Automation in Manufacturing
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Lecture – 29
Hydraulic pumps

I welcome you to the lecture 2 of week 9 of Automation in Manufacturing. In this lecture we will be studying the Hydraulic Pumps.

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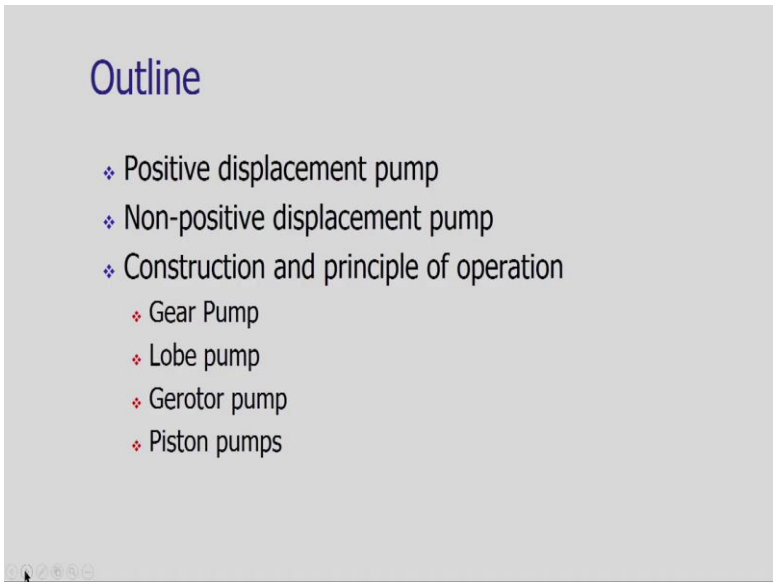

The outline of the lecture is as follows. At start of the lecture, we will have a discussion on the classification of the pump. Basically, the pumps are classified into two classes. These are positive displacement pumps and non-positive displacement pumps.

We will study various pumps in the perspective of their construction, principle of operation, advantages, limitations and applications in the automation. Some of the pump pumps the gear pump, lobe pump, gerotor pump and the piston pumps.

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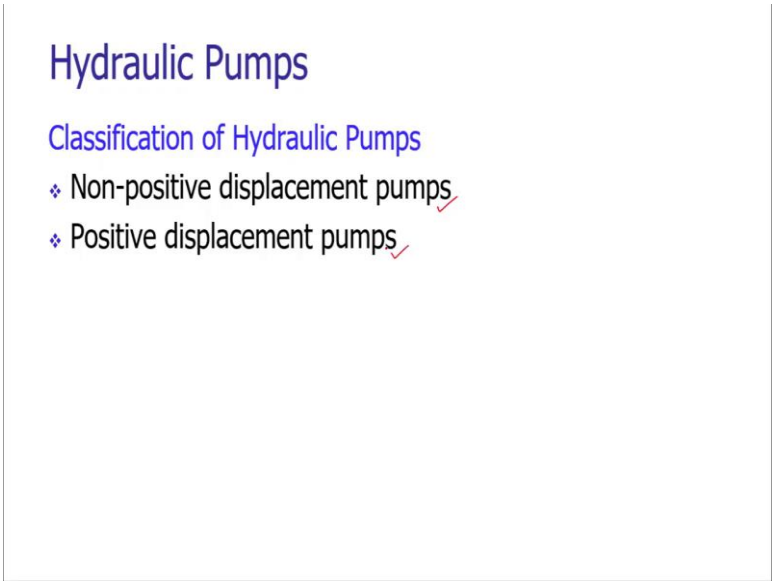

So, let us begin. The hydraulic pumps are basically classified into two groups. The first one is non positive displacement pumps and the second one is positive displacement pumps. Let us look at the meaning of non positive displacement pump and positive displacement pump. Also we will look at what are the various types of these pumps are utilized, their construction and working.

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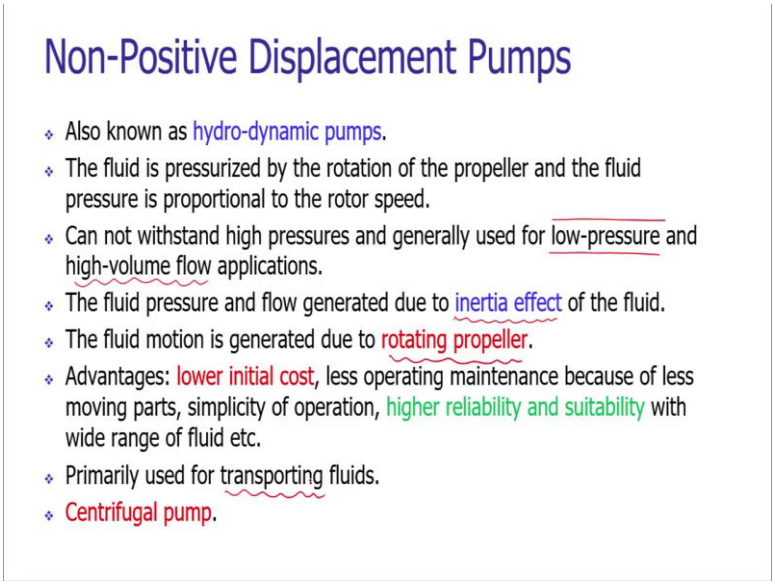

The non-positive displacement pumps are also called as hydrodynamic pumps. In this pumps, the fluid is being pressurized by the rotation of a propeller. The construction is having a

propeller, the rotation of the propeller i.e. the centrifugal force is generated and that centrifugal force will be utilized to increase the pressure of the fluid inside the casing. The fluid pressure is proportional to the speed of the rotor.

The non-positive displacement pumps are basically used for the low pressure applications. This pumps are generating very high volume of flow. Basically, the fluid pressure and the flow is being generated by the inertia effect of the fluid, whereas, the fluid motion is generated due to the rotation of the propeller. Motion is generated by the propeller rotation and the inertia of the fluid itself, the weight of the fluid itself is creating the pressure and a flow inside this kind of pumps.

In general the hydrodynamic pumps are utilizing water and they are widely used for the domestic water distribution purposes. These pumps are having low initial cost. Their maintenance is also quite easy because the number of moving parts are less. The construction is simple.

The reliability of this pumps is quite high and they are suitable for a wide range of fluid. It can be a water it can be any sort of oil or chemical. We can easily have the hydrodynamic nature of fluid flow by using this non positive pumps.

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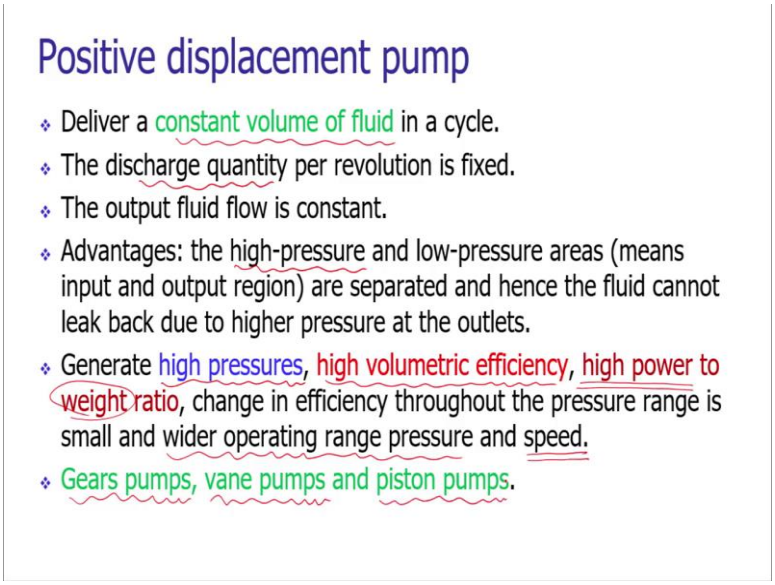

The primary purpose of the non-positive pump is for the transportation is for the conveyance and the best example is the centrifugal pump. The second category of the displacement pump

is the positive displacement pump. These pumps are generating a constant volume of fluid. In many applications we need a constant fixed volume of the fluid in a typical cycle of the pump.

As the constant volume is being delivered we are getting the fixed discharge from this pump. That these are the advantages of the positive displacement pump. The output fluid flow is constant.

In positive displacement pumps there is distinction between the high pressure areas and low pressure areas. Due to these separations the fluid cannot be leaked from the pump area from the casing that is not the case in centrifugal pump. There is no clear cut distinction between the low pressure area and the high pressure area.

Positive displacement pumps are generating high pressures. They do have a very good volumetric efficiency. They are generating high power in comparison with the application of very small weight very small construction. Therefore, we can say that they do have or they do provide high power to weight ratio.

Positive displacement pumps are offering us it is a wide range of pressure and they are offering very good variations in the speed as well. There are various types of pumps being utilized in the manufacturing industry and these are gear pumps, vane pumps and the piston pumps.

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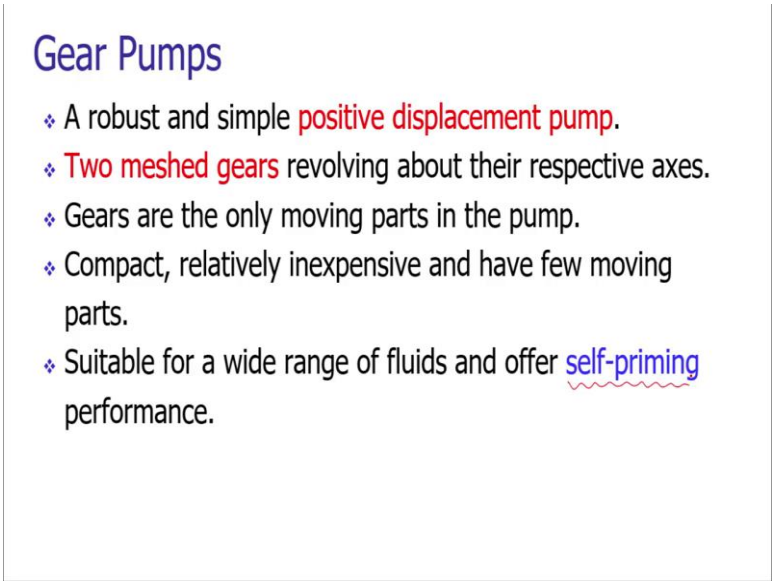

Let us look at the construction working of the gear pump. Gear pump is robust and simple positive displacement pump. As the name indicates, it is having two gears. These two gears are

meshed and they are revolving about their own axis. The both the gears are rotating. These are the moving parts in the pump.

The gear pumps are quite compact and they are inexpensive due to less moving parts. They are suitable for the wide range of fluids and they do have the self-priming performance. They can create a vacuum so that we can get the fluid in.

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Various types of gear pumps are being utilized. These are the external gear pumps, lobe pumps, internal gear pumps, gerotor pumps. And certain applications are there in front of you. The gear pumps are basically used to convey petrochemicals, chemicals, paint and ink resins and adhesives, pulp and paper and the food products as well or the products or the raw material which are needed for the food products.

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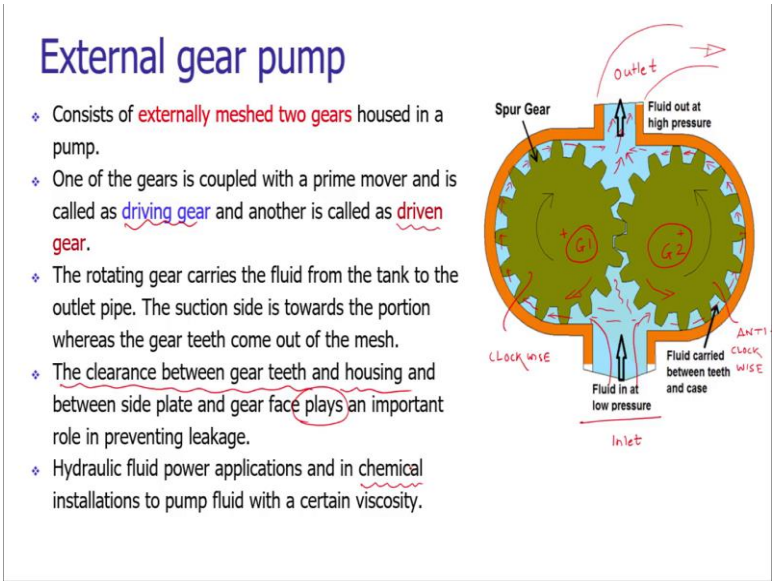

Now, let us look at an interesting configuration of the gear pump that is external gear pump. On our screen you can see there are two spur gears which are meshed together. This is a gear number 1 and we are having the another gear that is a gear number 2. These two gears are meshed and they are assembled in a casing. The casing is having two ports.

The first port is the fluid in port and the second port is the output port. This is the inlet port and this is the outlet port. The gear 1 is rotating in clockwise direction, whereas, gear 2 is rotating in anticlockwise direction. As we can see that during the rotation, some of the gear teeth are getting engaged and they will get disengaged. Here you can notice that the gear teeth are engaged and as the gears are rotating there would be disengagement.

When there is a disengagement a negative pressure is created in this zone. The negative due to the negative pressure the fluid will get driven in. As the fluid is coming inside in the inlet, this gear teeth are driving them. The fluid will become inside in this way and they will occupy the empty spaces in the gear teeth in between the gear teeth and the casing.

The fluid will get occupied in the vacant spaces as the teeth are moving further as the teeth are moving in this direction, the fluid will be pass through the empty spaces. The teeth are driving the fluid along these directions, along the space between the casing and the gear teeth.

As the gear is rotating at a higher speed, the pressure over the fluid would be increased and suddenly at the outlet port the pressurized fluid is getting space to get out of the casing. From

here the pressurized fluid will come out and it will be utilized for the intended load application purposes.

In this way by having the rotation of the gear teeth we can have the generation of pressurized fluid. Out of these two gears, one has been attached to the electric motor and that is called as the driving gear and other one is the driven gear.

The clearance between the gear teeth and housing and between the side plate and their face they are playing the important role in preventing the leakage. Basically in chemical applications such type of gear pumps are widely used.

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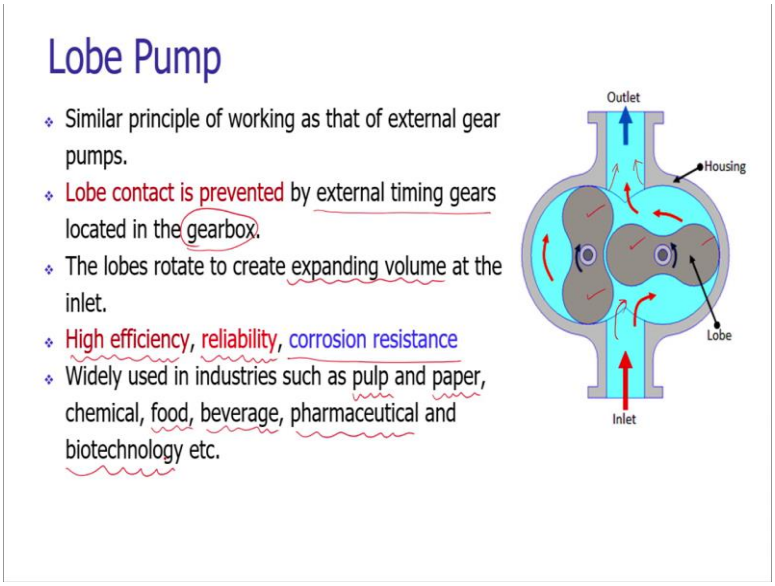

The next variant is the lobe pump. It is you can say the modification of the external gear pump itself. Instead of having many number of gear teeth, the gear teeth profile can be changed into a lobe ship kind of thing. Instead of having many number of teeth we are having only 2 teeth.

We can consider as teeth number 1 and teeth number 2 of gear 1. Teeth number 1 and teeth number 2 of gear 2. The same principle or similar principle as of the external gear has been utilized in the lobe pump itself.

The contact between the corresponding lobes of the two gears is avoided by using the external timing gears. In case the lobe 1 of gear 2 and lobe 1 of gear 1 they will come in contact they may be there may be collision and that will lead to the ceasing of the lobe pump itself, it will be a failure. That contact has been prevented by using an external timing gears, which are

located in the gearbox of the pump. The lobes are rotating and they are generating expanding volume.

As the volume is getting expanded, there would be drop in pressure and the drop in pressure will get the fluid inside the casing. And as the lobes are rotating that low pressure fluid will get driven by the lobes and they are increasing its pressure. The high pressure fluid will be moved through the outlet.

The lobe pumps are having quite good efficiency. The efficiency is quite high. They are reliable in operation. The lobe pumps are basically used to handle pulps and papers they are able to handle the semi solids. Food items, beverages, pharmaceutical and biotechnology products are also being handled by the lobe pumps.

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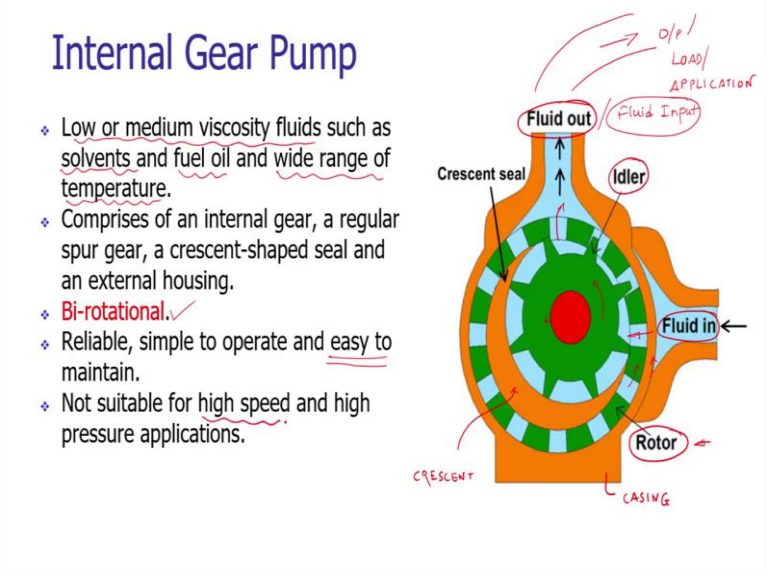

The next variant is internal gear pump. In internal gear pump the construction is little complex. Here we are using a casing. This is the casing of the internal gear pump. There is a rotor. The rotor is having the slots and that slots can get the fluid. There are two ports; fluid in port and the fluid out port.

We can interchange the fluid in and fluid out. The internal gear pumps are bidirectional by rotational. There is a crescent. Crescent is a special or it is a specially shaped mechanical element, which is kept stationary inside the housing.

The crescent will help to get the required generation of the pressure inside the internal gear pump. In addition to the rotor gear or rotor element we are having an idler element, idler gear. The rotor is being driven by the electric prime mover. As the rotor is rotating which is meshed with the idler gear, the crescent is creating an offset between the axis of the idler gear rotation and axis of the rotor gear rotation.

This crescent as you can see that there is offset, the rotations the rotational axis are having an offset. As the rotor is rotating, we can notice here the gears are getting disengaged and due to the disengagement of the gears there is a creation of negative pressure. The fluid will come inside the gap between the idler gear and the rotor gear.

As the rotor is rotating further, it is driving the idler gear as well. As there is a fluid inside during the rotation of the rotor along with the idler gear there would be application of compressive force on the fluid itself. Both the gears are rotating, the fluid will be moved along the radial direction. Gears are rotating in this direction, the rotor is rotating, it is driving the idler gear. During the disengagement the fluid will come inside and during the engagement it will be pressurized.

Fluid will be pressurized and that fluid pressurized fluid would be released wherever it is getting the empty space. When the pressurized fluid will come at the fluid output port, the pressurized fluid will be taken out it, it will take the path of the output port and it would be applied at the lobe.

The construction of the internal gear pump is complex. It is quite difficult to generate a very precision crescent because the shape of the crescent, it itself is the crucial element in the efficient pressurization of the fluid by using the internal gear pump. There are basically two rotating parts, but the number of contacts are more. The wearing and tearing of the internal gear pump is quite high. The friction is very high because the number of contact points are quite large.

The gear pumps are basically used for low to medium viscosity fluids such as the chemical solvents, fuel oils and we can handle these solvents at a wide range of temperature. At high temperature as well the internal gear pump can work. So, as I mentioned it is a bi-rotational arrangement. Either we can have this as a fluid output port or we can have this as fluid inlet port as well.

We can interchange this. The internal gear pump is so, reliable, simple to operate and easy to maintain. The internal gear pump is reliable and it is simple to operate and it and it is easy to maintained.

Although the construction is quite complex and there is a wear and tear, but the maintenance of the internal gear pump is quite easy because there are only two elements, if we just remove the idler gear or the rotor gear and we can easily clean it out. However, the internal gear pumps are not suitable for high speed application and the high pressure application.

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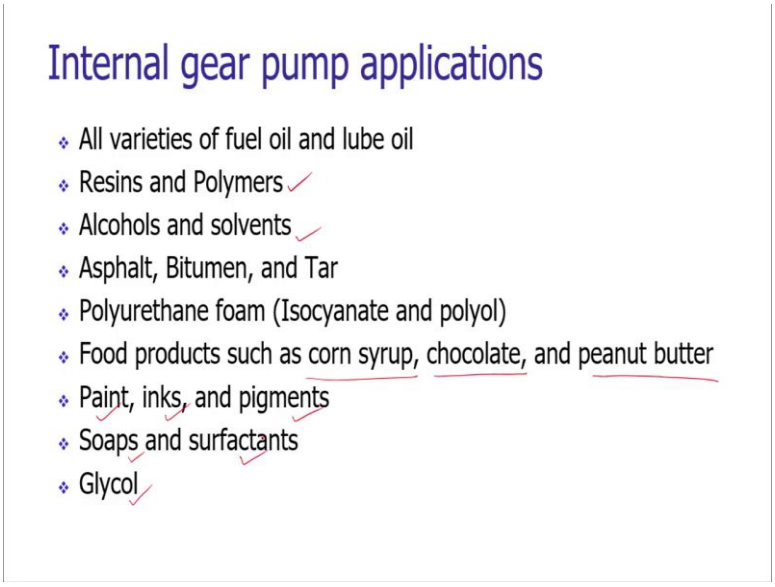

The internal gear pumps are widely used for all varieties of fuel and the lubricating oils. They are used for resins and polymers, alcohols and solvents, bitumen tar, various types of foams; food products such as corn syrup, chocolate and peanut butter. This pumps are also utilized for transportation of paints, inks and pigments. They are also used for soaps and surfactants of the detergents which are used for the cleaning purposes. They are also used for the glycol.

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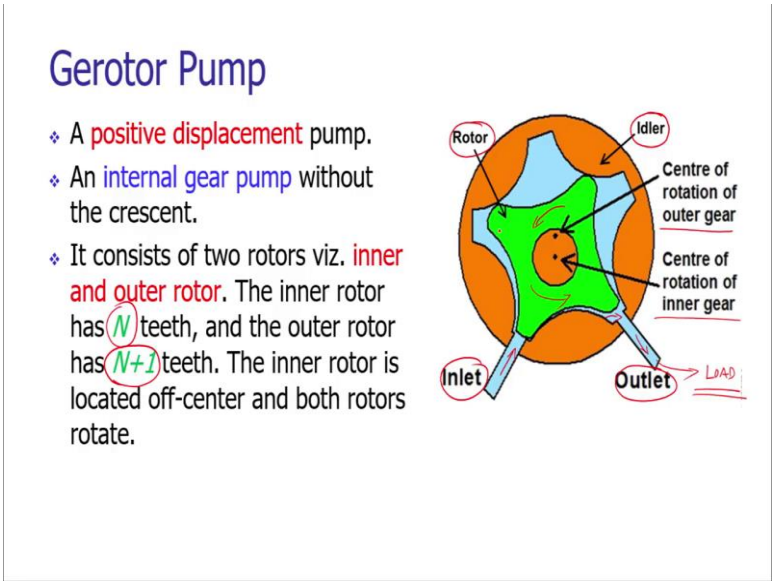

The next positive displacement pump is gerotor pump. As we have seen, the crescent is generating the pressure difference. It is helping to get the fluid in the pump, it is helping to increase the pressure of the fluid, but manufacturing of crescent, assembly of the crescent is little difficult, little complex.

Instead of having a crescent, can we have another configuration which will do the same work of the internal gear pump? That is possible by using the gerotor pump. If we look at the diagram of the gerotor pump, we will find that there is a idler gear and there is a rotor gear. If we look at the number of teeth on the rotor gear and the idler gear, we will notice that the rotor has 4 number of teeth whereas, the idler is having 5 number of teeth.

The difference in number of teeth is working as the crescent. The difference is working or it is carrying out the function of the crescent which was there in the internal gear pump. If it is said that the number of teeth that to be there on the inner rotor are N then the number of teeth that to be put on the idler gear as N+1.

Now, how it is helping to get the required work done? If we look at the construction you will find that there is offset between the center of rotation of the outer gear and center of rotation of the inner gear.

These two points are not concentric and this eccentricity is also helping to carry out the function of the crescent. There are two ports that is the inlet port and the outlet port. They are doing the

regular duty of taking the fluid inside the pump and to deliver the pressure as fluid to the load or the application.

The fluid is coming inside; the rotor is rotating. As the rotor is rotating it is driving the idler gear as well. If we notice here, if we consider the rotor is rotating in anticlockwise direction. It is coming in contact with the idler gear, it is driving the idler gear and as it is driving the idler gear there may be disengagement of the rotor gear with the idler gear.

There may be disengagement of the rotor teeth with the idler teeth and that disengagement is creating a gap its creating negative pressure at the inlet. Due to that negative pressure the fluid will be coming inside, but the rotor is continuously rotating as the fluid is getting inside the rotor driving that fluid inside the gap of the rotor and the idler.

The gap is small. That is why there is increase in a pressure of the inside fluid. The rotor is driving the idler and it is also driving the fluid with increasing the pressure. As the pressurized fluid will come at the opening of the outlet port through the opening, the pressurized fluid will come out of the pump and that will be applied to the load. As the rotor is continuously rotating there is a disengagement.

Due to the disengagement of the teeth the fluid will come inside. As the teeth are gradually getting engaged, the fluid will be pressurized and it will be conveyed further to the outlet port. In this way the difference in number of teeth is driving the fluid, it is pressurizing the fluid and we are getting the required output at the outlet port.

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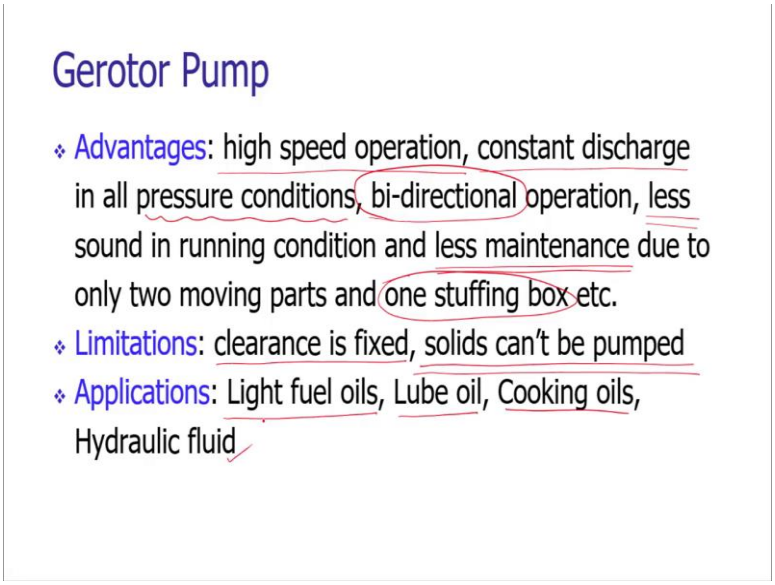

Gerotor pump offers various advantages and these are on our screen. They are providing us high speed operation; they generate constant discharge in all pressure conditions.

We can have the bidirectional operation, the in a clockwise or anticlockwise direction we can easily carry out the operation. The sound is less and the maintenance is also less. The construction is compact. They are accommodated in a stuffing box. However, gerotor pump has certain limitations.

The clearance is fixed. We cannot modulate. We cannot vary the eccentricity. We cannot vary the offset between the rotation. These forms are not suitable to pump the solid or the semi solid fluids. If the solid is like cherries or the tomatoes or the slurry of cherry or tomato in the food processing industry, it is very difficult to convey them.

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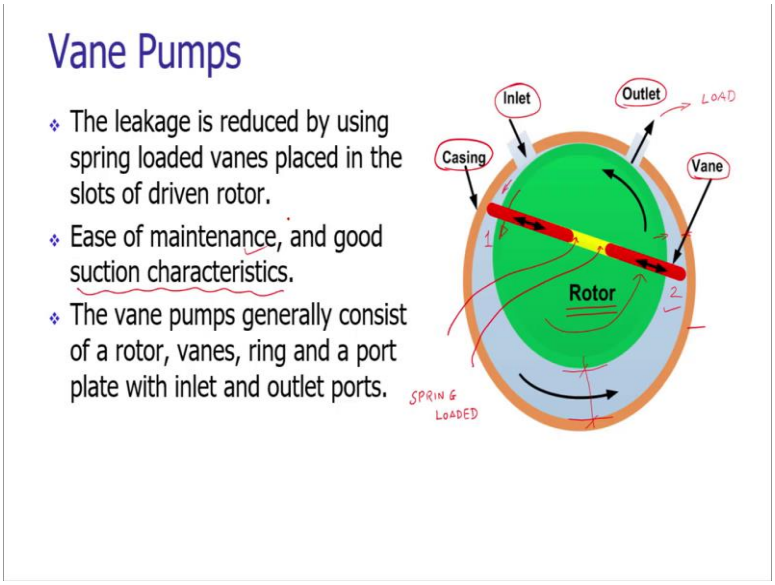

The gerotor pumps are very good for the light fuel oils or lubricating oils, cooking oils and the hydraulic fluid itself. The vane pumps are designed with spring loaded vanes which are placed in the slots of the driven rotor and this arrangement is reducing the leakage. On our screen we can see the schematic of a vane pump. It is having a circular casing.

This circular casing is hosting a rotor, but we can note here the rotor axis is offset to the axis of the circular casing. The rotor has radial slots and inside the radial slots we are hosting the vanes. The vanes are spring loaded. These springs are ensuring the contact of the end of the vane with the casing. The casing is having an inlet port and it also has an outlet port.

The rotor is rotating by the prime mover electric motor. As the rotor is rotating, there is translatory motion of the vanes inside the slot and the translatory motion is due to the offset of the rotor axis with the casing axis. If we consider if the axis of the rotor and casing is concentric there will not be any displacement. Wherever the outer surface of the rotor is in contact with the casing internal surface or it is in close proximity with the casing internal surface. We do not get any gap.

When the rotor is rotating, due to the spring action wherever there is a gap is high the vane will come out it will move radially outward due to the spring pressure. As it is moving radially outward, it is creating the pressure difference, it is creating the negative pressure at the inlet and it is creating positive pressure at the outlet.

Let us consider the rotor is rotating in anticlockwise direction as it has been shown. As the vane is moving in anticlockwise direction there is a generation of the negative pressure. The fluid will be taken inside.

As a rotor further rotates then the vane number 2 will come in contact. It will come a disposition and whatever the fluid which has come inside the gap which is created by the vane number 1, that fluid will be pressurized further by the vane number 2.

The vane number 2 will drive the fluid and it will take the fluid inside the inlet and it will take the fluid, it will convey the fluid inside the casing. As there is a gap is getting reduced between the outer surface of the rotor with the inner surface of the vane the fluid will get pressurized. Here we notice the gap is getting reduced. As the gap is getting reduced wherever there is opening the pressurized fluid will get through that opening the fluid will just move with the high pressure and that will be applied to the lobe.

In this way the offset between the rotor with the casing is creating the pressure. It is working as a crescent in this vane pumps. As there is a continuous contact of the vane winds with the casing these vane pumps are having very good suction characteristic. They are easy in maintenance as well. What are the applications of the vane pumps?

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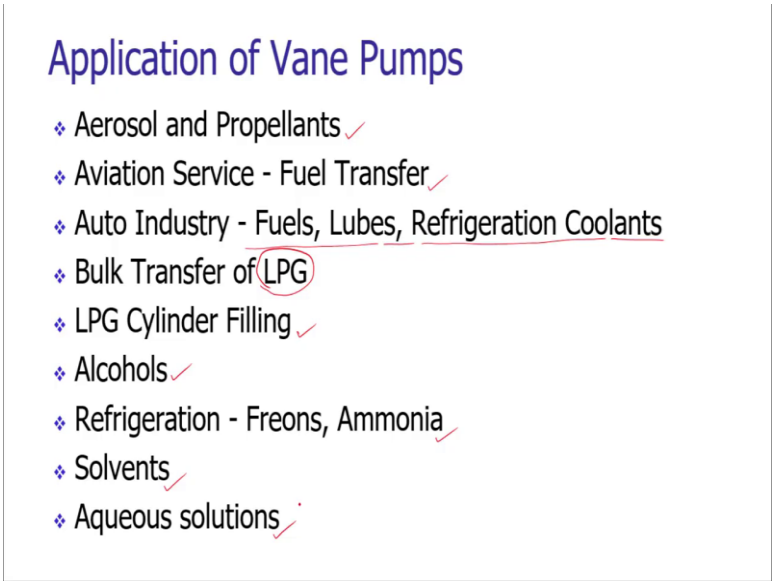

Vane pumps are used for aerosol and the propellant transportation. They are used in the fuel transfer in aviation services. They are widely used for transportation of the fuels, lubrications

and refrigerant coolants. These pumps are also used for transfer of liquid petroleum gas, filling of the LPG inside the cylinders. They are widely used for conveyance of alcohols, various refrigerants such as Freon's and Ammonia, various chemical solvents and aqueous solution.

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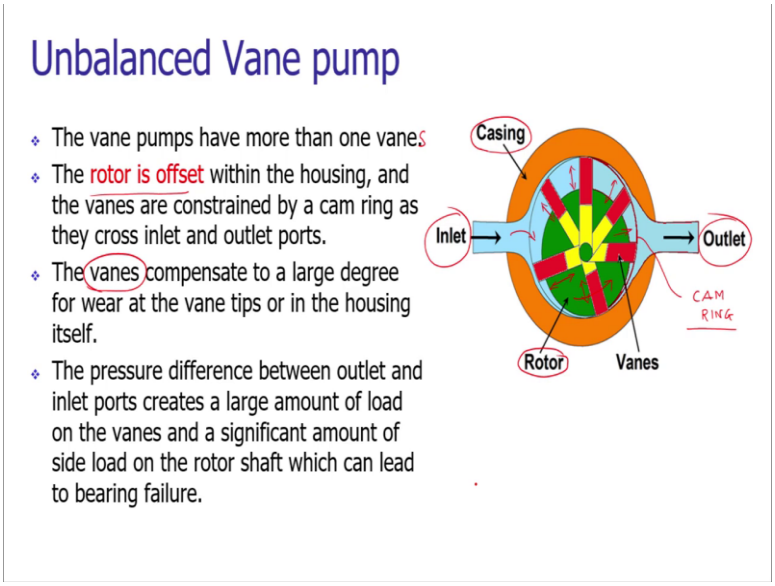

On our screen we can see a configuration of vane pump and it is called as unbalanced vane pump. We can notice the construction. As the cylindrical casing which is having a rotating element that we called rotor. The rotor has radial slots and these radial slots are housing the vanes.

The vanes are spring loaded. The rotor axis is offset to the casing and there is one element that is added called as the cam ring. A ring which is having a cam shapeor abron shape, it is not circular. It is to be noted that the cam ring is not circular.

The abron shape of the cam is helping to get the required pressure done. The rotor is rotating and as the rotor is rotating the contact length or the protrusion or the projection of the end point of the vanes out of the rotor is getting changed. We notice here that this vane which is in contact with the cam ring, the outer surface of the rotor is in contact with the cam ring.

The entire vane is inside the slot itself, but as the rotor is rotating and when there is an increase in gap between the outer surface of the rotor with the inner surface of the cam ring due to the spring action, the vanes are coming out and that vanes which are coming out are driving in the

fluid. Here we notice they are driving in the fluid and then they are pressurizing, they are applying the pressure on the fluid as well.

Getting the fluid inside and driving them will be carried out by this translatory motion of the vanes inside the respective slots. Thus the unbalanced vane pumps do have more than one vanes. The rotor is offset as we have notice. The vanes are compensating. It is very useful characteristics of the vane pumps. Although there is wear and tear of the endpoint of the vanes due to the sliding friction between the casing and the end point, due to the spring action that wear and tear will get compensated.

There is the compensation of the wear, is by itself that is a very good characteristic of the vane pump. However, the difference at the inlet; however, the difference at the pressure at inlet and outlet is creating problems in the unbalanced vane pump.

That inlet the pressure is very low and outlet the pressure is very high due to this imbalance in the pressure that is affecting on the performance of the bearing. There are regular problems of bearing failure on which the shaft of the rotor is mounted. To tackle these problem, we are using a balanced vane pump.

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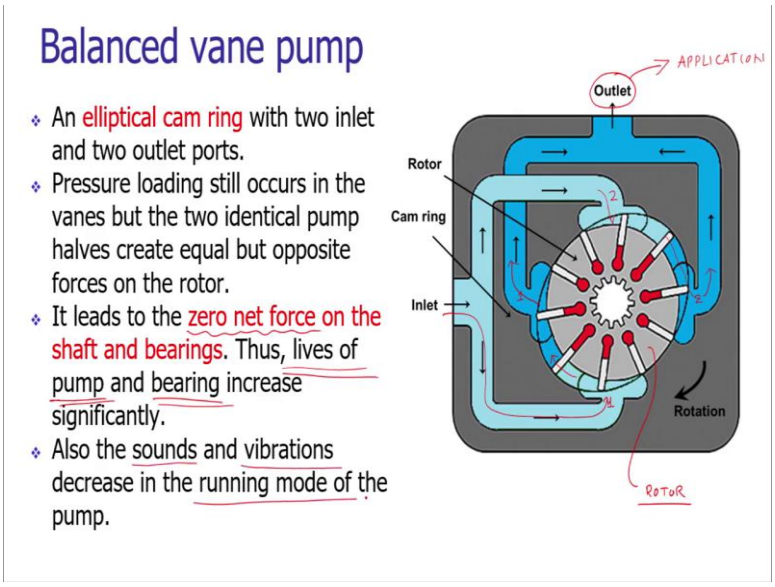

Instead of having one pair of inlet outlet we can have two pairs of inlet outlet. This peculiar arrangement can be seen on our screen. It has the rotor and as usual the rotor is having radial slots with the vanes. The vanes are spring loaded.

There is a cam ring which is very similar to unbalanced vane pump. Instead of having only one pair of the inlet outlet we are having two pairs. We notice here the inlet. This is inlet number 1 and inlet number 2. Now, we are having the outlet number 1 here and the outlet number 2.

As the rotor is rotating, the similar kind of fluid taken operation and pressurization operation would be carried out. But, due to the balancing of the pressure, we will not be getting the imbalance pressure application on the bearing. The bearing pressure will be balanced by having the equal pressure on the both the side of the shaft by having two different outlet ports on both the side of the shaft.

Here we notice 1 and 2 are exactly in opposite direction. The pressure which is being applied by the outlet port 1 and port 2 will cancel each other's effect. Through inlet the fluid is coming inside the balance vane pump and it will be pressurized here.

The pressurized fluid will be taken out by the outlet port 1 that is a respective outlet port 1. In a similar fashion the fluid will come here in the inlet port 2 and that will be pressurized that will be driven by the vanes and the pressurized fluid would be taken out by port 2.

Cumulatively we are taking the pressurized fluid from 1 and 2 and that would be utilized for our application. Due to the balancing of the forces, the net force which is zero on the shaft and bearings are certainly increasing the lives of the pump and the bearing and this also helping to reduce the sounds and the vibrations in the running mode of the pump.

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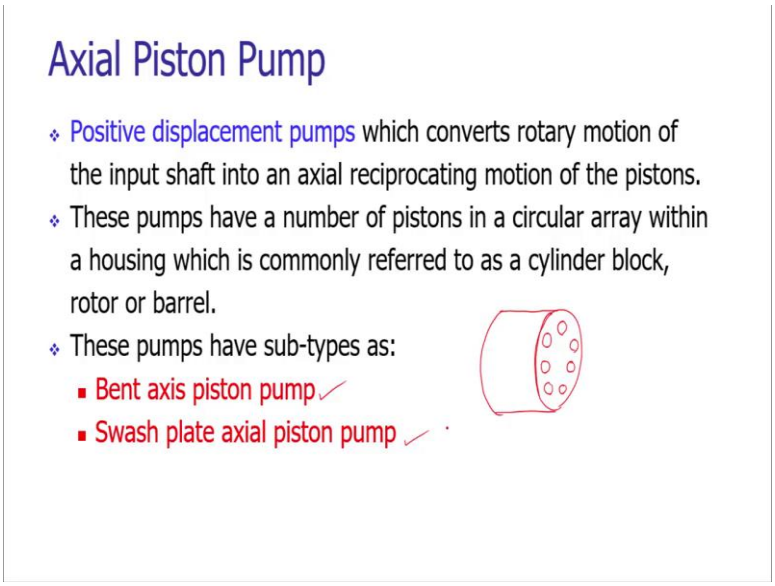

The next group of pumps is axial piston pump. Axial piston pumps are positive displacement pumps and they are converting the rotary motion of the input shaft into the axial reciprocation of the pistons.

Rotary motion of the input shaft is being converted into the reciprocating motion of the pistons. These pumps have a number of pistons which are assembled in a circular array within housing which is commonly referred as a cylinder block or a rotor or a barrel.

Typical arrangement can be shown. This is circular block and on the surface of the circular block there are bores. There is an array of bores and these bores are housing the pistons. In addition to a circular cylinder block, we are having one more block which is the fixed block through which we are getting the fluid in and through the same block we are sending the pressurized fluid to the application.

As we rotate the cylinder block pistons are reciprocating. Rotary motion of the cylinder block will be converted into the reciprocation motion of the pistons. There are two types of piston pumps used in the industry. These are bent axis piston pump and swash plate axial piston pump.

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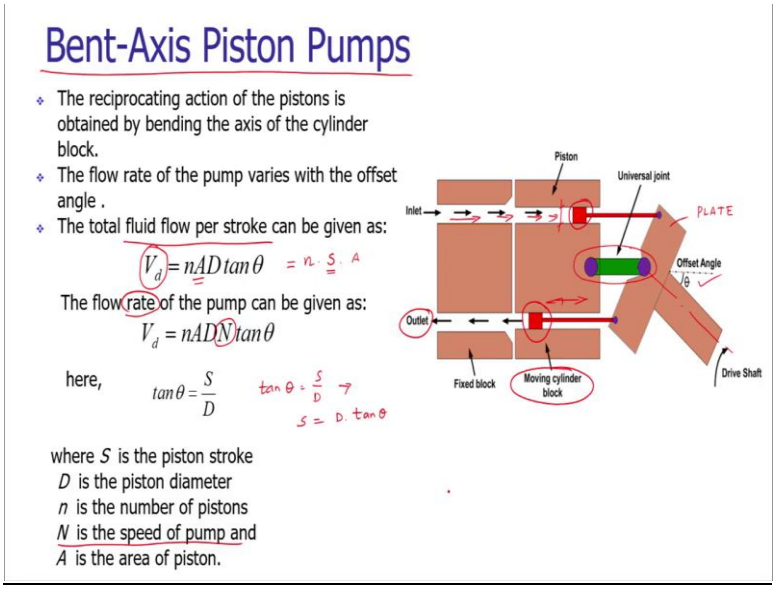

Let us look at the construction and working of the bent axis pump and swash plate type of the piston pump. In the first type that is bent axis piston pumps we are using a moving cylinder block. This moving cylinder block has a number of bores. These bores are thorough bores.

Inside this bores we are housing the pistons. These are the pistons. The pistons are having piston rods and these rods are connected to a plate.

This is a plate. This plate is also connected to the rotating block with the universal joint and the plate is having a shaft, but the shaft is offset. This offset angle is ɵ. We are driving the shaft by using an electric motor. As the shaft is rotating the plate is also rotating. As the plate is rotating there would be reciprocation of the piston rods and pistons inside the respective bores.

It is to be noted that as the shaft is rotating, it is driving the plate it is driving the cylinder as well, but due to the angle ɵ we are getting the reciprocation motion. If this angle is 0, so, what will happen? There will not be any movement of the piston inside the bore. This moment would be 0.

As we increase the angle ɵ from 0 to some positive value we can get the reciprocation motion. And these reciprocatory motion is utilized to take the fluid inside the empty bores and when the gap between the end of the plate with the cylinder which is rotating is reducing, during that moment the piston would be pushed inside.

During the movement of the piston inside the cylinder block, it is applying the pressure over the fluid and that pressurized fluid will be taken out at the outlet port. The drive shaft is driving the plate and that plate is converting the rotary motion into the reciprocation motion and that reciprocation motion is utilized for sucking in the fluid and generation of the fluid pressure.

The total fluid flow per stroke can be computed by a correlation.

$$V_d = nADtan\theta$$

V_d is the volume, A is nothing but the area the cross sectional area of the bore or we can consider the area of the piston into the distance travelled by the piston that is the stroke. Distance travelled by the piston or the stroke can be computed as:

$$tan\theta = \frac{S}{D}$$

$$S = Dtan\theta$$

Here we can see that:

$$V_d = nADtan\theta = nSA$$

Flow we can easily be computed by using this correlation. Then the rate of the flow that is to compute that we need to just multiply the flow volume into the speed of rotation N.

In this way we can easily compute flow and the flow rate of the bent axis pump. During the operation during the operation it is very difficult to have the exact bent angle. It is also having the universal joint and many reciprocating distance and rotating parts. The construction is quite complex. A simplified version is by using this swash plate axial piston pump.

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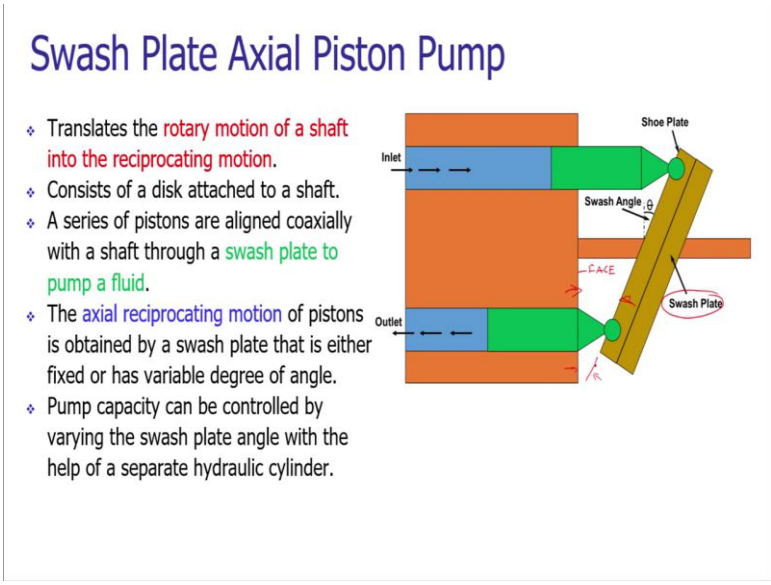

Here a swash plate is used instead of having the bent axis, we are using a plate. The plate is inclined. The plate is not parallel to the surface of the cylinder block. It is inclined to the face of the block. This is the face the block and this swash plate is making angle ɵ. This swash plate is connected to a shoe plate. The assembly of the shoe plate and the swash plate is mounted on the rod.

This rod is connected to the rotating block, this block is rotating. This movable block or the rotating block is getting the fluid from the fixed block as we have seen in our previous slide.

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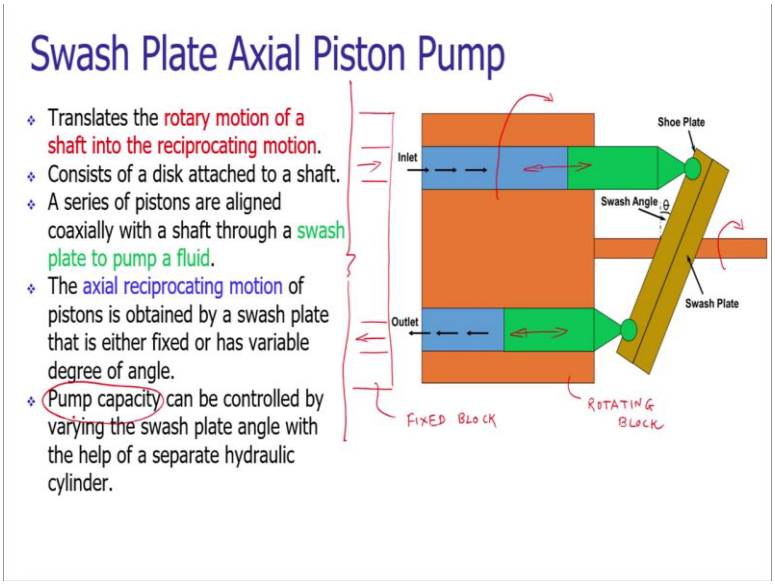

We are having a fixed block here and there is inlet. So, this is the fixed block. Fixed block has the inlet port as well as the outlet port. This is a rotating block. We are giving the rotary motion to the rotating block by using a prime mover.

As the rotating block is rotating, due to the inclination given to the swash plate we are getting the reciprocatory motion of the pistons along the axial direction. The operation is very similar to the bent axis piston pump which we discussed in the previous slide.

Now, here we are having a opportunity to control the pump capacity. By changing the angle of the swash plate we can easily modulate, we can easily change the pump capacity.

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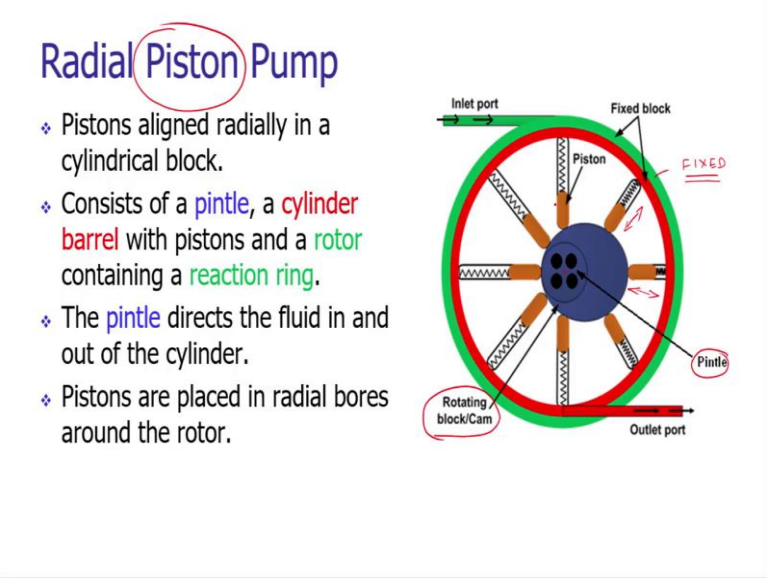

Now, instead of having the axial reciprocatory motion we can also have the radial reciprocatory motion of the pistons. These kind of configuration is called as radial piston pump. The diagram or the schematic can be seen on our screen, which is having a pintle. Pintle is mechanical element which is holding the casing.

There is a cam; this rotating block or the cam. The pintle and the cam block are housed inside a fixed block. Radial piston pumps has the radial slots and inside the radial slots, the pistons are housed. The pistons are spring loaded. The reciprocatory movement of the piston would be coordinated by the shape of the cam.

As we can see if the shape of the cam is very similar to the pintle here, we may not get any reciprocatory motion. As the shape of the cam is abron, we can get the reciprocatory motion. Here we notice from the center of the pintle this point is near to the center; however, this point is at the farthest distance from the center.

This increase in the radial distance from the center we can get the reciprocatory motion of the pistons. We have seen that principle in the lecture of the mechanisms, we have seen various types of camps. As the rotating block is rotating they are driving the piston and that pistons are doing the regular duty and that is taking the fluid inside and the pressurizing the fluid to the outlet port.

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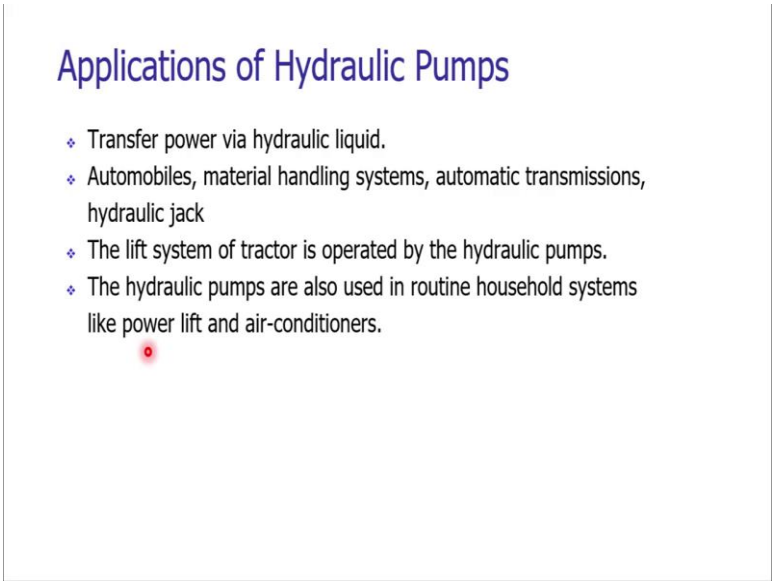

The hydraulic pumps are having a variety of applications in the industry as well as at domestic level. In industry we need the power that to carry out variety of processing. Say hydraulic based shipping operation, for material removal as well we can utilize the hydraulic fluid.

For power transfer, for power application we need hydraulic fluid. In automobiles, in material handling system, in automatic transmissions and to have the lifting based on the hydraulic jack, we are using the hydraulic pumps. In tractors also we are using the hydraulic pumps to arrange the lift system. In household atoms, we are using the hydraulic pumps, in air conditioners as well as the lifting operations.

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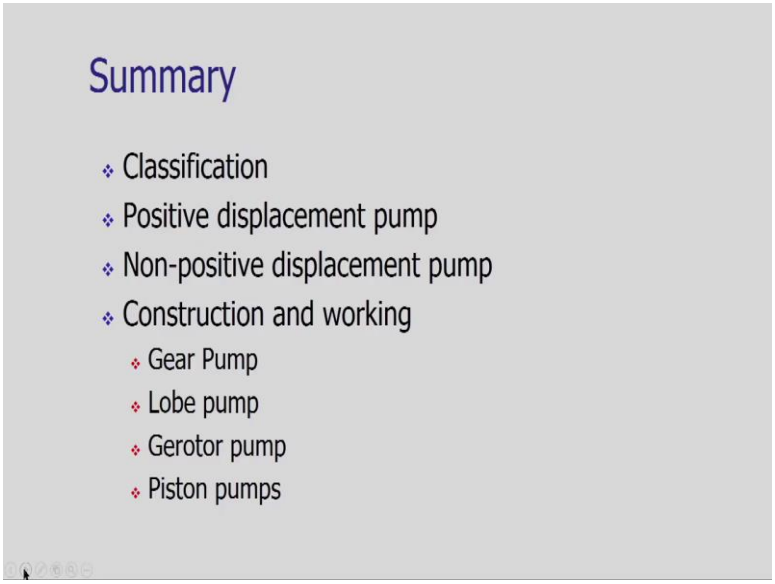

Let us summarize the lecture 2 of week 9. In this lecture we studied the classification of hydraulic pumps. We have seen various important pump such as gear pump, lobe pump, gerotor pump and piston pumps. We have seen their construction, their working, their advantages, limitations and applications in automation in manufacturing.