Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture – 35
Key Enablers of Industrial IOT: Process Control

So, far in this particular module, we have talked about different layers; layer such as sensing. It started with the sensing, connectivity which took care of communication networking and so on. Connectivity, processing, so the data that are collected will have to be processed; so, processing we have talked about and then, comes the control. So, basically based on the processing may be some kind of a feedback will have to be given back, some kind of a control. So, for this actually there are different process control mechanisms are there particularly, in automation industries.

Industries which support different automation technologies such as PLCs, SCADAs etc. are used. So, we are going to have a brief look at each of these technologies PLC, SCADA and so on and at the end, I promised you to show you the use of this PLC, SCADA kind of system in a case study that we have used for implementing a certain application with the help of this PLC, SCADA kind of system. So, I will show you that at the end.

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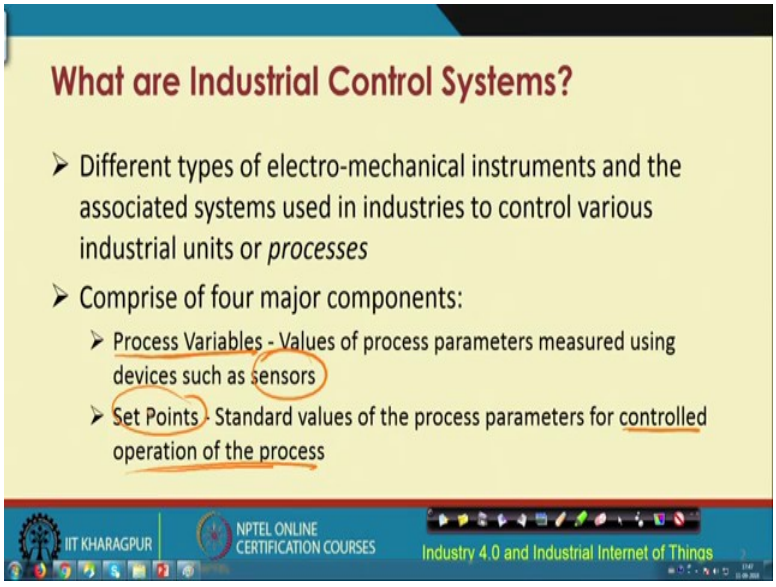

So, let us start with at the very beginning we need to understand this control part in the industrial scenario. So, there are different processes which control this in industrial instruments, the way they work and so on. So, there are different electro-mechanical instruments that are there and this their associated systems are used in the industries to control and offer feedback to the machinery that is used the process that is being implemented that is in process that means, it is being executed and so on.

So, there are four major components. The first one over here is we need to understand, the first one is the Process Variable. Process variable are basically the values of the process parameters measured using devices such as sensors. So, this process variables or the values of this process parameters would be measured with the help of sensors.

Then, comes the Set Points; set points are basically the standard values of the process parameters for controlled operation of the process. So, this is very important, this is for feedback control. So, controlled operation of the process for that we have this concept of the set points, which are the standard values of the process parameters.

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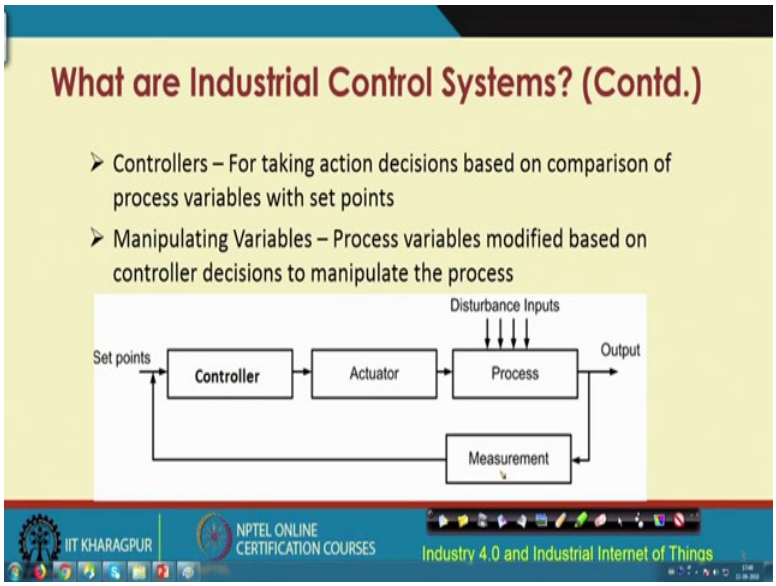

Next comes the concept of the Controller. So, the controller basically takes certain actions. So, based on the process variable based on set point value and so on, it takes certain decisions it or actions and it compares the process variables with the set points before it takes the action. So, this is what this controller does and this is what you see over here in this picture as well.

So, we have this controller, we have the actuator, the process and the measurement. So, the based on the set points basically this controller. So, this controller does this controlling, then comes the actuator. The processing is done over here and then, based on the measurements of how things are. So, this there is a feedback back to the controller. So, this feedback cycle where based on the measurements of the current process parameters and so on, there is a control loop back to the controller and then, we have the manipulating variables which are basically process variables modified based on the control decisions to manipulate the process.

So, this is important part, the manipulation of the variables is the most important part in this particular process and for that this measurement is very important.

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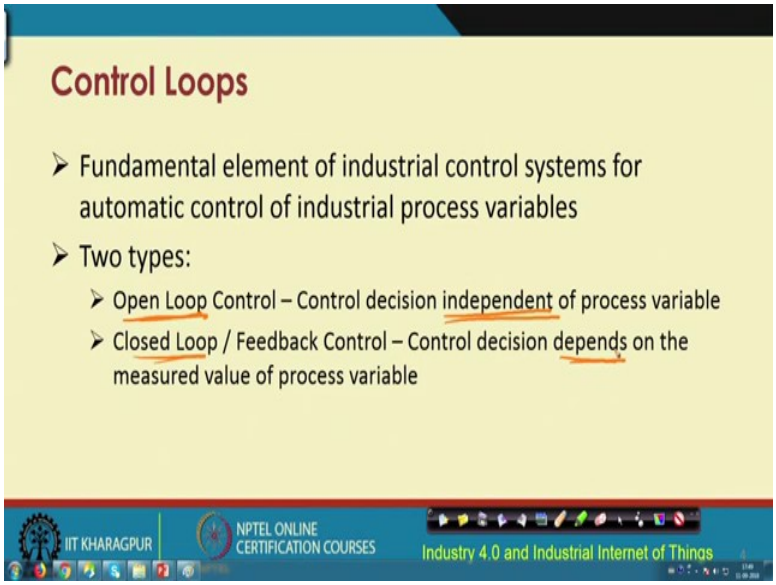

So, we let us look at this Control loop because it is this control loop which is the attractive part in the whole process control automation and so on. So, this control loop is the fundamental element of industrial control systems and this basically these control loops help in automatic control, unmanned autonomous control, automatic control of industrial process variables is offered with the help of this control loop.

So, there are two types of control loops; one is the Open loop control rather and the other one is the Feedback control or the Closed loop control. So, open loop control; open loop here the control decision is made independent of the process variable, control decision independent of the process variable whereas, in the feedback mechanism of the closed

loop mechanism, the control decision basically depends on the measured value of the process variable. So, there are two types of control.

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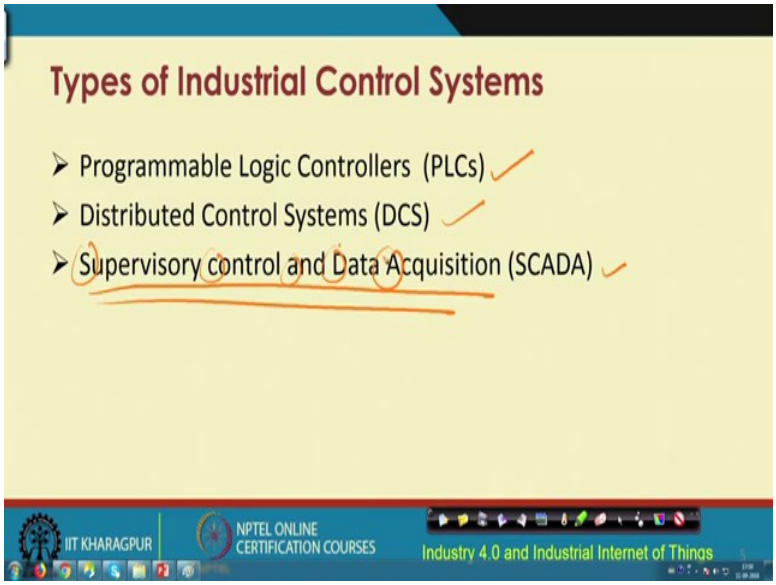

So, there are different industrial control systems that are used for process control. One is the PLC, the Programmable Logic Controller; second is the DCS, the Distributed Control Systems and the third is the SCADA which stands for Supervisory Control and Data Acquisition; Supervisory Control and Data Acquisitions S C A D A. So, this SCADA and SCADA in turn basically use the concept of the PLCs.

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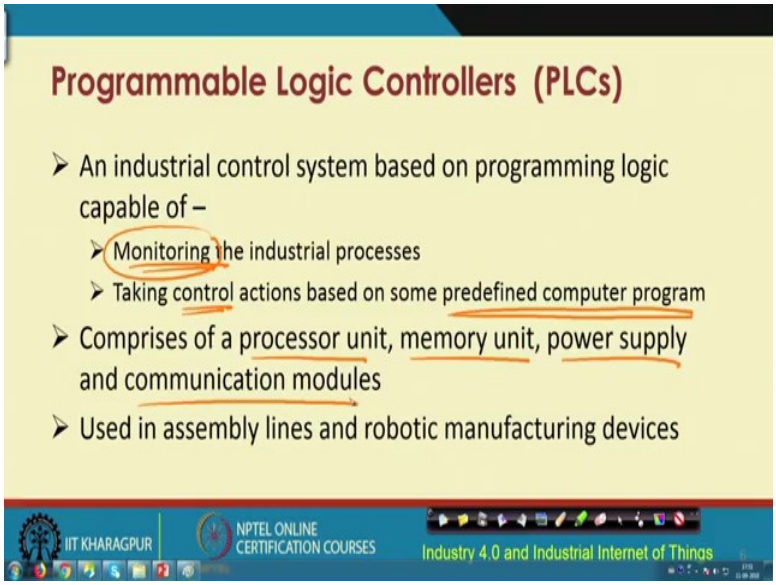

So, what is this PLC? So, basically PLC is the industrial control system. So, it is the industrial controller in control system and this is based on the programming logic of monitoring the industrial processes and taking control actions based on certain predefined computer program. So, the computer program has a predefined set of instructions is provided to the system and based on that the control actions are taken and for that first the monitoring will have to be performed.

So, it comprises of a processor unit, a memory unit, and power supply and communication modules. It is used in assembly lines and robotic manufacturing devices a lot. So, all assembly line things nowadays where there is automation, robotic manufacturing facilities mostly you will find that what is used are these different PLCs in different forms.

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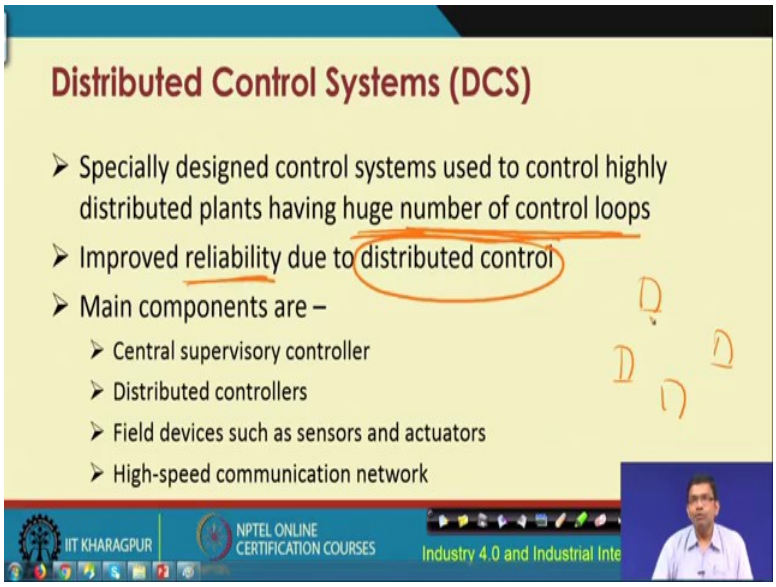

Distributed control systems are specially designed control systems that are used to control highly distributed plants having large number of control loops; large number of control loops is basically the characteristics of the use of DCS and DCS basically provides an increased reliability because there is distributed control. So, if you have distributed control, then that basically offers large reliability because so the control itself has been distributed. So, if one element fails you are going to still have improved reliability.

The major components in use in DCS are the central supervisory controller, distributed controller, field devices such as the sensors, actuators and so on and this communication backbone, the high speed network communication and it has to be high speed. That is the requirement for serving the different communication requirements in the industrial sector, particularly the manufacturing process plant and so on.

So, we will now have a look at the SCADA which is very popular. SCADA is very popular in industrial automation plants and this is very attractive in the industry 4.0 context, because these are the building blocks basically. Because in the industry 4.0, we are talking about a lot about automation, connectivity between these different machines autonomously, autonomous monitoring, control feedback and so on.

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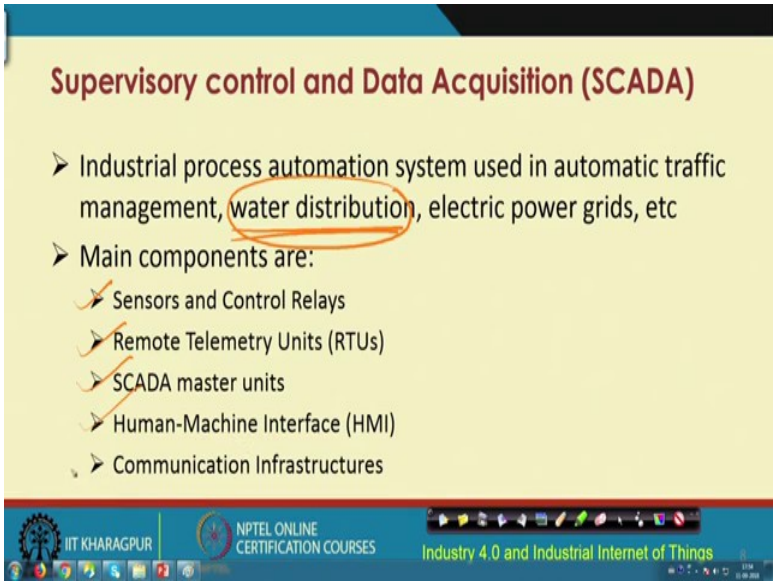

So, this kind of device SCADA based device basically is helpful in order to achieve the requirements of industry 4.0. So, industrial process automation systems are used in automatic traffic management, water distribution then, electrical power grids and so on and in this particular lecture, I am going to show you the case study of use of SCADA in water distribution system, but it could be used in other plants also.

So, water distribution system, I will show you where we are using SCADA based control system for monitoring the water distribution in test bed scale in one of our facilities in our campus at IIT Kharagpur. So, these are some of these different components. Sensors, Relays, Telemetry Units, SCADA master units, HMIs that means, the Human-Machine

Interfaces and the Communication Infrastructure. These are the different facilities that are used and that are the, these are the different components that are used.

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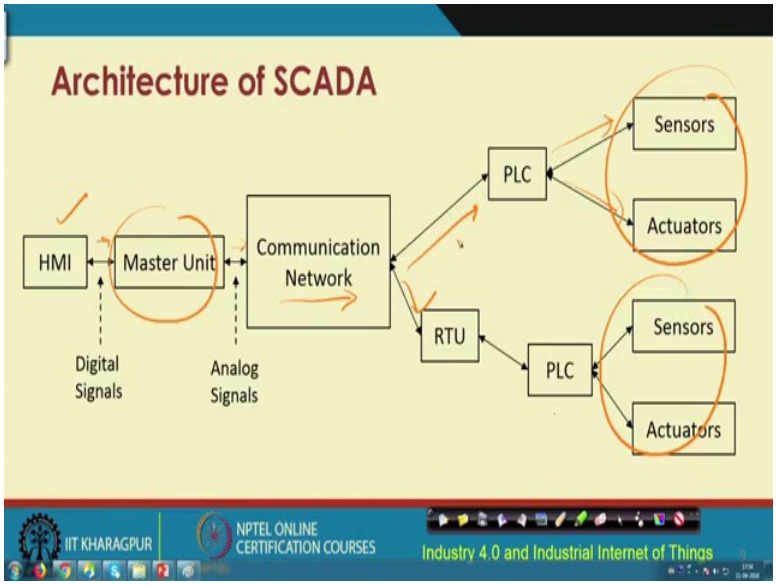

So, here is the Architecture of SCADA. So, here we have as you can see we start with the HMI which is the Human Machine Interface. Then, comes the master unit which takes the digital signals from the HMI and then, converts to the analog signal. So, this basically these master units sits in between the HMI and the communication network and converts the digital signals to analog and analog to digital and vice versa.

Then that particular signal after conversion flows through this communication network and goes to the PLC, to the RTU. From the PLC the sensors, actuators, the different field devices are controlled like this and so on and these communications are two-way communication as we can see over here the double headed arrows basically represent the that there is double sided communication SCADA systems.

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So, right now I am going to show you one of the applications of the use of SCADA and PLC. So, this application I have chosen from the water sector; water distribution particularly and this is basically a facility that we have in IIT Kharagpur in the school of water resources. So, this is a kind of lab test bed setup for water distribution monitoring particularly with respect to leakage and autonomous and continuous monitoring and so on. So, of a water pipes monitoring with respect to leakage and it can be in even extended for other types of monitoring of water quality and so on and so forth.

So, I have with me Professor Manoj Kumar Tiwari, who is a faculty member in the school of water resources and also Miss Deena, who is a PhD student in this particular department. So, I would request you to talk about little bit explain about this particular facility that you have. So, Professor Tiwari, could you explain like what is this setup all about?

Thank you Professor Misra. So, actually what you are seeing here is as Professor Misra suggested it is a test bed for water distribution. So, it is kind of a prototype for water distribution network, what usually we see in the fields. There are pipes of different sizes which represents mains, sub mains and the branch or distribution pipes and this network is nicely equipped with the various pressure meters.

Right now, I am going to show you a practical demonstration of the use of PLC and SCADA based system. So, this specific system is about water distribution monitoring

and so, we have a system in the school of water resources in IIT Kharagpur and this particular system basically has end-to-end monitoring of water distribution and it would be also extended for water quality monitoring.

So, we have with us Professor Manoj Kumar Tiwari, from the school of water resources and also Miss Deena, who is the PhD student over here. So, I would request them to explain more about this particular facility that they have and then, we will also look at the applications of SCADA in water distribution.

So, Professor Tiwari, what is this facility that you have would you please explain?

Thank you Professor Misra, So, actually this is a prototype of a water distribution network, the kind of networks that we see in the real field. So, there are if you can see there are different pipe sizes. So, some are simulating kind of mains then sub mains and branch pipe.

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So, the idea of developing this network is to test the things that actually occur in real field.

So, this network or this system is equipped with various pressure sensors, flow monitors and actuators in order to control, monitor and operate it in the real time, through a SCADA and PLC-based systems. Deena is a working on this system. So, see will further explain the details of the system.

So, Deena could you please explain?

Yes.

Like how things work over here?

Thank you sir, as already it has been explained that this is a prototype of a real water distribution network and we all know that water distribution networks expand over vast areas. Hence, its manual monitoring is a pretty challenging task. So, the aim of our work is to devise a methodology of a remote monitoring of these systems through the use of SCADA and PLC. When we come to a water distribution network, both quality and quantitative parameters are important and right now we are monitoring only the quantitative parameters which are essentially the pressure at intermediate locations of the system and the flow rate at the demand nodes of the system.

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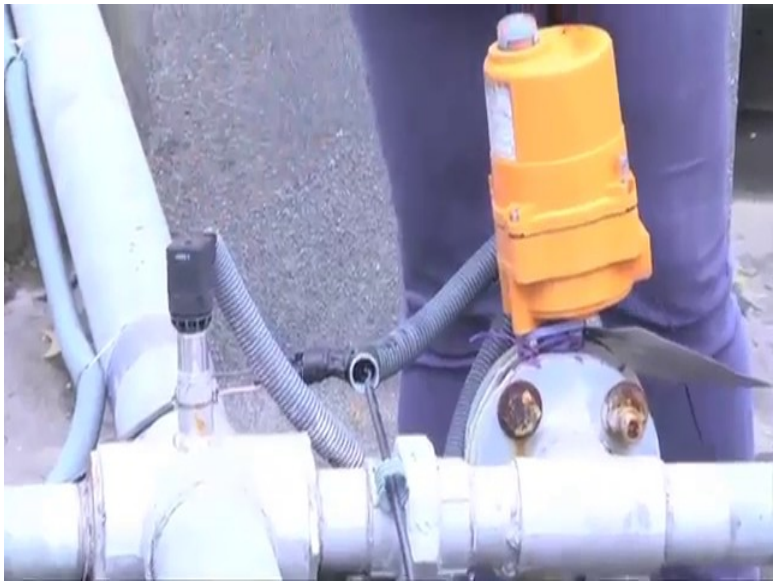

So, here for example, we have a pressure sensor installed at the junction of the pipe network to give us the pressure at this point. Likewise we have the pressure sensors at many locations of this network.

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Again, we here have actuators which are installed at different locations of the network. So, these actuators are actually control devices where we can control the rate of demand from the locations itself.

So, here we have the actuators which are located at different locations of the network and these actuators are basically control devices, where we can increase or decrease the demand flowing through these locations in the network.

So, if I may add actually it is a there are the amount of opening how much flow is to be maintained from this outflow junction can be controlled with such actuators. So, these actuators that way will be able to control the flow in a distribution network or a distribution pipe from a junction that way and these further, these actuators can be controlled remotely; can be monitored remotely. So, with the like in the real time system, we always need not to go to the field in order to control the flow in a pipe or in order to sort of maintain the distribution or the demand from one particular sector.

So, the next component that, I am going to show are the flow meters. Flow meters in a pipe network is essentially the demand node from where consumers can take the water for their necessity. So, here we have a manual paddle wheel flow meter which is connected to an electromagnetic flow meter for knowing the flow through the paddle wheel flow meter here. So, the electromagnetic flow meter is monitored remotely through the SCADA system and the data will be available to us in our system.

Ok.

So.

So, Deena what is this flow meter all about; what does it do?

Sir, basically the flow meter is installed here. So, that we know how much demand is consumed at the consumer point.

And this data is required to actually in real systems this data is required to bill the customers on the amount of water that the customer is using.

Ok. So everything can be monitored in real time.

Yes sir.

In that SCADA.

Yes sir.

SCADA based systems.

So, actually this flow meter essentially records the quantity of water flowing at a given instance and then, it has a totalizer also.

Ok.

So, over a period of time how total water has passed through this pipe will be known to us.

Excellent.

And that is what actually is used while billing the consumers.

Ok.

Because how much water has been passed to their homes and what consumption they have made. So, based on that the billing for water can be done.

So, Deena, so could you explain little bit further about this particular instrument?

Viscometer.

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Yes sir, yes sir. So, this paddle wheel flow meter needs to be a pull and so, this is how we open the paddle wheel flow meter. As soon as this paddle wheel flow meter is opened and the water flow is stabilized.

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The reading for the flow rate of the through this paddle wheel flow meter will be displayed here and also the total amount of water passing through this flow meter over a period of time will also be displayed here.

So, like right now although the there is no flow. So, it is showing 0 meter cube per hour the instantaneous flow. But the totalizer is saying that it is, it has been basically over 1300 meter cube flow has been passed through in a given span of time. So, from (Refer Time: 18:33) this like the operation was installed or reset at 0 point.

Ok.

From that point forwards 1345 meter cube of flow has already been passed throughout there.

Ok. Wonderful. Is there anything else that you have over here other instruments that you might have?

Other instruments as such like there is a weather monitoring station.

That can be seen here ok. This also basically collects the data and transports in the real time the weather data and from this network the other interesting work which we are doing is because one of the major challenges in the real field network is in terms of water losses.

So, in India the urban distribution network, distribution networks only faces losses of the order of say 40 percent.

Ok.

That is a huge amount.

Right.

And there is no mechanism over there to basically detect these losses in real time or and then, because until unless we detect.

There is no rectification possible. So, first challenge is the detection.

So, with this the kind of actuators we have we artificially create leaks in these networks and then developing a system for the real time detection of the leakages from the distribution network.

So, Professor Tiwari, earlier you said that at present what you have is the water monitoring particularly with respect to distribution, control over the distribution over the network and can it be extended for monitoring the water quality as well at different points of the network?

Absolutely, Definitely. So, like whether we are monitoring a quality parameter or a quantity parameter all we need a sensor. So, like we have pressure sensors which are monitoring pressure in the distribution line. We can of course, install water quality sensor like residual chlorine, PH, ORP, TDS. So, there are sensors available for this and if we install those sensors in this network which eventually we might do we have some idea of that.

So, when we installed these sensors in these things; so, we will be able to getting the real time water quality parameters as well. So, we can basically make the consumers assure that the water quality they are getting through their distribution network or through their water supply systems are of the portable quality or domestically usable quality.

So, this the different sensor values these are also tagged with the specific location from where this particular value is coming. So, whether it is with respect to the quantity or quality. So, the specific reading that is coming. So, one can know that this is from this particular point or location from where this sensor value has come?

Absolutely, Professor Misra. So, all these devices, sensors can be geo tagged also ok. So, let us go downstairs and there we can see that how these sensors located at different places are tagged in this thing.

So, that you can know specifically.

Yeah.

From which location.

Absolutely.

The data has come.

From which location how much reading or like we can monitor, these specific locations in real time with the help of quality or quantity sensors.

Ok. Thank you. So, what we have seen so far is basically the water distribution network, the physical part of it. How the test bed showing the different water pipes, their branches and so on; how they have been structured; how they have been organized; how they have been located so we have seen that. We have also seen that there are different sensors, IOT devices like water pressure sensor and different other water monitoring sensors are located at different points and these values the sensor values also come tagged with the specific geo location from where that particular value has come.

So, all of these things can be monitored from a central point where basically one can sit and monitor have a look at the complete picture of the water distribution system. So, we are going to go downstairs at the other location from where this particular facility has been installed and we can have a look at how things are being monitored from that, that particular location. It is enabled with SCADA, it is enabled with PLC. So, we are going to see how this SCADA and PLC-based system will help us to monitor centrally the overall water distribution network.

So, we are at the control room the monitoring point from where the water distribution system that you have seen so far can be monitored and centrally controlled. So, on my back is basically the PLC controller.

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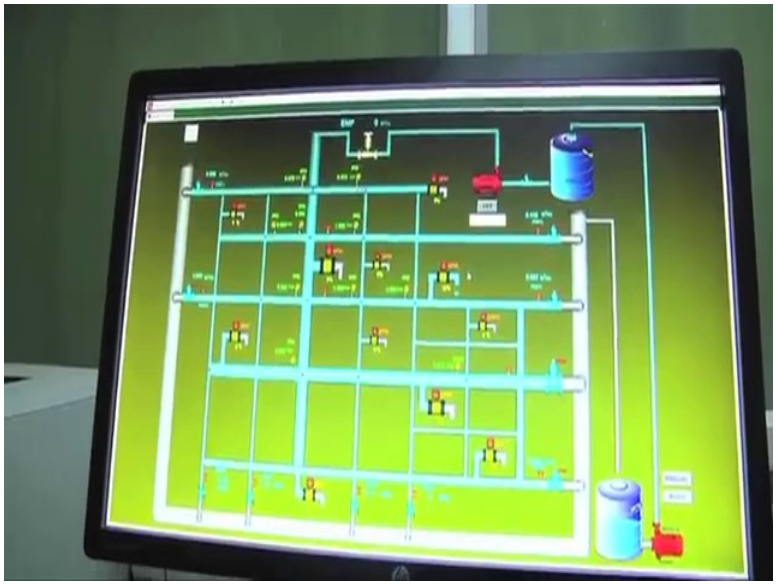

And on my left is the SCADA-based system that can help in the supervisory control and monitoring.

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So, what we have I will just show you what is inside this particular panel. So, this is the PLC control panel.

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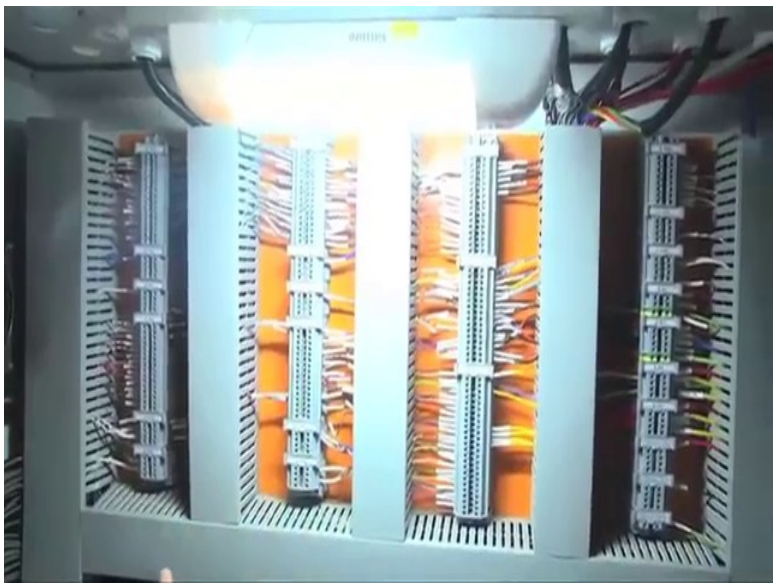

So, as you can see over here there is lot of electronics and so on.

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So, this is the main thing the PLC controller. This is the main PLC controller and Deena, can I now request you to explain the different other functionalities that we have over here.

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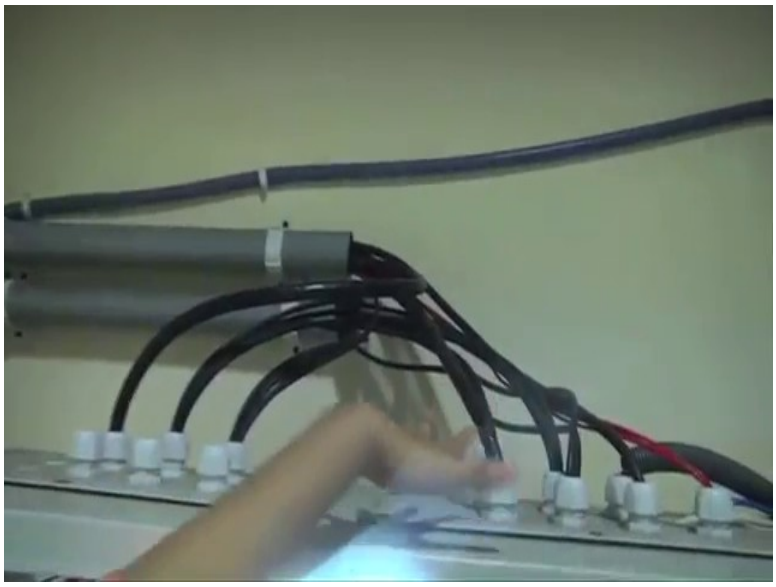

Sure sir. As you can see here sir, the system of wires here are connected to the sensors on the top floor, where we had already seen the system. So, all the pressure signals and the flow signals are in analog form.

And it is transferred to the system of wires to this location.

So, all these components here are basically to change the analog signals to digital form.

Ok.

And these components are for that purpose.

Right

However, this is the main part of this system, where these are the analog input signals.

These are the two analog outputs.

Right.

And these are the digital outputs.

And as you have already mentioned, this is the PLC.

So, I will add a little more onto this. So, because we have the network installed right over the rooftop of this one building. So, we are getting the signals or which are monitored from the sensors through these wires, but what happens in the real fields these SCADA systems or real field systems when we apply it to the let us say larger distribution network and there are system is actually there at few places.

So, it becomes very difficult.

To get the wired signal from far off points.

Right.

So, what we can use is we can use wireless technology.

So, the sensors that record the data and through wireless communication it could be directly sent to the PLC.

Excellent. So, basically what you are saying is that instead of using the wired technology, we could use wireless communication technology in order to send the data from the real sensors to this particular controller.

Absolutely and it is actually in place and like it is already in installed at few places.

And as you were saying that, it is more useful and more convenient basically because wireless technology you do not have to really the dig wires and through that.

Absolutely.

You do not have to connect through the different cables.

Yes. So, that becomes much more handy because you need not to basically control the need not to install such a long wired system to bring all the information to the PLC.

Ok.

You can just the sensor records it and through wireless communication, it directly sends to the PLC system and the rest of the process then becomes easier.

Right.

Thank you. So, on my right is basically the SCADA HMI which basically helps you to graphically have a look at the entire water distribution system and basically to have complete knowledge of from which point how much water is flowing through and also if there is any leakage at any of the points that also can be detected through this particular interface. So, can you show us how we can monitor leakage in this particular panel?

Sure sir. Sir, for an experimental purpose if I want to create a leakage at a location I will be using the actuators where I have control from the HMI. So, here as you can see it is zero percent now that means it has no leakage at all.

Right.

So, I just click here and I click the desired percentage of leakage that I want to create and the same percentage of opening will be done in the actual system and the water will flow through as it is shown here.

Ok.

So, this leakage is actually monitored like the detection of leakage what we were discussing.

Is because this is an experimental network. So, here we artificially create leakage.

Alright.

And then, through a software simulation we are which we are developing, we will be able to identify the location and some extent the quantitative volume of the leakage.

Correct ok. So, Professor Tiwari, so you have a wonderful facility over here. So, SCADA-based systems are available everywhere and so this is an example of the use of SCADA-based system in for water distribution monitoring and so on and so, this has been developed by one of the private farms what it can you speak little bit about?

It is actually a Chennai based company PLC systems private limited.

Ok.

So, they have done this installation and this is as far as I know of this is the first such facility in the nation.

Ok.

Where, on a lab scale we can basically monitor control and try to operate a water distribution network.

Alright and so, basically with the help of this kind of installation, you are able to emulate the behavior of water distribution in a reals real kind of environment?

Absolutely, absolutely.

Thank you.

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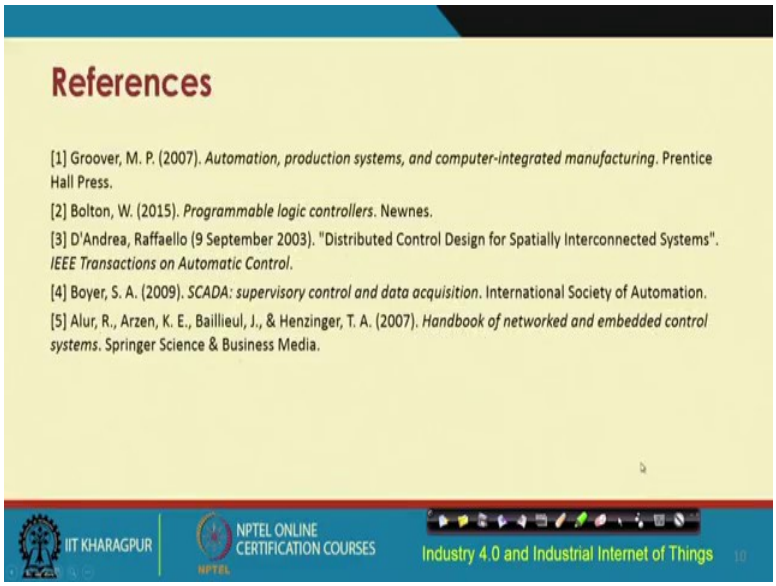

So, these are the differences that one could go through in this particular context and these are some of these references if you are interested to know about SCADA, PLCs, process control and so on; these are some of the ones that I would encourage you to go through. With this we come to an end of this particular lecture.

Thank you.