Fundamentals of Industrial Oil Hydraulics and Pneumatics
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Lecture 24
Module 06
Selection of HST units and components

Welcome to today's lecture on hydraulic and pneumatic. Today's topic will be selection of HST that is hydrostatic transmission units and components. Now, HST stands for hydrostatic transmission, we have already known that why it is called hydrostatic transmission because in this stage we can neglect the hydrodynamic part performance of such machines only with hydrostatic, not hydrodynamic except when we are analyzing flow through any orifice or any capillary passages.

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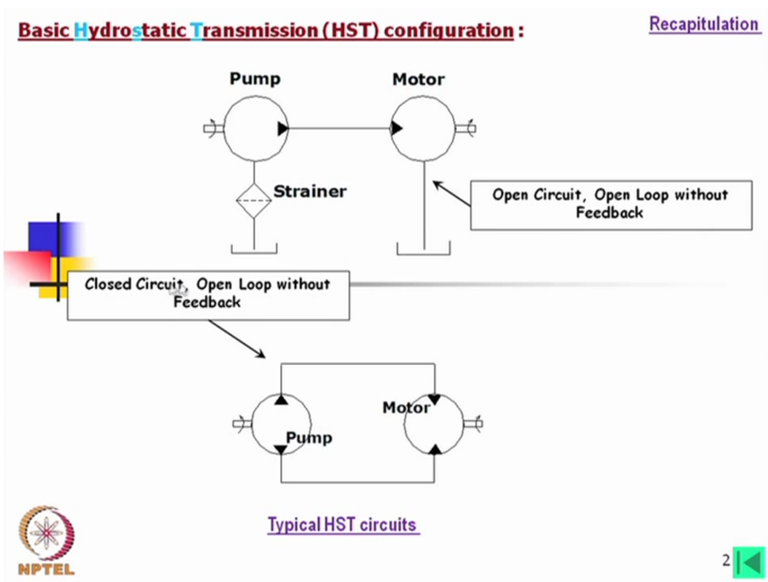

Now, also we have known what is hydrostatic transmission, essentially hydrostatic transmission should have one motor and a pump. In that way, any hydraulic and pneumatic drive is hydrostatic drive because in that case there will be a pump or source of flow and pressure and that flow and pressure is sent to an actuator, which gives some motion so in that way we should say every system or hydrostatic transmission in hydraulics or pneumatics. However, when we mean HST transmission then basically we mean there is a rotary pump and rotary motor. In these pumps and motors they are they may be identical looking their body, the reciprocating units, valve, et cetera, they may look alike.

In fact, the same components can be used for pump and motor except there is some differences in the flow distributor valve. And even it is possible that we can combine that pump and motor together and that unit can be used both as pump and motor. Anyway this what we look in this figure that there is basically a pump is there, this is driven by some prime mover and then there is some reservoir and oil is going in, then oil is transmitted to the motor part and which actuates this means that that rotates and the oil goes out to the reservoir, so this we should say an open circuit.

It is also possible that we can instead of using that reservoir we can drive this pump which can be rotated in both directions by some arrangement is there and that is driving a motor and depending on the direction of flow that motor will rotate in both the directions that means it can be rotated in clockwise direction as well as anticlockwise direction. It is not necessarily that prime mover is rotating in both directions, prime mover may be rotating in one direction only and there is a mechanism in the pump by which we can change the direction of flow that means it can be flowing out this way or it can be flowing out it is flowing out from the other side, so this is called closed-circuit.

So if we mean that hydrostatic transmission then we either mean to this open circuit or to the closed-circuit okay. Now this is open circuit, also open loop without feedback there is no feedback, open circuit and open loop. Then we would say this one is the closed-circuit and open loop that means without any feedback. If there is feedback then will be called it is a closed circuit closed loop, et cetera, we are coming to that.

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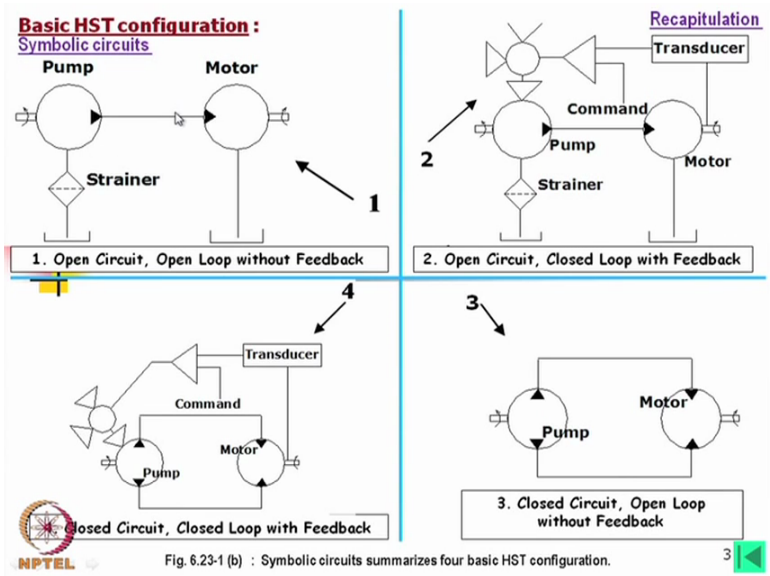

Now this is already we have seen, so this is open circuit open loop without feedback. Then we can have the open circuit closed loop with feedback so there is a feedback so this means that depending on the output of the motor this pump can be controlled, so this is open circuit closed loop. Similarly we can have the it is a closed-circuit but open loop and finally we can have closed-circuit close loop with feedback that means this is not only closed-circuit as well as closed loop.

So 1st part this term is the circuit term and 2nd part is the control term, in that way we can name like this so if we are asked usually in the classroom question paper or the examinations, these are the popular questions that describe the hydrostatic transmission system then you have to write all such things with such simple diagram okay.

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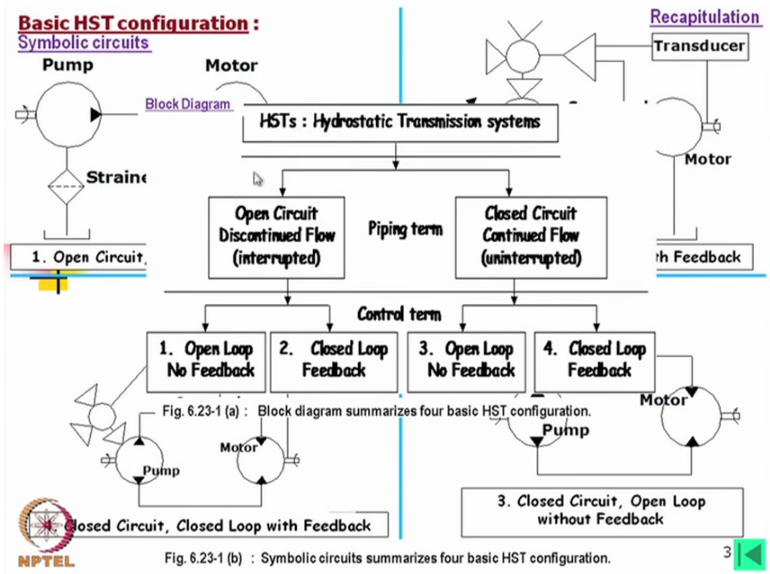

And finally we can make a block diagram like this, hydrostatic transmission systems, you see when we use HST term, many people write that hydrostatic transmission system. No, it is not for hydrostatic transmission system, HST word comes from hydrostatic transmission only, S static that s is here. Now when we add the system then S will come here, so this HSTS means hydrostatic transmission system. Now as you have seen the piping term or circuit term, open circuit discontinued flow interrupted flow and closed-circuit continued flow uninterrupted flow then both may be open loop no feedback, closed loop with feedback this part is also same.

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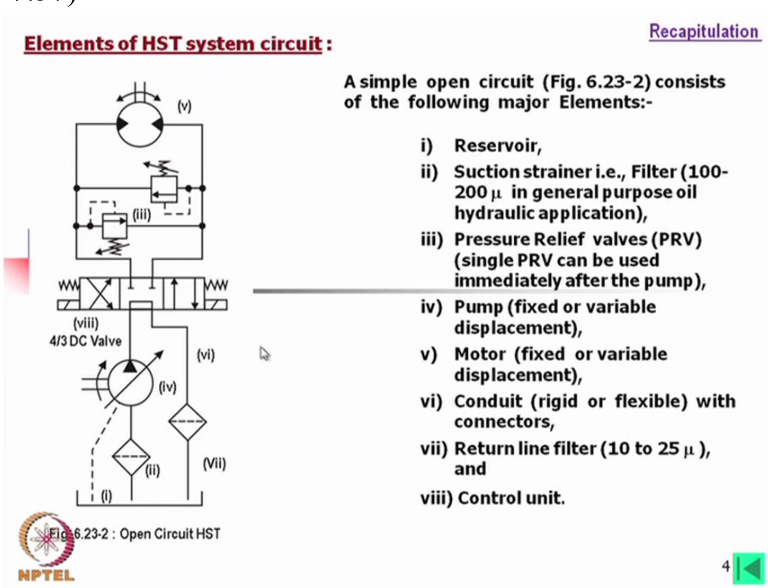

Now in reality circuit will look like this, this is simple a open circuit consists of the following major elements, what is that? There is a reservoir, then suction strainer these are called suction strainer is too, this filtration is usually 100 to 200 micron in general-purpose oil hydraulic applications. Now what does it mean? This mesh of the usually the wire mesh is used also filter papers are used then it is 100 to 200 microns say if we consider the 100 micron that means within 1 inch there will be 100 mesh it is like that, so you can imagine how small particles they are being filtered. This particle size say maximum size is 200 micron that means if we think of a square mesh then diagonal length is equal to 200 micron approximately, you can imagine in that way.

Now 3rd one is the pressure relief valve, this one is the pressure relief all. In this case system is like that, we have a pump source, there is a filter and then it is going into a valve which is 5th item, 7th actually the pump fixed or variable this one, this may be fixed or maybe variable also and then motor fixed or variable displacement, this one may be fixed or variable that means that swept volume may be fixed or maybe varying. Now this conduit, et cetera are make this piping this may be rigid as well as flexible, then return line filter, this is usually 10 to 25 micron. Now why is like that?

Now actually this strainer is used, it has it has practical it is not required, only thing due to swept reason we put it there that means if there is any big particle that is being filtered that should be filter, otherwise pump will be damaged but actual filtration is done in the return line because why in the return line? If we put such a strainer at the inlet then this pump will need very high power, so to avoid that and then there will be loss, to avoid that we put in the return line and this is also justified because there is no exposure up to this motor part that that can come inside. But in case of motor, usually that output shaft is rotating and then through that some that particle may come inside because there is a exposure, the output is external to the from the introduced body.

Although there is the ceiling but there is a possibility of coming inside and that is being filtered in the return line. Next the control unit, this is the control unit, control unit is actually the valve, the first there we have seen that how this valve is functioning, but here I would like to say with this arrangement you can see this is a tandem type valve that means a normal time this oil will go to the tank and these 2 will remain close, but if we actuate in this direction then oil will go to this and it will come back through this and then say for base it is a clock clockwise rotation and for this function it will rotate in the opposite direction.

Now these are the 2 valves are used that is relieve valve that means oil is being relieved from here to here, so this is although open loop but it can be shared with which this feature it is somewhat acting in a close closed not loop, closed-circuit also. However, we can use this filtration line also other place that I will show.

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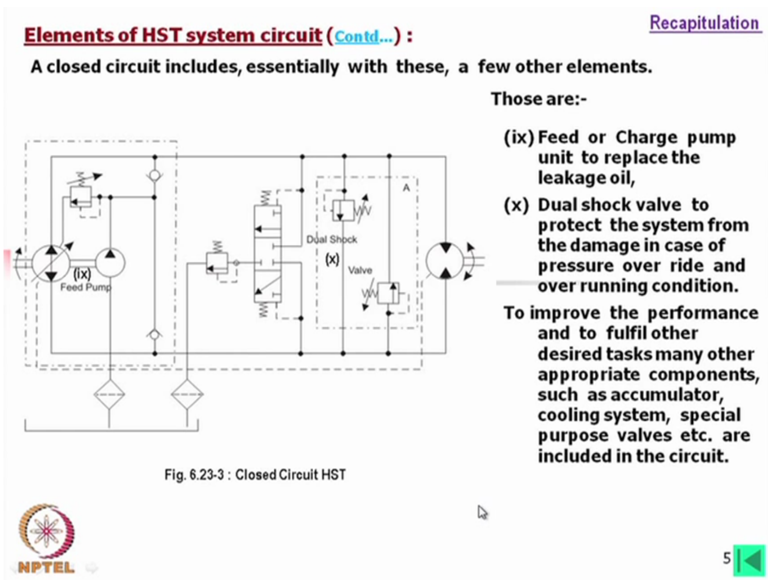

Now what if you would like to construct a closed-circuit, in that case the pump this is this arrow means variable displacement pump we are using and this pump is being driven by the prime mover and then these are directly connected to the motor, two ends of this pump is connected to the 2 ends of the motor. Now depending on the direction of flow which again can be controlled by this control not changing the direction of rotation of the prime mover, we can change the direction of the motor rotation. Now if we look into the circuit then we will find many things inside, what these are we need there will be leakages in any hydraulic components, we cannot avoid that.

Now this leakage to be compensated, for that we need a feed pump, this feed pump means it is only compensating the leakage flow so capacity of this pump is both pressure wise and the flow wise is very small pump and it is usually connected to the main pump also. So through the same shaft it is connected, now this is connected to the reservoir and from there oil is being pumped to the circuit to compensate the leakage and there is a relieve valve the access oil is going back to the tank. In fact, the access oil is coming to do this casing in this diagram, it can be directly coming out or through this casing it is coming out to the oil because for such components usually casing where the automatically case is being that is leakage and that always to be kept filled for the lubrication purpose, so this arrangement is shown like this.

And then what we find the 2 non-return valve, suppose the oil is going through this from the pump it is flowing like this then this means that this is high-pressure oil because it is rotating the motor. So due to this high-pressure this will remain close and oil will go through this trade valve non-return valve to this side, this means that high-pressure oil is directly same to this motor for rotating and if there is any leakage that is being compensated here and then again it is being fed to the pump, this means that there will be no shortage of oil in the circuit.

If it moves, this oil moves in the direction then this side will remain close and oil will be fed through this okay, so this is to compensate leakage we need a feed pump. Next, this is called dual shock valve, these are nothing but 2 relieve valves, these relieve valve means if there is this pressure is exceeds the need of the motor that means system pressure, then oil will directly go back to this part of the circuit and it will go back to the tank and this motor will stall. Similarly, when it is trying to rotating in the opposite direction, it will go to the other part of the pump.

So this would operate but time to time we need to bypass the oil to the tank and for that the system is there and this is again sensed by the system pressure. In that case what will happen, oil will go back to the tank so minimum requirement for such a circuit should be like this okay. Function of this part is that due to the high-pressure this will operate and oil will go through this setting pressure, this this is set at the system pressure, it will go back to the tank.

Say for example, this is operating at 10 mega Pascal. Suppose due to some reason due to high load it has it has exceed that exceeded 10 Mega Pascal then in that case oil will bypass through this may bypass through this otherwise, it will go to the other side of the circuit. So here the pump is also stalled, oil has to pass through this. However, it is possible that without this we can have the system but using this, this is a foolproof circuit means the pump and no components will be damage, oil will go back to the tank. Now these components are feed or charge pump, this is called feed pump or charge pump, then Dual shock valve it is called Dual shock valve, protects the system from the damage in case of pressure over ride and overrunning condition.

To improve the performance and to fulfil other desired task many other appropriate components such as accumulator, cooling system, special-purpose valves, et cetera are included in the circuit. Say this is the minimum but we can use say for example for smooth performance we can add accumulator, to cool the oil we can add cooler, this means that in the path on the written path that will be cooler like that.

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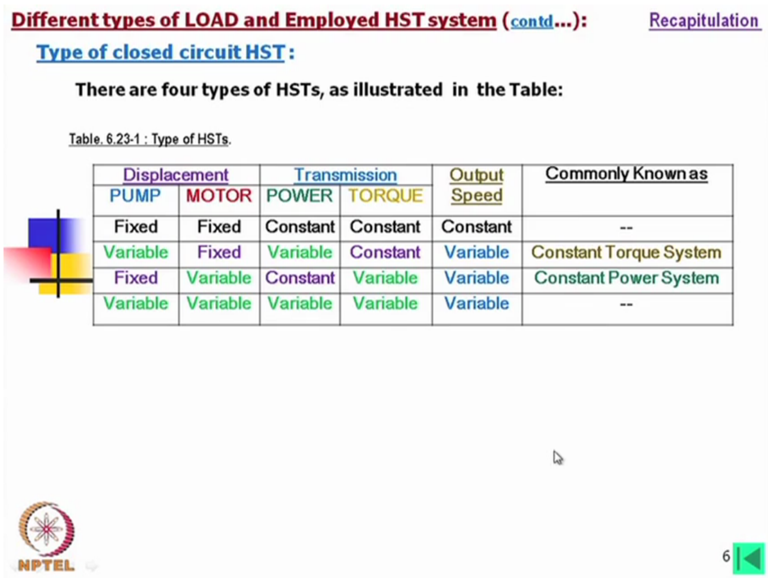

Now we shall look into the circuit, we have seen few circuits as well as we have seen that the motor open circuit, closed-circuit, et cetera. Now depending on different types of loads, the HST system employed may be of different types, type of here we are discussing the type of closed-circuit because these were normally called hydrostatic transmission system for driving say earthmoving equipment, for driving a truck tractor, for driving a forklift truck, in that case we mean closed-circuit, may not be closed loop but it is essentially closed-circuit.

So if you consider the closed-circuit hydrostatic transmission system then the displacement of pump and motor we will consider what type of displacement is there, then transmission type and from there we will look into this what are the different types. Now 1st one is that, pump is fixed displacement, motor is also fixed displacement, fixed displacement means it is having constant swept volume, what is constant swept volume? Swept volume is the volume displacement by one revolution whether it is motor or whether it is pump, so only 1 revolution, whatever the geometric displacement that is called the swept volume without considering any leakage.

Now if that remain fixed in that case we should call fixed displacement. Again with some mechanism it can be varied that means in a revelation that total displacement will vary, we should call them variable displacement. So here we understand now what is fixed displacement, we have fixed displacement pump, fixed displacement motor, so power in that case will be constant, torque will also be constant, obviously this is for a constant pressure, then output speed is also constant and commonly we call as ordinary simple circuit

Next if we consider pump as variable and then motor is fixed then power will be also variable, however, it would be usually for constant torque that means when the pressure is constant then torque is also in motor it is a constant, but we are varying this power so output speed will be variable in that case, then we call it constant torque system. Next what we get, fixed pump, variable motor and in that case power remain constant, with that constant power torque can be varied, this is also variable and we should call it constant power system.

You will find that this is a simple system 1st one, 2nd one is very widely used but looking into some we should say that power saving system, this is not suitable for where the torque is I mean very wide range, this may be controversial but I would say this is power is varying but range is not that high and we can go for such system. This is also used, but in that way I would say we can make all variables, now all variable means then we can keep at a certain position so this will be fixed, this will be fixed or it might be variable, this is fixed, this means that if we make this one variable, variable then we can have all 3 features out of this.

Now this has no special name, this can be made constant power system, this can be made constant torque system or an ordinal system, but this will be definitely expensive. Otherwise, I would suggest in every case we can go for such arrangement, but if it is not required not much variation in power and torque is there, we need not go for such a system because this will be expensive.

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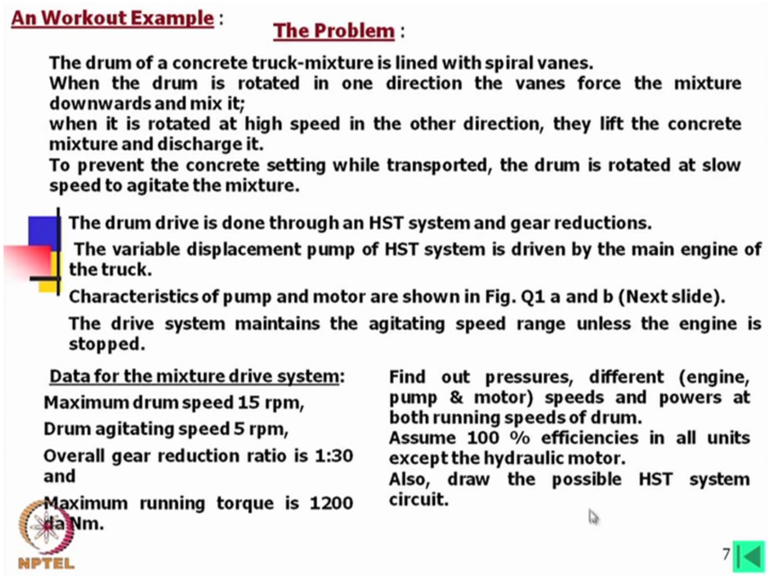

Now we shall look into the selection of such components through an workout example. Now this let us see this what problem is there, the drum of a concrete truck mixture is lined with spiral vanes, this means you might have seen a big truck with a rotating drum, it is moving say for a it is carrying cement, you will find the cement, what it is there? The cement mixture that is done at one place and that is being carried to other place but it should not that means if you do not rotate it then this may solidify I mean it will take the concrete shape, to avoid that it is done. Also, this is used for cement manufacturing when cement is being manufactured for that purpose.

This might there might be something else also, so there we use a drum which should be rotated and while it is being carried. Now this drum is rotated in one direction, if it is rotated in one direction the vanes forced the mixture downwards and mix it, it is mixing. Now for unloading what it is, it is rotated at high speed in other direction, they lift the concrete mixture and discharge it. It is like that, at one place it is being mixed then it is being carried and then it is being mixed going up and down, detailed arrangement I cannot explain here but it is like that.

However, while it is carrying in that case it should only just move so that they are I mean some we adjust mixing like this, vanes are rotating inside and these are not allowed to be (())(26:20) it is like that, so that is called agitating speed. To prevent the concrete setting, while transported, the drum is rotated at slow speed to agitate the mixture. Definitely, we need not rotate at high speed neither we need that much power okay at that time. The drum drive is done through an HST system and gear reductions.

The variable displacement pump, we have a variable displacement pump of HST system is driven by the main engine of the truck okay. Characteristics of pump and motor are shown in figure, there is a figure in next slide. Now the drive system maintains the agitating speed range unless the engine is stopped. Now this is important that means if you suppose you are not moving, you have stopped the car are not moving, but engine it is not stopped that it is usually you know for any car that is low speed, not high-speed. At this speed the agitating operation should continue that means drum will rotate okay so this means that.

Now data for the mixture drive system is that; maximum drum speed is 15 rpm that means when it is mixing or discharging. Drum agitating speed is 5 rpm only, one third of that. Overall gear reduction ratio is 1 is to 30, this means that from the motor output hydrostatic transmission motor output, there is another gear reduction 1 is to 30 so that we can have 15 rpm otherwise, directly by the motor 15 rpm is very difficult, performance of this motor will be then very poor that is why we use the gearbox so 1 is to 30 gear ratio is there. Maximum running torque is 1200 deca Newton meter the value is given in deca Newton meter.

Now find out pressure, different speeds of the engine, pump, motor, et cetera and power at both running speeds of drum that means normal running speed as well agitating speed. Assume hundred percent efficiencies in all units except the hydraulic motor. Now I would say that every that rotating units of maybe ordinary units having its own efficiencies, say for example, this motor it cannot run at 100% efficiency that means there will be losses, losses may be leakage, losses mechanical losses that is the section losses and also there is called hydraulic losses, not in this lecture, we shall discuss maybe in other lectures that what are the losses.

Now leakage losses can understand what it is, mechanical loss means there will be fiction loss and such mainly friction loss you should say, mechanical also thermal loss will be there in other form. Then there is a hydraulic loss, hydraulic loss is usually that fluid is although you consider the hydraulic fluid is incompressible but it may be compressed a little bit so there will be some loss, also the body of the conduit the particularly flexible hose that will that will be also expand so there will be some loss so that normally put into hydraulic loss. It is very difficult to calculate all such loss losses separately but experimentally we can find out what are the total losses also we have to make a circuit for this

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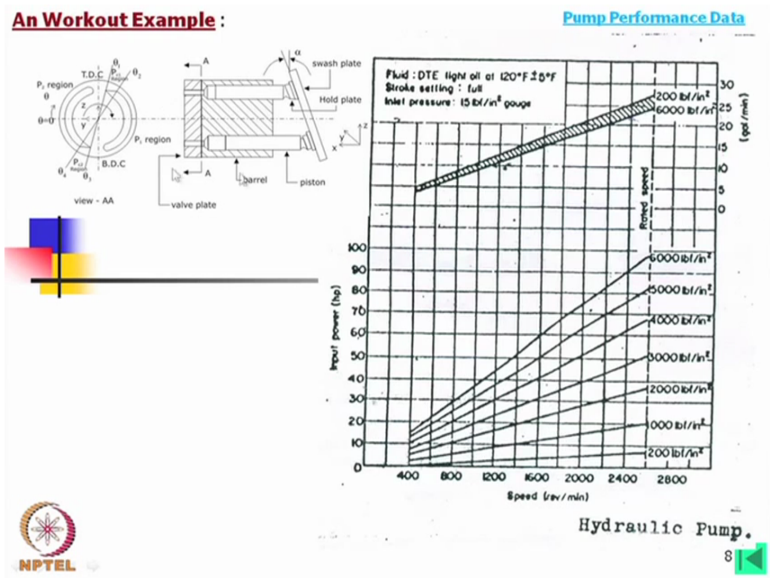

Now here we have considered the variable displacement pump, in that case we have considered the swash plate type pump which we can move and by that we can increase or reduce the swept volume. Now the characteristics of this pump is shown here that means this chart is available from the Manufacturer and while we select the components we have to look into this. Say for example, here this flow output are given but that you can see against this rpm of the pump input and against the pressure, say if it is a maximum pressure is 6000 pounds per square inch, in that case you will find that we have to follow this line.

Now if the pressure is very low then definitely the higher flow is available at lower speed okay. And these lines are the power say power will vary at different pressure following these lines at different rpm, so this is the pump characteristics.

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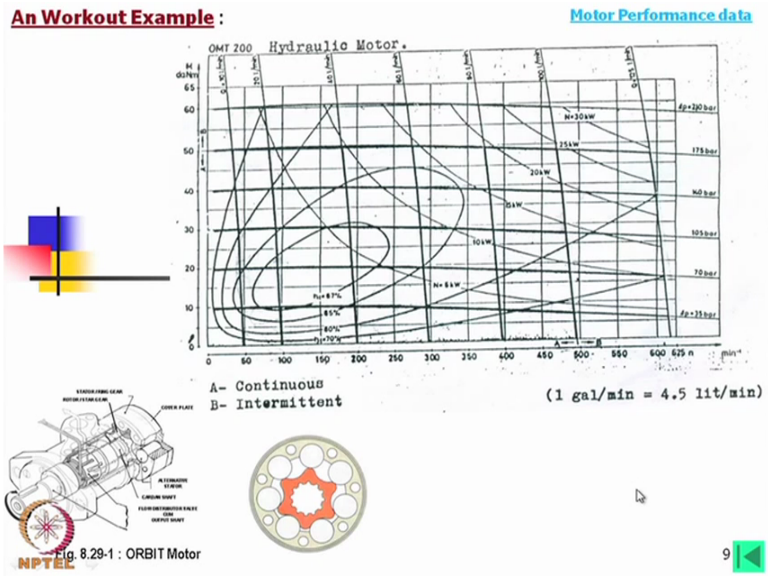

And motor what we have used so this is called orbit motor which is low speed high torque that means this can give output of very high torque at low speed. As you can see, the maximum speed continuous speed only 500 rpm, whereas that pump you have seen 2000 rpm or more. And you can see this torque is 60 deca newton meter continuous and for intermittent it may be up to 625 rpm and output torque is 65 so here A is continuous up to this point so we will normally follow this curve for continuous operations, I mean this portion is for continuous operations.

However, we can either increase this may be both cannot be increased, we can increase the speed or we can increase the torque up to this limit okay that is for a few seconds only maybe at the starting or so, 10-15 seconds it can run at high speed or at high torque, so we are using this type of a motor.

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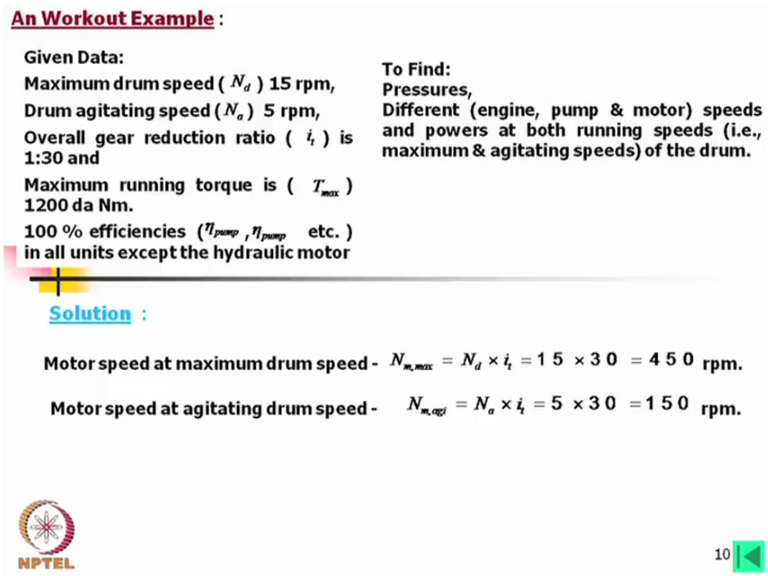

Now the solution will be like this, the giving data are; maximum drum speed 15 rpm, drum agitating speed is 5 rpm, overall transmission ratio of the gear unit is 30, maximum output torque we need 12 deca Newton meter, 100% efficiencies for all components, this is for the solution purpose we have considered like this, actually we should consider efficiencies of all. However, we have considered that hydraulic motor we should consider its efficiency, I will show that how the calculation is done. Now what we have to find, the pressures, different speeds of engine, pump, motor, et cetera, powers and also we have to draw the circuit.

Now, motor speed at maximum drum speed is we would say 15 into the transmission ratio 450 rpm that means we should motor output speed maximum that is why it is mixed mixing or maybe discharging, definitely at the time of mixing the more power will be required. Look at this, how the that this is inclined, it is arranged in such a way it is mixing materials are moving normally downwards direction because that time we need more force so gravity force helps us for mixing. While we are discharging it, probably it is not mixing so some power optimization is there, but anyway we do not know maximum torque will be 12 deca Newton meter. Now motor speed at agitating drum speed is 5 into 30 = 150 rpm.

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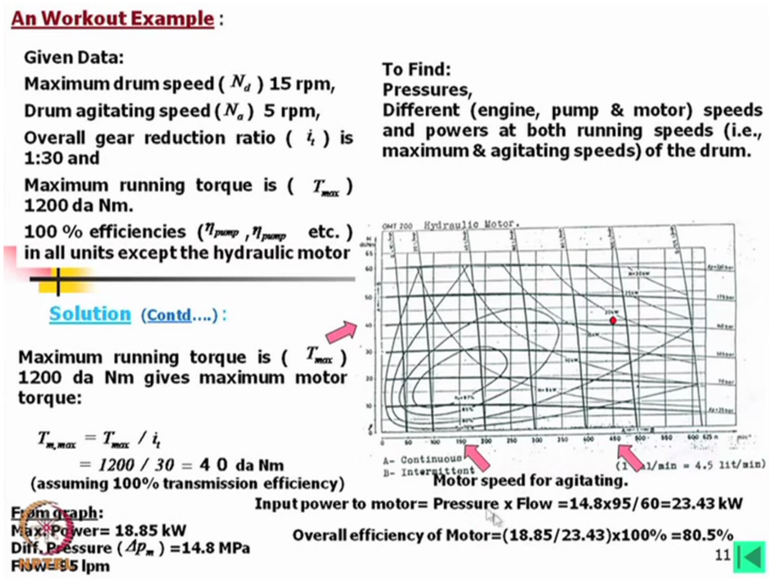

Now maximum running torque, 12 deca Newton meter gives maximum motor torque okay. Now definitely, if this is the output torque then input I mean output from the motor should be 1200 divided by the transmission ratio so 40 deca Newton meter assuming 100% transmission efficiency. Now here that gearbox efficiency we have considered 100% so we would say if the motor can transmit 40 deca Newton meter, it can output this 40 deca Newton meter then it is it will suffice the purpose. Now looking into this curve, we will look into this motor curve motor characteristics curve.

Then 450 rpm is here because we need 450 rpm, so we will follow this line and then torque is 40 deca Newton meter so we will find that this is our operating point, now at that operating point we will find the power, et cetera, we will look into this. So from this graph what we find maximum power 18.85 kilowatt, how I have done can you see this? This is 20 kilowatt and this is 15 kilowatt and we have to I mean estimate from these 2 curves, to me it is around 18.85 kilowatt, okay. And what is the pressure? This is 140 bar means 14 mega Pascal so therefore, it is around 14.8 mega Pascal we have estimated, so this much this means that this line if you look into this from low speed to high speed it is slightly bending, this line is (())(38:11) pressure lines okay, so here we consider that this is the pressure.

Now this is again this is not the output pressure or so, it is called the differential pressure that means when in a motor oil in and oil out, when the oil out, there is also some pressure because there is a filter and other components so oil in that pressure should be higher, that means to know what is the actual pressure input to this motor we need to know output what is the pressure. In case of closed-circuit it will be always there, so it is estimated we have to calculate considering these 2 pressure, in open circuit somewhat we may consider that outlet pressure is very low, anyway this this remains unknown in this problem.

However, we know thisthis is actual characteristic, it is on experiment so we can say that this is the power output and the flow is 95 litre per minute, how we can find out the flow? This is 100 litre per minute and this is 80 litre per minute and we have estimated this is 95 litre per minute. Now, input power to motor pressure into flow we can say, so what we find it is 23.43 kilowatt you can simply calculate like this. Pressure into flow will give you the power, 60 is for per second to find calculate this power per second, this is mega Pascal we have written and this is liter per minute, if you directly divide by that automatically you are going to how much kilowatt is there.

Then from the chart what we find output of this motor is 14.8, which is directly can be found out from 450 rpm into the torque available. Available speed and available torque will give us this power, so this means that definitely there is efficiency matter of efficiency overall efficiency, that efficiency what we calculate 80.5, now if we look into this say this is I show efficiency lines, this is 80 percent and this is it 5 percent that means if motor operates within this zone, it is 85 percent, if it operates within this zone then you can say something between 80 to 85%. And you can see this is 80.5 so this is 80 line but it is coming 80.5, may be some estimation it is slightly wrong but we can say if this is 85, this is 80, this will be something in between so it is maybe 81 or 82 percent okay.

So our calculation is going in the right direction and we can say that we have estimated more or less correctly, so this motor can supply this maximum torque required. Now if we consider that agitating, this is 150 but we have not said much torque is required, now in that case the material is not moving this way or that way, not going up, not going down, it is just simply maybe that time drum is kept more or less horizontal and it is just rotating not to allowing setting it. In that case let us consider the half of the torque will be required, we have assumed this one.

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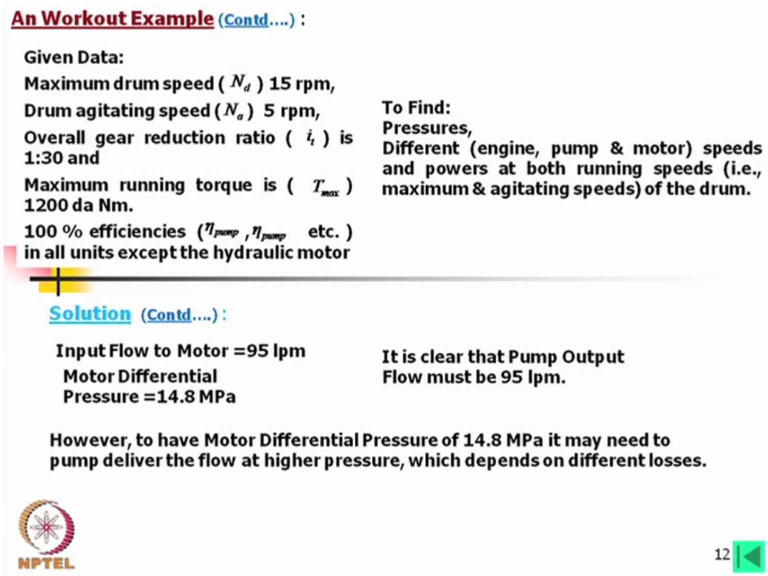

Sorry, in that case what we find that it is the maximum efficiency zone, if you look into this you will find that one is the maximum efficiency zone, we will come into the other this slide later. Now again we are continuing, now motor differential pressure is 14.8 mega Pascal and input flow to the motor is 95 lpm. It is clear that pump output flow must be 95 litre per minute that we have seen that we need 95, this is actual chart so 95 litre per minute that is fixed. However, to have motor differential pressure 14.8 mega Pascal it may need to pump delivers the flow at higher pressure, which depends on different losses that is known.

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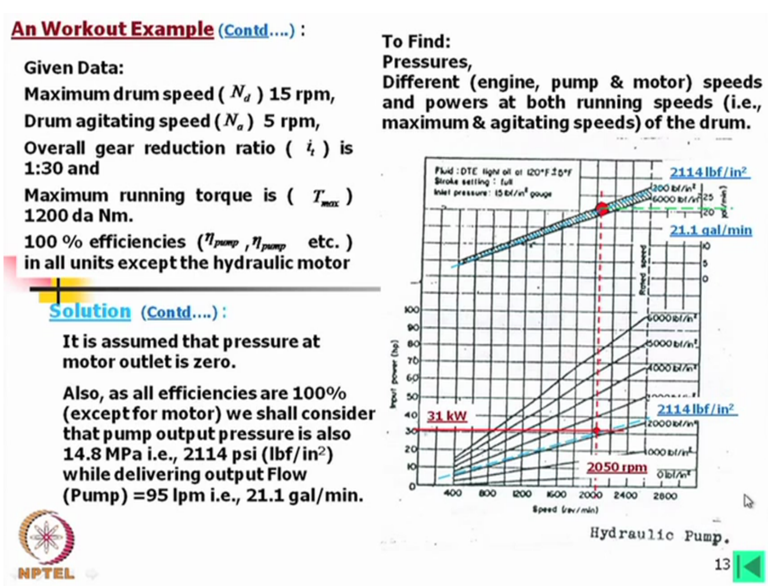

But we shall we will consider let us consider as we have considered the efficiency of the pump is 100% so it is it will be 14.8. It is assumed that pressure at motor outlet is 0, if we assume in that way then as 100% action before all other components, we will now consider that pressure output from the pump is 14.8 mega Pascal itself, now it is equivalent to 2114 psi that is pound force 4 inch square. Now how to calculate this? Roughly you can say 1000 psi is equal to 7 mega Pascal 1000 psi is equal to 7 mega Pascal, then while delivering output flow is equal to 95 litre per minute, assuming this is an imperial gallons then we will consider divide by 4.5 will give you gallons per minute okay.

So this we need this one, pump flow output and pump pressure output, now we should look into the pump chart. First we will consider that the flow, for that flow we have to assume that for 2114 psi where maybe the line, so this blue line is there okay. Then we will consider the flow, this is 20, this is 25 so 21.1 gallon per minute, then that intersection point is our this output point in terms of flow output at that pressure. Now from there if we come down then we will find that rpm is around 2500, this is all estimation which one can calculate by measuring a scale and then calculating, from my estimation it is 2050 rpm of this pump.

Then we shall consider the power, how to estimate the power, again we will consider this 2114 psi, this might be this line okay, then this is the point where the power estimate the power and we are getting this is 31 this is in horsepower, oh sorry in horse power, 30 horsepower means what will be in kilowatt, 1.6 horsepower is equal to 1 kilowatt, is not it? 1.6, so 30 divided by 1.6, around 18 what we are calculated there okay, I think this is we made a mistake here. So it is not 31 kilowatt, this will be 31 hp around 31 hp, so this will be 18 or 20 kilowatt like this.

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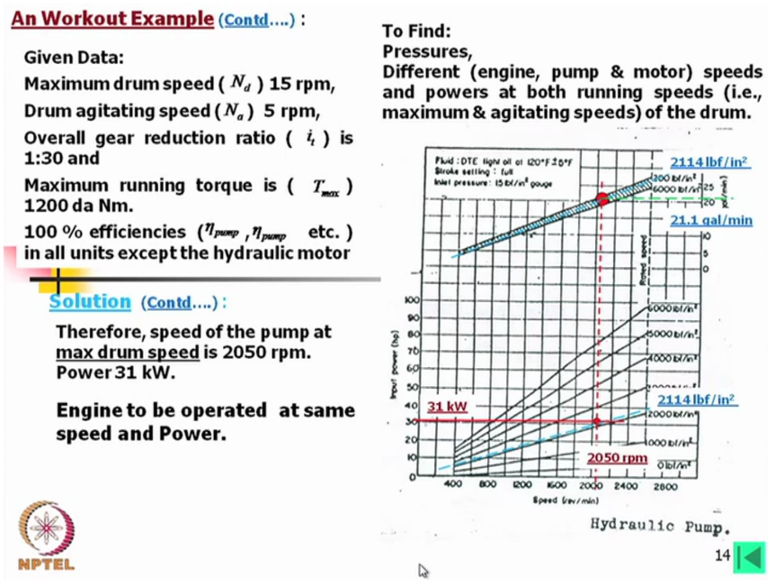

But actually if we carefully consider, we will find it will be 23 kilowatt what we have calculated in terms of flow and pressure, we as we have efficiency these results are coming in this way. Now therefore, speed of the pump at maximum drum speed is 2500rpm and it is 31 hp so this please note this correction. Engine to be operated at same speed and power so that is we have selected the engine like that.

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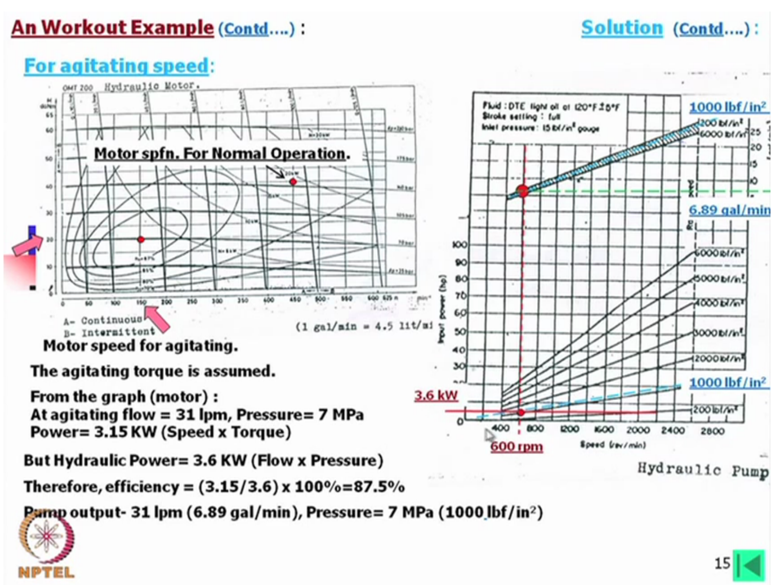

Now for agitating speed, say this this speed was as you see this is for motor specifications for normal operations, but for resulting speed what we found that 150 rpm and this is the torque okay. Now here I would say looking into this rpm is 150 and here rpm is 450, so just it is 3 times less also output speed was 15 and 5 so we may be tempted that in that case the flow will be just 3 times less and as the torque is half then maybe we can consider the power is totally 6 times less, but actually it is not because due to the efficiency factor you have to again reconsider this.

We will find that there at that speed, loss is not much and again this agitating speed it is the normal, say this is carrying quite a long distance that time we would try to replace the power in such a way this is at the maximum efficiency zone so it is designed accordingly okay. So this efficiency apparently it is closed to the 100% but it will never happen because this here it is this line is 87% and within this zone it may be at the most 90% efficiency but never 100 percent, so we would say this it is 90 percent efficiency it is operating. So again we have to find out the power in the same way what we did earlier okay.

Now the agitating torque is assumed this 20 deca newton meter we have assumed. From the graph that this is 31 litre per minute and pressure is 7 mega pascal what we find that 70 bar means 7 mega Pascal and power we find is 3.15 kilowatts. But hydraulic power is 3.6 kilowatt calculating from the flow and pressure term okay, there is efficiency is around 87.5 percent within this zone even the efficiency is showing like this, not showing hundred percent and this seems to be correct. Pump output 31 litre per minute, 8.89 gallons per minute and pressure is 7 mega Pascal so if I consider it the same say what we have calculate…

Not the line for the flow term on which this is the pressure term and we get this point there okay and then speed we find 600 rpm. If you have any idea about this engine, industrial diesel engine or so, you will find normally 600 to 700 their ideal speed you will find that. So 600 speed when when the track is not moving, we can have that speed and we can have that power for the purpose of agitating. Now this is 600 rpm and again if we consider the 1000 pound per inch square and then we found this power is actually again this is not 0.6 kilowatt, it is around you can find around 5 hp which is 5 divided by 1.6 will be something like this of course, but this is a mistake, by mistake I have wrote like this, actually be slightly different from that.

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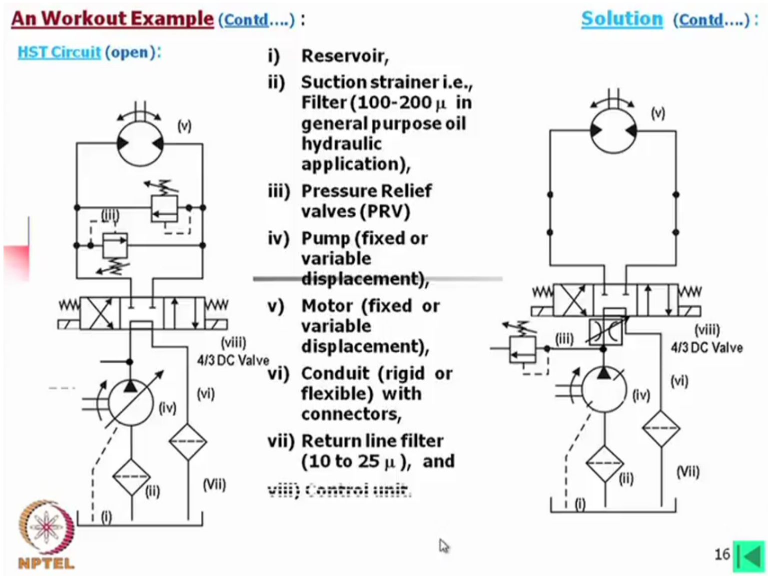

Now we have to draw the diagram for the circuit, normally if you would like to make an open circuit what you can do, you can choose the same circuit what we have seen but instead of using the relief valve here, we can add one relief valve there okay, so this is open circuit we have considered. However, instead of that whatever original was there we can use that one also, this circuit mind it this is only for rotating the drum, this is not driving the truck. For truck from engine there is a separate driveline with might be that ordinary speed gearbox and there is differential, et cetera et cetera, not hydrostatic transmission. Hydrostatic transmission system is although the same engine as the power source but this circuit is only for rotating the drum.

As well what we can do, instead of this variable here the pump is variable displacement, instead of variable displacement pump we can use a flow control valve is also there that is another possibility. Now you should keep in mind, if there is a pressure setting say for example this pressure setting we have seen 7 mega pascal so this pressure setting not 7 mega Pascal for agitating but 14 point something for the maximum torque so it might be set at 15 mega Pascal okay.

If you use this flow control valve, your access flow will always go through this relief valve by blowing this relief valve that means pump to this point always pressure will be 15 mega Pascal, in that case loss will be more but the advantage is that this oil is always ready with the pressure, so performance of this part will be better. So usually if we would like to rotate for a very short time output, flow control valve will be better than this variable displacement pump. Variable displacement pump you have to make the pressure ready everything so there will be a sluggishness in the response, so these are the differences.

Anyway, depending on the cost optimisation you can select which one to use. No again this while you are trying to answer such a question you should name all the components like this, this is same as what we have discussed earlier.

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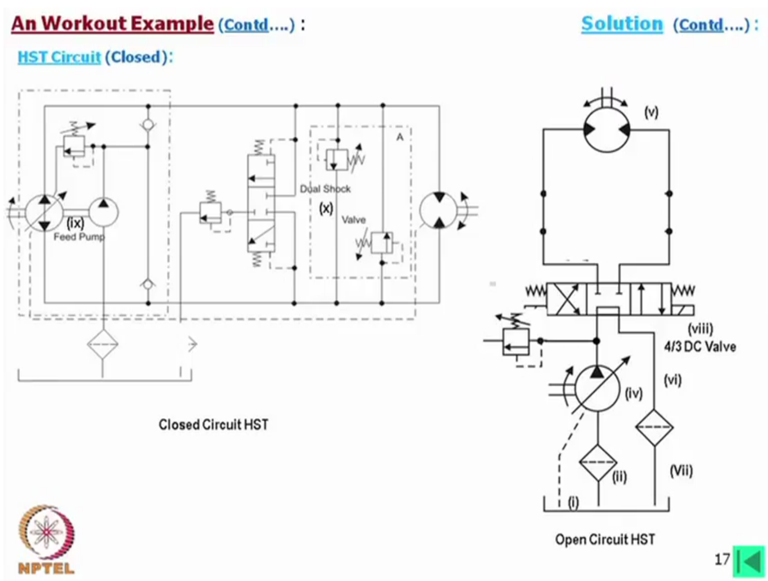

Now also you can go for closed-circuit, mainly we may choose the closed-circuit for this particular transmission because we have seen that this while it is mixing and while it is discharging, it is having motion in both directions. You need clockwise and until clockwise output and that might be not for longer time, I mean time period it is like that, for a few minutes you are rotating in clockwise and few minutes in the opposite direction. So looking into do this maybe closed-circuit is the better option, that case as I have told that this you may use or may not use, but it is better to use this for more safety, this is considering safety of whole circuit okay.

So while you are answering, you may draw such a circuit that this will be for the drum drive and a gearbox is connected here, after that drum is connected here. So if you come either this circuit or this circuit, anything will do you can answer, if you answer both showing that and you can discuss so your answer will be better, that is all. So thank you very much for listening