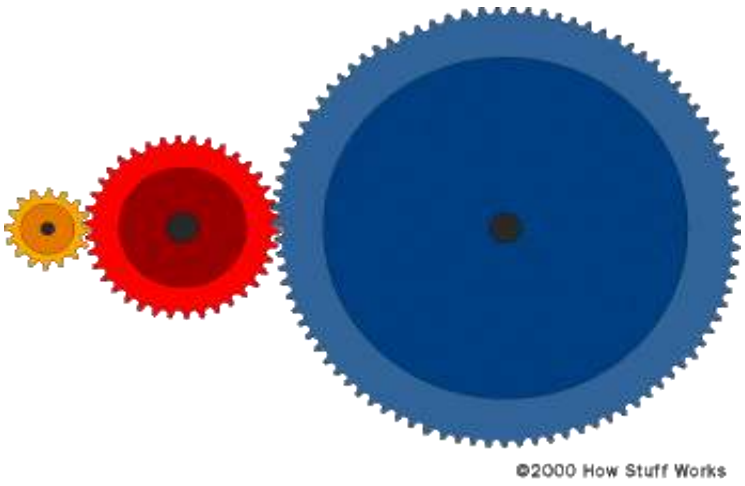
The most common of the gear train is the gear pair connecting parallel shafts. The teeth of this type can be spur, helical or herringbone. only one gear for each axis. The angular velocity is simply the reverse of the tooth ratio. The main limitation of a simple gear train is that the maximum speed change ratio is 10:1. For larger ratio, large sizes of gear trains are required. The sprockets and chain in the bicycle is an example of simple gear train. When the paddle is pushed, the front gear is turned and that meshes with the links in the chain. The chain moves and meshes with the links in the rear gear that is attached to the rear wheel. This enables the bicycle to move.



Simple and compound gear trains

Compound Gear Train

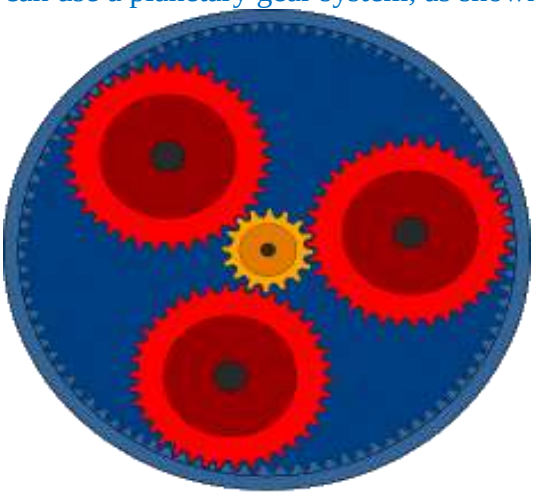
For large velocities, compound arrangement is preferred. Two keys are keyed to a single shaft. A double reduction train can be arranged to have its input and output shafts in a line, by choosing equal center distance for gears and pinions. Two or more gears may rotate about a single axis



Planetary Gear Train (Epicyclic Gear Train)

Planetary gears solve the following problem. Let's say you want a gear ratio of 6:1 with the input turning in the same direction as the output. One way to create that ratio is with the following three-gear train:

In this train, the blue gear has six times the diameter of the yellow gear (giving a 6:1 ratio). The size of the red gear is not important because it is just there to reverse the direction of rotation so that the blue and yellow gears turn the same way. However, imagine that you want the axis of the output gear to be the same as that of the input gear. A common place where this same-axis capability is needed is in an electric screwdriver. In that case, you can use a planetary gear system, as shown here:



Planetary Gear Train

In this gear system, the yellow gear (the **sun**) engages all three red gears (the **planets**) simultaneously. All three are attached to a plate (the **planet carrier**), and they engage the inside of the blue gear (the **ring**) instead of the outside. Because there are three red gears instead of one, this gear train is extremely rugged. The output shaft is attached to the blue ring gear, and the planet carrier is held stationary -- this gives the same 6:1 gear ratio. Another interesting thing about planetary gear sets is that they can produce different gear ratios depending on which gear you use as the input, which gear you use as the output, and which one you hold still. For instance, if the input is the sun gear, and we hold the ring gear stationary and attach the output shaft to the planet carrier, we get a different gear ratio. In this case, the planet carrier and planets orbit the sun gear, so instead of the sun gear having to spin six times for the planet carrier to make it around once, it has to spin seven times. This is because the planet carrier circled the sun gear once in the same direction as it was spinning, subtracting one revolution from the sun gear. So in this case, we get a 7:1 reduction.

You could rearrange things again, and this time hold the sun gear stationary, take the output from the planet carrier and hook the input up to the ring gear. This would give you a 1.17:1 gear reduction. An automatic transmission uses planetary gear sets to create the different gear ratios, using clutches and brake bands to hold different parts of the gear set stationary and change the inputs and outputs.

Planetary gear trains have several advantages. They have higher gear ratios. They are popular for automatic transmissions in automobiles. They are also used in bicycles for

controlling power of pedaling automatically or manually. They are also used for power train between internal combustion engine and an electric motor.

Applications

Gear trains are used in representing the phases of moon on a watch or clock dial. It is also used for driving a conventional two-disk lunar phase display off the day-of-the-week shaft of the calendar.

Velocity ratio of Gear trains

We know that the **velocity ratio** of a pair of gears is the inverse proportion of the diameters of their pitch circle, and the diameter of the pitch circle equals to the number of teeth divided by the diametral pitch. Also, we know that it is necessary for the mating gears to have the same diametral pitch so that to satisfy the condition of correct meshing. Thus, we infer that the **velocity ratio** of a pair of gears is the inverse ratio of their number of teeth.

For the ordinary gear trains we have (Fig a)

$$\frac{\omega_1}{\omega_2} = \frac{N_2}{N_1} \quad \frac{\omega_2}{\omega_3} = \frac{N_3}{N_2} \quad \frac{\omega_3}{\omega_4} = \frac{N_4}{N_3}$$

These equations can be combined to give the velocity ratio of the first gear in the train to the last gear:

$$\frac{\omega_1}{\omega_4} = \frac{N_2 N_3 N_4}{N_1 N_2 N_3} = \frac{N_4}{N_1}$$

$$\frac{(N_2 N_3 N_{4)}}{(N_1 N_2 N_3)} = \frac{(T_1 T_2 T_3)}{(T_2 T_3 T_4)} = \frac{N_4}{N_1} = \frac{T_1}{T_4} = n$$

Note:

The tooth numbers in the numerator are those of the driven gears, and the tooth numbers in the denominator belong to the driver gears.

Gear 2 and 3 both drive and are, in turn, driven. Thus, they are called **idler gears**. Since their tooth numbers cancel, idler gears do not affect the magnitude of the input-output ratio, but they do change the directions of rotation. Note the directional arrows in the figure. Idler gears can also constitute a saving of space and money (If gear 1 and 4 meshes directly across a long center distance, their pitch circle will be much larger.)

The gear drive refer more to the larger open type sets than those used in speed reducer or speed increases. When used as open gear sets, their design considerations are similar to those of chain drives. As an example the gear speeds and sizes may be limited by the machine they are driving and its surrounding framework. As a result, their design is more customized.

While these gear drives are frequently referred to as open gear drives, they will usually be enclosed in guards formed from sheet metal. These guards primarily are a safety

device, but sometimes act as a lubricant reservoir. Gears mounted in reducer housings are usually thought of as enclosed gears.

Gear Definition:
Before understanding the gear drive it is necessary to know some of the terms used to describe gears. It should be remembered that the definitions for the various gears will be similar and the strength and size of different gears varies.

Different types of tooth formations and designs,gears

PITCH DIAMETER:
The diameter of the pitch circle. In parallel shaft gears, the pitch diameters can be determined mathematically from the shaft center distance and the number of teeth in the gears.

DIAMETRAL PITCH:
The diametral pitch is the ratio of the number of teeth to the number of inches in the pitch diameter.

OUTSIDE DIAMETER:
The outside diameter of the gear measured over the teeth. It is equal to the pitch diameter plus twice the addendum.

PRESSURE ANGLE:
In involute teeth, the angle between the line of action and a line tanget to the pitch circle.

CIRCULAR PITCH:
The length of an arc of the pitch circle measured between corresponding points on adjacent teeth.

CHORDAL THICKNESS:
The length of a chord subtended by the arc of circular thickness when the tooth thickness is measured at the pitch circle.

ADDENDUM:
The radial dimension between the pitch circle and the top of the gear tooth.

DEDENDUM:
The radial dimension between the pitch circle and the bottom of the tooth space

WHOLE DEPTH:
The total height of the tooth equal to the addendum plus the dedendum is the whole depth.

WORKING DEPTH:
This is the depth the gear tooth extends in to the open space between teeth when mating.

FACE WIDTH:
The length of the tooth from one side to the other is the face width.

FACE OF TOOTH:
The surface of the gear tooth between the pitch circle and the top of the tooth.

FLANK OF TOOTH:
The surface of the gear tooth between the pitch circle and the bottom land, including the fillet.

BACKLASH:
The amount (measured on the pitch circle) by which the width of a tooth space exceeds the thickness of the engaging tooth.

(v) Cardon Shaft Transmission:

In this method power transmission is achieved through different cardon shafts and accordingly power is transmitted from end to the another. Different sizes of cardon shafts are used on different track machines.

Various cardon shaft used in old Duomatic machine :

1. Engine to main gear box 1 No.
2. Main gear box to system pump 1 No.
3. Main gear box to vibration pump 1 No.
4. Six speed gear box to driving motor 1 No.
5. Six speed gear box to distribution gear box 1 No.
6. Distributor gear box to axle gear box 1 No.
7. Distributor gear box to intermediate axle 1 No.

Clutch assembly:

Clutch plate burn.	1. Withdrawal bearing CT-1310 get jammed. 2. Fingers not working properly. 3. Springs not working properly.	1. Replace withdrawal bearing. 2. Finger (6 no.) & console fit properly & replace if need. 3. Springs should be cleaned& replace the defective one, if required.

Power take off assembly:

1. Output shaft (1240 310 013) get broken bearing also damage.	Lock of shaft get broken, lock bolt loose.	Tighten the lock bolt and adjust the flange at proper place.

Axle gear box:

1.Bearings (NU231531313) of tail pinion get seized.	1. Plunger pump not operating properly. 2. Hyd pipe may be choked.	1. Spring at pump should be changed if required. 2. Clean the hyd pipe through which gear oil is passed to bearings at tail pinion.
2. Teeth at crown & tail pinion get damaged.	Not match properly.	The teeth matching done properly.

PRECAUTIONS DURING FITMENT OF CORDON SHAFT:

Shaft should be dynamically balanced

Male portion	-	Long
Female portion	-	Short
In road vehicle	-	Male portion in the direction of driving.
In Track Machine	-	Male portion in towards working direction.

To avoid the dropping of cordon shaft cradle is provided.

- Arrow mark on male and female portion should be in line. If there is no arrow mark then yoke should be in same plane for both male & female.

- In female shaft, there is through hole from yoke centre to other end, so that excess grease may come out, other wise this will act as a solid part.
- Bolts should be fit tightly, bolts should be of proper size.
- Greasing in X (cross) and splines should be done after 50 Hrs.
- Play in splines and yoke should be checked every 50 Hrs.
- Nylon locked type nuts should be use.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)
Lesson-II: Gear Box and Clutch Assembly in UNO/DUO Session-2: Working, Construction and Maintenance practices of Main gear box and Clutch assembly.

GEAR BOX AND CLUTCH ASSEMBLY IN UNO / DUO

MAIN GEAR BOX, SIX SPEED AND REVERSING GEAR BOXES:

The track machines are driven/traveled from one station to another station by means of either hydraulics system or mechanical. System. In mechanical system of traveling, Gear Boxes are used. In Duomatic old, Unomatic and other machines various Gear Boxes are used such as main gear box directional Gearbox reversing gear box, reduction gear boxes and six speed Gear Boxes etc.

Following are the Gear Boxes used on 08-Duomatic machine.

1. **Main Gear Box = 1 No.**
   From engine the power comes to this gear box. This gear box distributes the power in three directions:
   Main power to reversing and Six speed gear box.
   RH side for operating Hydraulic pump – 38 x 17 GPM
   38 x 22 GPM
   L.H. side for operating hydraulic pump – 38 x 17 GPM

   The following are the main parts of main gear box

   A = Driving shaft
   B = Flange
   C = Washer for bearing housing left
   D = Seeger rings
   E = Spacer ring
   F = Shims
   G = Retaining rings
   H = Crowns nuts
   J = Rings
   K = Splits pins
   L = Seeger rings
   M = Cylindrical roller bearing
   N = Bearing housing left
   O = Lid for bearing housing left
   P = Bevel gear
   R = Bearing housing right
   S = Self alignment roller bearing
   T = Spacer sleeve
   U = Clutch gear
   V = Conical roller bearing
   W = Washer for bearing housing, right

2. **Reversing Gear Box 1 No.:**
   In this gearbox arrangement has been provided to drive the machine in either direction at the same speed.
3. **Six Speed Gear Box 1 No.:**
   This gear box is used to achieve different gear ratio and speed from 1^{st} to 6^{th} .
4. **Differential distributor Gear Box 1 No.:**
   (Power is transmitted from different distributor gear to both Axle Gearbox.
5. **Axial Gear Box 2 Nos.:**
   Power transmission to axle by crown tail pinion arrangement is the out come of machine movement.

Trouble shooting of main gear box, 08 Duo (old)

Problem	**Causes**	**Remedies**
1.Crown wheel teeth (a)get worn out (b)bearing no.22310 on drive shaft get seized. (c)pump not engages easily.	The teeth on crown gears UD 70.03 provided on main shaft and UD 70.04 provided on drive shaft not matching properly.	Both crown gears should be manufactured by same firm. It should lie between 0.1 to 0.2 mm after fitment. Thickness of tooth space, width space, whole depth etc. should be in proper specification.
2. Oil seal damaged on clutch shaft. (size 125*150*13).	1 Shaft not chamfered. 2 Seal material is not proper.	1.Chamfering must be done on shaft for fitment of seal. 2. Use proper seal.
3(a).Drive shaft get broken (b)Splines of drive shaft get wear out. (c)Internal splines of flange get shear.	Cardon shaft is eccentric.	Cardon shaft and drive shaft should be kept aligned.
4 Train of gears running not proper.	Gears on train of gears not fit properly.	Check back lash, this should lie between 0.07 to 0.25 mm.
5. Intermediate shaft rotates with gear.	Lock on axle cone 2E71.03 not fit properly.	Fit axle cone properly.

MECHANICAL GEAR BOXES USED ON 08-DUOMATIC MACHINE:
Main Gear Box: 1 No.

From engine the power comes to this gear box. This gear box distributes the power in three directions

1. Main power to reversing and six peed gear box.
2. RH side for operating Hydraulic Pump 38 x 17 GPM
   38 x 22 GPM
3. L.H. side for operating Hydraulic Pump 38/17 GPM

1. Reversing Gear Box: 1 No.
   In this gear box arrangement has been provided to drive the machine in either direction at the same speed.
2. Six Speed Gear Box: 1 No.
   Through this gear box we achieve different gear ratios & speed i.e. from 1st to 6th.
3. Differential Distributor Gear Box: 1 No.
   Power transmission from differential distributor gear box to both axle gear boxes.

Axle Gear Box: 2 No.
Power transmission to axle by crown-tail pinion arrangement & machine moves.

MAINTENANCE PRACTICES OF GEAR BOXES:

The modern track machines are very complex and costly assets. Even one day down time is very costly. Increased availability of machines result in more output with good quality at cheaper ratio.

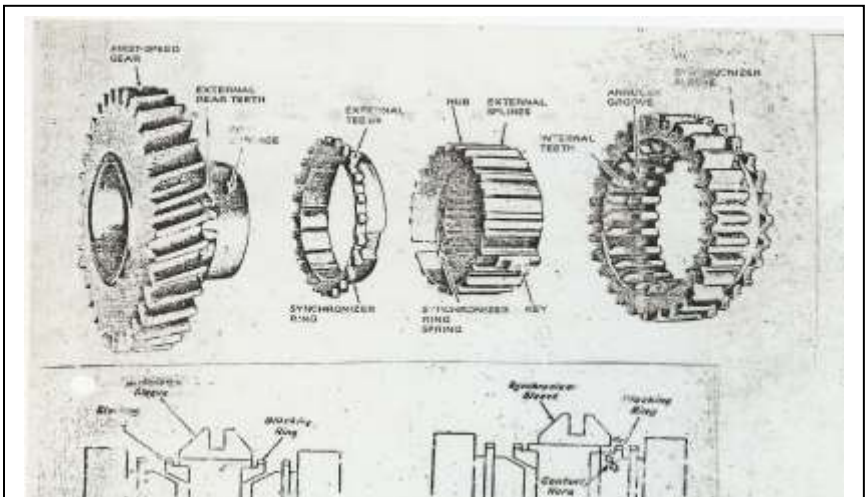
As this is a mechanical gear box, lot of wear and tear takes place on amount of its movement the gear box should be filled with the proper graded oil i.e. SAE-C-90 and while working with this machine as mechanical gear boxes are provided, it is to be ensured that when machine is required to be operated, whenever we want to put the machine in working mode i.e. at the time of engagement of hydraulic pump, first of all the engine should be stopped and the lever is to be operated for engagement of working pumps,. Similarly when the work is over it is to be ensured that engine is stopped and the lever is operated to disengage the working pump for travelling mode.

This should also be ensured that no dust or dust is allowed to enter the gear box as it is very much harmful for the smooth functioning of Main Gear Box directional gear box or Six Speed Gear Box.

During assembling this factor should also be taken into consideration.

ENGAGER BODY FOR DUOMATIC MACHINE PART NO. G – 70-11

Engager body shall be manufacture out of EN-353 engager body shall be slide fit with crown gear and drive shaft components found suitable in visual inspection as well as correct from the dimensional characteristics minimum one engager body of each lot should be taken randomly for its chemical testing



Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

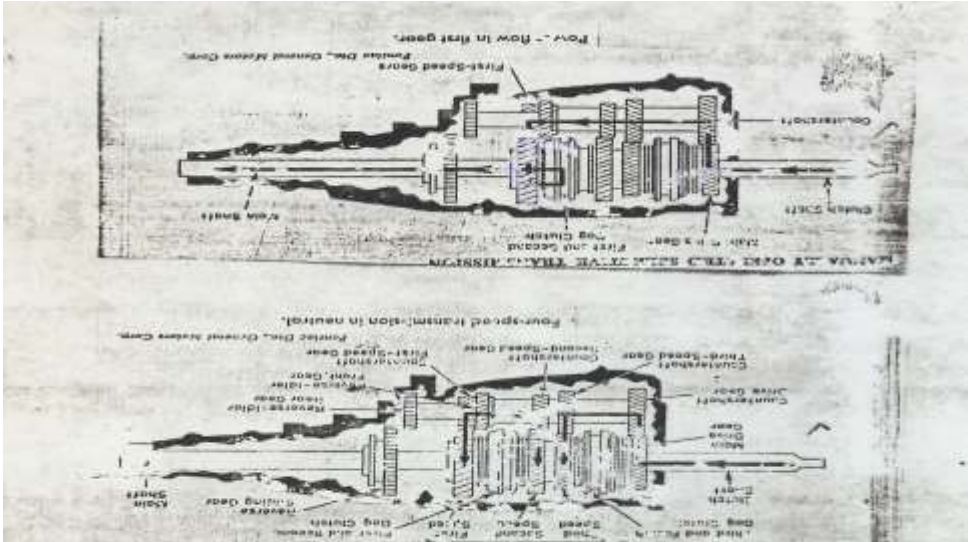
Lesson-II: Gear Box and Clutch Assembly in UNO/DUO Session-3: Working, Construction and Maintenance practices of Reversing gear box and Six speed gear box.

MAINTENANCE OF REVERSING AND SIX SPEED GEAR BOXES:

The track machines are driven/traveled from one station to another station by means of either hydraulics system or mechanical system. In mechanical system of traveling, Gear Boxes are used. In Duomatic old, Unomatic and other machines various Gear Boxes are used such as main gear box directional Gearbox reversing gear box, reduction gear boxes and six speed Gear Boxes etc.

For reversing gear box proper lubrication has to be ensured and proper matching of gears to be provided so that there is no problem with regards to the movement of the machine. Proper maintenance schedule has to be observed as per the manual laid down for this purpose.

For six speed gear box it is also to be ensured that proper clearance of gears are maintained and proper backlash along with the proper matching of gears are in co-operated. As per the laid down procedure for schedule maintenance, six speed gear box maintenance to be done accordingly.



Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-III: Distributor Gear Box **Session-4:** Working, Construction and Maintenance practices.

Distribution Gear Box (Its construction and maintenance practices):

This is the Gear box use for the purpose of power transmission in different track machine and with the help of this distributor gear box power is directed and distributed to different directions with the help of cardon shaft as per requirement. As this gear box is subjected to maximum wear & tear due to mechanical arrangement of gears, maximum care should be taken with respect to its maintenance as well as changing of the gear oil provided for the gear box. Attention should also be paid with regards to the contamination because if contamination is entrapped in the gear box, it will damaged the gear box.

(Fig.)

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

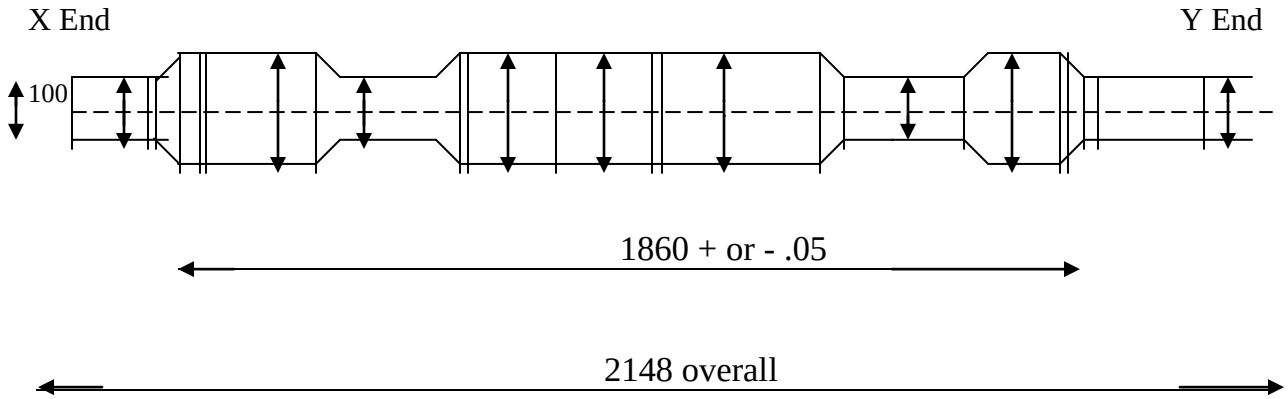
Lesson-IV: Driving and Running Axle **Session-5:** Function, Parts and Maintenance aspects, setting of crown & tail pinion

---

Driving and Running Axle for (Duo):

Driving axle is the power axle this axle has the arrangement of Crown & Peinion Assembly. Wheel is pressed and 50 Tonne load. There is arrangement of axle gear box assembly. In axle gear box assembly roller bearing NU-2220 or NU-2224 is provided. The driving axle being powered axle gets power through cardon shaft transferred through flying over. Schedule maintenance of the axle is to be carried out by greasing of axle gear box housing as per requirement. All new Track Machines working in Indian Railways are powered axles. They have been provided with the hydraulic motors for power transmission.

Driving Axle



ALL DIMENSIONS ARE IN MM.

Running Axle:
Running axle is normally known as idle axle and it is not a powered axle. Running axle has arrangement of Axle & Wheel only. Wheel pressing is carried out in the axle to complete the whole assembly. Wheel is pressed at 50 tonne load. There is no crown and pinion arrangement in running axle. There is axle box assembly provided on running axle. This consists of roller bearing NU-2220 or NU-2224 alongwith the distance pieces. Under the maintenance schedule the axle box bearing are greased through bearing grease periodically. As per latest circular of Track Machine Manual the driving axle and running of different machines such as BCM, Unimat, CSM & DGS are required to under go Ultrasonic testing for their better performance.

Crown and Tail Pinion Assembly:
Clean axle and bevel gear check the bevel gear bore with boring gauge for taper and ovality, to be removed by grinding the above defect.

To hold the axle vertically by a Crane with a device fixed to the locking taped holes. Check with spirit level that the device is perfectly vertical.

Heat the bevel gear placed on a cylindercal support perfectly leveled with spirit facing down ward to about 220^0C with anyactelene flame so that after its bore 0./mm larger than the diameter of bevel seat on the axle. Cool the axle from around bevel seat if possible. Introduce the axle from the above fill the bearing collar touches the bevel. After 5-10 minutes, bevel gear will be tight on the axle. For proper meshing of (Crown bevel gear, shims are provided for wheel proper alignment.

Driving Axle (front bogie) – csm:

(1) Taper roller bearings – 32032x – 02 No. in each axle.
(2) UD 62 - 2610P (plasser) NJP – 2224 outside - 02 No.
UD 62.2618P (plasser) NJ – 2224 inside – 02 No.

NJP 2224 – P is separate round piece which supports the bearing from outside.
NJ 2224 - for support a coller is already provided. In both bearing. Inner race and thin ring already provided.

1.Tapper roller bearing 31313 – Q- ec7A - 02 mm.
At tail pinion roller bearing NU2315 - 01 No.
2.Crown Em 163.105.Z31 – 36 teeth.
Tail pinion – 10 teeth
3.Namda is provided is csm & unitmat to prevent leaving of grease.
4.Oil seal (130*160*13) is provided in Duo to prevent leaving of grease.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-V: Z.F. Hydro-dynamic Gear Box **Session-6:** Function and Construction

---

Working Principle of Z.F. Gear Box: (Zahnrad Fabric – Friedrichshafen:

The power transmission in various tamping machines have been associated with mechanical methods of transmission of transmission as envisaged by Plasser & Theurer. Gone are the days when we were utilizing mechanical gear boxes such as six speed gear boxes, directional gear boxes etc. but with the past experiences it has been observed that such mechanical gear boxes have typical arrangement of gear-train etc. which were not only subjected to wear and tear but also at the same times it tends to more-failure and more maintenance.

So, in order to eliminate all such things new conception for power transmission is the Generation of Z.F. Gear Box.

ZF is a German Nomenclature

ZF stands for Zaharaid Fabrick

Original ZF is 4WG.65II WK

Abbreviations are:

4	-	Speed
WG	-	Hydro-dynamic fluid
65	-	Input – Torque
II	-	Electric – Shift
WK	-	with converter clutch
Gear box oil	-	Ultra -10
Capacity	-	Approximately 45 Ltrs.

Manufacturers –

BP	-	Actuma Super with ultra 10W
10C	-	Servo ultra 10
HP	-	HP auto transmission fluid.

Various Parts of Z.F. Gear Box:

Torque Converter:

Torque Converter is a special type of fluid coupling. It is very much effective when the engines speed is increased. At idle speed it does not transmit any power and keeps as slipping. Thus the

vehicle is declutched automatically in manual transmission if the driver does not declutched property the engine stops. This problem is overcome in automatic power transmission. In this case need is to idle the engine only within the converter the oil is the medium of the power transmission. At about 80% of pump speed i.e. impeller the turbine becomes one and the turbine movement becomes equal to the pump movement.

Some of the toque converters are provided with a converter clutch W.K. which locks the turbine with impellor and then prevents the slip and improves the fuel efficiency. The torque converter then acting as a fluid clutch. It consists of three main parts.

1. Impellor
2. Stator
3. Turbine.

1. **Impellor –** It is a depend having curved blade to its inner face and attached to engine fly wheel. As the fly wheel turns the impellor also turns and throws the oil with a certain velocity. The velocity and mass being projected which is actually responsible for turning the unit. The oil escaping from the impellor wheel enters to the turbine wheel giving the direction of movement.
2. **Turbine –** Turbine is attached to the driven-unit i.e. input of gear box and faces of impellor on account of which the oiler projected from the pump causes the turbine to run. The turbine shaft runs the gear system.
3. **Stator –** It is a curved fine wheel mounted on a free wheeling device between the impellor and turbine. As the fluid leaves the turbine, the fluid would be thrown back to the pump in reverse direction i.e. opposite to that of rotation of pump. Thus, it requires more power to drive it. The oil coming from the turbine is directed by the stator vanes in a direction which is favourable to the directions of moving of pump. The stator (reaction member) following the turbine wheel has the task of redirect against the oil which is streaming out of the turbine and direct it to the correct streaming direction to the pump wheel. The stator receives a reaction movement due to this reversing motion. Thus it improves the efficiency of converter. Also the oil in favourable direction gets added up with the oil which would normally had been projected by the pump and thus multiples the torque. As the turbine speed increase the direction of oil coming from turbo charges. Thus the oil direction does not appose the impellor movement. Also of the direction of oil is such that the stator direction is reversed. The stator stepson free wheel and allowing the oil to flow in the required direction.

   As the conversion is increasing the correspondence with the speed difference between pump wheel and turbine, therefore the maximum. Conversion takes place when the turbine wheel is not moving with increasing output speed, the torque conversion gets decreased. The out put speed is automatically adopted to required output movement of the torque converter.

   A gear pump of capacity volts/minutes circulations oil to converter and used for shifting of gears. Gears pump supplies pressurized oil of pressure (10-12 bar) for actuation of clutches. This oil is controlled by electrically operated solenoid valves which get current from PCB and is operated by electric solenoid which get current from PCB and is a function of engine rpm and turbine speed.

   Gear shifting is operated by electrical solenoid which are provided on top of the gear (M_1 M_2, M_3 & M_4.
   Power transmitted through torque converter to selected gears.
   Current consuming of each solenoid is equal to 0.25A – 0.5A.

Function of the Gearbox:

Driving of machine in case of traveling.
Providing the input of mechanical energy to hydraulic pumps.
Transmit the engine power to different units of machine.

Main Assemblies:	**Special Features:**	**Torque Converter:**
Torque Converter	It is a hydrodynamic Gearbox.	It is initial power receiver.
Gear Train	Gearbox is electrically controlled.	Medium of power transmission is fluid.
Shifter Assembly	It has separate hydraulic system.	
Selector Lever	No clutch paddle is required.	Impeller, turbine and turbine are main parts.
Power Take Off	Medium of power transmission is fluid.	
Final Drive	No movement of gears as in mech.Gbox	Pressurized fluid is acting over moving impeller blades.
	More than 2500 types of components.	

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-V: Z.F. Hydro-dynamic Gear Box **Session-7:** Precautions during working and Maintenance aspects.

PRECAUTIONS DURING WORKING AND MAINTENANCE ASPECTS:

1. Z.F. Hydrodynamic gear box should be handled by a skilled & trained workman only with a special emphasis on cleanliness.
2. It is preferable to keep special tools recommended by OEM for limited maintenance operations to be carried out at field or else similar indigenized tools must always be made available in the machine.
3. Use only recommended brand of Locktites, i.e.:
   270 No. for nuts & bolts
   574 No. for Sealant (Liquid Gasket)
   641 No. for Bearing surface.
4. Replace oil ULTRA-10/SAE 15-W-40 (as the case may be) after every 500 hrs. of working. During oil replacement, strainer should be checked for any accumulation of impurities over magnetic rod. 'O' Ring over strainer must be replaced at the time of oil change.
5. Check the oil level weekly:
   (a) While the machine is in horizontal plain.
   (b) Keep transmission in neutral position.
   Cold level at 40^0C & 1000 RPM – Lower mark.
   Hot level at 80^0C & 1000 RPM – Upper mark
   Where 80^0C is not achieved, checking at 40^0C for lower mark will serve the purpose.
6. Replacement of pressure filter (25 micron) at the interval of 250 hours of working.
7. Replace the filter along with oil in case of buzzer alarm heard for choking of filters.
8. Check external connections at regular interval for their tightness.
9. Operation of gear shifting should not be done below:
   1200 r.p.m. of the engine.
10. Towing speed restriction of 10 Kmph should be followed; otherwise it may lead to the damage of gearbox. Connecting two machines for block operation should not be done.
11. Shifting of gear should be carried out at the proper time. Any delay or early shifting will reduce the gearbox life in long run.

Proper Time for Lockup indication

Indicator is not provided in operating panel, gears are being shifted only based on experience and assumptions. A LED connection may be provided in cabins as has been provided in SPURT car. CPOH can provide circuit diagram if desired.

12. Frequent variation of speed should be avoided.
13. Z. F. key should be put off only after stopping of machine as two clutches out of seven clutches remain engaged even in neutral position and counter speed of the wheel through cardon shaft will affect those clutches which may damage the frictional bearings and slippage of clutch may occur.
14. If for any reason external impurities enter the gearbox, working of machine should be stopped and after rectification of defect complete oil should be replaced. In that case clean the gearbox as much as possible including torque converter.
15. Pressure cut off switch should be checked for its functioning at 2.5 bar. Early or late cut off may reduce the life of the costly Z.F. gearbox.
16. In case of any obstruction while moving, r.p.m. should be reduced and brakes should be applied below the cut off pressure i.e. 2.5 bars. Avoid the excessive application of brake above 2.5 bars.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-V: Z.F. Hydro-dynamic Gear Box Session-8: Failure Analysis and Troubleshooting.

FAILUES ANALYSIS & TROUBLE SHOOTING:

COMMON FAILURES OCCURED IN Z. F. GEARBOX ALONG WITH THEIR REMEDIAL AND PREVENTIVE MEASURES BASED ON FIELD EXPERIENCE.

MAIN NPRESSURE HAS GONE TO ZERO AND MOVEMENT OF THE MACHINE STOPPED

Case Study:

Earlier it happened on different machines that suddenly during the course of working, main Pressure dropped to‘0’. After checking the oil level And functioning of electrical pressure gauge, it was observed that 0.6mm orifice, provided on intermediate plate in shifter assembly was found choked completely.

Due to contamination of oil. After cleaning of plate & orifice, gearbox started functioning with normal pressure.

Remedial Measures

(a) Check the functioning of pressure gauge by providing spare hydraulic gauge (0-25 bar) in place of electrical, if it is ok.
(b) Check of flow of ZF pump by flow meter or any other suitable means (Shaft key of pump may get slipped), if it is ok.
(c) Check the intermediate plate for choking of pressure orifice, clean if choked.
(d) Finally overhaul the shifter assembly or get assistance from CPOH.

Preventive Measures

The machine operator must be attentive for 25-micron pressure filter choking buzzer due to passage of contaminated oil and once it is heard or in case of hydraulic oil entering in ZF gearbox chamber due to bursting of pump oil seal (38-22, 38-17,20-14, variable pump) stop the working of machine and clean the gearbox immediately by flushing out oil as much as

possible including torque converter. Under any circumstances safety switches or filters should never be bypassed.

Flickering Movement of Pressure Gauge and Sound Observed from Torque Converter
Case Study
At times this happened in field after replacement of oil. Reason for such failure is, less oil level due to improper topping up or due to external leakage. After checking it has been found that recommended procedure for checking oil level was not followed properly by field staff.

Remedial Measures:
(a) Check the oil level at recommended procedure
And refill the oil as per requirement.

(b) Check & attend the external leakage if any.

Preventive Measures
(a) Check the oil level as under:
At 1000 rpm and 40^{o}C-Lower mark (Cold level).
At 1000 rpm and 80oC-Upper mark (Hot level).
Checking oil level at less than 1000 rpm will
generate malfunctioning.
(b) Fill extra oil while travelling on gradients (Ghat section).

3. Machine Movement Stopped but Pressure and Temperature Are OK.
Case Study
This happens due to dislocation of towing lever bolt /splines during process of working. In past it did happen on few machines. On investigation it has been found that field staff normally do not put their attention on this particular subcomponent. For this small failure several times machines had been under break down for 5 to 10 days for want of CPOH staff. After checking it was observed that towing lever bolt /splines were dislocated during the process of working.

Remedial Measures
(a) Towing lever was found dislocated from its locking. Tightened the bolts of the lever.
(b) In case it is spline type, temporary arrangement by welding can also be done over shaft and lever.

Preventive Measures
(a) Check the tightness of nuts regularly.
(b) In case of spline type shaft, replace the shaft and lever.

Engine Taking additional Load or Engine Stopped While Shifting First Gear.
Case Study
In several machines it was observed that machines are under break down for the said problem and help of CPOH is sought for. After going through the failure it was observed that it happens mainly due to failure of electrical circuit. In exceptional cases torque converter clutch also gets damaged. Early actuation of lockup clutch is the reason behind such failure.

Remedial Measures
(a) Check electrical connection of lockup circuit.
(b) Check inductive transmitter resistance 1.5K-Ohm & distance from pulse disc shall be kept 0.7mm to 1mm.
(c) Check the functioning of electronic module. Frequency 650Hz at 14000 rpm for lock in.

4. Preventive Measures

Check the 24-Volt power supply over WK valve by keeping the machine in towing mode and increase the rpm after engaging the gear. Electrical supply of 24 D.C. should reach to WK valve at 1400 rpm and above & should k not beless than said rpm in any case otherwise adjust the gap of inductive transmitter as above at (b).

5. Excessive Temperature

Case Study

In several machines it has been observed by CPOH that improper operation has resulted in rising of temperature of the gearbox. Early late shifting of gear is one of the reasons behind this failure. It is also suggested that working of the machine above 120^{o}C should be prohibited. Safety switches should never be bypassed.

Remedial Measures

Keep the machine in neutral. Increase the RPM from 1200 to 1500, within 2 to 3 minutes temperature should drop quickly to normal. If not, then ask the assistance from CPOH as the overhauling of shifter assembly is required in that case.

Preventive Measures

(a) Don't overload the machine.
(b) Keep the rpm minimum up to 1200 while passing through down grades.
(c) Don't down k shift on higher speed.
(d) Check the oil level regularly; less oil may lead to such failure.

6. Burning Of Clutches:

Case Study

In few machines it has been observed that fume suddenly starts coming out through breather though the pressure and temperature was normal. It happens due to choking of lubrication line resulting in hunger of oil in clutch assemblies. Once this happens, the only solution left is to overhaul the complete gearbox at CPOH.

Remedial Measures:

Complete overhauling is required. Burning of any clutch at normal pressure and temperature is due to choking of lubrication lines (internal tubing's).

Preventive Measures:

Check the lubrication oil pressure, if it reaches to 3.5 bar and above at 1000 rpm, stop the machine and ask CPOH for further check as in case of choking of lubrications lines, complete oil will go to sump by pressing the valves setting. In no case lubeoil pressure should rise above 3.5 bars at 1000 rpm continuous watching of lube oil pressure of the gearbox can save an extensive damage.

7. Main Pressure Is Tool Low:

Case Study

It is observed that many old machines are kept on working for a long time at lesser main pressure. Working at lesser pressure below 10 bars may lead to slippage of clutch and finally can damage the gear box. Initial symptom of this failure oil turning out blackish.

Remedial Measures:

(a) Check pressure gauge for its functioning by providing hydraulic pressure gauge.
(b) Tighten the Allen bolts over shifter assembly upto 50 Nm. Pressure will increase by this process from 1 to 2 bar.
(c) Contact CPOH for further checking, as the overhauling of complete shifter assembly or gearbox is needed in this case.

Preventive Measures:

(a) Nut bolts (external) should be checked during schedule maintenance.
(b) Operating the machine at less pressure can damage the gearbox due to slippage of clutch.

8. Abnormal Sound

Case Study

Abnormal sound may be observed due to damage of any mechanical component inside, damage of bearing, nut & bolts, locks etc in the process of working. In case of any abnormal sound machine working should be stopped immediately to avoid further damage to gearbox.

Remedial Measures

Complete overhauling is required to be carryout in workshop.

Preventive Measures

(a) Don't tow the machine above 10 Km/h.
(b) Skipping speed should be avoided.
(c) Down Shifting should be done at recommended speed.
(d) Acceleration of machine should be avoided after placing the brakes.

9. Oil Becomes Blackish

Case Study

Black colour of oil is the indication of poor health of gearbox. Complete checking of the gearbox including replacement of oil is required to be carried in this case.

Remedial Measures:

(a) Replace oil and 25-micron pressure filter. Keep watch on the colour of replaced oil.
(b) Check the lubrication pressure, if it is 3.5 bars at 1000 r.p.m. stop the machine. Further operation of gearbox may lead to excessive damage. If pressure is within range, replace oil, check strainer, if nothing is found in it, and keep on working by frequent checking of lube oil pressure unit till it reaches to 3.5 bars.

Preventive Measures

(a) Don't keep on working if the main pressure is less than 10 bar.
(b) Filter/oil should be replaced as per prescribed schedule.

Jerks Observed In All Three Speeds

Case Study

Whenever jerks are observed while shifting the gear, itis the indication of poor condition of the gearbox. Clutch gaps are increased resulting longer gear shifting time (recommended gear shifting time is1.17 seconds to 1.7 seconds). Early checking of the gearbox is required after said indication during working.

Remedial Measures

(a) If jerks are felt only while placing the first gear,
Check external connections.
(b) If jerks observed in all three speeds complete gearbox needs checking, may ask CPOH for the same/

Preventive Measures

(a) Shifting of gears should be done at proper time, for that lockup indication may be provided over operating panel.
(b) Down shifting should be avoided.

(c) Check your pressure switch for its functioning replaces if required

good maintenance practices

ZF Hydrodynamic gearbox should be handled by a skilled & trained workman only with a special emphasis on cleanliness. It is preferable to keep special tools recommended by OEM for limited maintenance operations to be carried out at field or else similar indigenized tools must always be made available in the machine.

Use only recommended brand of Locktites, i.e.:-

270 No. For nuts & bolts.
574 No. for Sealant (Liquid Gasket).
641 No. for Bearing surface.

Replace oil ULTRA-10 / SAE 15-W (as the case may be) after every 500 hrs. of working. During oil replacement, strainer should be checked for any accumulation of impurities over magnetic rod. 'O' Ring over strainer must be replaced at the time of oil change.

Check the oil level weekly:

(a) While the machine is in horizontal plain.
(b) Keep transmission in neutral position.
(c) Cold level at 40^{o}C & 1000 RPM - Lower mark
(d) Hot level at 80^{o}C & 1000 PM - Upper mark
Where 80^{o}C is not achieved, checking at 40oC for lower mark will serve the purpose.

Replacement of pressure filter (25 micron) at the interval of 250 hours of working.
Replace the filter along with oil in case of buzzer alarm heard for choking of filters.
Check external connections at regular interval for their tightness.
Operation of gear shifting should not be done below:-

1200 r.p.m. of the engine:

Towing speed restriction of 10 Kmph should be followed: otherwise it may lead to the damage of gearbox. Connecting two machines for block operation should not be done.
Shifting of gear should be carried out at the proper time. Any delay or early shifting will reduce the gearbox life in long run.

Proper Time for Lockup indication:

Indicator is not provided in operating panel, gears are being shifted only based on experience and assumptions.A LED connection may be provided in cabins as has been provided in SPURT Car. CPOH can provided circuit diagram if desired. Frequent variation of speed should be avoided. ZF key should be put off only after stopping of machine as two clutches out of seven clutches remain engaged even in neutral position and counter speed of the wheel through cardon shaft will affect those clutches which may damage the frictional bearings and slippage of clutch may occur. If for any reason external impurities enter the gearbox, working of machine should be stopped and after rectification of defect complete oil should be replaced. In that case clean the gearbox as much as possible including torque converter.

Pressure cut off switch should be checked for its functioning at 2.5 bars. Early or late cut off may reduce the life of the costly ZF gearbox.
In case of any obstruction while moving, r.p.m. should be reduced and brakes should be applied below the cut off pressure I.e. 2.5 bars.

Avoid the excessive application of brake above 2.5 bars.1-MAIN PRESSURE HAS GONE TO ZERO AND MOVEMENT F THE MACHINE STOPPED

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VI: Funk Gear Box **Session-9:** Working, Construction and Maintenance practices. .

FUNK GEAR BOX

Funk gear box is a mechanical gear box used for the purpose of power transmission. This has got the gear arrangement in such manner that with the help of a common shaft input power is taken and the power is transmitted in to two opposite directions. For example hydraulic pumps being in two opposite directions get power from one common input and pumps (LHS & RHS) can be driven in to two different directions.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VII: Reduction Gear Box **Session-10:** Working, Construction and Maintenance practices.

REDUCTION GEAR BOX:

It is a mechanical gear box use for power transmission in Track Machine. This gear box is used whenever we want to run the working unit at lower speed. Gear trains are selected as according to match the speed of the working unit. This gear box is used mainly in the working mode when the machine works during sleeper to sleeper movement.

Maintenance practices for the maintenance of reduction gear box there is a need of oil changing as per the prescribed manual. This should also be ensured that dust and dirt should not entrapped in the gear box as otherwise it will damaged the gear box and their will be no smooth operation of the gear box.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VIII: Satellite Axle Gear Box **Session-11:** Working, Construction and Maintenance practices

---

WORKING AND CONSTRUCTION OF SATELLITE AXLE GEAR BOX:

In 09-CSM machine, Plasser and Theurer provide a Continuous machine movement along with tamping for achieving more out put. For this purpose, tamping and lifting unit has been provided on Satellite frame which moves independent of machine movement. While tamping, main Machine moves continuously and the Satellite unit Stops for each tamping cycle and go distantly again and again. For the movement of Satellite frame, we use a satellite gear box which takes mechanical Energy through a hyd. Motor. Satellite gear box is a very sophisticated gear box and engaging of two big and small Spur gear depends upon Pneumatic Pressure. If Pneumatic Pressure is less than 2.5 bar then it will affect gear box as well as out put. In order to avoid long idling and long life of Satellite gear box. Following points are to be help in mind during operation.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-VIII: Satellite Axle Gear Box **Session-12:** Precautionary steps to avoid failure.

PRECAUTIONARY STEPS TO AVOID FAILURE.

i) It is to be ensured that Pneumatic Pressure should not be less then 2.5 bar.
ii) Engaging and disengaging of both Spur Gears should be 100%.
iii) Satellite brake of 5 bars should act properly while tamping.
iv) Longitudinal Transducer limit switch should be in working order, limit switch connection should be in NO Position.
v) 32mm, 25mm pin Rocker Bearing GE-25, link plate, torque plate, Gear Box top housing must not any play.

vi) Proximatic Switch (1422k) should be set properly according to fork Position after ensuring 100% engaging and disengaging of both spur gears.
vii) There should not be any play between fork hole and guide rod. Pneumatic cylinder and shifter rod should be tightened along with the check nut.
viii) Pneumatic cylinder and valve should work properly and get it cleaned periodically.
ix) Rubbing block and brake gap should not be more than 3mm.
x) The seal of satellite brake cylinder should be checked regularly and replaced after every 1000hrs if required.
xi) Booster cylinder should be in working condition and pressure should not be less than 40 bar(40-60 bar)
xii) According to Track condition Machine speed should co-inside with satellite movement.(Machine Speed 1.2km/hr)

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-13:** Function and Parts.

TAMPING UNIT FUNCTIONS & PARTS

Tamping Units/Bank:

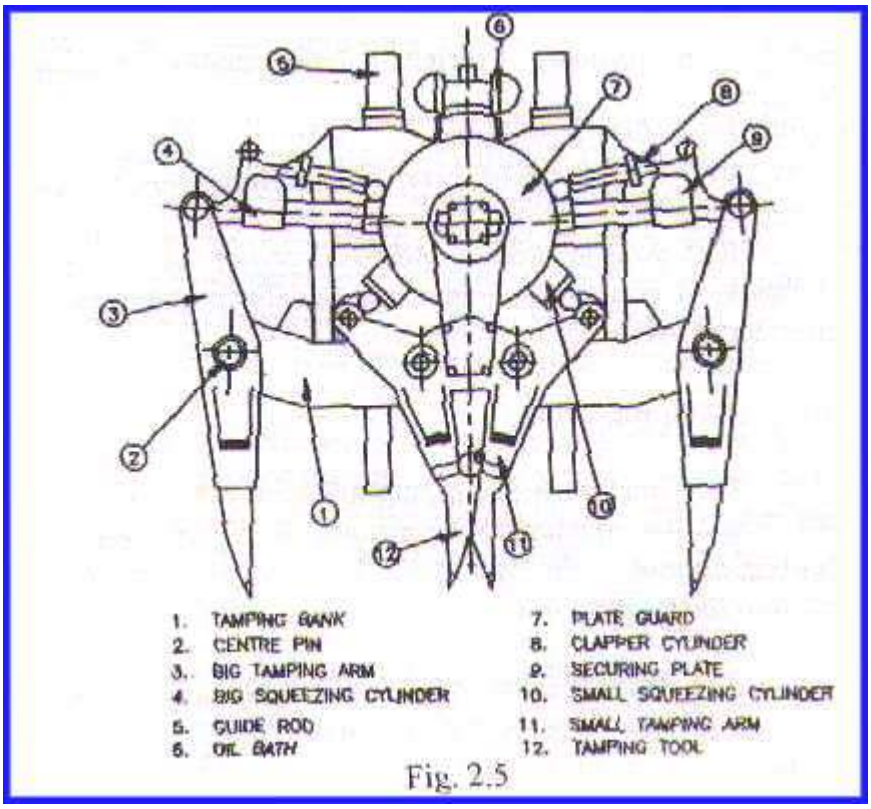
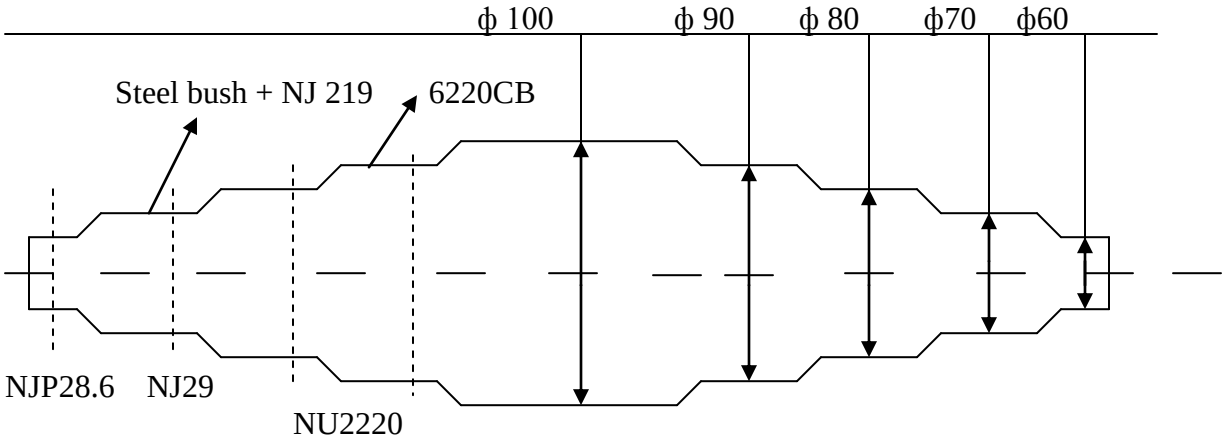


Fig. 2.5

The tamping unit is the most important mechanical assembly of the machine in addition to the Diesel Engine (which has been dealt separately). There are various designs of tamping banks suiting different types of machines and track requirements e.g. single sleeper tamping. Double sleeper tamping, switches and crossing etc., whatever type of machine it may be, M/s plasser & Theurer has world wide patent for its non-synchronous design of tamping banks. Which are discussed one by one.

Vibration Shaft:

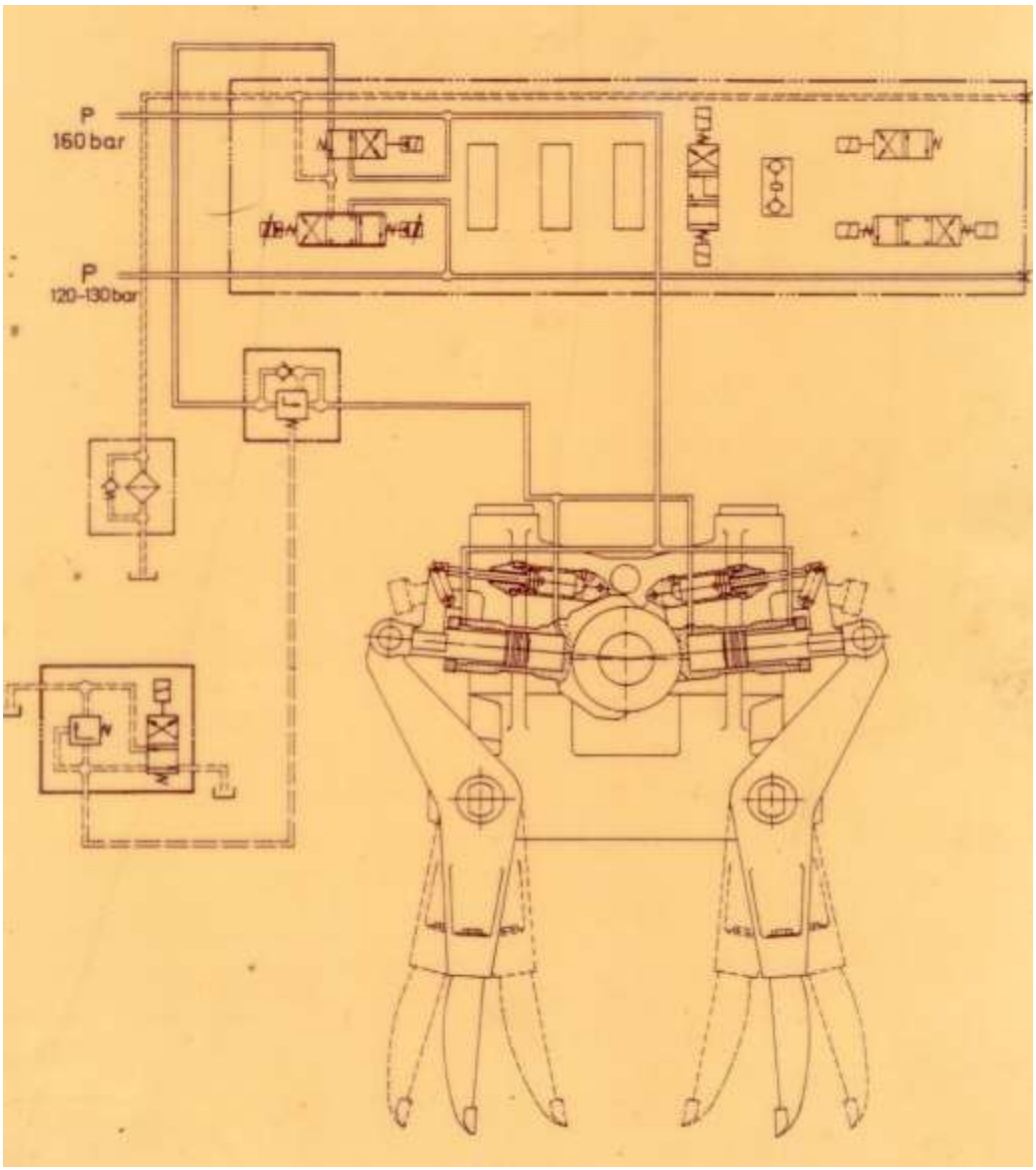


All Dimensions ARE in MM

1.1 Tamping Bank For Tamping Single Sleeper

The mainliner universal machines having this tamping bank are designated 06-16 type. Non-synchronous constant pressure-vibration tamping is achieved by 8 tamping tools on each bank, arranged in pairs, in side and outside the rails, on both sides of the sleepers. The machine operates with a total of 16 tamping tools.

Non-synchronous feed adjustment results in all tamping tools exerting the same pressure on the ballast bed, regardless of the in-feed movement. There is complete force equilibrium between tool pairs, and uniform specific surface pressure on all **tamping tools. The pairs of tamping** tools move completely independently, according to the resistance encountered in the ballast bed.



During the in-feed action of the tamping tools, resistance builds up in front of each individual tool pair. When the resistance has reached the level of the chosed tool in-feed force, the tool pairs concerned come to rest. The other tamping tools continue to work until they too exert the same force on the ballast bed.

The plasser & Theurer non- synchronous constant pressure tamping system therefore guarantees completely uniform tamping of the sleeper bearing surface.

The tool blades are corrugated and have a spade shaped edge. This means that they adapt more more easily to the grain of the ballast, and deal with a wider tamping zone. Due to the spade-shape of the blades the tools encounter less penetration **resistance.**

The vibration is generated by a hydraulically driven eccentric shaft. Connecting rods (hydraulic cylinders) are supported on the shaft conveying the eccentric movement to the swing arms, which in turn vibrate the tamping tools.

Speed of rotation of	
Vibration shaft approx	: 2,100 rev/min.
Vibration of tamping	
Tools approx	: 35 cycles.
Amplitude of vibration	: 10 mm.

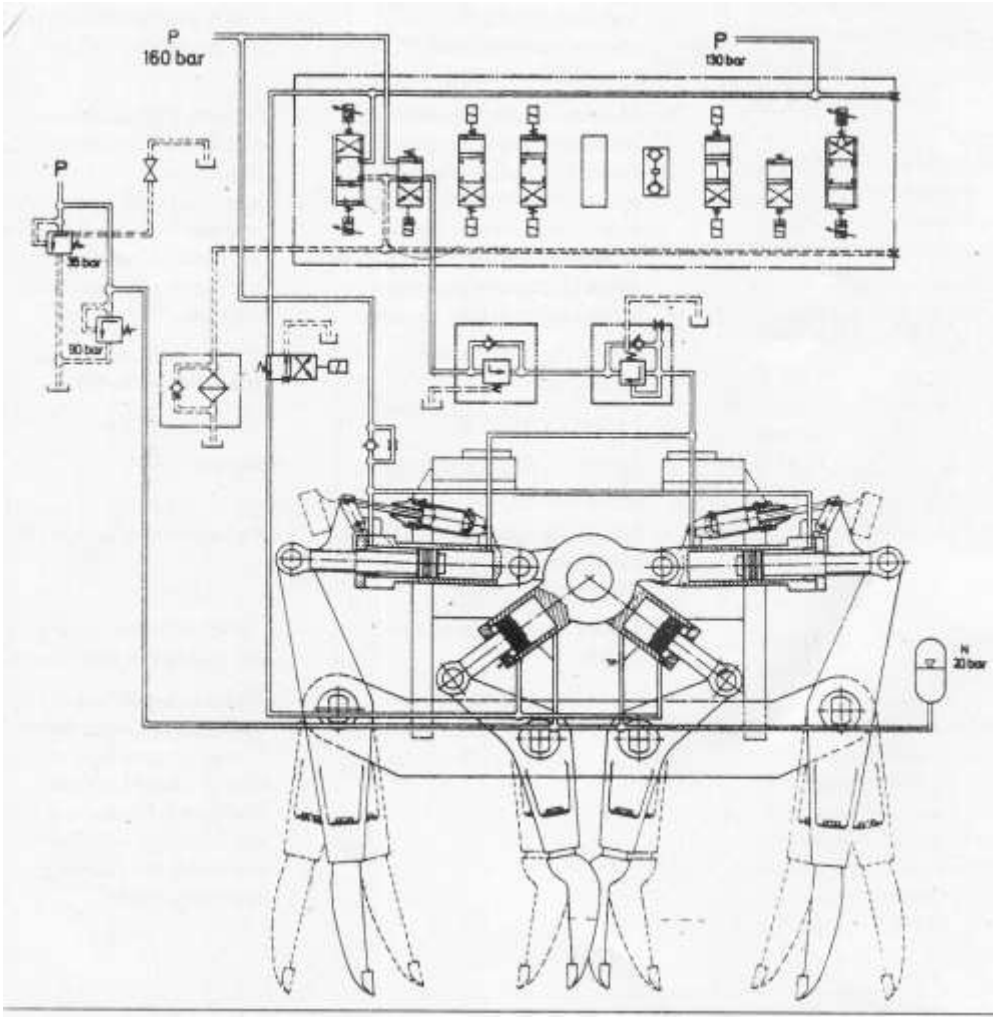
1.2 Tamping Bank For Tamping

Two Adjacent Sleepers

The double headed tamping machines are of the type mainliner Duomatic 06-32 series.

Two independent tamping banks are laterally movable on horizontal guide columns for automatic centering above the rails, allowing a perfect tamping even on curves. Each machine has 32 tamping tools arranged in pairs for the simultaneous tamping of two adjacent sleepers.

A uniform compaction of the sleeper bearing surface is achieved by non-synchronous constant pressure vibration tamping. The design of the tool plates vibration frequency, etc., are similar to that of the 06-16 tampers.



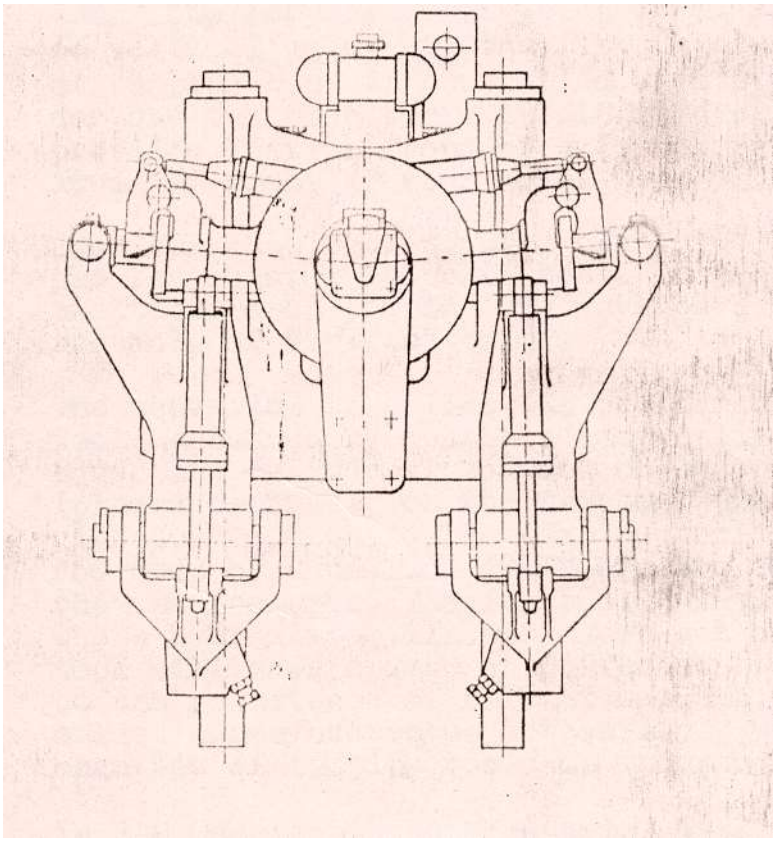
The simultaneous tamping of two adjacent sleepers increases the output., as compared to that of machines with a single tamping bank. Tamping machines with double-sleeper tamping banks are therefore considerably more economic in operation than those with single tamping banks. The generally track layout achieved with these machines is better than achieved tamping for individual sleepers. The output of double-headed tamping machines being greater, they are preferred by railway administrations even when used by contractors, as traffic restrictions and expenditure on personnel is lower than that which would be used for double the number of single-headed tamping machines.

Speed of rotation of vibration shaft : 2,100 rev/min.

Vibration of vibration : 10 mm.

1.3 Tamping Bank for Switches and Crossing

The tamping machines with these banks have the type designation mainliner unviers al 2 W 75.



One tamping bank per rails is equipped with 4 titable tamping tools. This disposition allow the tamping of all parts of the 5 & C layout. Even such parts as frogs, switch blades, etc. can be under-gripped by swinging in the tools. The non-synchronous feed adjustment of the tamping tools is by hydraulically produced vibrations.

For tamping double sleepers the opening width of the tamping clamps is increased. The tamping tools have a large surface and are manufactured of wear resistant manganese steel. Tamping tools with extra wide plates can be used for tamping plan track. The tamping banks are raised and lowered by hydraulic cylinders. The tamping banks can work independently.

The tamping banks can also be equipped with tool spades to apply on a larger area. The sleeper can then be tamped once with vertical tools and once with tools slightly tited outward so.

Rotations of vibration shaft	:	Appox 2, 100 rev/mins.
Vibration of tamping tools	:	Approx 35 cycles.
Amplitude of vibrations	:	Approx 10 mm.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-14:** Precautions during working & repairing. Maintenance schedule.

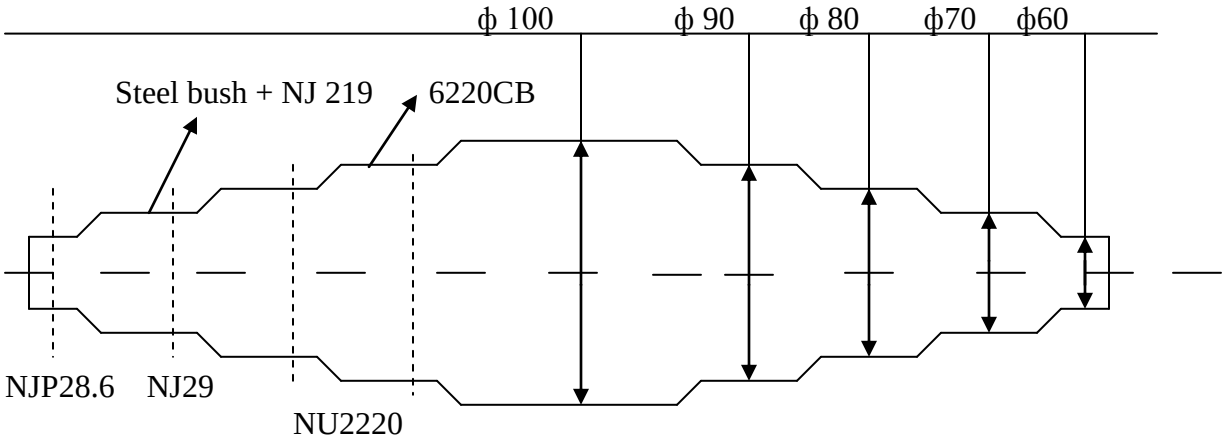
Trouble Shooting and Failure Analysis:

Trouble in Tamping Unit	Solution
1. Wear and tear of tamping tools.	1. Repair, welding and replacement of tamping Tools
2. Play developed in the Tamping Arm.	2. Requirement of Replacement of Tamping after certain specified time.
3. Leakage in the radial seal of tamping arm (955mm pin)	3. Replacement of Radial Seal of tamping arm (955m pin)
4. Breakage of Cover bolt 16 x 35 of small squeezing cylinder.	4. Replacement of cover bolt of 16 x 35 of small squeezing cylinder.
5 Shearing of piston screw of squeezing cylinder.	5. Replacement of bearings of Tamping Unit.
6. Seizure of bearings of Tamping unit.	6. Replacement of bearings of Tamping Unit.
7. Breakage of Vibration shaft of Tamping clip.	7. Replacement of vibration shaft of tamping unit.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-IX: Tamping Unit **Session-15:** Dimensions of different Parts and Tolerances, setting of bearings and spacers on vibration shaft.

Vibration Shaft:



All Dimensions ARE in MM

Trouble Shooting and Failure Analysis:

Trouble in Tamping Unit	Solution
2. Wear and tear of tamping tools.	1. Repair, welding and replacement of tamping Tools
2. Play developed in the Tamping Arm.	2. Requirement of Replacement of Tamping after certain specified time.
3. Leakage in the radial seal of tamping arm (955mm pin)	3. Replacement of Radial Seal of tamping arm (955m pin)
4. Breakage of Cover bolt 16 x 35 of small squeezing cylinder.	4. Replacement of cover bolt of 16 x 35 of small squeezing cylinder.
5 Shearing of piston screw of squeezing cylinder.	5. Replacement of bearings of Tamping Unit.
6. Seizure of bearings of Tamping unit.	6. Replacement of bearings of Tamping Unit.
7. Breakage of Vibration shaft of Tamping clip.	7. Replacement of vibration shaft of tamping unit.

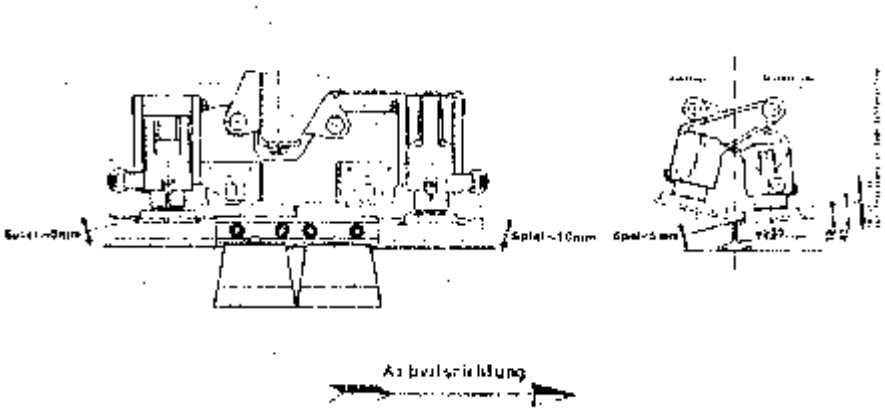
Lifting and Lining Unit

The track lining equipment and the roller lifting unit are complied. Two double-flanged rollers and one horizontal hydraulic cylinder on each unit line the track. When the combined lifting and lining unit have been lowered the 8 lifting rollers as well as the 4 lining rollers roll along holding the rails.

The track is lined by the lining cylinders moving the two tool carriers in the required direction. The lining force acts on the track on four points by the flanges of the ling rollers. The track is moved into the correct piston without impact. As lifting and lining are also carried out simultaneously and the combined unit is arranged immediately in front of the tamping bank, the track is is tamped in its corrected position.

The Leveling, tamping and lining machines of the mainline universal series are equipped with the combined unit for simultaneous lifting and lining of the track.

The lifting force is applied centrally over each rail without support on the ballast. Two pairs of rollers grip each rails under the head from inside and out side. This means that the track is lifted on four points. Because of the clamp like arrangement of the lifting rollers, and of the vertical lifting roller of the vertical lifting roller of the vertical lifting force, no tilting moment is conveyed to the rail and therefore no excessive loads exacted on the rail and therefore no excessive loads exacted on rail fastenings. In moving forward, the clamps remain closed, rolling under the rail top without touching the fastenings. The clamps also over-roll joints, fish-plates, welds, etc., without having to open. For tracks where the closed roller clamps cannot roll clear (e.g. bull head track) a special automatic control device is provided, which opens the clamps when the machine moves forward to close them again when the machines reaches the next tamping spot.



GENERAL INFORMATION

The sequence of dismantling the lifting and lining unit is basically the versed sequence of its assembling.

Utmost cleanliness is to be observed all through out the dismantling, repair and reassembling. Before repair the lifting and lining unit is to be cleaned with an adequate cleansing agent.

When repair is carried out on a unit which is mounted to the machine the site is to be protected against dropping dirt.

Before reassembling thoroughly clean all parts, replace used washers and remove sealing from sealing surfaces trim all burr and similar roughness. Replace by new ones damaged and worn parts.

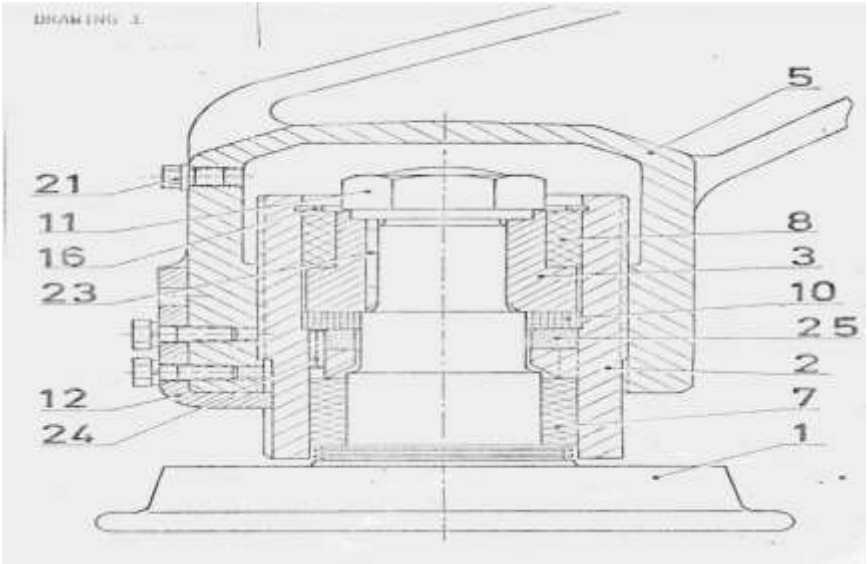
A competent machine is to assess which of the parts submitted to normal wear are to be re-used. Washers, sealing rings, locking plates split pins and the like are to be replaced in case they were damaged during dismounting.
No clips, or splinters or other foreign matters are to be left in the housing.
Observe during reassembling the indicated torque and adjusting date. Screws and nuts for which no torque is indicated are tighghtended according to standard charts.
The numbers indicated in these instructions (e.g. 1/A,B) mean.
1 = number of figure
A,B = position
Numbers not followed by letters refer to the illustration as a whole.
V.B. = Numbers of devices used.

13.0 ASSEMBLING THE LIFTING ROLLER CLAMP ASSEMBLY

Hold lifting disc (1/1) in vice and insert adjusting spring (1/23) into shaft using a hammer of plastic material or of aluminum.
Drive to the bushing of plastic material (1/7) into the clamp sleeve (1/2) by means of device (VB 815) insert the intermediate ring (1/25) and secure against torsion by means of the clamping sleeve (1/24).
Grease the plastic bushing (1/7) and drive pre assembled clamp sleeve (1/2) in the shaft of the lifting disc (1/1)
Subsequently insert the greased axial pressure plate (1/10), the pressure bushing (1/3) and the plastic bushing (1/8), in using device (VB815)
Secure plastic bushing (1/8) by seeger ring (1/16).

Degrease nut (1/11) and thread of lifting disc shaft (1/1) coat them with loctite and tighten the nut.

1.	Lift disc	2.	Clamp sleeve
3.	Pressure bushing	5.	Clamp lever
7.	Bushing of plastic	8.	Material
10.	Axial pressure plate	11.	Nut
12.	Protector	16.	Seeger ring
21.	Plug screw	23.	Adjusting spring
24.	Clamping sleeve	25.	Intermediate ring.



Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XI: Bearings **Session-18:** Functions, Types, Bearing Clearance and Maintenance aspects. .

Functions, types, bearing clearances and maintenance aspects

Bearings are required while transmitting rotary power from the source to the points of its usages through various linkages to reduce friction, undue power losses, to give even support to the rotating unit and to avoid setting up of undue vibrations in the rotating member thus increasing life of the unit, by reducing wear.

Various types of bearings have been developed by bearing industries in the world for use on various machines and working units to suit to various loads, RPM, condition of working like vibration, jerks, etc. Various weathering condition like sun, dry wet, hot, cold or chemically contaminating atmosphere. There are generally the following types of bearings available.

Bush bearings.
Ball bearings.
Roller bearings
Needle roller bearings.
Thrust bearings.
Spherical bearings
Tapper roller bearings.
Special bearings (Rocker bearings)

Use of Bearings on Track Machines:

On track machines use of various types of bearings on their working units like tamping units lifting units, scrapping chains, ballast regulating units etc. is made e.g. besides this bearings are used in the following assemblies.

Wheels and axles.
Gear boxes.
Axle gear bogies.
Various bogies.
Pumps & Motors.
Radiator fans.
Engines, etc.

Numbering of Bearings:

Each bearing is given certain No. as per International standardization organizations ISO as per their diameters Plan for ball and roller bearings for other bearings different methods are used.

Bearing Number with series: (Example Of 62 Series)

Bearing up to 17 mm dia, bore the number are given as under:

SEREIS NO.	**DIA**	**SERIES NO.**	**DIA**
3 mm	623	9 mm	629
4 mm	624	10 mm	6200
5 mm	625	12 mm	6201
6 mm	626	15 mm	6202
7 mm	627	17 mm	6203
8 mm	628	20 mm	6204 From 20 mm on wards.

Last Nos. when multiplied by 5 given the bore dia of bearing..

Selection of Bearings:

Many factors have to be considered like.

1. Loads (Radial and axial)
2. RPM
3. Vibration
4. Shocks
5. Reversal of directions.
6. Atmospheric conditions (Clean dusty) full of chemicals.
7. Space to fit bearings.
8. Precision required in running.
9. Lubricating conditions
10. Quite running.
11. Temperatures while running.
12. Ease of mounting and dismounting
13. Clearance required in a bearing.

Bearing Clearance:

Bearing internal clearance is defined as the total clearance through which one bearing ring can be moved relative to the other this is indicated by shelters from C1 to C5.

Mounting and dismounting of bearings:

Before mounting any bearing the shaft or housing should be checked for proper tolerances for fits etc. if this is not observed the bearing may fail prematurely.

For providing bearings on a shaft interference fit the bearing should be heated in a oil bath tub and provided.

For providing bearing in a housing the bearing may be cooled in ice.

The bearing should be mounted square.

Lubrication paths should always be available if not these should be provided.

fixing of bearings should preferably be done in dust free atmosphere.

Axial location of bearings must be done as interference fit alone is generally not adequate for the axial location of bearing. As a rule therefore some suitable means of axially securing the ring is needed.

Bearing Technology

1. History Of Bearing

Bearing is a great invention of mankind. Even primitive man knew the use of balls and rollers for carrying heavy materials since when Egyptian pyramids were constructed . Recorded facts are available that in 1558,a Frenchman applied rollers to well bucket for drawing by reducing water the labour to great extent.

Pre-historic instances reveal that chariot was the most important asset of Assyrian Empire used for carrying weapons and soldiers in the war. The chariot axle used to get damaged by friction and hot axle trouble even with a load of four soldiers and a little weapons. The soldiers had an earnest desire to develop less friction chariots and their wish was granted in the later half of the nineteenth century when bearings were introduced.

In 19^{th} century a huge stone weighing 1000 tones and eight meters high used as a base of Russian czar peter I's statue was carried to its site by use of bronze balls.

Today this industry is so advanced that hundreds of bearings in thousands of sizes are available. Right from the simplest machinery like bicycle using balls for reducing friction to the most complicated rockets and satellites launched so far, utilize bearings for speed and service to the mankind and it is the best way to overcome friction.

2. **Bearing Materials**

The material for race ways and rolling elements have very small contact surface which are repeatedly subjected to stresses, must be such as to withstand wear and high elastic limits and high fatigue limits.

As a rule, high carbon chrome bearing steel Grade SAE 52100 or EN-31 is used for races and rolling material.

2.1 Chemical Composition

Grade	**C**	**Cr**	**Mn**	**Si**	**P**	**S**
SAE 52100	0.95 to 1.10	1.30 to 1.60	0.50	0.15 to 0.35	0.025	0.025

Other bearing steels depending upon the methods of heat treatment involved are as following.

S. No.	**Group of Steel**	**Specification**	**Bearing Hardness**
01.	Tool Steel	EN-31	HRC = 58-64
02.	Case Hardening	EN-32 & EM-207	HRC = 58-64
03.	Flame/Induction Hardening	EN-9K EN-43D EN-42E EN-43	HRC≥ 55

3. Bearing Life

The following relationship exists between the life in terms of millions of revolution and the load on rolling bearing.

$$L = (C/P)^P$$

Where

L = Rated life in millions of revolution
C = Dynamic Load capacity in Kgs.
P = Bearing Load in Kgs.
p = Constant i) For ball bearing = 3
ii) For Roller bearing = 10/3

If the speed n is constant, the life of rolling bearing can be determined in terms of operating hours (Lh) from the following formula.

$$L_h = \frac{16666}{n} (C/P)^P$$

$$= \frac{16666}{n} (Ca/Pa)^P$$

Example :- (Roller Bearing)

Given C = 1740 Kgs.
P = 415 Kgs.
n = 900 r.p.m.
For C/P = 4.2 and n = 900 r.p.m.
Read Nomograph for p = 10/3
L_h = 2200 hrs.

Example: (Ball Bearing)

Given C = 1850 Kgs.
P = 300 Kgs.
n = 2200 r.p.m.

For C/P = 6.16 and n = 2200 r.p.m.
Read Monograph for p = 3
L_h = 1800 Hrs.

4. Selection of Bearing

The bearings are selected keeping in view the equivalent load, desired life and operating speed or r.p.m. as discussed earlier. Tables showing load factor and r.p.m. are available for selection of bearing size for a desired life. The following table can be used as guide for calculating bearing. life of different machine.

5. Recommended Life Value

Type of machine	**Life L_h in Operating hrs.**
Infrequently operated machines Apparatus, devices, Demonstration gear.	500
Machine intended for brief operation lifting gear, Domestic equipment, hand tools.	4,000……8,000
Machines on intermittent operation: conveying Equipment, infrequently operated machine tools, Agricultural machinery.	8,000……15,000
Machines for I-shift operation: Machines tools, ventilators, countershafts, general Production machinery, extruders.	15,000….30,000
Machines on continuous operation: Pumps, compressors.	30,000…60,000
Machines on continuous operation with high production Capacity: Paper machines, textile machinery	100,000

NOTE: It will be seen from above table that the Track Machines fall in the Category of Machines on intermittent operation having life L_h = 8000 – 15000 operating hrs.

6. **Bearing Construction:**

Every Bearing has four main constructional features:
Inner race
Outer race
Balls/Roller/Needle.
Cage

The race (Outer & inner) provide the path for rolling elements for their smooth and frictionless motion that is why the bearings are termed as antifriction bearings also. The rolling elements (Ball/Roller/Needle) are sometimes mounted on the inner race where as in some cases on outer race. The rolling elements are kept intact, equally spaced and in one plane by a cage which can be pressed or fabricated type depending upon the manufacturer's design.

6.1 **Specification Of Cage:**

The cages are specified as follows and find their asses in industry/machinery as per requirement. The cage not only keep the rolling elements in position but also retain grease for their lubrication which if lost, the bearing is damaged and or results in over heating and caesura

S. No.	Code	Cage Material.
1.	F	Steel cage
2.	L	Light alloy cage
3.	M	Brass cage
4.	TM	Plastic cage
5.	J	Sheet Steel cage.

These days even Aluminum cages are also provided by the manufacturers.

7. RADIAL AND AXIAL CLEARANCES:

The radial or axial clearance ofa bearing is the amount by which the two races may be moved from one end position to the other radialy or axially.

7.1 RUNNING CLEARANCE:

Running clearance may be defined as the clearance of the mounted bearing produced as a result of fitting conditions and operating temperature. In other words:

Radial clearance > Running clearance

Radial clearance - Mounting tolerance = Running clearance

In order that the running clearance of a radial bearing always has the correct value to ensure an efficient function bearings are available with reduced or enlarged radial clearance for special conditions.

7.2 CLEARANCE SYMBOL:

Symbol	Clearance Classification
C2	Radial clearance smaller than normal

Radial clearance normal

C3	Radial clearance larger than normal
C4	Radial clearance larger than C_3
C5	Radial clearance larger than C_4

7.3 Radial Clearance of Deep Groove Ball Bearing With Cylindrical Bore:

Bored (mm)		**Radial clearance (In units of 0.001mm)**							
		C 2		**Normal**		**C 3**		**C 4**	
Over	**Incl**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
2.5	10	-	7	2	13	8	23	-	-
10	18	-	9	5	18	11	25	18	33
18	24	-	10	5	20	13	28	20	36
24	30	-	11	5	20	13	28	23	41
30	40	-	11	6	20	15	33	28	46
40	50	-	11	6	23	18	36	30	51
50	65	-	15	8	28	23	43	38	61
65	80	-	15	10	30	25	51	46	71
80	100	-	18	12	36	30	58	53	84
100	120	-	20	15	41	36	66	61	97
120	140	-	23	18	48	41	81	71	114
140	160	-	23	18	63	46	91	81	130
160	180	-	25	20	61	53	102	91	147
180	200	-	30	25	71	63	117	107	163

Radial Clearance of Cylindrical Roller Bearings With Cylindrical Bore and Interchangeable Components:

Bored (mm)		Radial clearance									
		C 2		Normal		C 3		C 4		C 5	
Over	Incl	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
18	24	0	30	10	40	25	55	35	65	55	85
24	30	0	30	10	45	30	65	40	70	60	90
30	40	0	35	15	50	35	70	45	80	70	105
40	50	5	40	20	55	40	75	55	90	85	120
50	65	5	45	25	70	45	90	65	105	100	140
65	80	5	55	30	80	55	105	75	125	115	165
80	100	10	60	35	85	65	115	90	140	145	195
100	120	10	65	35	90	80	135	105	160	165	220
120	140	10	75	40	105	90	155	115	180	185	250
140	160	15	80	50	115	100	165	130	195	-	-
160	180	20	85	60	125	110	175	150	215	-	-
180	200	25	95	65	135	125	195	165	235	-	-

7.5 **Radial Clearance Specified for High Temperature:**

Operating temperature	120-150^{0}C	150-180^{0}C	Over 180^{0}C
Radial clearance	C_3	C_4	Greater than C_4

8. **Classification of Bearings:**

There are three main classification of bearings e.g.
Ball bearing
Roller bearing
Needle bearing

They are further classified as follows:

I. **Ball bearings:**
Rigid Ball Bearings
Deep groove ball bearings
Angular contact
Double row-self aligning
Thrust Ball bearings
Single Thrust
Double/Duplex thrust.

II. **<u>Roller Bearing</u>:**
Cylindrical roller bearing
Spherical roller bearing
Taper roller bearing

III. **<u>Needle Bearing</u>:**
Needle cage
Inner Race
Shell type needle bearing
Needle bearing with hard shoulder.
Needle bearing without shoulder
Adjustable needle bearing
Self aligning
Cam follower type needle bearing

Roller follower needle bearing
Thrust Needle roller bearing
Flat cages.

Maintenance Aspects of Bearing:

9. **Lubrication of Bearings:**

Rolling bearing generally require a minimum of lubrication as the load is transferred under rolling friction. Primarily sliding friction occur only on the guide surfaces of the cages, but the quality of lubrication is never-the-less a decisive factor in the life of an antifriction bearing as the main function of lubricant is to prevent corrosion, wear and over heating.

9.1 **Importance of Lubrication:**

The lubrication plays very important role in antifriction bearings and serve various purposes as below:
It reduces friction and wear.
It prevents corrosion
It acts as coolant
It works as noise damper
It acts as dirt remover
It acts as seal/sealent also
It acts as retainer for rolling element.
NOTE: Lack of lubrication is one of the most common reasons for premature bearing death.

9.2 **Type of Lubrications:**

There are three types of lubrications commonly in use for antifriction bearings.

9.3 **Grease Lubrication:**

Properties of various types of greases are reproduced below for guidance of the users.

Type of Grease	**Calcium**	**Sodium**	**Aluminum**	**Barium**	**Lithium**	**Benton**	**Silica gel**
Name of Grease	Cup Grease	Fiber Grease	Mobile Grease	Multi purposes Greases	Non soap base greases.		
Outward appearance	Evenly butter like	Fiber out or butter like	Evenly thread like	Evenly fiber out	Evenly butter like	Evenly butter like	Evenly butter like
Dropping point ^{0}C	85	160-	85	175	175	More than 200	More than 200
Maximum Temp. Recommended ^{0}C	70	125	80	135	135	125	125
Water resistance	Good	Poor	Good	Good	Good	Fair	Poor
Mechanical stability	Fair to good	Fair to good	Poor to fair	Poor to fair	Excellent	Fair	Poor
When heated above 120^{0}C and then cooled	Bleeding	No Change	Jelly like	No Change	No Change	No Change	No Change

9.4 **Dry Lubricants:**

Dry lubricants are recommended for operating temperatures above 250^0C under normal operating conditions there is no advantage in using them even when used in conjunction with grease or oil.

10. **Maintenance of Roller Bearings Axle Boxes:**

Normally we do not require any maintenance except inspection and re-lubrication which is done at 6000-10000 miles (or 96000-160000 Kms). However depending upon the dynamitic conditions, if it is necessary lubricate the bearing earlier. Provision for grease nipple should be kept if possible.

BCM Assemblies:

1. Excavating Chain

Shovel or main link	-	82 Nos.
Intermediate link	-	82 Nos.
Chain finger	-	5 Nos. in each shovel total 410 Nos.
Chain bolt	-	2 Nos.
Cutter Bar	-	1 No.
Dredger drum	-	1 No.
Wear Plates	-	56 Nos.
Corner Roller	-	5 Nos.
Chain Speed	-	1.8mmt
	-	2.4 mt/mt
	-	2.7 mt/mt
	-	3.4 mt/mt
Length of cutter bar	-	2.0 meter

Height of Cutter bar - 250mm

Screening Unit:

1st	80mm size
2nd	50 mm size
3rd	32 mm size

Screening Drum:
This is responsible for creating vibration. Vibration is done through hydraulic motor. It is a bi-directional motor which gives bi-directional movement to the cutting chain.

Track Lifting & Lining Unit:
This is used for the purpose of lifting and lining. Lifting is through a centralized hydraulic cylinder. Track can also be slewed as per requirement.

Maintenance Practices of Excavating Unit:
As excavating unit consists of shovel, intermediate link round shaft chisel. 'T' head bolt, chain bolt etc. due to vibration bolt may shear up so proper attention to be done with respect to the taper and ovality. In addition to this worn out round shaft chisels should be replaced.

The teeth of dredger drum may get worn out. So it should be replaced after a certain period say 25 Km. or so.
Originally the cutting chain is provided with carbide tip as it is much more wear resistant. So these are to be replaced after 60 Km. progress and so on.

There are following conveyor belts provided on machine.

1.	Main conveyor belt	-	1 No.
2.	Distributor conveyor belt	-	2 Nos.
3.	Waste conveyor belt	-	1 No.

Above are rubber – materials, so due to their movement they are subjected to wear and tear. While working it must be ensured that there is no wear or tear or damaged occurred to the belts. So they need to be replaced. Some times the belts are joined through vulcanization process.

Screen Maintenance – Following are the Various: Screens provided on BCM.

1.	80mm	-	9 pieces
2.	50 mm	-	9 pieces
3.	32mm	-	9 pieces

Due to excessive vibration at 380 bar, the screen get damaged. For this, there is need of welding of these screens. Screens are welded through welding plant and ‘U’ clamp is also done for the purpose of proper fastening. The maintenance of screen is very much important from machine point of view for smooth working of BCM.

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XIII- Lubrication

Session-21: Oil and Lubricants used in different gear boxes, Tamping unit, Lifting unit, Screen -drum etc., types and their capacities.

Lubrication:

Oil and lubricants used in different gear boxes, Tamping Unit, Lifting Unit Screen drum and their capacity. Following are the various oil & lubricants used in machines.

Gear Box	-	C90 – 20 lts.	
Tamping Unit	-	SS-100 Hyd. Oil	
Grease for Tamping Unit	-	RR3	
Grease for Axle	-	Bearing grease	
Main gear box of BCM	-	Hyd. Oil HLP68	
Screen drum for BCM	-	Hyd. Oil HLP68	70 lts.
Axle Gear Box	-	Hyd. Oil HLP 68	45 Lts (each axle)
Dredger drum	-	Amola 100	25 lts.
Turn table	-	Hyd, oil	15 lts.

Turn

Sub-discipline:- Mechanical (Lessons: 14 Sessions: 24)

Lesson-XIV: Maintenance Schedules **Session-22 & 23:** Maintenance Schedules of machines.

Maintenance Schedules of Track Machines

Following are the various schedule maintenance of different machines given as under:

Schedules	**UNO/DUO**	**CSM/09-3X Unimat/MPT DSG/BRM**	**BCM**	**FRM-80**
	Engine Running Hours	Duration	Engine Running Hours	Duration
Schedules- I	Daily	1hr.	Daily	1hr.
Schedules-II	50hrs.	2hrs.	50hrs.	2hrs.
Schedules-III	100hrs.	1 Day	100hrs.	1 Day
Schedules-IV	200, 400, 600, 800hrs.	2 Days	200, 400, 600, 800hrs.	2 Days
Schedules-V	1000, 3000, 5000hrs.	7 Days	1000, 3000, 5000hrs.	7 Days
Schedules-VI	2000, 4000hrs.	45 Days	2000, 4000hrs.	45 Days
Schedules-VII	6000hrs. (POH)	90 Days	6000hrs. (POH)	90 Days
Schedules-VIII	-	-	-	-

	PQRS		**TRT**		**T-28**	
Schedules	Engine Running Hours	Duration	Engine Running Hours	Duration	Engine Running Hours	Duration
	Daily	1hrs.	Daily	1hrs.	Daily	-
Schedules- I	50hrs.	2hrs.	50hrs.	5hrs.	50hrs.	-
Schedules-II	100hrs.	1 Day	200hrs.	1 Day	100hrs.	-
Schedules-III	200hrs.	2 Days	500hrs.	7 Days	150hrs.	-
Schedules-IV	1000hrs.	7 Days	1000hrs. (IOH)	7 Days	200hrs.	-
Schedules-V	2000hrs. (IOH)	45 Days	6000hrs. (POH)	-	300hrs.	-
Schedules-VI	4000hrs. ((POH)	60 Days	-	-	500hrs.	-
Schedules-VII	-	-	-	-	1500hrs.	-
Schedules-VIII						

OVERHAULING OF MACHINES

This can be said without any fear of contradiction that lot of wear and tear takes place on account of machine working and as machines are subjected to wear and tear, failures are bound to take place, so in order to prevent the failures of machines, schedules have been framed which are followed and then chances of failures are reduced. The various schedules have been incorporated in the track machine manual-2000 depending upon the type of machine which reduces down time of machines and this are known as preventive maintaining but this is not sufficient to meet the requirement of machines and accordingly with the certain passage of time and specified working hours of machines after which, other than schedules, machine are taken to zonal or central periodical overhauling workshop for conveying out IOH/POH of machines which are given as under for good health of machine. Yard stick of IOH/POH of machines.

POH of machines.

Overhauling of tamping Units, Gear Assembly, axle assembly and lifting lining assembly for unit change either at shop floor or field.
Post POH service to zonal railway and performance monitoring of overhauled.
Development of Expertise, Standardization/documentations and dissemination of knowledge with respect to overhauling of assemblies.
Study of Interchangeability of components and subassemblies.
Study of failures, finding out remedial measures, troubleshooting and development of maintenance practices.
Procurement of stores and equipments required for POH and their inspection.
Inspection and testing of machines/assemblies received prior to and after POH.
Study of new imported machines and preparations of inventory list with complete series of machines. (machine wise) and checking for changes with reference to old series of machines.
Development of drawings and material specification for manufacturer of spares.
Providing shop floor training regarding maintenance of machines.