Automatic Control
Dr. Anil Kumar
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 01
Definition and Types

So, welcome to the lecture on Automatic Control. Today is the first lecture and we will discuss in this lecture, the first module; that is, automatic control system. And we will in this first lecture, we will discuss the definition of the control system and the types of the control system. So, automatic control is used in many applications from aerospace, automobiles, manufacturing sectors, robotics and others.

So, what does it mean automatic? Automatic means that we are going to get certain output performance of the system for different inputs. So, we are able to maintain the performance of the system, even though the input is varying or we are giving some specific input. Because, there are some disturbances that comes in the system from environment and therefore, we need a control system. And therefore, this subject is very important to mechanical engineers, electrical engineers, electronics engineers and similar subjects.

So, now we start, to understand; what is a control system? Let us understand what a system is.

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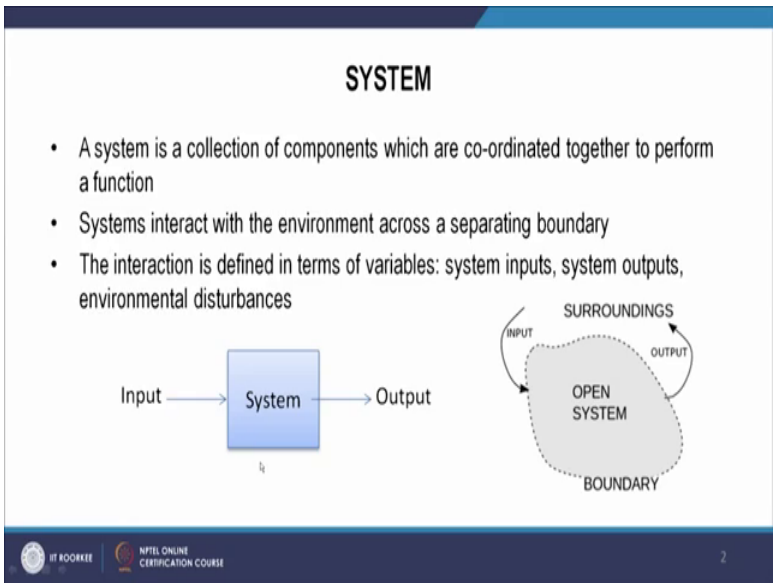

So, a system is a collection of components, which are coordinated together to perform certain function. So, if we want to draw a system a general system, so, suppose this is a system.

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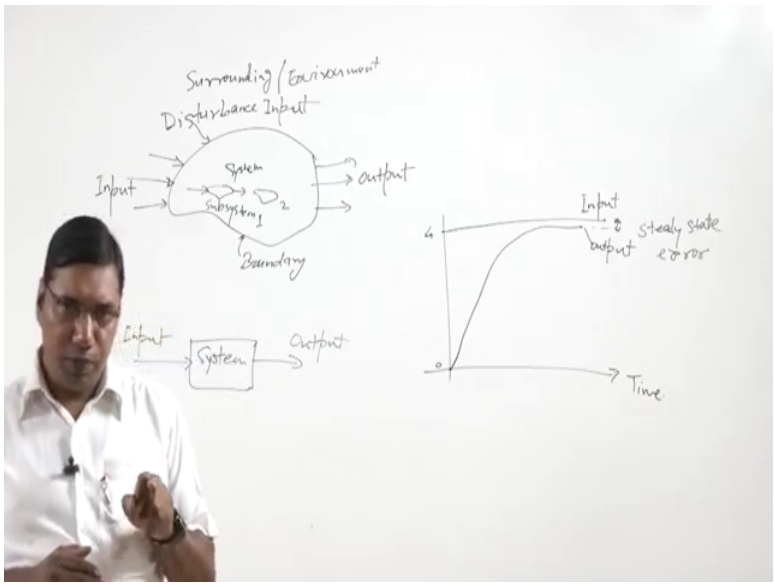

So, why we call it system? Because, it is some region that is separated from the surroundings or environment. So, here is surrounding or environment and this is boundary.

So, this system and environment, there is interaction through the boundary. So, there could be some inputs to the system from the surrounding. And then, system will give some output. As a response of that input, so there is some output. It is possible that, there could be several inputs to the system and there could be multiple outputs from the system. Now, system inside the system, there are several components. We call it subsystems.

So, let us say, there is some subsystem. This is subsystem 1 and this is 2. And each subsystem has certain input and then it gives some output. So, therefore, when we define a system, we say that it is assemblage of or collection of several components and their coordinator coordinated such that, they give certain output they perform certain function.

Now, from this environment, there could be entering certain disturbance input means, the input that we do not want and that may in enter into the system. For example, if we want

to listen some music, there could be some outside noise that is entering to the room and we cannot listen properly that music. So, that noise, that is coming from outside from the environment, that is the disturbance input.

So, this is our system and that gets disturbance input from the environment. So, a system is basically represented like, it gets some input and it gives some output. So, therefore, the interaction is defined from input and output and environmental disturbances. Now, we try to understand what a control system is. Because, we understand this is the definition of a general system.

Now, what is a control system? So, a control system is defined again.

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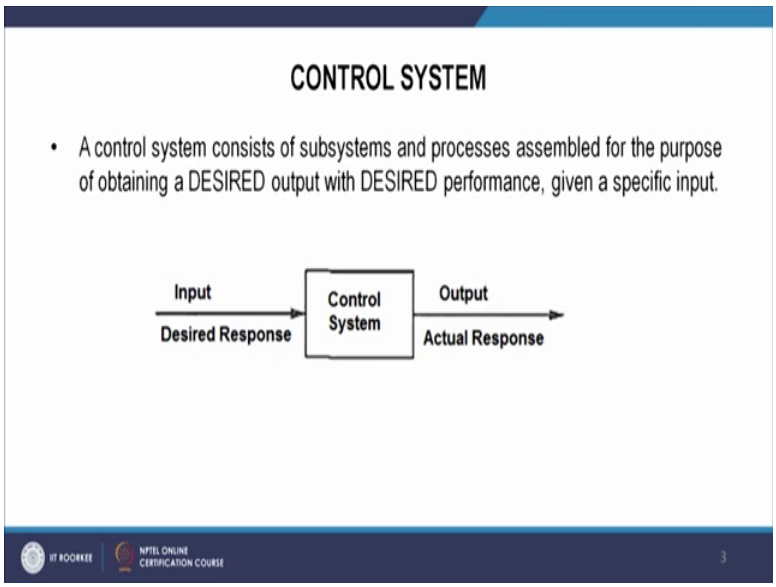

It is assemblance of or collection of subsystems and processes and the purpose is to obtain a desired output with desired performance given a specific input. These 3 points we must understand in detail, that what is desired output and desired performance and specific input. So, in any system, the mechanical system or electrical system, we try to give specific input means, we want we know that we are going to give the input and system should give certain output.

So, that a desired output. We expect some output from the system not any output, but some desired that we want with desired performance. Performance of the system is the specifications of the output; means, whether this is giving output, but with what degree

of accuracy? With how much it satisfied the user? So, this is the desired performance and specific input. Input is in our hand; we are going to give input.

But, what happens, we are going to give certain input to get some desired output. But, we saw that, for any system that can interact with the surrounding or environment and it can get some disturbance input. So, due to this disturbance, input the system will not be able to give the desired output. Because, now, input if it is purely the input that we are giving; that is, specific input, it is made to give this desired output.

But, if there is some disturbance input also, the system will give some output that is different from the desired output. And therefore, we need a control system. So, therefore, what is your definition of control system? That, if we give a specific input, that system should give the desired output with desired performance. So, this we can understand here, from this diagram, here is input or desired response, many times the input is the same as desired response.

For example, the elevator. If we want to go on the 4th floor, we will press the button 4. And so, here input is 4 and our desired output is 4. So, therefore, many times input is the same as the desired response. We can see here, an elevator. So, suppose, this is time and elevator, let us say, we are at the ground floor and we want to go at 4th floor. So, we give some input command 4. This is input we press; the button 4, number 4, so that, the lift can or elevator can take us to that floor.

Now, the elevator from time t equal to 0, we press the button. It will take some time to reach at this floor and it is response will be something like this.

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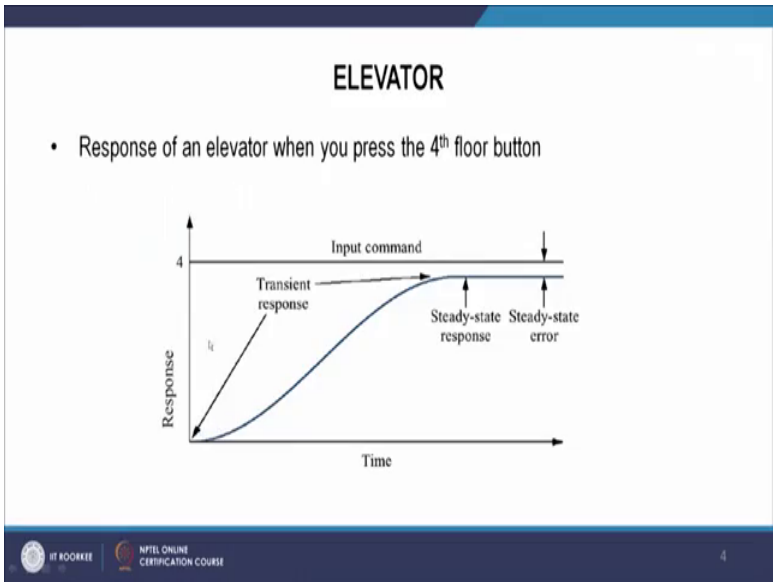

Now, you can see from this diagram here, that, this initial part of the response is transient response. Transient response means, it is a time varying response. Here, it is varied with time. After this point, it is going to be constant and this is called a steady state response.

Now, this difference between the 2. So, this is the output. And, so that, there is a difference between the 2; that is, steady state error. So, this is a steady state error. This difference between input and the output of the system steady state output. Now, we should understand that, this elevator, if this transient response is very fast, so what will happen? The elevator will start and to move very quickly and very fast response can make this comfortable to the people who are in the lift.

Suppose, this transient response is very slow; I mean, it takes much time to reach to the steady state response, so, it means you have to wait for long time. And so, your patience; you have to be more patience of the people. So, more waiting time.

Now, what about this steady state? We see that, we desired to fourth floor, but it is not reaching. It is little bit lower than that floor. It means, the lift is not leveled to the floor; it is little lower. So, these wheels govern the safety of the people. Because, if it is lower, you have to jump to go out from the lift. And so, it could be even unsafe to the people. So, we can understand that, when a control system, we have a specific input and this is specific, this is the desired output.

But, now, there is certain difference between the input and output. So, therefore, the question or these topics are more important that, we should learn how to design a proper system that can give a transient response, that is comfortable to the passengers or the people in the lift. At the same time, it does not give more waiting time and secondly, it reaches to as close to as 2; the input that is to the level of the floor.

So that, people are safe and that is why, we should try to learn the design and analysis of control system. Now, we try to discuss the type of the control system. So, there are basically 2 types of control systems: open loop system and closed loop system. So, what is open loop system? So, what we are seeing here in this slide, this figure that is the open loop system. Open loop system is, there is no any feedback to the system.

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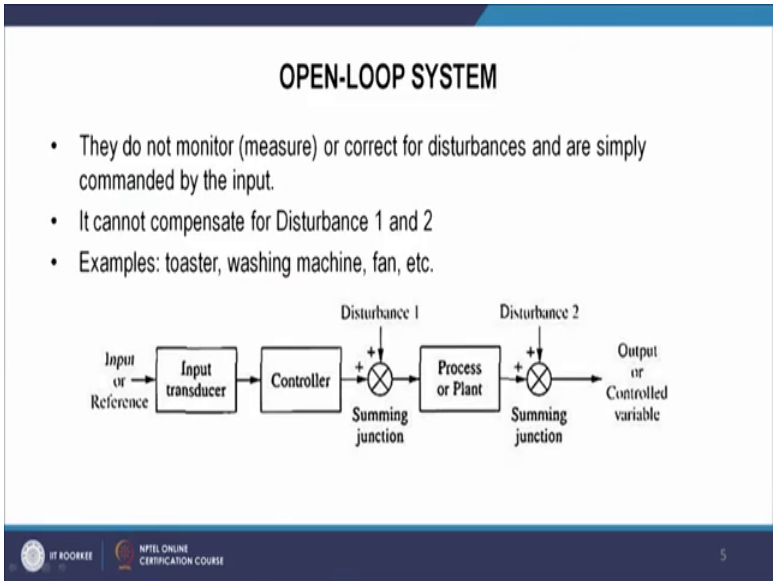

So, we can see here, we are giving input and there is some input transducer in the system. Then, there is controller, here is some summing junction, then this is the processor plant, then again, there is summing junction and then there is the output. Now, we can see that, we give certain input and what is the role of input transducer? So, input transducer converts a signal the input that we give, it converts to a signal, may be electrical signal that is accepted by the controller.

So, if we press number 4 and our controller is going to read the voltage. This transducer will convert this number 4 to the corresponding voltage in and that voltage, which we will be input to the controller. Now here, we can see that, here is the processor plant. So,

process is, if we see the example of elevator, the elevator the lift is the process; our plant, this is the plant that we want to control.

So, but there could be entered a disturbance input. When the controller is going to control this process giving some input to the process, there can the input to the process can be corrupted by some disturbance one that is entering from the environment. And therefore, the actual input that is going to the process or plant it is different than what was given at the beginning of this system.

Now, second thing, when process will give some output, but the output that we will get actually can be mixed with some disturbance from the environment and the actual output will be again different. So, there is 2 types, 2 level of corruption of the signals here and at one at the input of the processor plant and second at the output of the processor plant. Therefore, there is risk of not getting the output that desired output. And therefore, we see that open control systems, there is no any facility to monitor that how much the output is different from the expected.

And, how to counter the disturbances that are entering to the summing junctions or to the input and output of the processor plant? So, these systems cannot compensate for disturbances. So, examples; if we take examples, there could be the simple toaster, like, we put the breads and we set maybe, some time. Now, it does not give the input that whether the bread is already burnt. If you said that time, it will after that time it will you will get what it remains. But and then, there is washing machines you set the time and they will they do not sense whether the input the inside conditions, but they will do the functions at that what he defined at that time.

Fan, we on the switch on the fan and fan will start. It does not matter, does not take any input from whether the fan's speed is actually as expected or not some fans are; you press button number 4 and some fans are very fast. Some fans are very at slow speed. So, we are not going to take the input as a feedback or we are not going to monitor that, whether what we pressed are we getting the same or not.

So, these are the open loop system and the advantage of these open loop system is that, they are not going to monitor the output. And they have no any mechanism to counter the disturbances that are entering to the system from the environment. So now, we come to the more sophisticated system; that is, a closed loop system.

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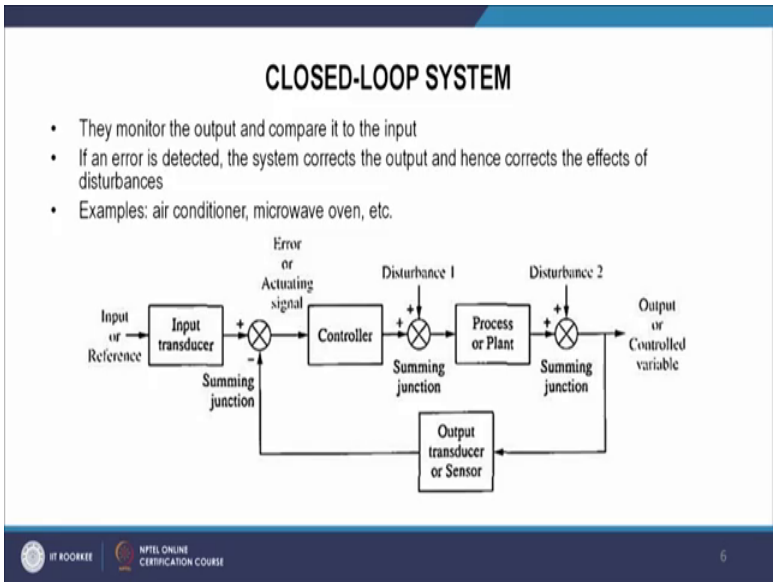

So, in contrary to open loop system, there is they can monitor the output and they can compare the output to the input. Now, we can see here, in this figure, here is the input, we are giving to the input, input is going to the input transducer. This transducer will convert the input to a signal that is accepted by the controller. Then, this controller will give certain output to actuate the process or plant and there is disturbance one entering to the summing junctions. It is corrupting the input to the process or plant.

Then, there is output and this disturbance to interest to this junction and it will corrupt the output. Now, what this closed loop system is a going to handle this problem is, it takes the output as a feed back to the input. So, we are taking back the output. We want to know, what are we getting actually the output that we expect? Means, are we going to get the desired output or not? That is why, we are taking back this output feeding back to the input.

So, this output we are taking. There is another transducer; that is, output transducer or sensor. So, this is going to convert again this output signal to a corresponding signal; that is, maybe electrical signal that is accepted to the controller. So, here, at the summing junction, there is input coming from input transducer and there is the output going from output transducer. Here, input and output, they are compared; means, the difference between the input and output is calculated here and given to the controller.

So, we are going to get that, how much difference is there between input and output and only that difference is given to the controller. And can we will give only that much signal to run the process or plant. This loop will be go working or the controller will be working or plant will be working till this difference between input and output will be equal to 0. And this will be the moment, when we can say that we have achieved the desired output.

And therefore, this system is monitoring the output and comparing to the input. And if there is some error, it corrects the output. And therefore, it has the mechanism to counter the disturbances coming from the environment and therefore, automatic control system should have this feature that should be based on the feedback control system. Our closed loop control system. Automatic control system cannot be based on open loop system.

The examples are air conditioner or microwave oven, there can be other numerous examples. So, air conditioner; we set some temperature and it is if the difference in the temperature, actual temperature and the set temperature is more the compressor will run fast faster and as we get closer, it will be when we reach to the same temperature, it will stop. And so, it will it continuously takes the feedback, whether it has reached to that temperature or not it measures the room temperature and compares to the output. So, air conditioner is a closed loop system.

The complex toaster, complex toaster that measures the color of the food material inside the toaster; they are also a sophisticated control system, closed loop system, because, they not only based on the time, but they are based on the color of the food. And therefore, they could be also a closed loop system.

So now, if we want to enlist the differences between an open loop and closed loop system. So, we can compare, so, open loop system has several disadvantages, but few advantages and vice versa to the closed loop system. So, the open loop system, they are incapable to respond against disturbances that are entering to the system further from the environment. They do not measure the disturbances or they do not correct the disturbances and they are simply commanded by the input.

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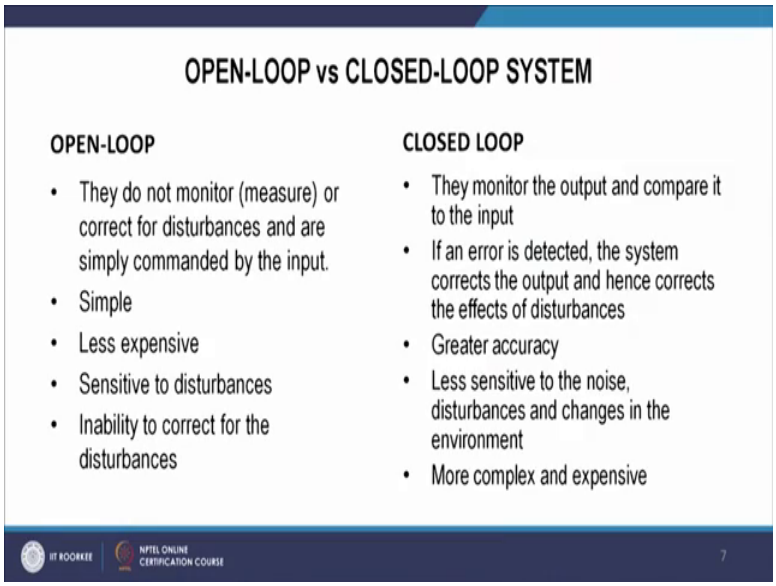

Once we give the input command, they will give certain output and that output might be different from the desired output because, there will be certain disturbances entering from the environment and they do not compensate. They do not take care of these disturbances while in contrary, closed loop systems, they monitor the output and they compare it to the input by giving a feedback loop. They give a feedback from output to the input and they compares this output and input and they find the error give through the give to the controller. And they will act till the error is 0; means, till we get the desired output what we expected.

So, therefore, this closed loop system has advantage over open loop. Now, this closed loop system has greater accuracy. They are more accurate, they give this input and output difference is very less. They are almost reaching to the same input command as we are giving here. So, this is steady state error is very less. So, we are more accurate to the output. In contrary, the open loop systems have a very poor accuracy.

Closed loop systems are less sensitive to the noise or disturbances from the environment or change in the temperature from the environment. Why because, these are the disturbances that are coming from the environment. And these systems have mechanism inside to counter these disturbances, whether it is noise or temperature disturbance or any other vibration disturbance, depending on the system, they have the mechanism to

counter these disturbances. So, they do not let the systems of performance get down due to these disturbances.

So, there we can say that, they are less sensitive to these disturbances while contrary to this, the open loop systems are very much sensitive to the disturbances. If the disturbances are more, the systems open loop systems performance will be affected very much and they will lose the actual desired output and the steady state error might be increasing. So, therefore, these open loop systems can be said that, they are very sensitive to the disturbances.

Now, what are the advantage of the open loop systems? One thing is simplicity. They do not have any feedback system. They are simple forward loop systems. So, they are simple systems. And if you have a simple system, it is less expensive, it is less costly. So, these systems are simple and less expensive. While if we compare to the closed loop systems, these systems are because, they have greater accuracy, they have more sophisticated control system. And therefore, they are more expensive and more complex.

So, these are the some common differences between the 2 systems, open loop and closed loop. So, here, we follow the mainly the 2 reference books.

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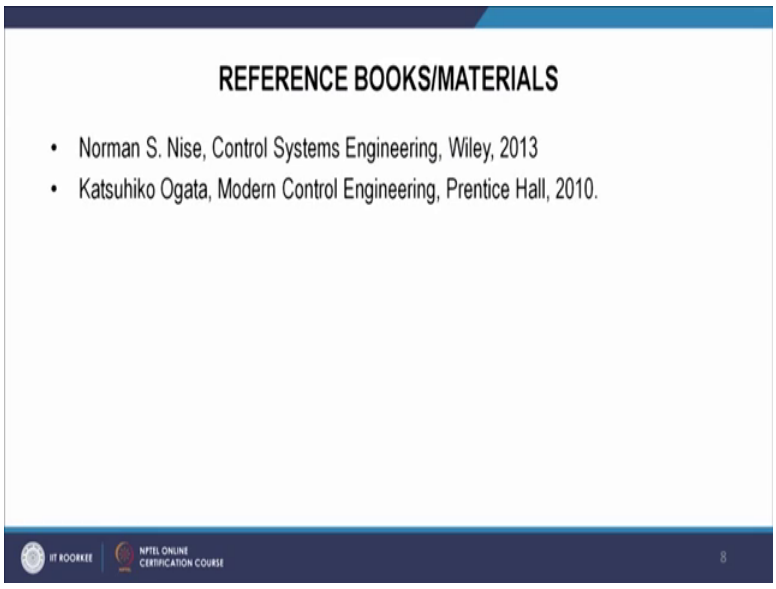

One, Norman S. Nise, Control Systems Engineering and second, Katsuhiko Ogata, Modern Control Engineering. So, these 2 books we will follow in this subject and several

examples will be taken from these books. So, here, now I thank you for listening this lecture and let us see in the next lecture.

Thanks.