Chemical Process Instrumentation
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Lecture – 02
General Principles and Representation of Instruments (Contd.)

We have a general introduction to Chemical Process Instrumentation in lecture 1.We talked about motivation, we talked about why should we measure, we listed the names of the different chemical process variables that will be interested in and measuring instruments for measuring those variables will be covered in this lecture. So, let us start with lecture 2.

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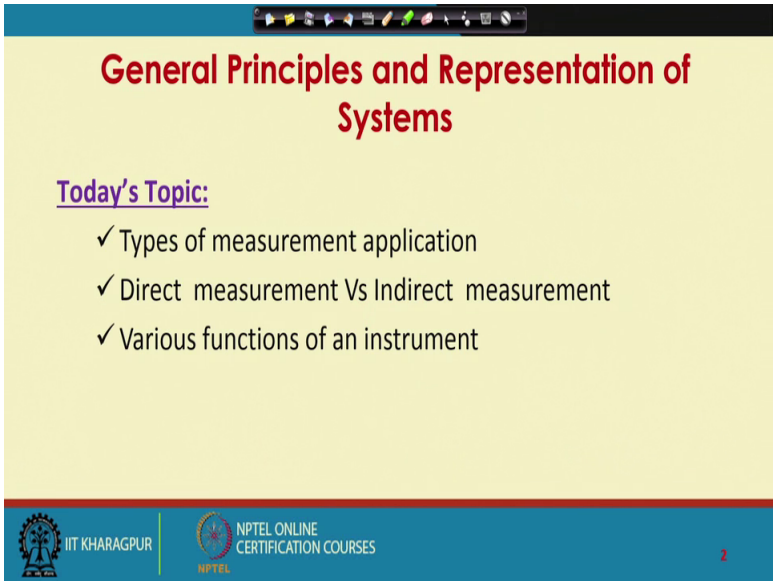

So, today's topic will be types of measurement applications here essentially we will be trying to figure out can we classify, all the measurement applications into a limited number of categories. So, people measure with various purposes. So, is it possible to classify those requirements? So, what are the different types of measurement applications, we will try to see in the first in today's lecture. Next we will talk about direct measurement versus indirect measurement and we will be talking about various functions of an instrument?

The primary job job of an instrument used to measure a process variable, but while doing. So, it serves several functions. So, we will try to list those different functions for an instrument.

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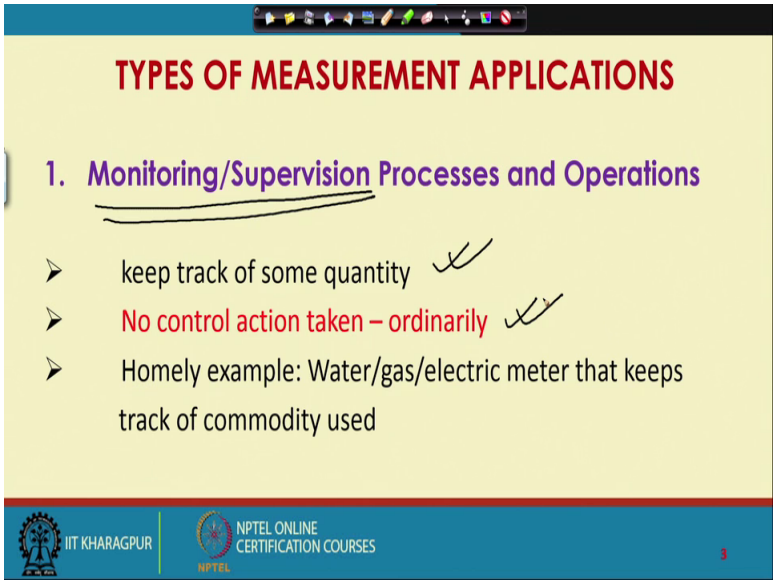

Now, let us start with types of measurement applications, the first measurement applications is monitoring or supervision of processes and operations. Please note this term monitoring or supervision of processes. As a name suggest you only monitor the process you do not control the process a process is going on several measuring instruments are placed in the process. So, there either indicating or they are giving you signals about the measure quantities you are monitoring those process variables. Suppose your monitoring what is the temperature in the top of the distillation column what is the liquid level in the reboiler the distillation column.

So, this information's can be monitored at the site of measurement or you can also be monitored sitting in the control room. So, they can be various types of instruments which can locally indicate the values of these measured variables at the site of the measurement or there can be instruments, which will be sending out the signals about the measure medium to the control room and sitting at the control room you will know what is the temperature what is the pressure what is the flow rate in different process units in your industry.

So, monitoring means keeping eye on those process variables, so essentially it keeps track of some quantity no control action is taken ordinarily because that is another different kind of application. Monitoring by itself is a class of application and home homely example will be say your water meter or gas meter or electric meter. So, these meters keep track of the commodity that we have used.

So, electric meter keeps track of the amount of electricity that you are consuming it does not tell you now immediately or while you are using that you are using more or using less it simply monitors it. So, monitoring is keeping an eye on the various process variables in your industry a control action usually will not be taken for the monitoring purpose.

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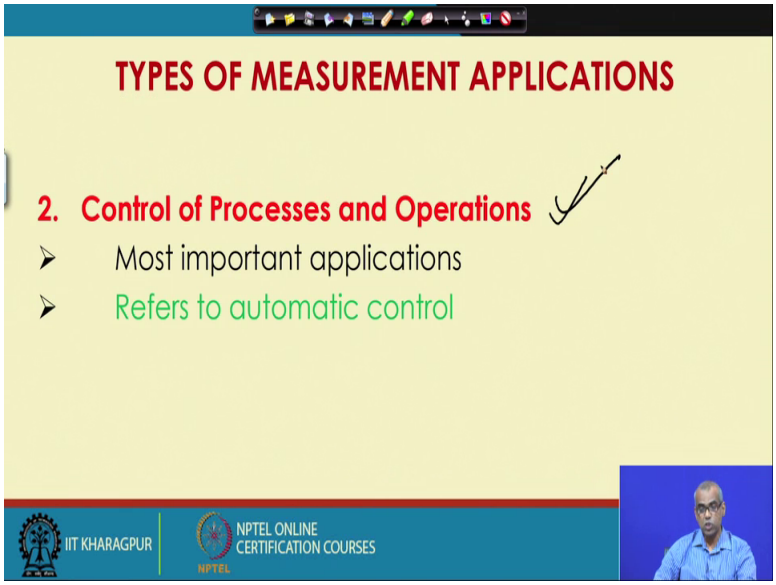

So, next comes control of process and operations. So, the first one was also monitoring the next is which is most important application and refers to automatic control of processes is control of process operations. So, here you not only monitor you actually take corrective actions. So, it is the most important applications and refers to automatic control of the process. So, let us take an example to know more about it.

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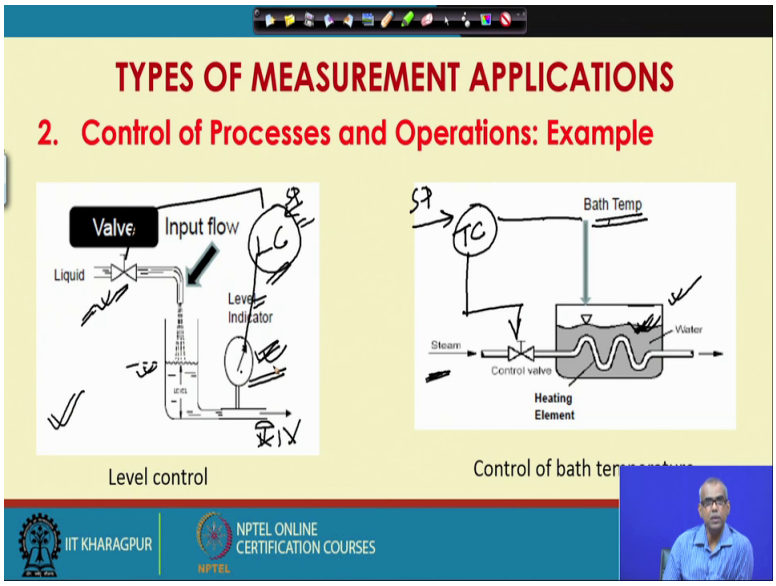

So, this is a level control example this is level controller example we have shown a slightly different schematic in lecture 1, imagine a liquid level is coming in to this tank and is goes here. You can control the level of the liquid in the tank either by manipulating the flow rate here or by here; here we do not have any such valve so will be controlling the level of the water in the tank using this.

So, the first information that is required is what is the level at current time. So, you need a level indicator. So, the level indicator receives information about the level and it sends it to a level controller and the level controller can in turn send signal to this control valve to open more or close more depending on the requirement, such that the level of the liquid in this time is at the desired level.

So, this is the control low level indicator first receives information; information goes to level controller the level controller has set point information said about the desert level, comparing these 2 signals level controller sends appropriate signal to the control valve to open more or to close more or do nothing depending on the requirement such that the level in the tank remains at desired level.

Another example is control of bath temperature. So, we are talking about water bath here there is a steam coil passing through this water bath by controlling or manipulating the steam flow rate I can control the temperature of the water in the water bath . So, the purpose here is to change or manipulate the steam flow rate. So, that the temperature of

the water bath remains at desired level. So, the first information that is required is the bath temperature at current time. So, once we have the bath temperature at current time we can send this signal where temperature controller.

The temperature controller will have the set point fed to it temperature controller will compare the current bath temperature with the set point bath temperature and if these 2 are not same temperature controller understands a corrective action has to be taken accordingly temperature controller will send the signal to this control valve to open more or close more. So, that more steam is allowed to pass through a list in is allowed to pass through and the temperature of the controller temperature of the water bath is maintaining a desired level.

So, we can have will at this stage we have some rough idea about the different control loops. So, what is see that in a controlled loop different elements can be indicated as follows first stage a sensor or the measuring instrument that measures level in case of level controller a sensor that measures temperature in a temperature control example so on and so forth.

Then that signal goes to a controller; the controller will be level controller for level measuring level control example, it will be a temperature controller for temperature control example. The controller will have a say point fed to it sometimes the signal from the measuring instrument goes to something call comparative and the comparative compares the measure signal with the set point signal and sends the error signal to the controller. Then depending on the error signal which is the difference between the desired set point value and the current value of the process variable controller will decide what is to be done what control action has to be taken.

Accordingly it will send the signal to the control valve or actuator which will implement the decision taken by the controller. So, the basic components that are involved in the control room is sensor then comparator controller then actuator. So, sensor first senses the information about the system being controlled controller takes the decision about what has to be done to the process. So, that control of variable is achieved and actuator will implemented the decision. So, this is true for whether you are talking about level control or whether you are talking about temperature control, this is in general is the

principle of feedback controlled loop why feedback because the information about the medium which is being controlled is being fed for the purpose of control.

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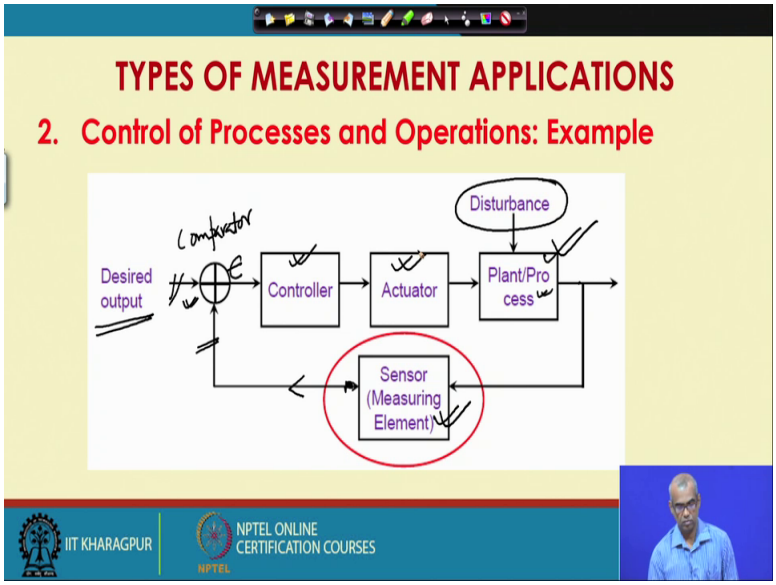

So, if I now put this into a formal what do you call is as block diagram it will look as shown in the slide this is the process which I want to control let us say this is the water bath whose temperature I am trying to control.

Let us say this is the whatever whose temperature I am trying to control, let us say the temperature I want to maintain at 40 degree Celsius. In a real process in a real process there will be many disturbances which will try to take the temperature away from the said point. Because if there is no disturbance you perhaps may not need a control action because there will be dispersed disturbances and the said point has to be maintain for all time we need a controller in place. So, we first measure the information about the process using a sensor. So, for the water bath temperature control we measure the temperature of the water bath by a temperature measuring instrument this is called sensor. Then this signal this signal will go to the comparative this is the symbol of a comparator the comparator as set point about the desired output.

So, desired temperature 45 degree Celsius this arrowhead should be this side this comparator finds the difference between this signal and this signal and the error signal which I can represent using epsilon is spread to the controller. So, controller decides what is to be done and the decision of the controller is implemented by the actuator

which in case of water bath temperature control is the control wall through which steam is flowing.

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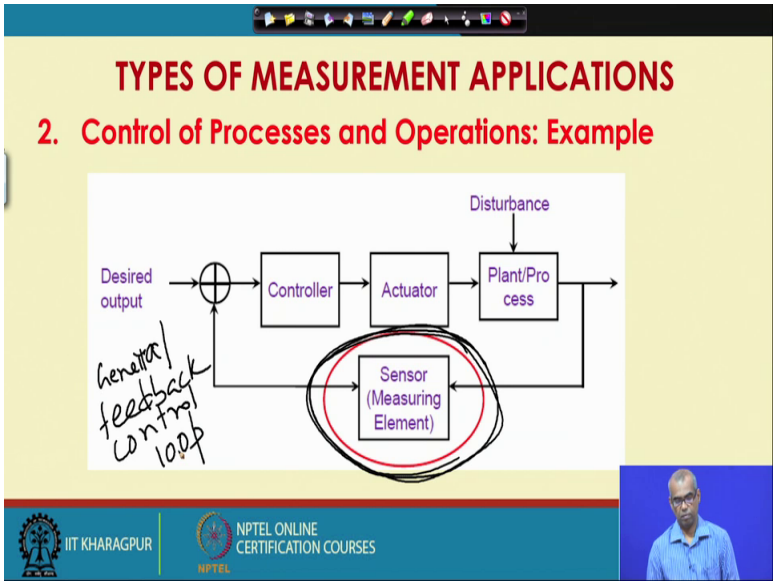

So, in this class we are talking about this part of the process control loop. So, this is an important measurement application. So, the first applications was monitoring or supervision of processes without any control action, second is control of processes or operations and when we talk about control of processes and operations sensor finds a place here in this general feedback loop. So, this is a schematic of general feedback control loop.

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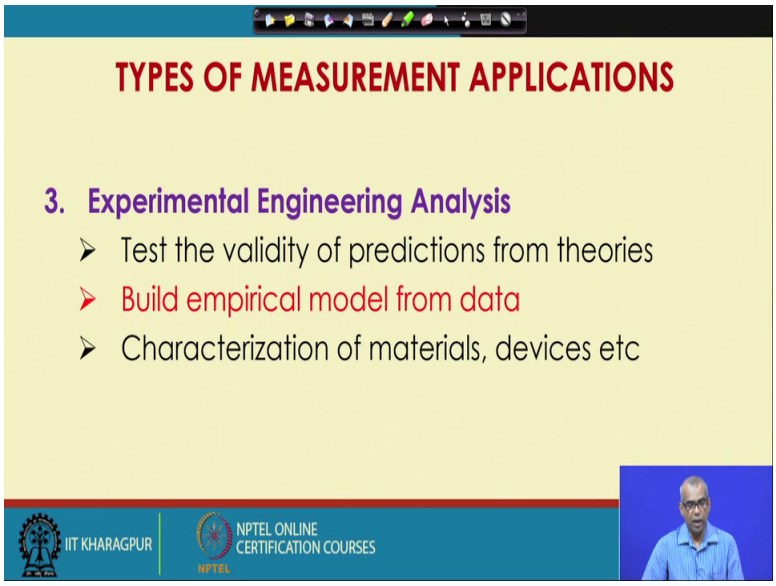

And finally, we have another important measurement application which is experimental engineering analysis. So, measuring instruments produce lot of data and this type of applications is focused towards analyzing those data such that information characteristics about the process can be extracted from the data obtained by various instruments for example, we can test the validity of prediction from theories.

Let's say I am measuring a process variable and I have a theory which has a prediction for that process variable. So, I can measure a process variable with an objective to validate the prediction from theories. So, this is one application we can build empirical model from data, this is another very important experimental engineering analysis. We have now several measuring instruments very sophisticated measuring instruments and they produce lot of good quality data.

Now these data can be used to build predictive models please note that it may not always be possible to build a model based on first principles; that means, using the principles of conservation of mass energy and momentum, but the systems with a data reach and for the systems for which we do not have much understanding it is possible to relate the output and the input from the data obtained. So, empirical models can be developed from such data a good example will be building neural network models from the data obtained from various process industries.

Characterization of materials and devices; characterization of materials and devices so, you can measure with an objective to characterize the material. So, you want to know, what are the different properties of the materials? So, characterization is an important aspect of measurement.

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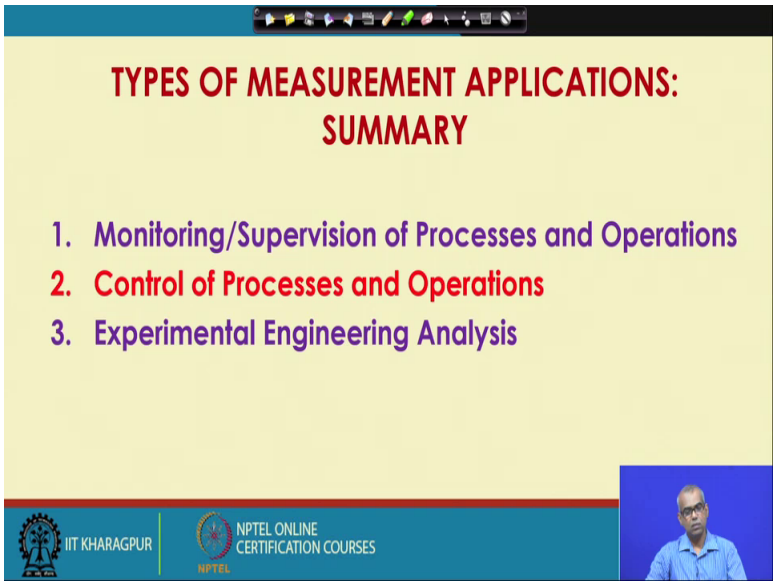

So, in summary we have 3 different types of measurement applications first is monitoring or supervision of processes and operations, second is control of processes and operations which is one of the most important applications of sensors and third is engineering analysis which is also extremely important these days. Because particularly there are many complex systems which we do not understand properly, but with the advent of more and more sophisticated instruments we can have lot of data about the process and it is possible to build empirical models such as neural network models for predictions of such processes.

Now, let us talk about direct measurement and indirect measurement. So, broadly we can classify the measurements into 2 categories direct measurement and indirect measurement as the name suggest indirect measurement you measure the quantity directly. So, you determine the value of the quantity or measuring directly. So, it does not involve any supplementary computations or steps the measurement or the determination of the variable is direct. In case of indirect measurement we measure a quantity which is

related and then infer the value of the measurement from this measurement of related quantity.

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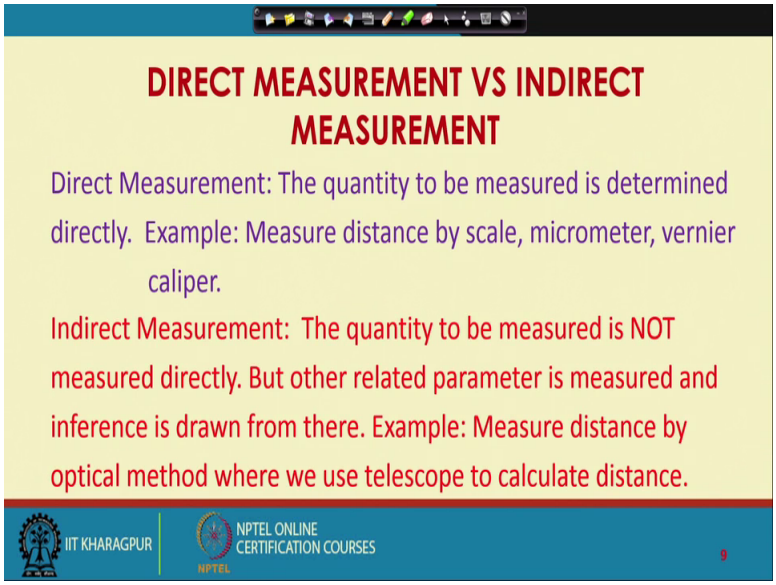

So, direct measurement the quantity to be measured is determined directly and example will we measure distance by scale micrometer, vernier calipers etcetera. Where is indirect measurement the quality to be measured is not measured directly, but other related parameter is measured and inference is drawn from their example measure distance by optical method where we use telescope to calculate distance. It is like you can use telescope to measure say that height of set a very high mountain, you do not have to take a tape and measure the height of the tall mountain, but what you can do is we can use telescopic observations and make use of simple geometric principles to infer the value of the height of the mountain.

So, this is an example of indirect measurement.

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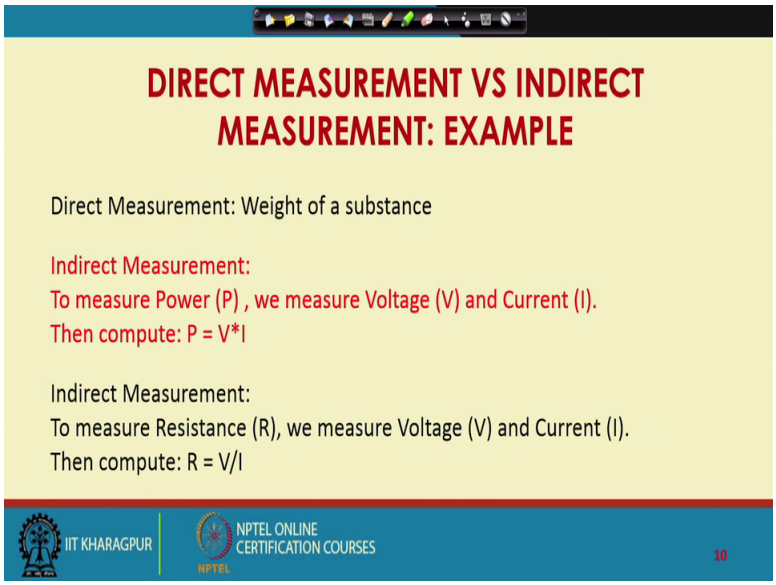

Another example of direct measurement the weight of a substance is always measured can always be measured directly, let us say you are measuring the bacteria count directly under microscope. So, you simply counting the number of bacterias in a colony under microscope should as an example of direct measurement indirect measurement to measure power we measure voltage and current and then computer power as product of voltage and current. Similarly to measure resistance we measure voltage and current and then compute resistance as voltage divided by current. So, the measurement of power and measurement of resistance is indirect measurement.

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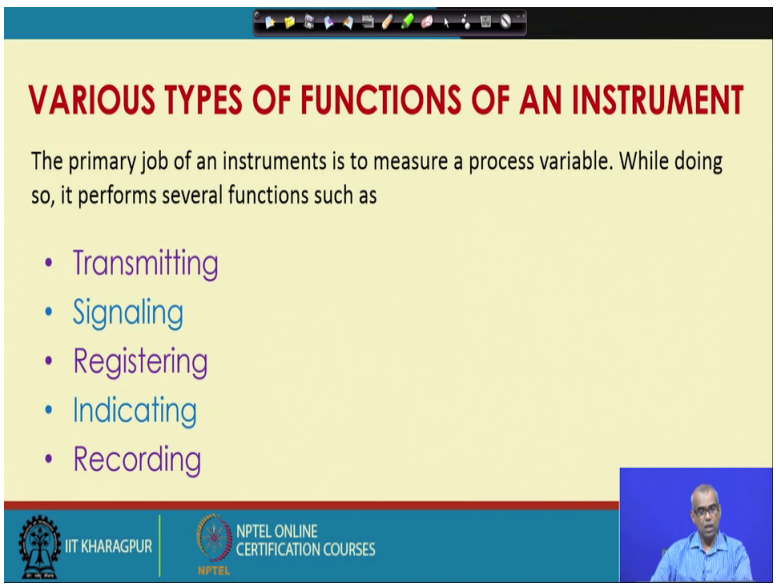

Now let us talk about various types of functions of an instrument the primary job of an instrument is to measure a process variable well being. So, it performs several functions such as transmitting, signaling, registering, indicating and recording.

So, let us go through each of these.

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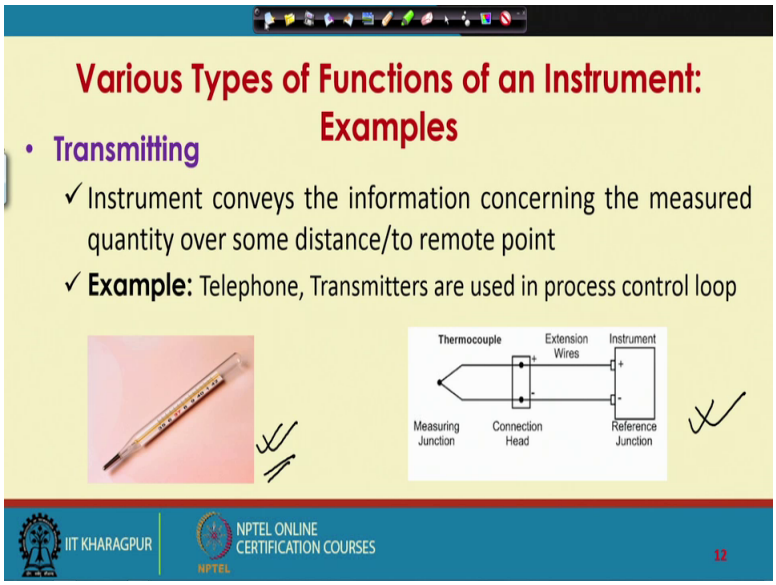

Transmitting functions instrument conveys the information concerning the measured quantity what to a remote point. So, an instrument when measures a process variable can indicate the value of the measured variable at the site of measurement or it can convey this information, about the measured quantity over some distance or to a remote point.

Let us say a measuring the temperature of the place of a distillation column, but you are collecting the information at the control panel say which may be several meters away from the site of distillation column. So, transmitting function is conveying the information concerning the measured quantity over some distance homely example is telephone. So, telephone transmitters. So, transmitters are used in process control loop. So, we have example of 2 temperature measuring instrument here one is mercury in glass thermometer, another is thermocouple.

Mercury in glass thermometer gives you the output directly at the site of measurement, because it indicates what it as measured by the level of the mercury against the calibrated scale. So, this does not transmit data, but in case of a thermocouple produces an EMF

which can be easily conveyed from one place to another because is an electrical signal. So, thermocouple is a transmitter. So, this is transmitting function where thermocouple is performing is a transmitting function.

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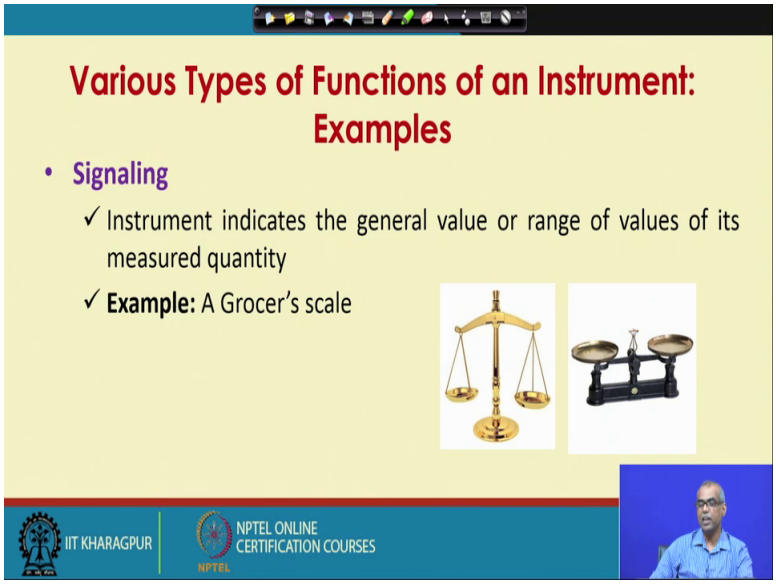

Next signaling here instrument indicates the general value or range of values of it is measured quantity for example, grocers scale look at the grocers scale it tells you whether the object you are measuring is heavier or not compared to some standard. So, this gives you a signal about the general value or the range of the values of the measured quantity.

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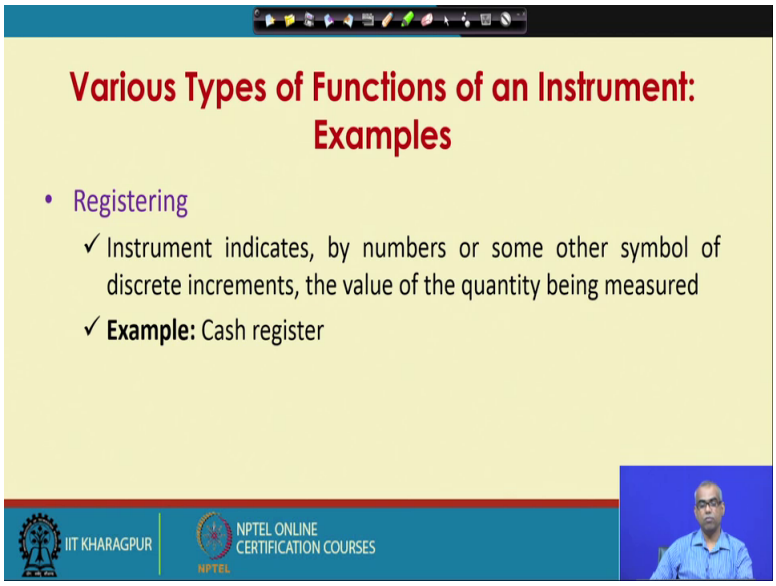

Next is registering function here instrument indicates by numbers or some other symbols of discrete increments the value of the quantity being measured. So, here instrument indicates by discrete numbers most commonly in some cases by some other symbols of discrete increments, the value of the quantity being measured a cash register is an example of this.

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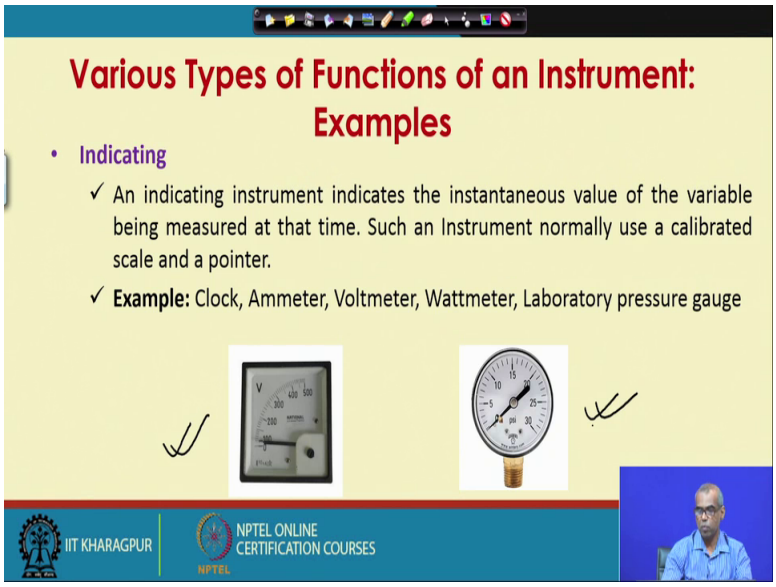

Indicating type instrument most of the instruments are indicating type of instruments and indicating instrument indicates the instantaneous value of the variable being measured at

that time, such an instrument normally used are calibrated scale and the pointer homely example is the clock.

Common laboratory instruments such as an ammeter, voltmeter, wattmeter, laboratory pressure gauge are all indicating type instruments. So, here examples of a voltmeter which indicates about the voltage by movement of this pointer against this scale, similarly this is a common laboratory pressure gauge again the measure pressure indicated by the movement of the pointer against this scale.

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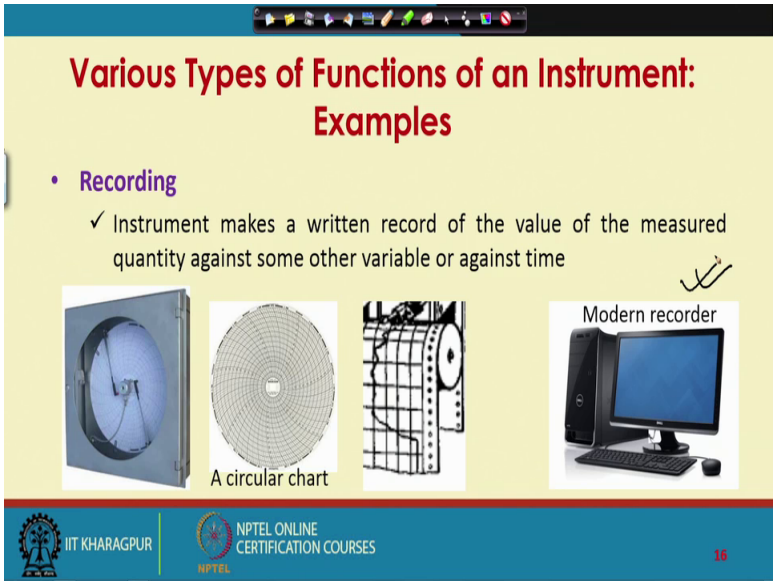

Finally, recording functions here instrument makes a written record of the value of the measured quantity against some other variable and most commonly it is against time. So, the recording function is that instrument will keep a written record of the process variable being measured against time. So, the most modern record that is of course, computer you can make use a computer to keep record of the process variables that are being measured, there are many instruments available which can be interface directly with the computer. So, the computer can keep record of the variables that are being measured against time.

On my on these on the left this is an example of a circular chart and a circular chart recorder. So, look at here this is a circular chart and this moves with a particular speed. So, this rotates. So, this rotates with a particular velocity now you have pane attached here. Now these panes suppose this is a pressure measuring instrument this is a pressure

measuring recorder measure measuring recorder. So, this pane will continuously put (Refer Time: 34:17) about the pressure being measured with time. Now since this is moving with time with a particular velocity and the pane all playing always keeps indicates the pressure that is being measured by a dot at the end, if I take out this circular chart I will have a curve something like this this is not an example of circular chart, but this type of charter also possible, but you can understand that similar mark will get on the circular chart. So, I can say adjust this rotational speed of this circular chart.

So, that in 8 hours it completes one rotation normally in industry 8 hours is a shift. So, after 8 hours when the next shift in charge comes you can look at the circular chart and we will get to know what happened to the pressure of that particular process for the last 8 hours. So, this way we can have a written record of the process variable that is being measured. So, this type of function is known as recording function. So, we will stop here and in the next lecture.

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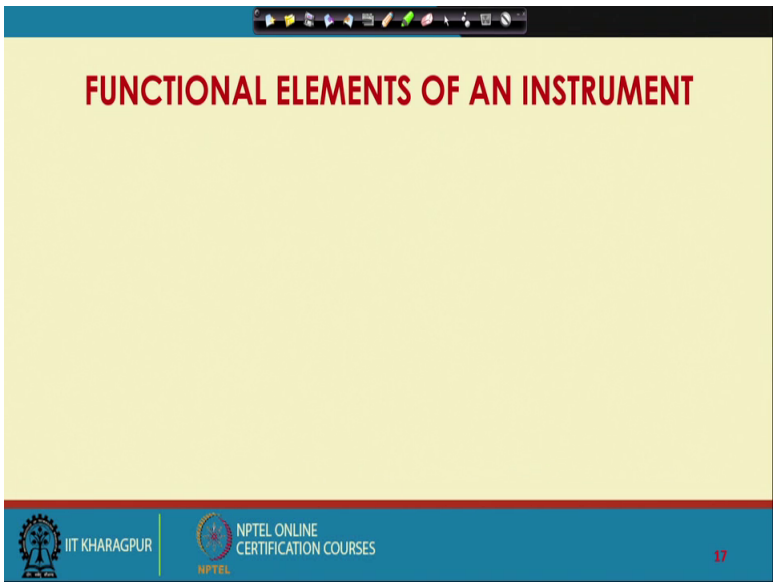

We will talk about functional elements of the instruments.

Thank you.