Upstream LNG Technology
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Lecture – 16
Flow Measurement in Natural Gas- II

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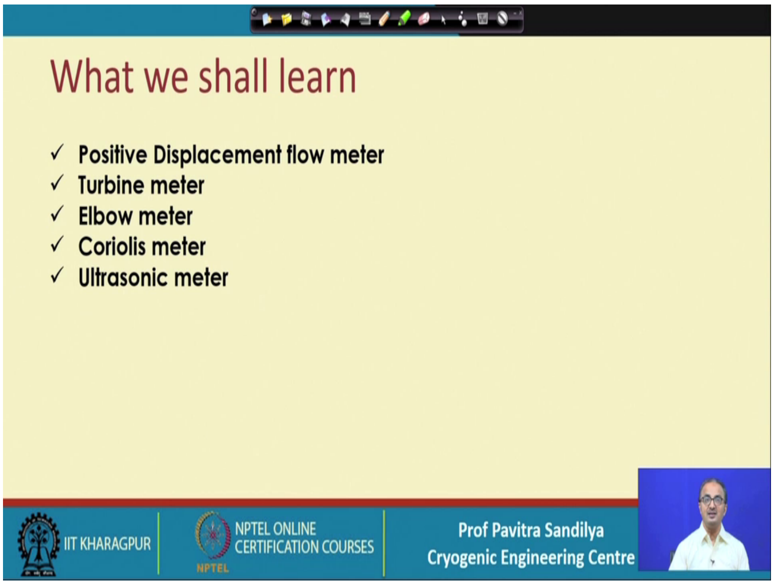

Welcome, today we shall see the second part of Flow Measurement of the Natural Gas systems. In this case, as I told you in the last lecture that we shall be covering many meters; in this particular lecture, we shall be looking into the rest of the meters which are used for the flow measurement. In this first come a positive displacement flow meter, turbine meter, elbow meter, coriolis meter and ultrasonic meter.

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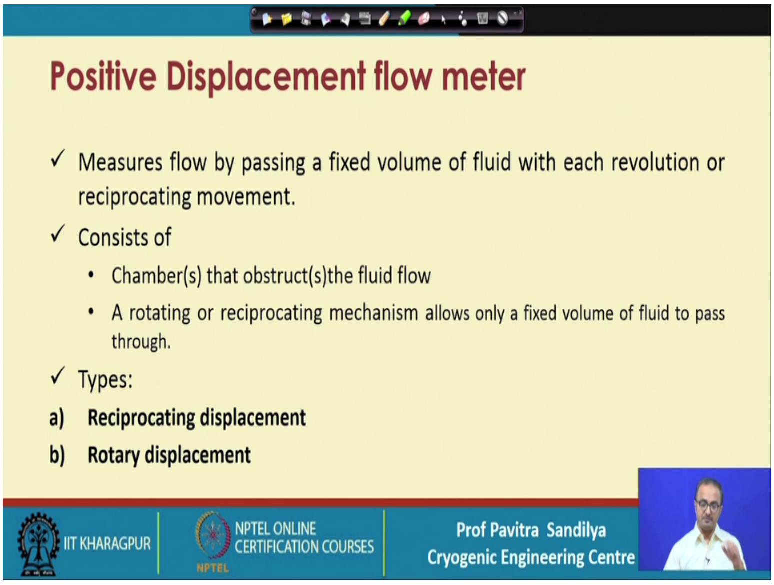

So, first let us look as positive displacement flow meter. What it means is this, positive displacement means that a particular fluid is displaced in a positive manner that means pushed ok. So, this metering depends on that a particular volume a specific volume of the fluid is passed through some device either by some rotation or by some kind of twisting action. Accordingly we have reciprocating or we have some revolution by rotating positive displacement meters.

Now, what it in general what it consists of? It consists of one or more chambers, and then that obstructs the fluid flow. Obstruction is always needed because we want to measure some delta p. And the rotating or reciprocating mechanism that allows a specific volume of the fluid to pass through. And in this we have two types of positive displacement flow meter; one is reciprocating displacement, another is the rotary displacement. Reciprocating meant, it will go to and flow that is reciprocating; and rotary means it will be rotating over the shaft.

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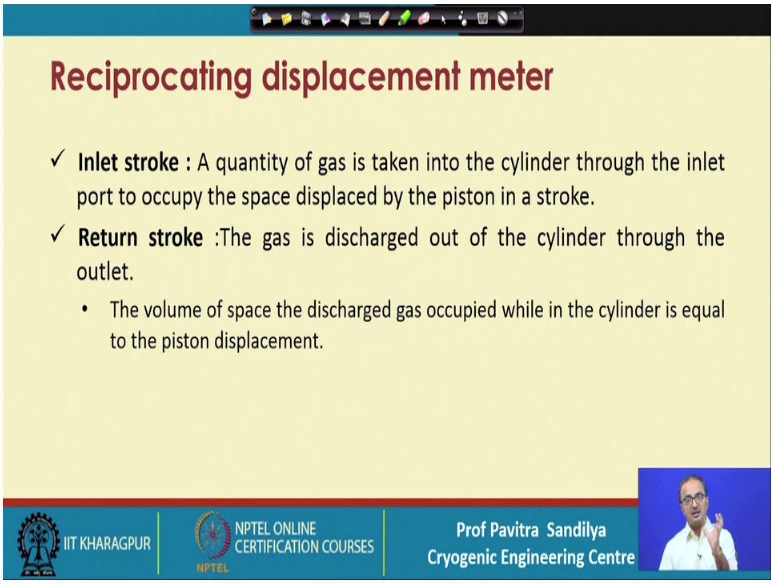

So, first we come to the reciprocating displacement meter. In this we have an inlet stroke, during which what happens the there is some inlet port and outlet port in the meter; so the inlet port opens up, the outlet port closes. And during this inlet stroke the metering meter will be sucking in some amount of the particular fluid in the inside the chamber.

And there is a return stroke during which the outlet port will open, the inlet port will close and whatever fluid was sucked in during the inlet stroke will be again pushed out from the outlet port, so these are return stroke. So, whatever displacement of the particular piston takes place, so that is the amount of the fluid that is going inside the chamber. The volume of the space discharged gas occupied, while in the cylinder is equal to the piston displacement. So, whatever the displacement of piston that will decide the amount of the gas that is going inside.

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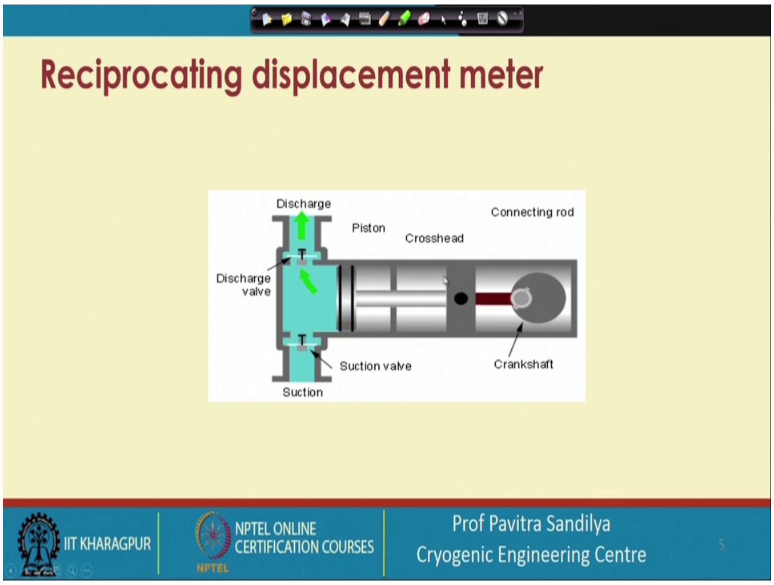

And this is the general working of the piston flow. As you can see that it is being sucked in first, the pistons going back is sucked in; and this is going out to the discharge when the piston is moving back. And when this is sucked in, this port is closed; when this is going out, this port is closed and that is how this particular reciprocating displacement meter works.

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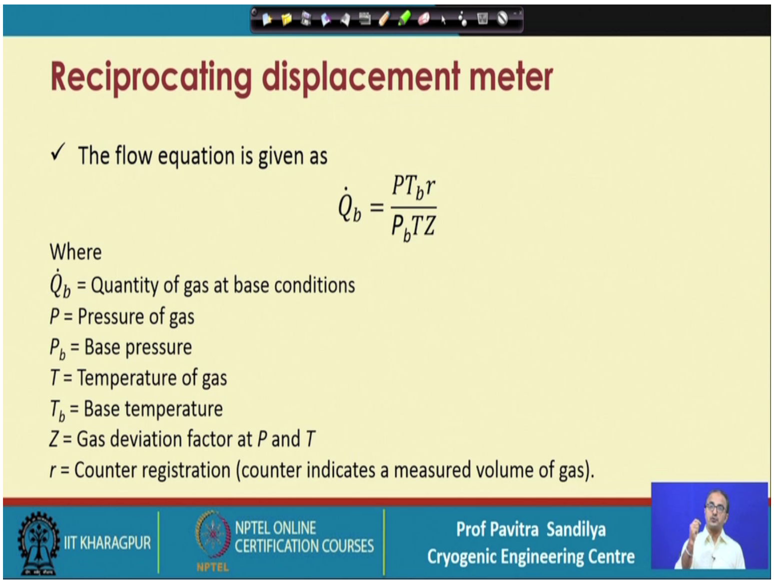

And this is the equation proposed to find out the volumetric flow rate to a reciprocating device. In this we have the pressure with the temperature and P b is the base pressure, T b is the base temperature, and r is some kind of counter registration. What it means that it counts the number of strokes per unit time. So, depending on number of strokes it will give me that how much fluid has passed through, so that number of strokes is counted, so that is what the r represents.

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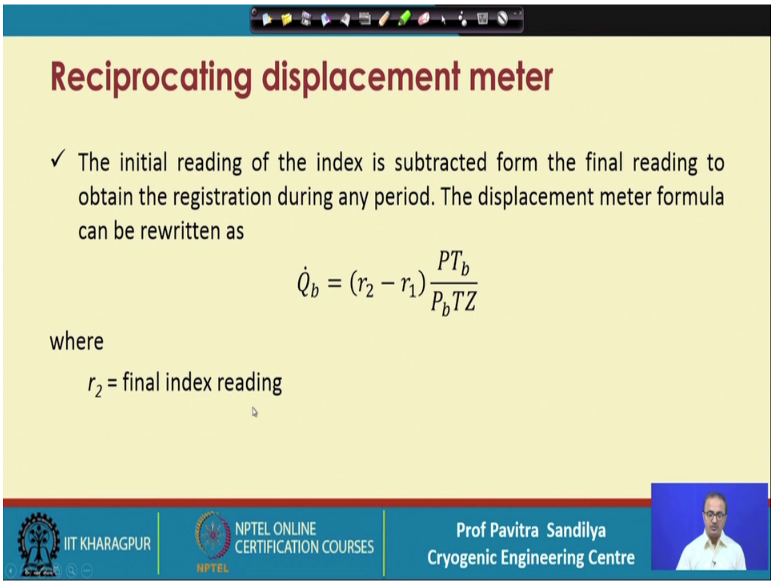

Now, the what we do in our application like we note the initial reading of r and then the final reading of the r and then we if we subtract the final from initial from final, we will get sorry, final from initial we will get the flow rate. So, this is what was done that r 2 is the final reading of the rotation; and r 1 is the initial registration and this we do to get the flow rate. So, this is the index reading.

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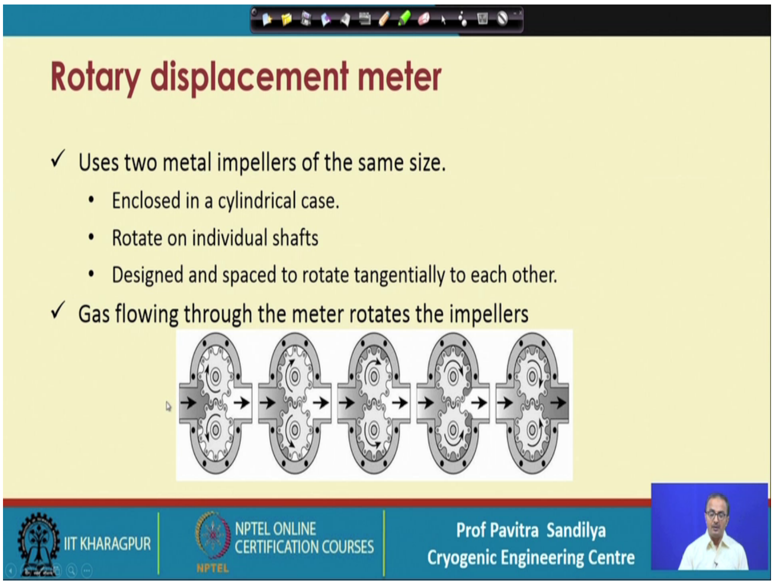

And then we come to the rotary displacement meter. In this case we as I told you that we have some rotary element which is put on a shaft. Here we see that how the rotary takes place that there are first there are two metal impellers over here. So, these impellers keep rotating in counter way. So, this is rotating in a clockwise manner; and the lower one rotating as anticlockwise manner. And what happens as is as you rotate what happens that this fluid is sucked in. So, this is getting sucked in through these this chamber and this chamber and this is the enclosure within which this particular rotating elements are enclosed. So, this fluid goes in and we can see that how the fluid path is getting inside this chamber, and ultimately the fluid comes out to the output chamber.

So, the fluid is sucked in and this is going out. So, this is the way this particular rotary displacement meter works. So, it is something like the rotary pumps we have and the amount of the gas flowing through will be rotating this impeller that means, the more the flow rate, the more will be the rotation of these cylinders. So, all this of this rotating elements.

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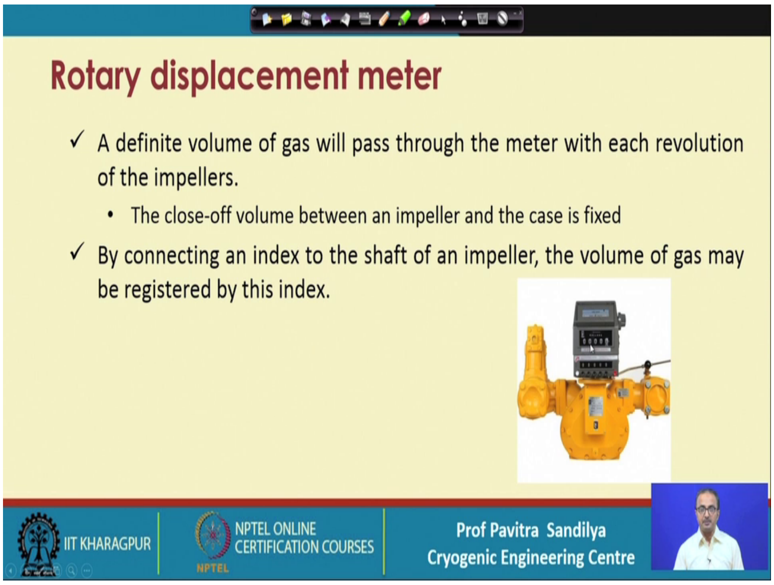

Now, if some specified volume of the gas will pass for each revolution on the impellers ok, so the close-off volume between the impeller case is fixed; close of volume means the volume that is enclosed between the these impellers and this particular chamber. This volume is fixed, fixed by design. So, whatever so depending on the fluid and fluid flow rate, this number of turns will keep on changing to accommodate the particular volume inside this spacing between the impeller and the casing. And by connecting this index of the shaft of the impeller, we can find registered read out the index as shown in this particular figure. Here we read out that how many revolutions have taken place.

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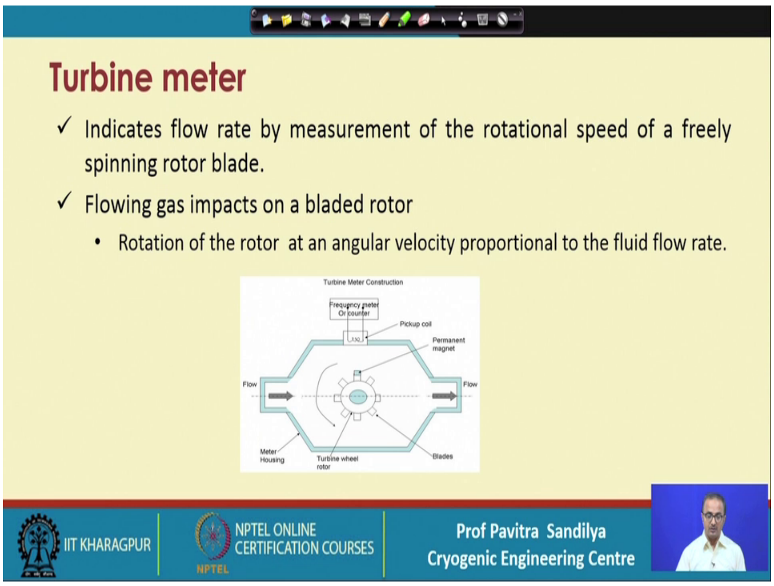

Now, the turbine meter indicates the flow rate that is measured by the rotational speed of the freely spinning rotor blade and here we can see that as the flow takes place, this turbine rotates and this turbine rotation is a function of the flow rate. So, this is different from the rotary displacement meter, because there some particular volume of the things rotating the two impellers, and turbine meter also rotating. And this rotation of this spinning blade is there, the spinning blade is dictated by the flow rate. So, the flowing gas, this flowing gas impacts the blade and the frequency of this movement of this free moving wheel is noted and correlated with the flow.

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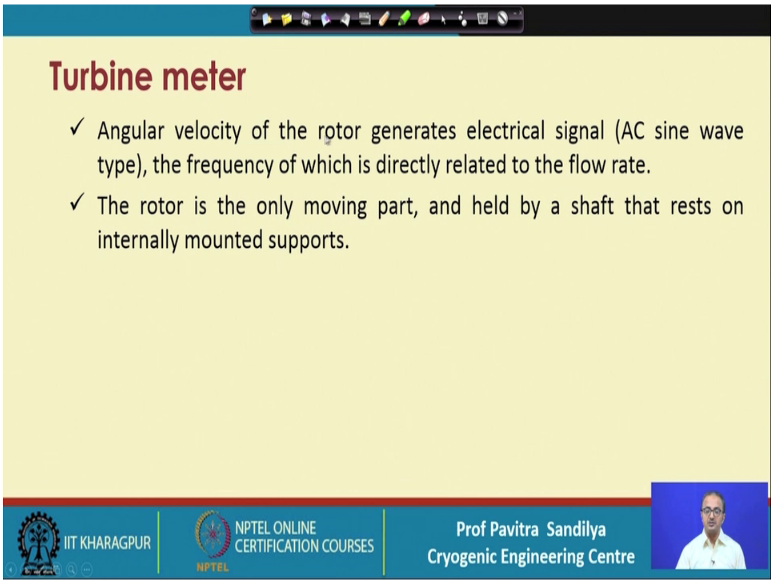

Here we see that angular velocity of the rotor generates some kind of electric signal that is AC signal which is related to the flow rate and the rotor is the only moving part here, and this is held by a shaft on an internally mount this support.

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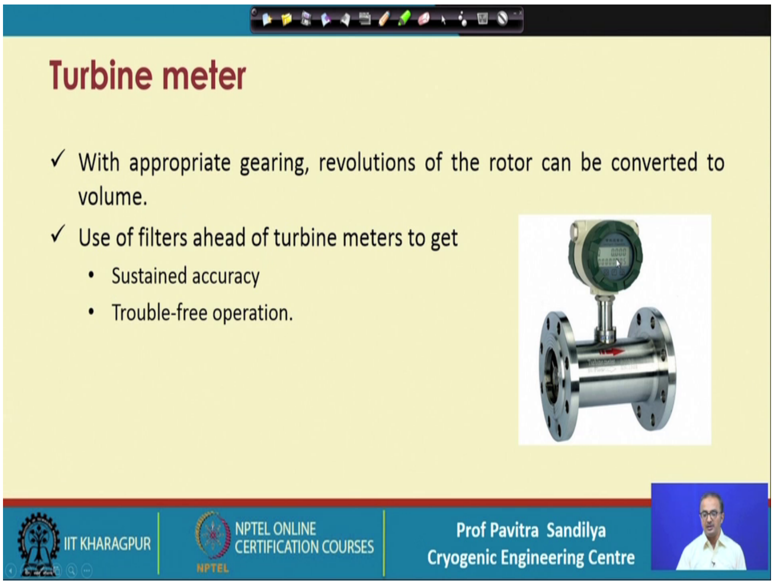

And with appropriate gearing arrangement, the rotation the revolution of the rotor can be converted to the volume of the fluid passing through the meter. Some kind of filters are filters to reduce the noise and to get better accuracy and trouble-free operation are used before the turbine meter. So, here we have shown a typical turbine meter which gives some reading in this particular recording device.

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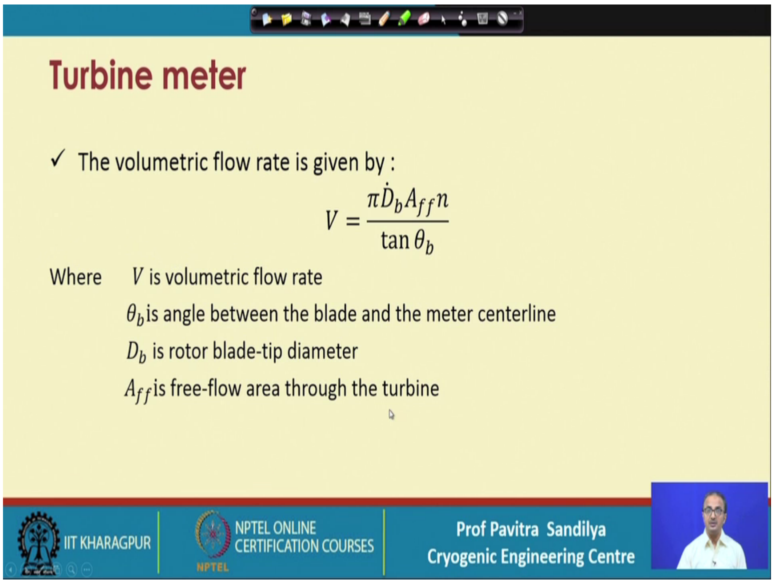

The volumetric flow rate through a turbine is given by this particular thing. In this case the V is the volumetric flow rate; theta b is the angle between the blade and the meter centerline; D b is the rotor blade-tip diameter; and A ff is the free-flow area through the turbine.

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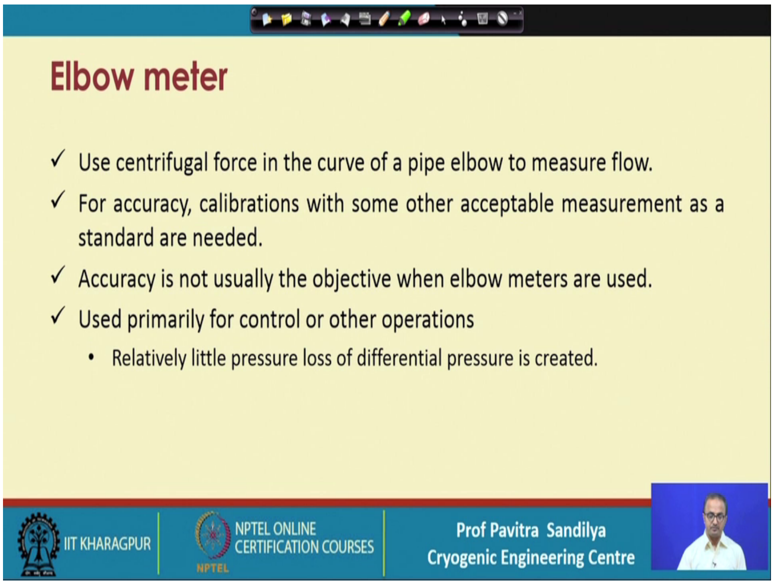

Next, we come to elbow meter. The elbow meter works on the basis of the centrifugal force.

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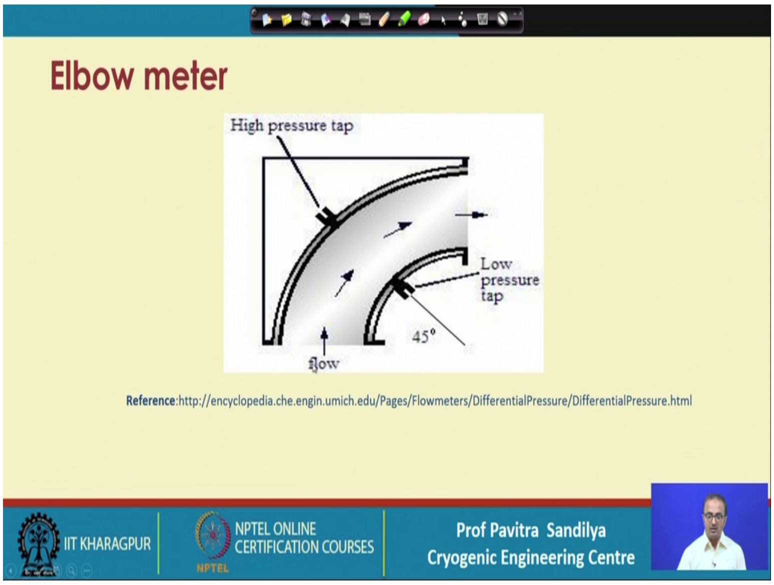

Elbow meter we know that it looks like this that here the flow takes place, and it goes through a curvature. And whenever it is a curvature effect, there will be some kind of a centrifugal force. And the centrifugal force will be changing along this diameter. Now, if there is some kind of a center of these radius and we can see that omega square r is the acceleration, so at this inner and outer radii, we find that there will be a difference in the pressure. This is something like that whenever we are taking or riding on a curved road, we find that we are being pushed out. And this is due to the centrifugal force and the same principle is used in the elbow meter that there will be a difference in the pressure at the inner and the outer radii and this delta p is measured by some appropriate gauge. So, this is the principle of the elbow meter.

And for accuracy, then it needs to be calibrated. And it is not a very highly accurate flow meter. So, when we do not need a very high accuracy of the measurement, we go for such kind of an elbow meter. And it is primarily used for control and other operations and it gives a relatively less pressure loss.

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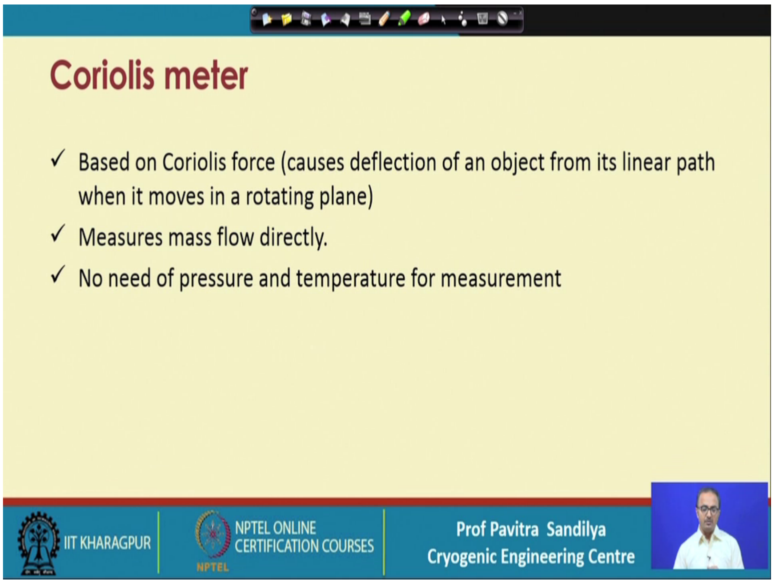

Next, we come to Coriolis meter and this Coriolis meter is based on the Coriolis force. Now, Coriolis force is something like a centrifugal or centripetal force. We know that this centrifugal, centripetal force come into action only when there is a rotating action. Similarly, the Coriolis force also comes into picture whenever there is not only rotation, but also a linear movement that is how it is different from centrifugal force, because in centrifugal force the body over which this force is acting remain stationary.

But, on the other hand, in case of Coriolis force, the body over which this force is acting will be also moving linearly and generally this is found in many ways in our day-to-day life. Suppose, we have those in our path, we find some kind of may be go round plate which rotates over which some children play, and they run around. We see that although that can rotating plate if we start walking from inside to outside or outside to inside in the linear path, we will find that we will experience some deflection from our linear path. This linear deflection is caused by the Coriolis force which is and this force is obtained by have a cross product between the rotational speed and our linear velocity. So, omega cross V, omega is the rotational speed; and V is the linear velocity of the object this gives us the Coriolis force.

So, this force comes into picture in many other ways also like for example, whenever the ships are going over the sea, whenever they are crossing latitudes, so we will find that their distance from the axis of rotation of the earth also changes. And due to which they will be experiencing different rotational acceleration and that will cause a some deflection from their linear path.

So, in various manner all the planets are experiencing this Coriolis force. Every many objects whichever is on a rotating train moving linearly will have this kind of Coriolis force. So, this force is an apparent force that causes deflection of an object from its linear path when it moves in a rotating plane. So, this particular principle is used for the measurement of the flow rate using the Coriolis meter. And it measures the mass flow directly that means it does not create any kind of rest pressure flow restriction to create a delta P. So, it will and it does not need the measurement of the temperature, pressure, it is just makes some kind of an action as we shall see later by which it will see that how much deflection takes place in the meter to measure and that deflection is correlated with the mass flow rate. So, as I was telling it does not need any measurement of the pressure and temperature.

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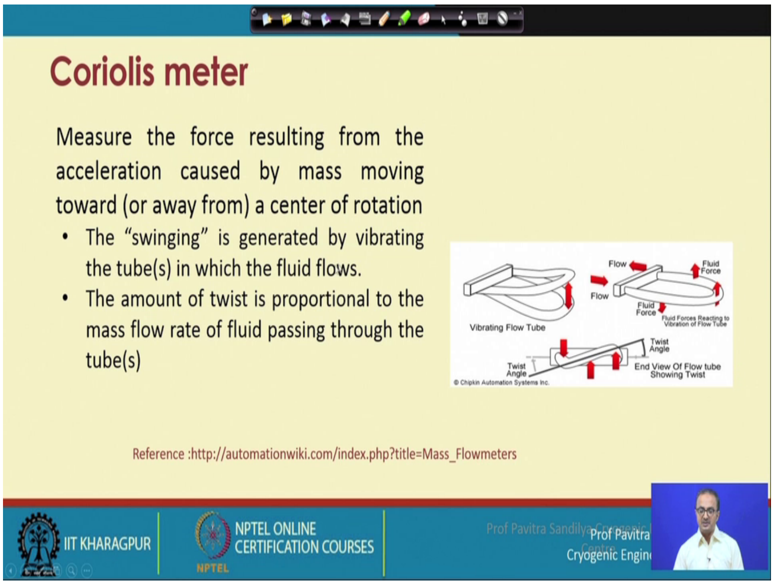

And here we see in the figure that how this works that if there is some kind of fluid takes place of we may measure the force resulting from the acceleration caused by the mass moving toward or away from a center of rotation as I explained you a while back. And with there is this pipeline is there, and this pipeline through which this flow is taking place. So, this particular element of pipeline is given this kind of a motion. So, this motion and it will cause a twist in the pipeline. The flow velocity of this particular fluid and this vibratory motion of this pipeline will cause a twisting in the pipeline and this twisting will be a function of the flow rate. The more the twisting action it will indicate that the flow rate is higher. So, this twisting action is measured and correlated with the flow rate and that is how we use the Coriolis meter.

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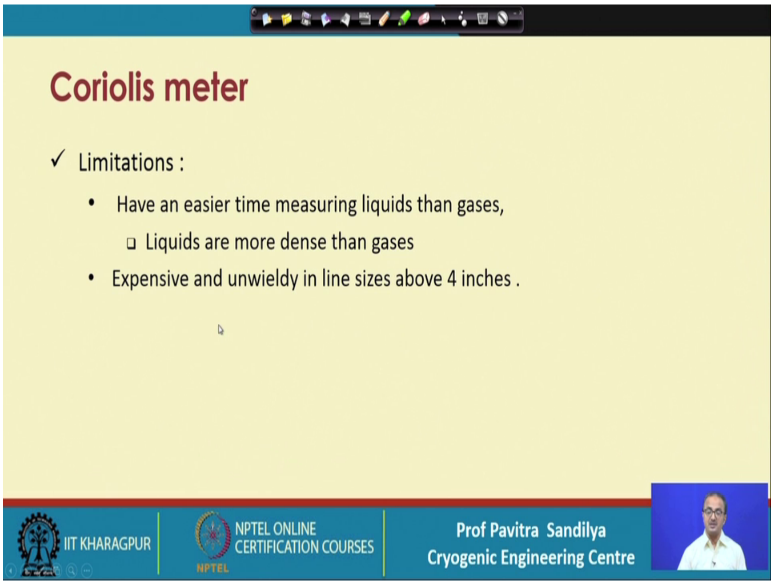

So, in a way, it is very good that it measures the mass flow rate and does not depend on the temperature-pressure, but it has some limitations and that is why it is not used so frequently in the industries. The limitations are that it has an easier time measuring liquids than gases means the liquid flow rates can be measured more easily than the gases. Why, because the liquids are denser than the gases.

However, it also is very expensive, and it is unwieldy in line size above 4 inches. So, it is become difficult to install this kind of meter for any big diameter pipelines and it is quite expensive , so that is why this kind of Coriolis meter is not so popular and as we learnt in our previous lecture orifice meter is the one which finds the most of its use and later the turbine meter, the positive displacement meter all these things also come. Coriolis meter is the only meter that can give us the flow mass flow rate unlike the other pipelines which measure the volumetric flow rate; but because of its some limitations, it is not so popular in the gas industry.

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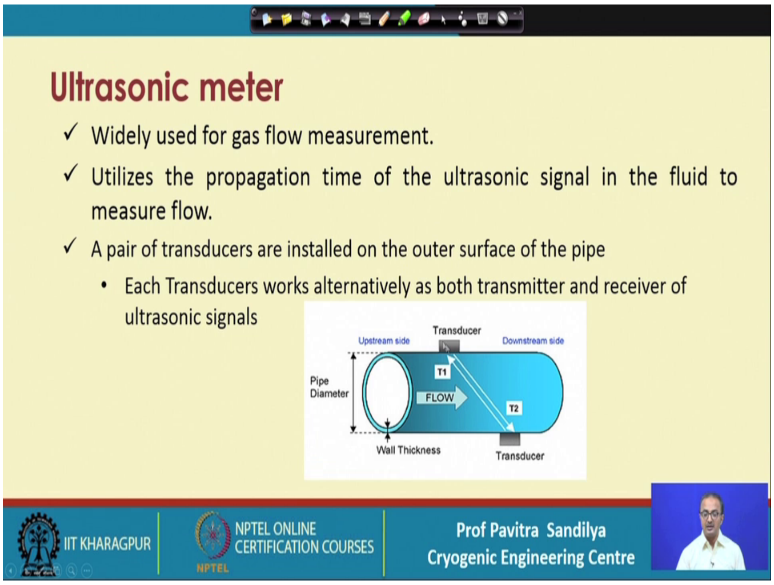

And lastly we come to the ultrasonic meter. As we said that this is the very widely used for gas metering and it utilizes the propagation time of some ultrasonic signal through the fluid. And this is how it is that some fluid is moving and we have some kind of transducer; transducers which are generating these ultrasonic waves through the fluid. And these waves are these transducers are installed at the outer surfaces of the pipeline. So, each transducers work alternately as both transmitter receiver that means once it will throw the signal, it will receive and next time it will throw the signal and the this one will receive.

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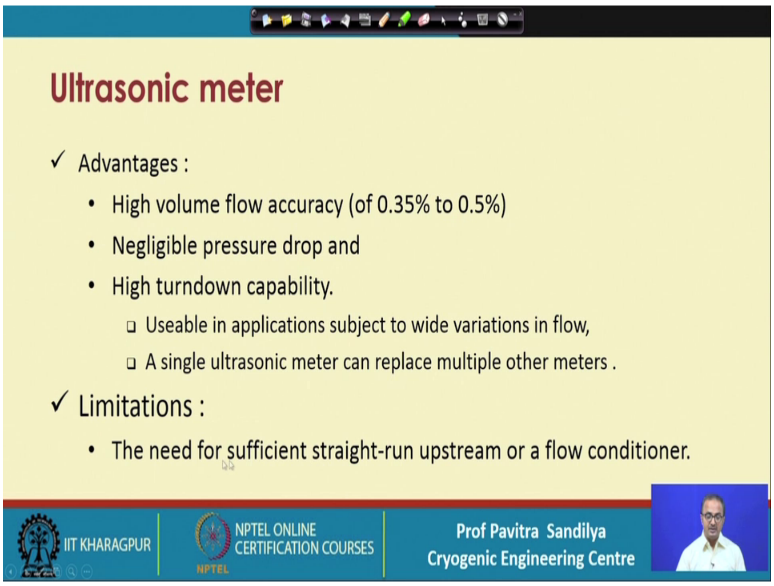

And these are measured and correlated with the flow rate that means, the time of the time lag between the generation and reception of the waves is measured. And it has many advantages like it can have very high accuracy like 0.35 to 0.5 percent accuracy and it does not cause the pressure drop, because it is not putting in restriction on the flow path. And it has very high turndown capability; that means it can handle a wide range of flow rates. So that is why it can be used for wide variations and a single ultrasonic meter may be replaced by multiple other meters.

And the limitations are that it needs sufficient straight-run upstream of a flow or a flow conditioner. The flow conditioner means that it will condition it will try to manipulate the signal generated by these meters so that they can be read, so that it needs a flow conditioner and it needs a long length of pipe on the upstream side of the ultrasonic meters.

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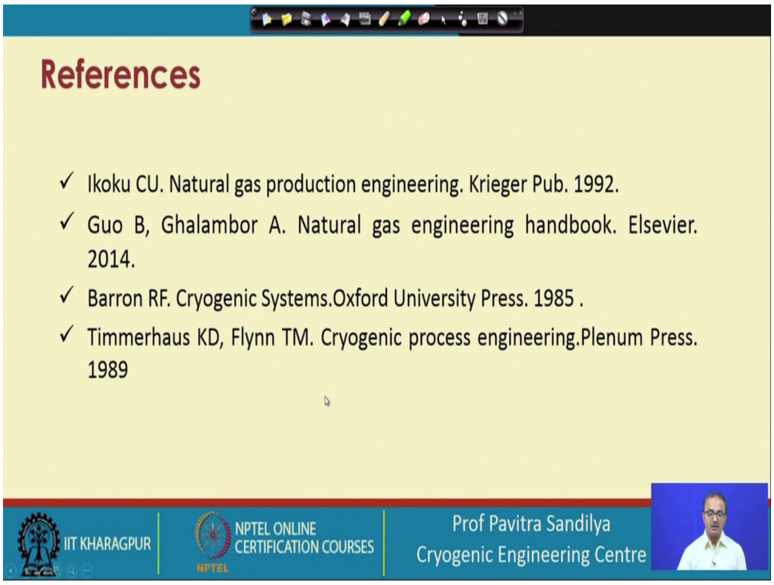

And these are the references from which these materials have been taken and there are many other books some handbooks on the flow metering devices which you might refer to get more detailed knowledge about the flow meters, but mind it the flow meters shown in these two lectures are pertaining to those used in the natural gas industries.

Thank you.