Oil Hydraulics and Pneumatics
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Part 6: Construction and Operation of radial piston motors, Wheel hub motors, Semi-rotary actuator
Lecture - 50
Hydraulic Motors

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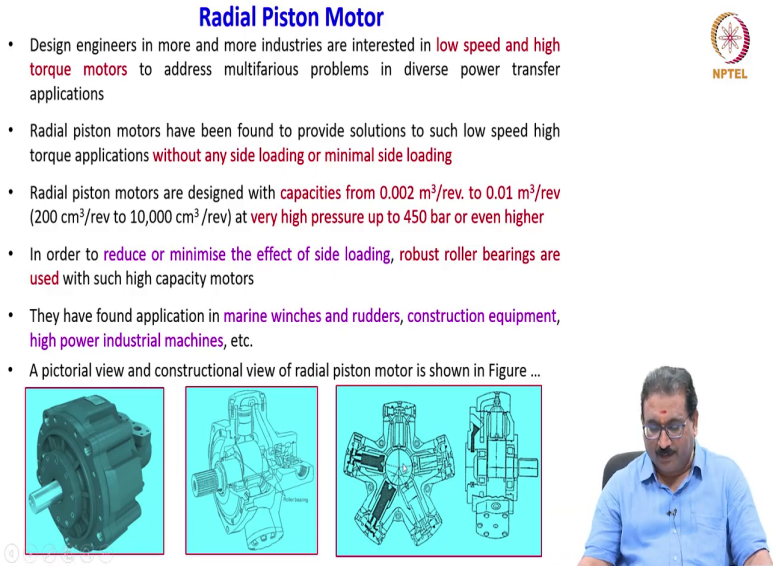

My name is Somashekhar, course faculty for this course. Now, last one which is rotary type radial piston motors. Design engineers in more and more industries are interested in low speed and high torque motors to address the multifarious problems in a diverse power transfer applications.

Radial piston motors have been found to provide solution to such low speed high torque applications without any side loading or a minimal side loading. Radial piston motors are designed with capacities from 0.002 m cube per revolution to 0.1 m cube per revolution; at a very high pressure up to 450 bar or even higher.

In order to reduce or minimize the effect of side loading, robust roller bearings are used with such high capacity motors. They have found applications in marine winches and rudders, construction equipment, high power industrial machines and many more. Here, I am showing you some pictorial views and a constructional views of the piston motor. This is a commercially available piston motor; here please understand friends pistons are reciprocating radially. You will see here the pistons are moving radially, shaft is at the middle and please remember inlet and outlets are also at the middle; I will show you neatly in the next figure, we will see here.

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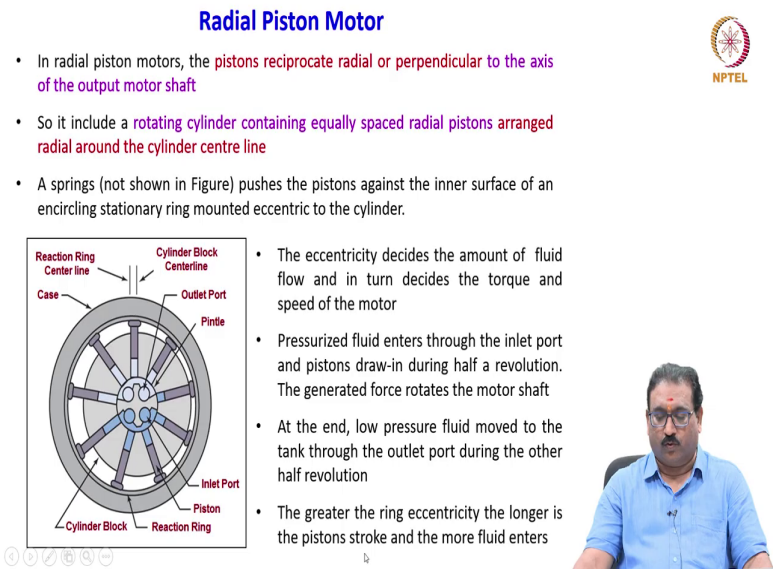

In a radial piston motors, the pistons you will see here the pistons; how they are moving; pistons reciprocate radially are perpendicular to the axis of the output shaft. So, it includes a rotating cylinder block, you will see here this is a rotating cylinder block; radial slots are there in which pistons are inserted. A spring not shown here generally pushes the pistons against the inner surface of an encircling stationary ring mounted eccentric to the cylinder.

Please remember here friends, how the stroke is achieved is; here you will see this is full one is a casing, cylinder block, here reaction ring; you will see here the reaction ring axis center line and a cylinder block they are offset; then only you will get the increasing and decreasing volumes. You will see here in all the piston, some pistons are inside and some pistons are outside; meaning high pressure oil will come here.

When they will rotate due to the eccentricity, they will go out and they will come in based on the directions. Correct here I am showing you high pressure oil will enter here through the inlet ports. You will see the in the pintle here inlet port and a outlet port. Inlet port where the high pressure oil will enters through outlet port where it is connected to the tank; after rotating the shaft, it will leads to the tank.

The eccentricity decides the amount of fluid flow and in turn decides the torque and a speed of the motor. Pressurized fluid enters through the inlet port and pistons draw in during half revolution. The generated force rotates the motor shaft. At the end, low pressure fluid moved to the tank through the outlet port during the other half of the revolution. The greater the ring eccentricity, the longer is the piston stroke and more fluid enters.

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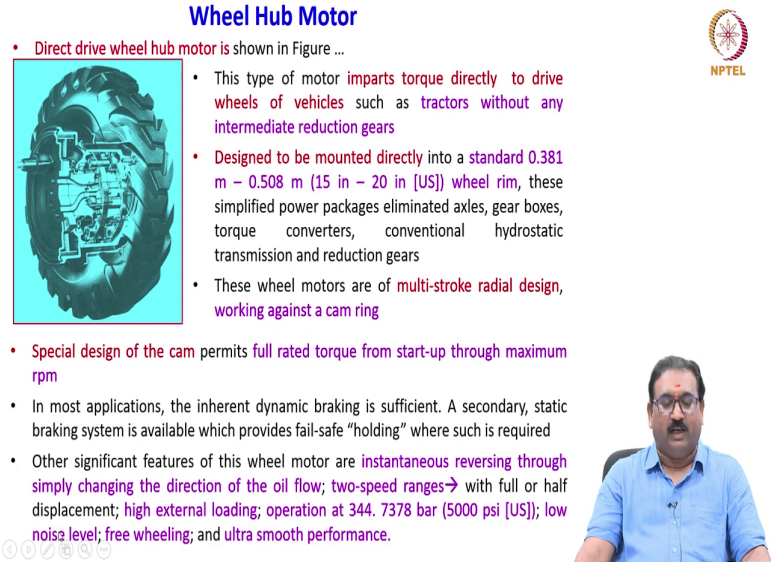

Then one more design we will see; wheel hub motors, this is a wheel hub motor what I have shown here that direct drive wheel hub motor.

This type of motor imparts torque directly to the direct drive wheels of the vehicles such as a tractors without any intermediate reduction gears. Designed to be mounted directly into a standard 0.381 meter to 0.5; half meter wheel ring, these simplified power packages eliminates axles, gear boxes, torque converters, conventional hydrostatic transmission and reduction gears.

These wheel motors are of multi stroke radial design, working against the cam ring; as I have explained in the previous slide. Special designs of the cam permits full rated torque from start up through a maximum rpm. In most applications, the inherent dynamic braking is sufficient. A secondary, static braking system is available which provides a fail-safe holding where such is required.

Other significant futures of the wheel hub motor are instantaneous reversing through simply changing the direction of oil flow; two speed ranges with full or a half displacement; high external loading; operation at 344.73 bar; low noise level; free wheeling and ultra smooth operations are possible with wheel hub motors.

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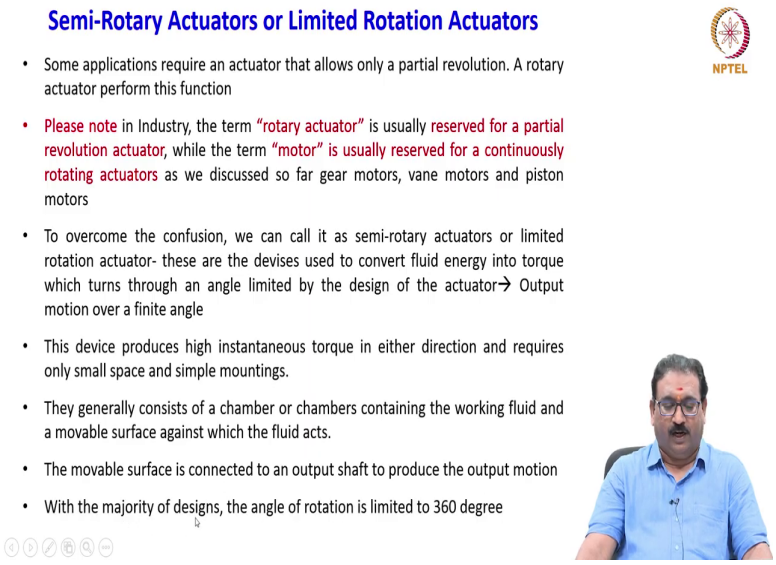

Now, we will move on to the semi rotary actuators; they are known as limited rotation actuators. Some applications requires an actuator that allows only a partial revolution. A rotary actuator performs this. Please note, in industry the term rotary actuator is usually reserved for a partially revolution actuator, while the term motor is usually reserved for a continuously rotating actuators as discussed so far gear motors, vane motors or a piston motors.

The term is reserved is a motors rotary actuator means what is semi rotary actuators are a limited rotation actuators. To overcome the confusion; do not confuse here now friends, we can call it as a semi rotary actuators or a limited rotation actuators. These are the devices used to convert the fluid energy into torque which turns through an angle limited by the design of the actuator meaning; output motion over a finite angle.

This device produces a high instantaneous torque in either direction and requires only a small space and a simple mountings. They generally consists of a chamber or a chambers containing the working fluid and a movable surface against which the fluid acts. The movable surface is connected to the output shaft to produce the output motion. With the majority of designs, the angle of rotation is limited to 360 degrees.

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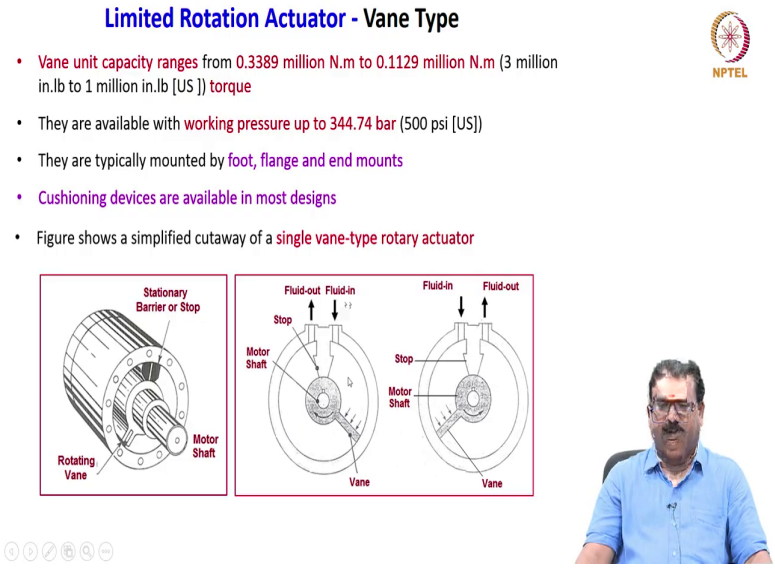

Let us we will see now limited rotation motor; the vane type. Vane unit capacities from 0.3389 million Newton meter to 0.1129 million Newton meter torque. They are available with working pressures up to 344.74 bar. They are typically mounted by a foot, flange and mounts. Cushioning devices are available in most designs; you will see here, I have shown you the simplified cutaway of single vane; the single vane type rotary actuator.

You will see; what is basically consists of here? You will see here in this sketch, here vane which is rotating due to the fluid pressure. And please understand dear friends here the stop is stationary barrier or a stop is provided here. You will see friends; just see the operation here fluid will enter here, then it will acts on the single vane, then it will rotate; direction of rotation you will see; motor shaft.

Then, whatever the fluid after doing rotating the shaft; it will goes out meaning I am achieving here the what is this clockwise rotation. A fluid flow change meaning fluid flow enter here; then it will acts here, then it will rotate in the anticlockwise direction; correct, but stop is provided here please understand this.

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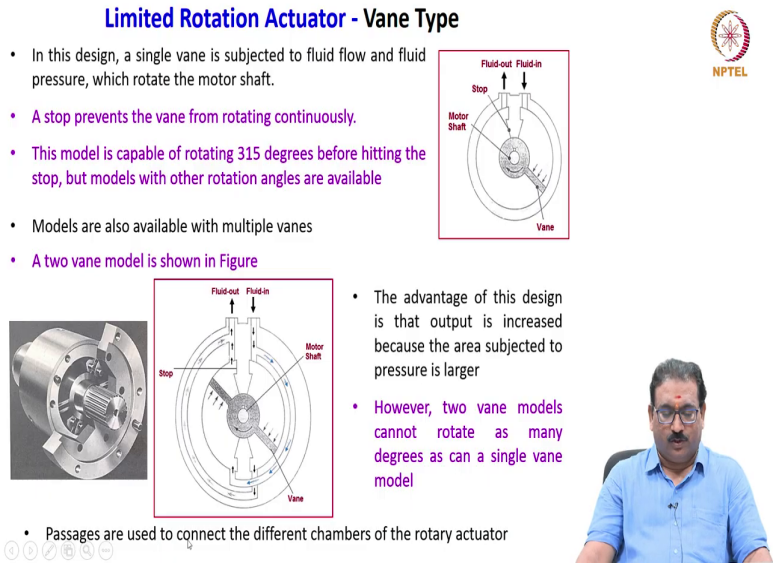

In this design, a single vane is subjected to fluid flow and fluid pressure which rotates the shaft. A stop prevents the vane from rotating continuously. This model is capable of rotating

315 degree before hitting the stop, but models with higher rotation angles are also available in the market. Models are also available with multiple vanes not only the single vanes. Here I have shown you here the two vanes; two vane model I have shown here.

So, you will see the two vanes; the motor shaft, again here a stop. The fluid enters here, enters here; please see here friends how it is? It is acting on the this side; then it will start rotating, then water fluid will go out. If you want a reverse direction, send the flow here; then it will enter from this, then the fluid will goes to outlets.

The advantages of this design is that output is increased because the area subjected to pressure is larger here compared to single vane design. However, two vane models cannot rotate as many degrees as can single vane model. Passages are used to connect the different chambers of the rotary actuators.

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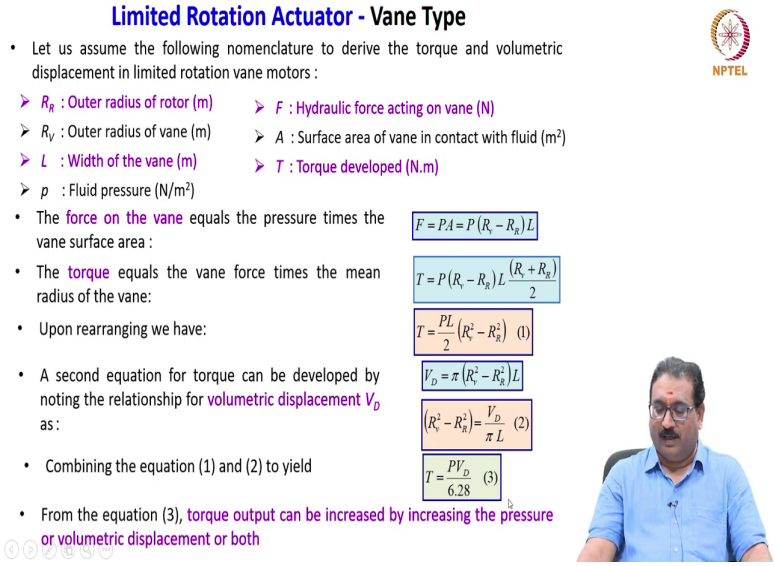

Then, quickly we will see the how to calculate the torque at the displacement in case of the single vane limited rotation motors. Let us assume the following nomenclature to derive the torque and volumetric displacement in a limited rotation vane motors.

R R; I am using outer radius of the rotor which is in meter R V; outer radius of the vane. Similarly L is a width of the vane, p is a fluid pressure; then hydraulic force F on the vane is Newton; A is a surface area of vane in contact with fluid, T is a torque developed.

Let us we will see the force on the vane equals the pressure time the vane surface; either it may be a single vane or a two vane design, you will take here P into A; A is now R V minus R R into L.

The torque equals the vane force times the mean radius of the vane; T equal to the this correct multiplied by R V plus R R by 2 because it is; a you have to take the mean radius. Upon rearranging the terms, I will get T equal to rearrange all the terms here; I will get PL by 2; multiply this two; R V square minus R R square; call this is an equation number 1.

A second equation for torque can also be developed by noting the relationship for the volumetric displacement V D as R V square minus R R square equal to V D by pi L. Then what you will do? Substitute this here, combining the equation 1 and 2; I will get combine these two; meaning we will substitute R V square minus R R square V D by pi L in this equation. After making the manipulations, I will get t equal to P into V D by 6.28 torque.

From the equation 3; torque output can be increased by increasing the pressure; R by the volumetric displacement or both; torque is depending on the pressure, as well as volumetric displacement.

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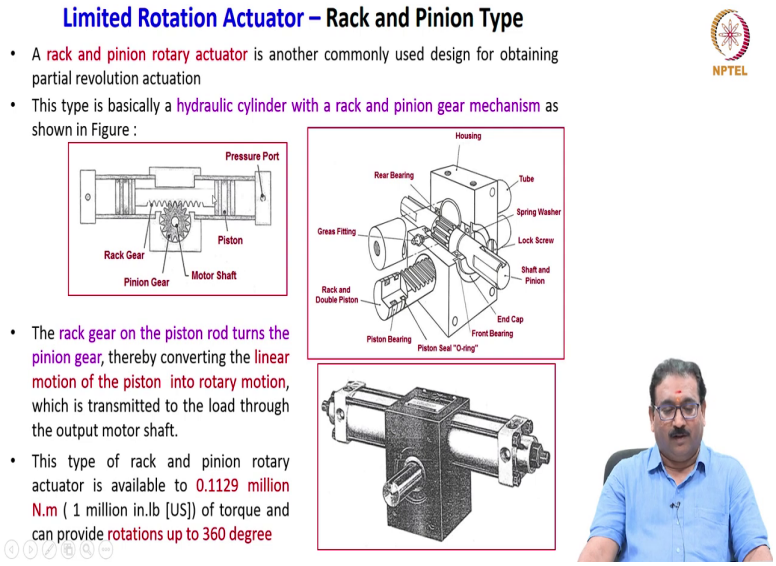

Then one more type, we will see the limited rotation motor rack and pinion type. A rack and pinion rotary actuator is a another commonly used design for obtaining the partial revolution actuation. Here you will see, this type is basically a hydraulic cylinder with a rack and pinion mechanism as shown in figure. You will see here friends; this is a rack correct this is a hydraulic cylinders.

This is a middle one is a pinion which is connected to the motor shaft, this is a pressure port; this is you will see the cut section model and a 3 D view; it is the rack and double pinion correct, here this is a housing.

Then, you will see here this one is a; the what I will call the pinion and this is a commercially available unit it is. The rack gear; the rack gear it is, you will see the rack gear on the piston

rod turns the piston gear based on the fluid inlet into rotary motion which is transmitted to the load through the output motor shaft.

This type of rack and pinion rotary actuator is available to 0.1129 million Newton meter of torque and can provide a rotation up to 360 degrees; meaning you will move this way or this way based on the fluid inlet; meaning what it what happens here? The linear motion of the rack gear is converted into the rotary motion of the pinion which is connected to the motor shaft very simple principle it is here.

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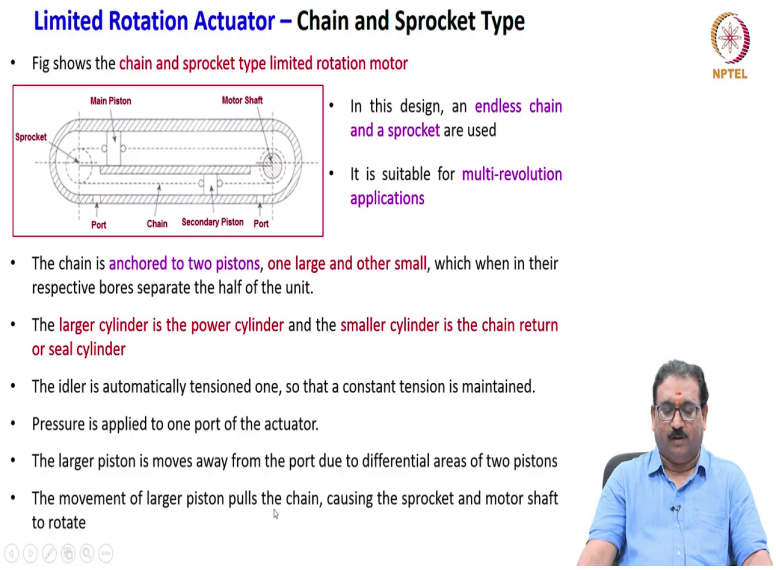

The another type one is there chain and sprocket type; here figure shows the chain and sprocket type limited rotation motor, you will see here friends this is a chain and this is a main cylinder which is a larger one and this is a secondary cylinder then this is are the two ports, this is a motor shaft and this is a sprocket.

Let us we will see; in this design an endless chain and a sprocket are used. It is suitable for multi revolution applications. The chain is anchored to two pistons, we will see here; one larger and other smaller which when in their respective bores, separates the half of the units. The larger cylinder is the power cylinder and the smaller cylinder is the chain return or a seal cylinder.

The idler is automatically tensioned one, so that a constant tension is maintained. Pressure is applied to one port of the actuator. The larger piston is moves away from the port due to differential areas of the two pistons.

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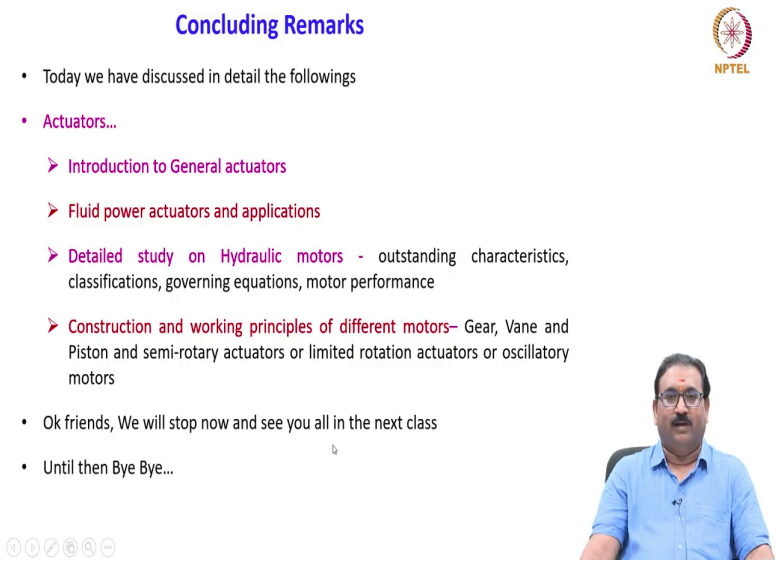

The moment of the larger piston pulls the chain, causing the sprocket and a motor shaft to rotate ok. Now, we will conclude from the today's talk; today we have discussed in detail the followings.

Actuators; started with introduction to general actuators, fluid power actuators and applications, detailed study on hydraulic motors; outstanding characteristics, classifications, governing equations and motor performance in terms of volumetric efficiency, mechanical efficiency and overall efficiency.

Also we discussed, construction and working principles of different motors; gear motor, vane motor and a piston and a semi rotary actuators or a limited rotation actuators or oscillatory motors ok. Friends, we will stop now and see you all in the next class; until then bye bye.

Thank you one and all for your kind attention. [FL].