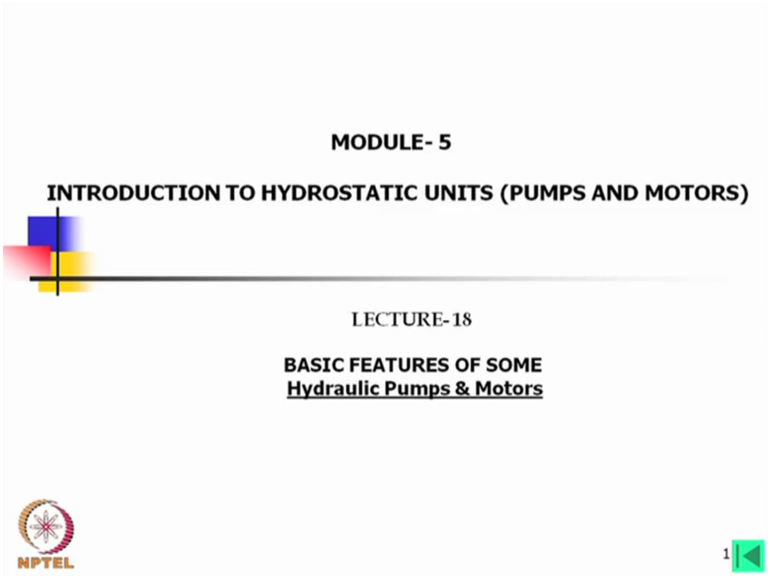
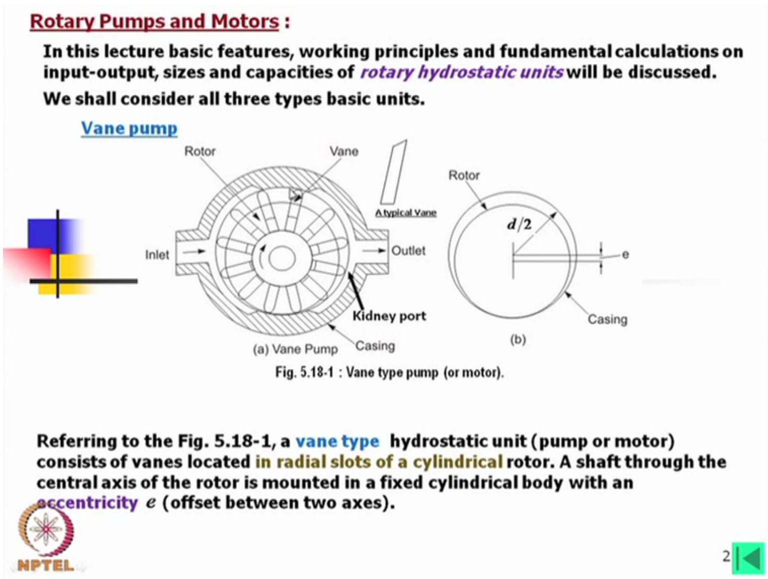
Fundamentals of Industrial Oil Hydraulics and Pneumatics
By Professor R. Maiti
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Module 5
Lecture 18
Basic Features of Some Hydraulic Pumps & Motors

(Refer Slide Time: 0:20)



Welcome to today's lecture on Hydraulics and Pneumatics, today's topic will be basic features of some hydraulic pumps and motors.

(Refer Slide Time: 0:32)

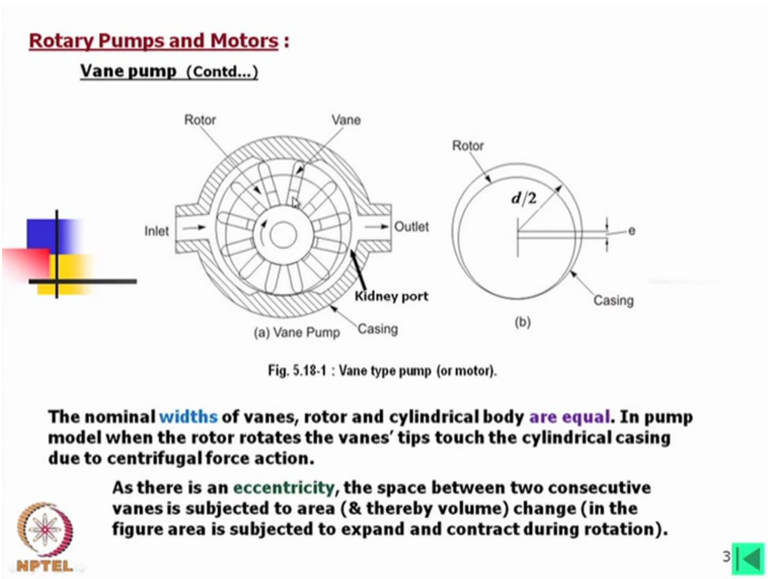


In last lecture we discussed about the rotary pumps and motors their flow ripple, etc. In this lecture I will show some basic features working principles, fundamentals calculations on input-output, sizes and capacities of rotary hydrostatic units. Now we shall consider all three types of basic units this means that we shall consider vane type, gear type and piston type. Now first to start with vane pump, in this figure what we look that centrally on a shaft rotating shaft there is a cam this is circular on this circular cam means it is like a barrel it is like a cylindrical body on which there are radial slots of uniform thickness.

In that slots we can put the vanes, vanes are nothing but flat plates of uniform thickness high (())(2:03) so that it can run smoothly within this grove and although here the stiffs are shown circular that it is never done such a circular stiffs rather stiffs are of this edge, okay so this is almost 90 degree it is not correctly drawn but it is 90 degree here we can find that the stiffs are like this. And we should always remember this stiff will be in the direction of rotation not in the opposite direction, in the opposite direction it will not perform anyway these vanes are put inside this cam.

Then this can be used as both pumps and motors I shall explain it this cam now has an eccentricity with this casing this eccentricity is given by e, within this casing we put an eccentricity and we mount this one with such an eccentricity. Now what will happen when this cam will rotate due to the centrifugal action this will touch the casing this in next slide we will discuss.

(Refer Slide Time: 3:44)



So if I consider this area between two vanes definitely this area is varying while this cam is rotating. Now if I consider the width which is a constant width of the vanes then this area multiplied by this vane is the volume so volume is also varying, the rate of change of area is equal to rate of change of volume the same rate it is changing. So definitely there will be expansion and compression and this can act as a pump and reverse process will be the motor.

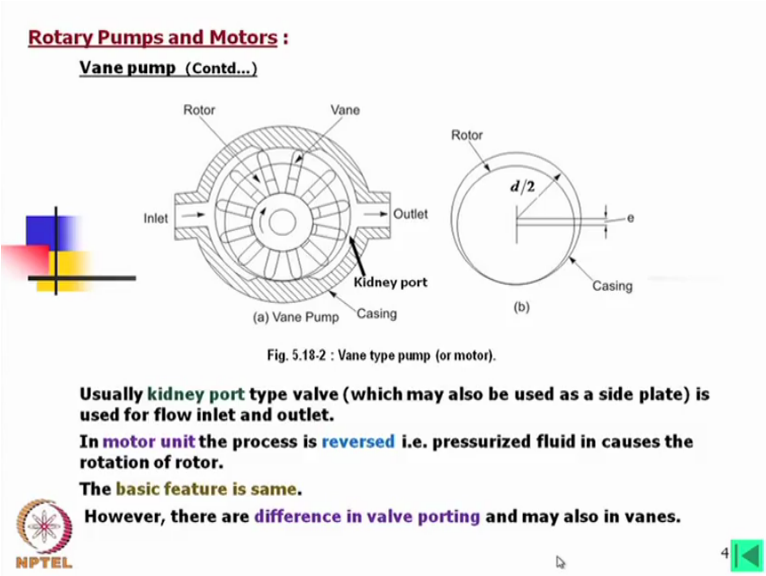
Now how the valve arrangement is there definitely if we consider a vertical axis about one side there will be suction, other side there will be delivery. If we consider this direction of rotation then gradually this volume is increasing so oil is coming in. Now at that zone there will be the interrupt volume momentarily there it will not be connected to any of this port and next moment it will be connected to delivery port and oil will be delivered with the pressure and pressure is experienced by the load.

So this is the basic feature of vane pump and in case of vane motors this will be just opposite this means that oil is coming in high pressure and it is going out and the torque is being transmitted to this shaft. Now if we look into the number of vanes how many vanes are there if we start counting 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 but yesterday in last lecture we discussed that it should be even number, it is odd number odd number are written. So in this case why the 12 in fact the 12 is in case of vane pump is less number usually you will find the more number of vanes are there.

And it might be odd or even there is not much difference in flow fluctuation because if it is 11 it is about 1.7 on percent of fluctuations if it is more than that so we can go for even number. In fact if it is just above the 11 then we can go for even number there is no special reason that we should use only the even number, we can use odd number also but very often we will find the numbers are even.

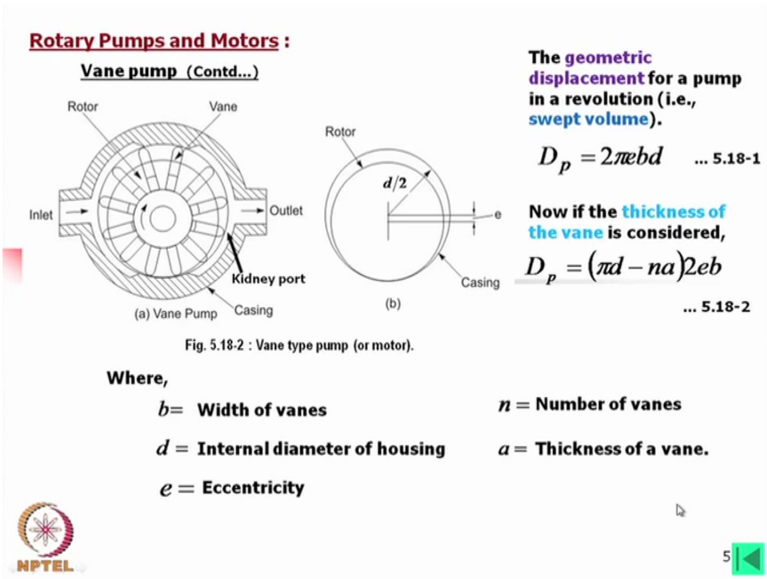
This I have already discussed that due to this eccentricity there will be variations in volume but one thing is there we cannot we can if we want to make it variable displacement then what we have to do look at this if we make this eccentricity 0 still this will rotate but there will be no compression and expansion, okay. So definitely this gives us a clue if we can change this eccentricity then we can then we can make it variable displacement also, what else in this features we find that due to the centrifugal action this will automatically touch and if we think of the leakage this stiff there will be chance of leakage through this stiffs, so to make it more positive contact sometimes springs are also used.

(Refer Slide Time: 8:28)



Now these ports which we have used here this is simply the kidney type port we call it kidney port as it looks like a kidney. And motor unit as I have told this is the reverse process and the basic feature is same only thing we have to careful about the vane direction of the vane. In case of motor as you see this pressurized oil coming in and vane is like this stiffs there is a possibility of leakage so in case of motor it is more vulnerable to leakage so we have to be careful about that.

(Refer Slide Time: 9:30)

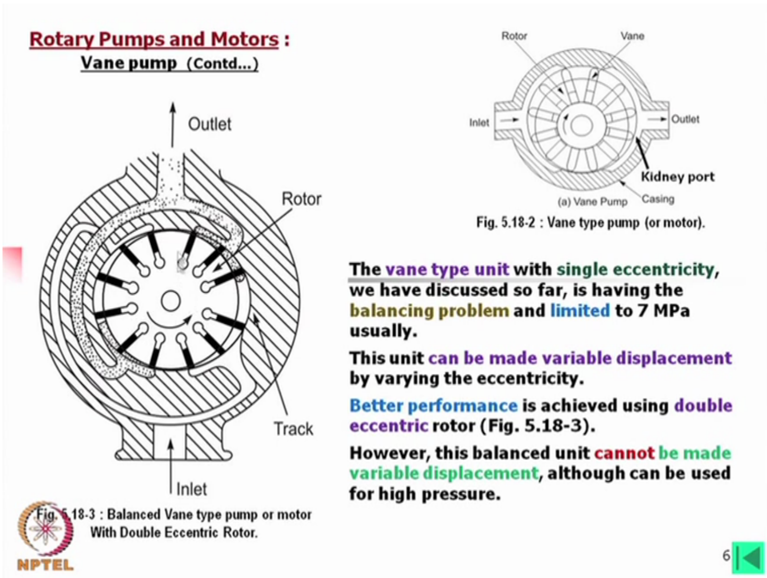


Now how to calculate the geometric displacement or which is called swept volume, if we can calculate whatever the total volume is being transmitted in one revolution that will give us the swept volume. Now the more refined formula can be developed but roughly we can say that this is 2 into eccentricity this side eccentricity and other side also that means total stroke length of the vane will be 2 e then Pi into d, d is the diameter of the casing and multiplied by the b is the width of the vane that will give us the swept volume of such an vane pump and simply we can multiply with the number of vanes, okay.

Now if I consider the thickness of vanes in that case sorry number of vanes will not be multiplied with this because we have approximately consider the area you see if you look into this apparently we are taking this periphery and we are multiplying with the width of this that is giving us volume why this formula is like that the reason is that the ultimately total volume if I consider this point this must be equal to this periphery if you develop this one totally the total length is Pi into d and twice e is the width of that rectangle and then it is multiplied by the width of the vane, this is in the axis directions of the axis.

Now if this thickness we consider the thickness of these vanes that to be subtracted. Now while we are subtracting definitely we have to consider the number of vanes, okay this is very simple things this gives roughly the volume displacement shaft volume of such an pump, why roughly this is ideally geometric volume displacement of such an vane pump.

(Refer Slide Time: 12:18)

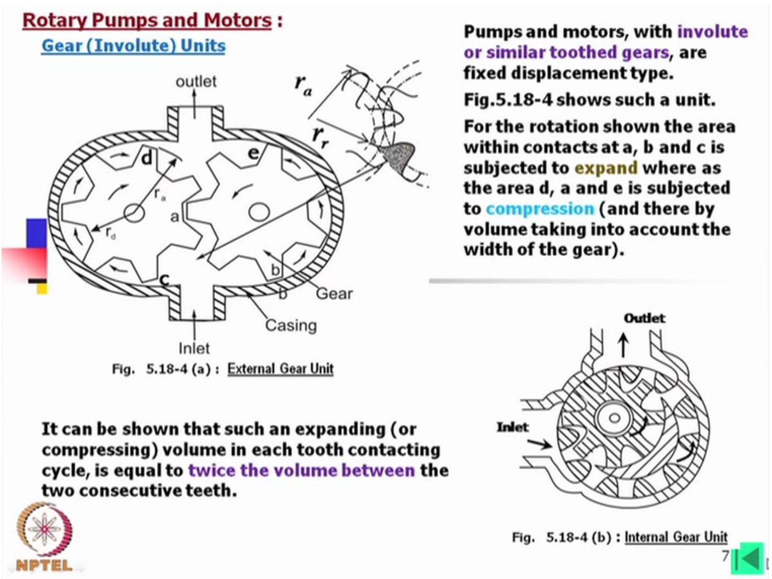


The vane type unit with single eccentricity is having a problem this is called balancing problem, we can see that this although this rotor is rotating or sorry this barrel the vane carrier is rotating about the shaft which is mounted on centre, so due to this there is no imbalance. However, all these vanes they are reciprocating so there will be a dynamics there will be a vibration and balancing problem.

Now as such for a single pump this cannot be eliminated, we have already discussed this can be made variable displacement by varying the eccentricity. Better performance is achieved by using double eccentric, what it is in double eccentric vane type pump we can see that this cam instead of this circular we can take this one as an like an ellipse, not exactly ellipse we should say rather it is oval, this is having major axis and minor axis so and this is completely circular one.

And on that while it is rotating it will have two suction and two delivery sides so you can see this, these are connected like this this is suction and this is delivery. So for each quarter 90 degree quarter there are ports, this is also kidney type ports but this is a special ports this is definitely expensive there is no balancing problem and this can be used the pressure more than 7 Mega Pascal whereas 7 Mega Pascal is roughly the limitation of single eccentric vane pump or vane motor and for this double eccentric we can go for higher pressure. However, the one great disadvantage is that we cannot make this one the variable displacement because it is not possible we cannot change this eccentricity, okay.

(Refer Slide Time: 15:12)



Now we shall consider gear type units. In gear type units mostly the involute or similar toothed are used. Now this is the gear unit, now here we have shown as if this is a trapezoidal tooth but this is not used usually you will find the most common is involute or with some corrections for better performance it is close to involute may not be exactly involute but close to involute.

Moreover if we consider say 20 degree teeth then we know there should have minimum teeth number is 17, otherwise there will be under cutting and interference which is called gear interference. Now for gear pump we can use corrected gears and even if we can go for 10 number of teeth or below 10 or below, okay. For 30 degree if you go for 30 degree pressure angle then for 10 tooth not much correction is required but for 20 degree there are corrections are required.

So with that corrections and also sometimes the teeth are truncated or made longer and there will be slight change from pure or ideal involute profile. Now how it works? This is an internal unit, now let me explain the external one first. Now what we see let us consider this is a unit and pump let us consider this is pump, so this is rotating in the clockwise directions so this definitely is rotating in the anticlockwise directions.

Now if you ask a (())(17:25) is not having much idea about these pumps immediately they will think if this is inlet sorry otherwise if this is rotating in the clockwise or anticlockwise direction people will say oil is coming and oil is going out, okay but it is not like that it is the oil is coming in here and it is being interrupted both the sides and it is going out, okay. Now this again people will confuse with the like the bucket pump you might have seen that in the paddy field sometimes there are in a wheel there are some bucket are fitted over there and they are taking water and it is throwing, it is being thrown in the other sides say input is that just picking up the water and it is throwing there.

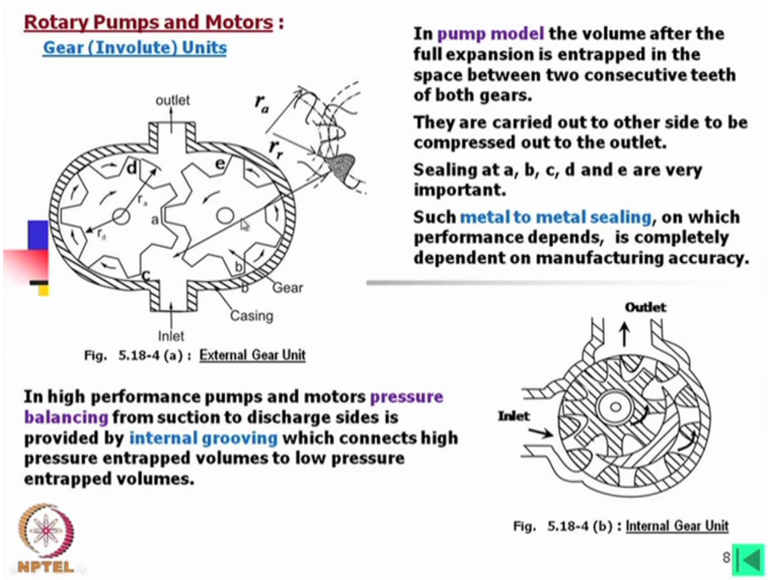
So one may think this is like that wheel but it is not like that. If we consider this area between a, c and b let us consider these are just touch the casing, okay c and a is the contact point here. So a, c, b you will find that if you can calculate this area this area is expanding while it is rotating and next moment another set will come in, okay whereas if I consider this area a, d and e point this is contraction this is so compression will be there, here there is a expansion this is compression.

So for the pump definitely this is the suction and this is the delivery, for motor also the same thing this is inlet, this is outlet part it will be the pressure will be just reverse and here we have shown the volume (())(19:38). In case of internal gear unit I shall explain later but you can see this both the gears are rotating in the same directions this also we can use the involute or similar type of teeth.

Now I have already explained that how this volume is expanding and compression expand and compression are there. Then it can be shown that such an expanding or compression volume in each tooth contacting cycles, is equal to twice the volume between the two consecutive teeth. Now what is meant here that if I consider the expansion of this zone that means a, c, b area if I consider the a, c, b area enclosed by this teeth and the casing that area minimum to maximum is equal to the total volume in two teeth space, this is one space space between consecutive teeth, this is another space.

So whatever this oil is expanding this is being interrupt in these two volumes and it is going to the other sides. Similarly this area also from the maximum to minimum again of a volume equal to between the two teeth, right. So as such if we can calculate this volume here then we can calculate what will be the swept volume or what will be the delivery of such an gear pump.

(Refer Slide Time: 21:45)



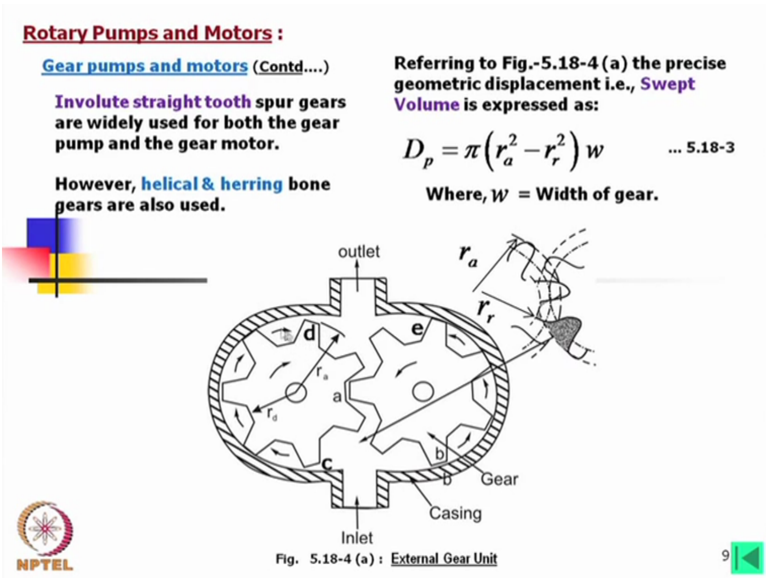
I have explained that this is interrupt and going outside. Now the important factor is that the ceiling between two chambers has to depend on metal to metal contact, okay so this metal as well as this is metal, moreover as it is rotating inside there is a gap very small within tolerance dimension but still there is a gap, as there is a gap definitely there will be leakage. So we this amount of leakage will definitely depend on the manufacturing accuracy.

In high performance pumps and motors pressure balancing from suction to discharge side is provided by internal grooving which connects high pressure interrupt volume to low pressure interrupt volumes. Now if we look into this pump features the pressure here is 0 or suction pressure, whereas here delivery pressure, definitely this pressure difference is very high if it is a say 10 Mega Pascal pump then we can say the 10 Mega Pascal pressure difference from here to here.

Now what happens this volume has interrupt here but pressure how much is the pressure it was having the minimum pressure here only this fluid will experience the pressure when it will come to the outlet side. So this zone you can say practically pressure is very small and suddenly it is being exposed to a very high pressure zone. Then what will happen there will be huge amount of leakage also there will be force imbalance to balance this what is done an internal grove is done from here look at this from here and it is connected say at that zone that means whatever pressure here through this it is being connected here.

And again another groove can be provided here and it is connected here, usually you will find that two sets of grooves in each side are provided for the pressure balancing. In case of internal gear it is also possible by grooving but you will find mostly the external tooth gear pumps or motors are used these are seldom used.

(Refer Slide Time: 24:58)



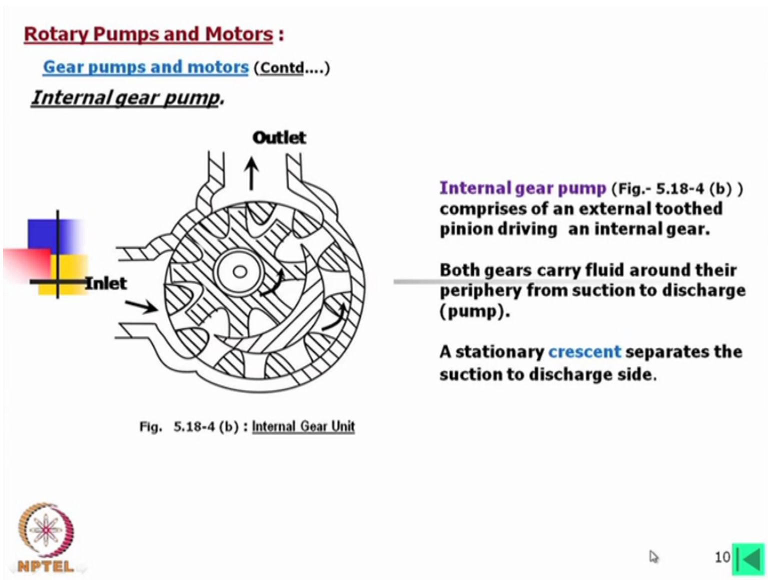
Now I have already told that common is straight tooth spur gear but also helical teeth are used for gear pumps this is a single word herring bone herring bone you know what is herring bone? You know double helical gears so it is double herring bone gears are double helical gears but at the middle they are connected, so herring bone gears are used. But you will find the most commons are straight tooth spur gear.

Now how to estimate the area the swept volume, what we do we just consider the area here r a is the radius if I consider r a is the addendum circle radius. Now r r is not the redundant circle radius rather if we consider a circle through the teeth of the other gear machine gears we consider this circle. So this area we take Pi r a square minus r r square into the width of the gear.

Now the thing is that if we would like to calculate this area roughly it is equal to that r a square minus r d square into Pi the total area. Now that divided by 2 is the oil being transmitted by one gear and again as there are two gears we multiply 2, so divided by 2 and then multiply by 2 this gives this area, this annular area. Now but there will be there is a gap that means although this total volume is being interrupt here but the same volume is coming inside that means this volume is not being utilized so we must subtract this volume instead what we will do we use this r r instead of r d, do you understand my point.

Otherwise the formula may be like this Pi r a square minus r r square r d square then again minus total periphery Pi r d into this gap that we can make sometimes this formula is modified like this but this is again very roughly because this volume and this teeth this teeth area and this space area is not equal.

(Refer Slide Time: 28:16)

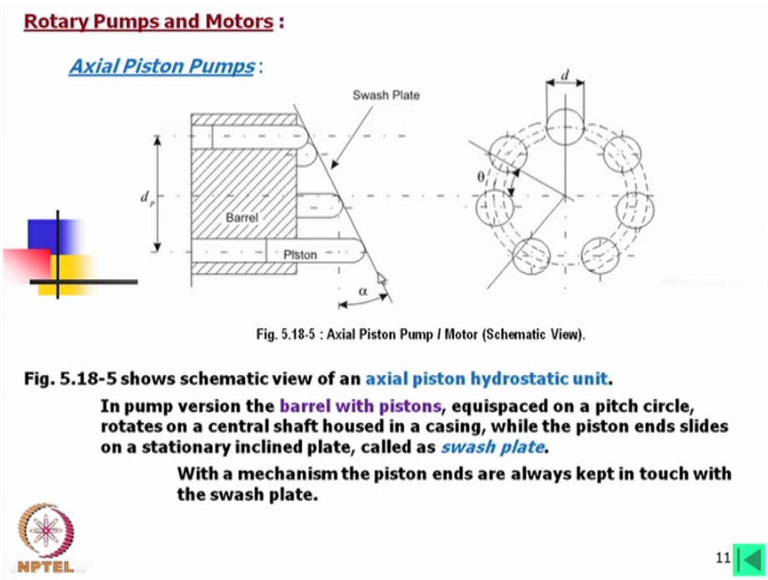


Now internal gear pump that one external tooth and internal tooth and to divide this this is if you look into this this oil is coming in and then that is being carried out through these grooves as well as through these grooves and then it is being transmitted. So at that point ofcourse we have to use some separator this separator is called crescent. However, if this is not given then what will happen then as you can see that there will be no compression and expression sometimes we confuse with this the oil is coming in here, oil is going out what is the meaning of putting this one.

But if you look into this half of that is being in the compression zone and half of this is in expansion zone, rather this is expansion zone and this is compression zone. So two we have to separate that this zone so we need we must need a separator which is like this, definitely the construction of such machines is more complicated then external tooth gear but this advantage of this internal gear you make it that we can make it is very compact in comparison to the external tooth gear units for the same volume displacement.

And these pumps are made very small usually with say for example shoe machineries or many other machineries even if the may be that weaving machines such small gear pumps and motors are used, not motors usually small pumps the size may be you can imagine just diameter is around 30 millimetre overall diameter is 30 millimetre and width is may be 20 millimetre only. And speed of such units may be as high as 3000, 4000 rpm we need high flow but not much pressure, as we have shown that may be 10 Mega Pascal maximum, ofcourse 10 Mega Pascal is a high pressure but it is used for lower pressure also.

(Refer Slide Time: 30:54)



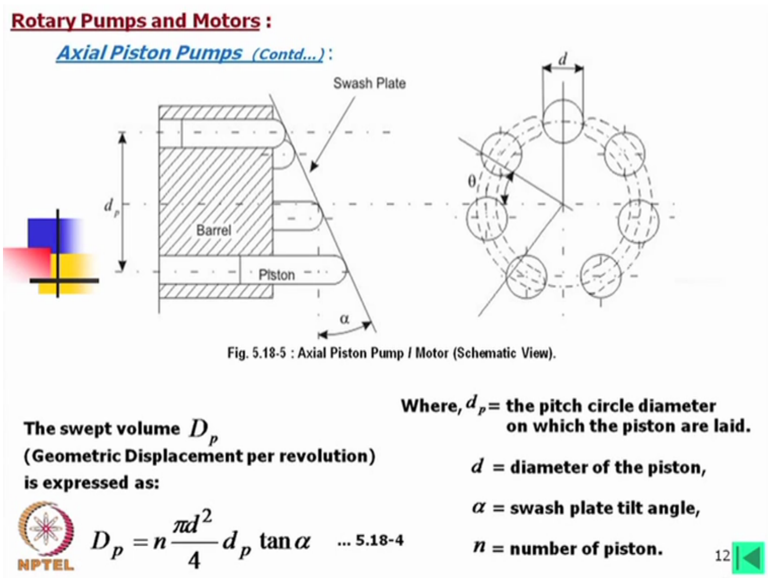
Now most commonly used are the axial piston pumps, in last lecture I have discussed so this is the swash plate and this is the barrel and on the barrel there are the pistons which are led at while it is rotating the pistons are moving reciprocating inside total stroke length we can simply calculate by just drawing this geometrically we can calculate. So from this point to this point if I draw a triangle so this will be the total stroke length.

I have explained still let me explain so this is the barrel in fact there is a shaft through this barrel which is rotating this barrel and this is positionally fixed I mean it is not rotating this one it can tilt in variable displacement pump this tilting angle can varied but this is not rotating and there is a casing outside and valve plate usually put in this side and this barrel between this barrel and swash plate there are spring so that with a high pressure this barrel is in contact with the valve plate.

We shall again discuss in the another lecture about the details of such pumps so let me explain only this much that oil is going out through this side and there is also kidney ports I mean kidney type ports are used also for these type of pumps. Now again this another point is that say for example for this type of pumps suppose this is being used as a pump, pump means the suction side means this piston is moving in this side, in this direction right hand directions.

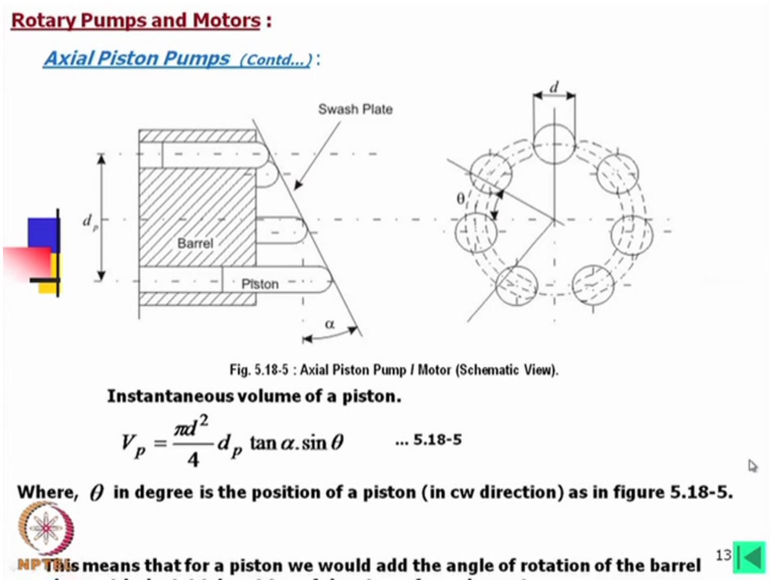
So how what is the guarantee that this will move with the swash plate type swash plate, the piston will move with the swash plate there is no guarantee with this although when the a little suction head is being generated the oil is coming in so whatever may be this small pressure still the piston can move but to make it guaranteed that the piston ends are always in touch with this swash plate, separate carrier is fixed with this.

(Refer Slide Time: 33:50)



Swept volume D p can now be expressed with this formula in last lecture I have discussed the we have consider here the total volume D p into tan alpha is this length this is D p and tan alpha is the this length, so this is the total stroke length. When alpha is fixed or even if for the variable pump we fix at an angle so for that alpha angle D p tan alpha is a constant and D is the piston diameter so Pi d square by 4 is another constant so this is a constant value multiplied by this value and into the n is the number of pistons. So once only the variable here may be the alpha and when a machine is already designed then D p and D are already fixed. So this swept volume can easily be calculated knowing the angle only this I have already explained.

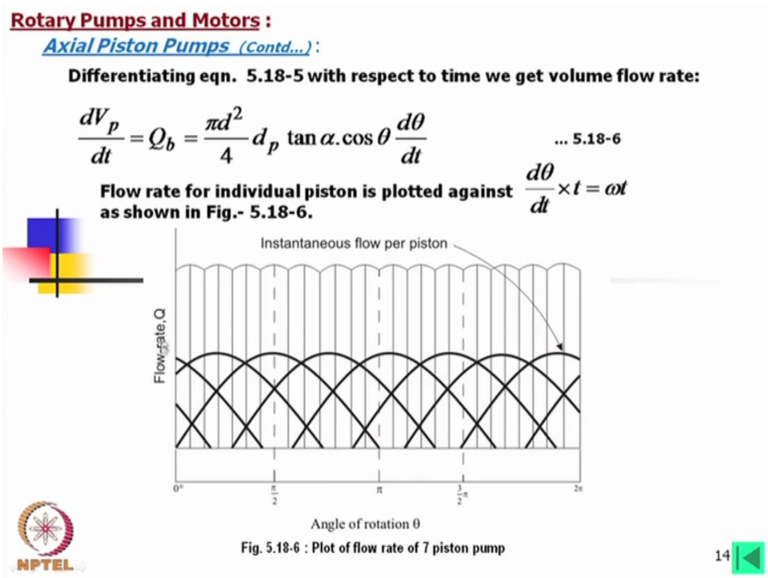
(Refer Slide Time: 35:15)



Now instantaneous to calculate the instantaneous volume of a piston that means of a single pistons, in that case again d p into tan alpha is the maximum stroke length now we have to consider this component of this at an angle theta so what we do if this is the total stroke length sin theta of this one will give the instantaneous stroke length of a piston you can just think over that and with this geometry we can calculate what will be the instantaneous stroke length that multiplied by the area of the piston will give us instantaneous flow rate. So this is the instantaneous volume not flow rate sorry instantaneous volume of a piston.

Now differentiating this we will get the volume flow rate. Now theta is the position of a piston, now if I consider this is the piston one this is at theta this theta angle was 0 when the piston was here now to consider the angle of this piston what we have to do theta plus number of total angle that is 2 Pi divided by the number of pistons and if I consider the third one then 2 into this angle plus theta in that way we can calculate.

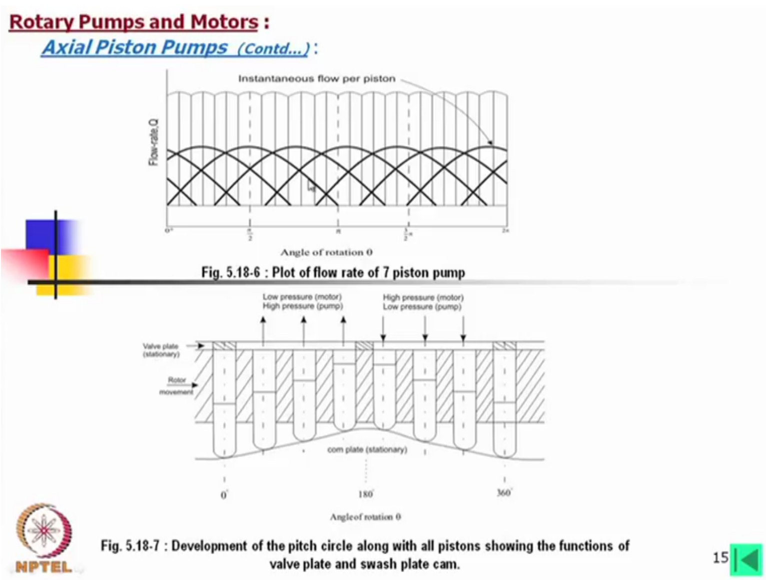
(Refer Slide Time: 37:08)



Now to get the volume flow rate per piston we do we differentiate this, this is simply the cos theta is coming instead of sin theta the cos theta is coming and d theta dt is the omega the speed of the shaft usually what we keep constant for the pump. Now if we plot this flow rate say this is let us consider this is a piston number 1, then for the piston number 2, then piston number 3, then piston 4, then 5, then 6, then 7 we have consider a 7 pistons.

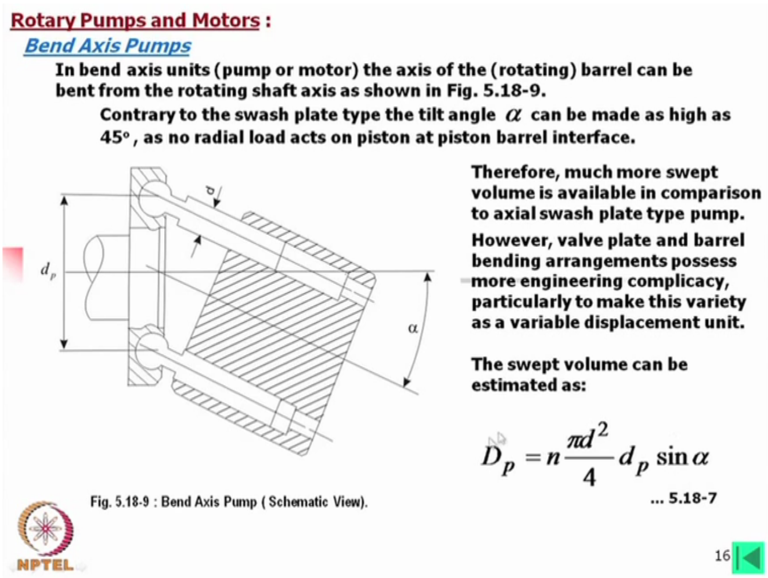
Now last lecture I have described but here also we can see what are the ripples and the flow rate individual piston is plotted against with this this is the omega and this omega t show in this directions this omega t is equal to theta and this is the flow rate.

(Refer Slide Time: 38:24)



Now we can also realize this by expanding by developing the figure, so this is like that suppose if I consider the 0 degree then considering the piston inclination at that point we are developing the swash plate the touching point of the pistons on swash plate and we will get this type of curve so from here we can also realize that what will be the flow fluctuation.

(Refer Slide Time: 39:02)



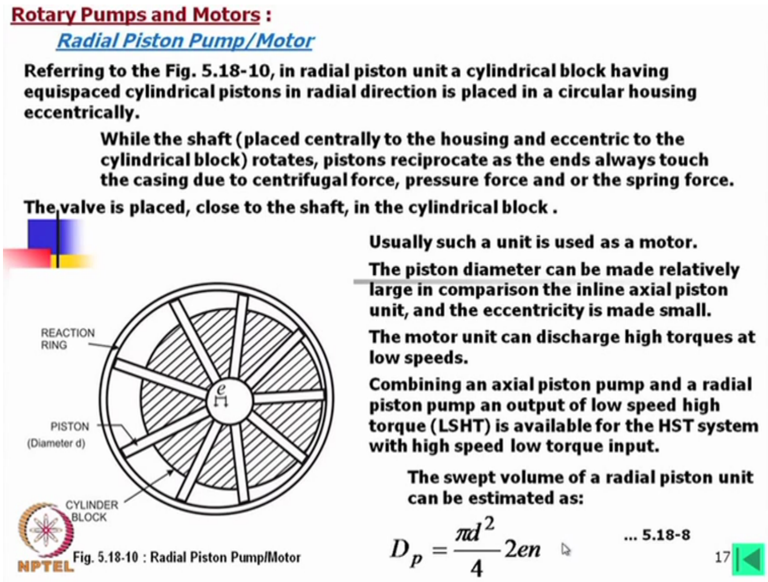
Now usually in case of that piston pump which I have discussed the swash plate type piston pump the alpha angle which is tilt normally around 20 degree 20, preciously 21 degree is good value which are commonly used but that is the maximum we cannot make it more what is the reason if you look into this on the inclined plate there will be a force along the transverse directions of the piston and if we think of the just the piston and first contact point into the barrel we will find due to that force there is a huge rubbing and both the piston as well as the barrel will worn out and if we make the angle alpha more than 20 degree or so you will find sometimes that piston is not trying to move.

Suppose if I make there itself the 45 degree you cannot move the piston you cannot push the piston with that inclined plate. So alternatively it was thought instead of using such an swash plate why not the whole barrel is bend and in that way the bend axis pump was invented and in bend axis pump this alpha angle can be made as high as 45 degree and for the same size of that means barrel size, piston size what you will find that if alpha increase by 45 degree so definitely tan 45 degree means so total displacement stroke length will increase.

So from the same size of barrel we will find more displacement of oil. So capacity of such pump will be higher. However this is expensive due to two reason one is that bend axis means the shaft is rotating in horizontally we have to make some arrangements so that it can be rotate in this directions this we have to use some sought of universal joint here that is one, second is that the valving problem because this is moving on the valve plate.

Already I have explained this alpha can be made 45 degree so much more swept volume is available in comparison to axial swash plate type and but the plate and barrel arrangement the valve plate and barrel arrangements, etc are expensive. Now in the case the swept volume can be estimated by using this formula is same but here we use the sin component, why this sin component why we are using this sin component? Because if we now consider this one so this is the sin component of D p not the tan component of D p so this will be the formula for swept volume and to find out the individual displacement we can exercise separately.

(Refer Slide Time: 42:40)



Now this is looks like vane pump the figure is very poor in that way but this is basically radial piston pumps these are not vanes rather we should consider these are the cylindrical cylindrical body. So and this is mounted on like exactly like a vane pump but in this case oil is going in and going out from this direction rather this is through the shaft not from the other sides this is this space is not being used for compression and expansion rather each and every cylinder is being used for compression and expansion and there is a special valve arrangement inside the shaft and definitely this also we can make variable displacement by changing this eccentricity.

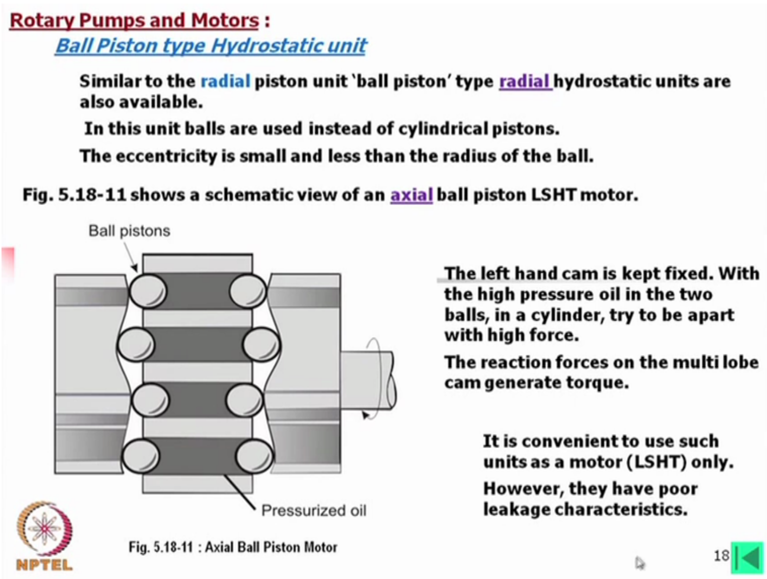
Now the thing is that this due to the if we look into the radial directions say on the cylindrical body periphery we will get more space then is we put the piston horizontally say let us consider the axial piston pump in that case say 100 millimetre is the D p is 100 millimetre and so total length will be how much Pi into 100 is about 314 millimetre. Now we are going to use 7 piston, so 7 pistons means totally we need one hole and one space between the two holes so roughly we can divide by 315 divided by 14, so this will become about 20, 22 millimetre.

So we can at the most for a 100 millimetre D p we can use only 20 millimetre pistons 20, 22. In this case say if the barrel size is same but all the pistons they are this angle is not much in that case we have to say 21 degree in that case this angle is not that high very small angle. So reducing the space in between we can probably here use upto 25, 28 millimetre pistons. So therefore we can use very large pistons there but eccentricity we cannot make very high that means the stroke length will be very small.

So for the same amount let us consider a pump is our inline piston pump and we are using this as a motor for the same displacement what will happen it can give much more torque much more force but this will rotate at very low speed, do you understand my point for the same number of pistons as the piston area we can increase so this displacement swept volume will increase but due to this eccentricity stroke length will be very less, area will be more, more thrust it can generate, so more torque it can generate so these are usually used as low speed high torque hydraulic motor.

Now combining an axial piston pump and a radial piston pump an output of low speed high torque is available for HST system. Now this will be radial piston not pump it will be motor this word is not pump it is motor. Now in this case the swept volume can be given by this is clearly this is the piston area 2e is the stroke length twice into eccentricity and n is the number of pistons.

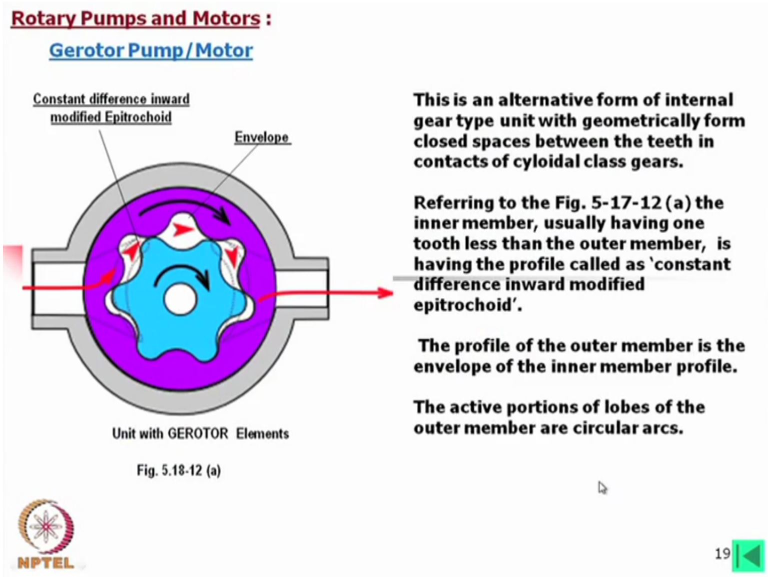
(Refer Slide Time: 47:54)



Now with the same idea instead of cylindrical piston we can use also ball pistons, now if you see look into just balls spherical ball and you put in a cylinder that also can act as a piston but remember with that you cannot go for very high eccentricity, very small eccentricity but you can simply instead of piston you can put a ball there so ball piston pump was also at one time it became very popular, only disadvantage of that there is leakage it is having very poor leakage characteristic but that is for the radial one radial pistons.

Next the in radial piston the balls are used instead of cylindrical pistons which I have explained the eccentricity is small and less than the radius of the ball obviously. Now another version is that we can make also axial ball piston type but here also stroke length is less whereas we can use very large size ball. So these are normally not used as a pump and if we use as a pump there will be no benefit at all but this can be used as a very slow speed high torque hydraulic motor only due to the reason is that we can use the large area to generate large thrust over a small stroke. So this is convenient to use as low speed high torque hydraulic motor but the poor with poor leakage characteristic.

(Refer Slide Time: 49:58)



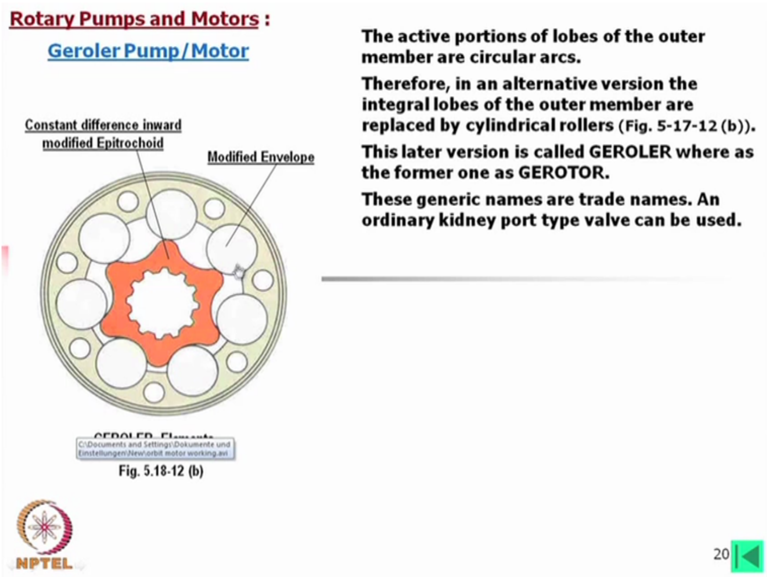
Now another gear type pumps I have already discussed about the vane pump, we have discussed about the gear pump ordinary type gear pump and the cylindrical piston pump but there is another type of gear pump where instead of involute teeth we use the cycloidal teeth here if you look into the inner member this is called usually star and outer member is the ring it is called ring and this is the star.

Now the fixed axis version what is there both the gears are rotating and you can see that this is the expanding and this is the compression, so in pump version the oil is coming in here and oil is high pressure is oil is going out and here also we can use this type of kidney port but this kidney port feature is slightly different than the ordinary gear type pump not gear type ordinary vane type pump.

Now this also can be used as motor now one thing is there if we look into this profile this profiles are epitrochoid whereas this outer member this is the envelop of this modified epitrochoid and at the active zone these are circular arcs active zone because if you look into this it is not contacting in all the points this contact is coming over here and then again contact is from here to here that means if we consider the centre of this arc from there we can have a two lines which is active zone and that zone is circular arc we will come later the details about that.

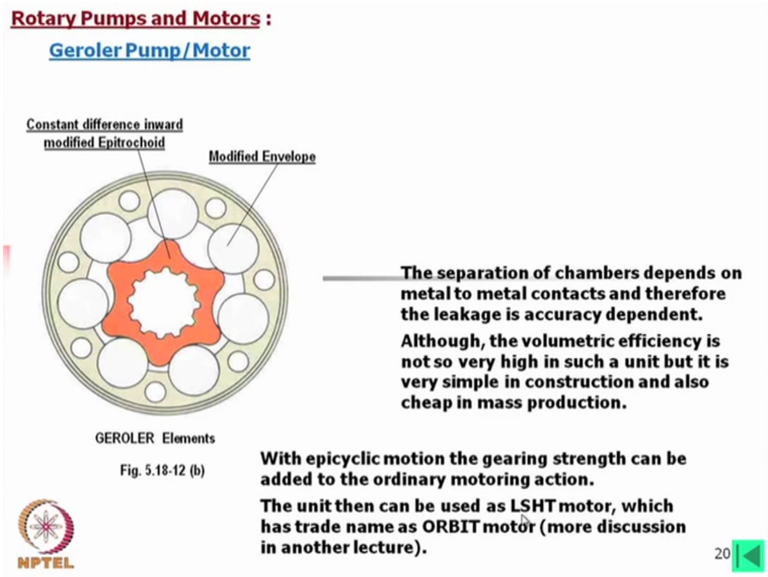
Now this is called Gerolor elements, this is epitrochoid is the modified curve of the cycloidal class of gears, you know this how this profiles are generated this cycloidal profiles is when a roller is rotating on another roller then a point on the periphery of the rolling body will generate a cycloid. If we take a point outside then this will be epitrochoid, okay outside this body.

(Refer Slide Time: 53:10)



Now instead of this as this is a circular arc (())(53:15) instead of integral one we can use a separate roller for that, okay when we find this circular arc is having smaller radius we can go for the roller also the advantage of using this roller this roller can be replaced easily, on the other hand this is having much poorer leakage characteristics in this case also you will find at one point one side is high pressure and other side is low pressure so there definitely will be leakage through this contact to reduce that we have to make such components very accurately with the integral one initially the leakage are less, whereas in case of this Gerolor type although the leakage are more on the other hand we can replace the roller and the life is longer.

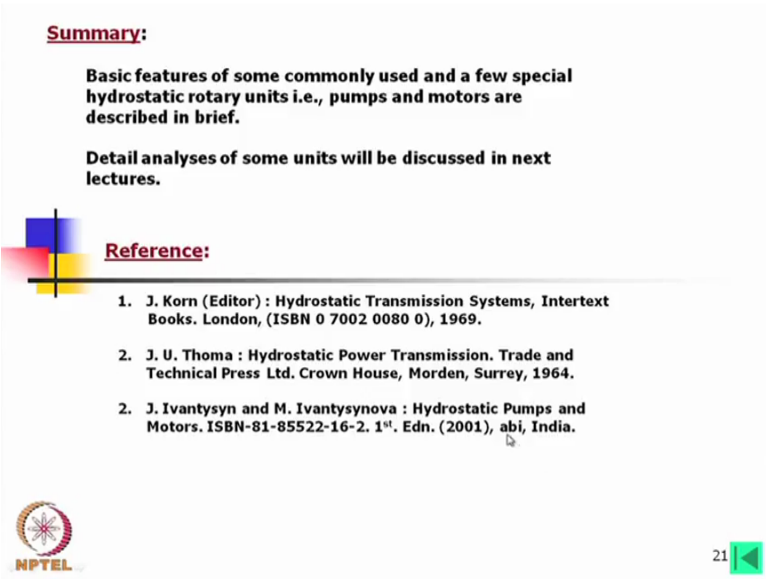
(Refer Slide Time: 54:21)



Now this I have already discussed this is a metal to metal contact only disadvantage of such machines are the leakage otherwise this is very simple in construction and not very expensive also. Now if we employ the epicyclic motion in that case this can be used as low speed high torque unit and usually why usually that is used only as a motor because there is no meaning to generate the high pressure fluid in at low speed.

In case of pump there is no meaning we will supply high torque at low speed for pumping, we will try to transmit very low torque at high speed because the engines are usually like that. So this is used as a motor with epicyclic motions however, these are element which are called Gerotor elements and other one with the integral one that is called gerotor both elements are used as fixed axis or the planetary motions, if it is used with the planetary motions then it is used only as a motor if it is used for the fixed axis then it can be used as both pump as well as motor again it is LSHT means low speed high torque motor.

(Refer Slide Time: 56:14)



Now in summary I would say basic features of some commonly used pumps hydrostatic units which we have described but this is only to have an idea how they are working, we will study some units in details. Now I suggest that you should to know the fundamentals you can follow the book by Korn, another good book will be the Hydrostatic power transmission by Thoma where the some basic principles of hydrostatic units are described in a very brief precious but effective way and also there is another book by Ivantysynova that is hydrostatic pumps and motors this we have an Indian publications of this book also, other two books are not available in the market this is out of print, whereas these book is available and you can go through these books to know details about this pumps and motors, thank you.