

Introduction to Industry 4.0 and Industrial Internet of Things
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Lecture – 56
IIoT Applications: Oil, Chemical and Pharmaceutical Industry

In the previous lectures, I have given you different examples of application of IIoT in different domains such as healthcare, food, food processing, facility management, inventory management and so on and so forth. I would like to briefly expose you to the different applications of a IIoT in the Chemical industry, Oil industry and the Pharmaceutical industry. As I told you earlier as well that in all of these different application domains, the core technology, the core technological ideas remain the same; they cannot be changed and they are basically the ones that we have discussed in the previous modules.

So, the only thing that changes is basically the type of sensors that would be used. The specific requirements that a particular industry has and certain industry specific industry, vertical industry domain specific requirements, but that is basically mostly dealt with in the application level and at the network at the device level more or less the concepts remain similar. So, in this lecture also consequently, I am not going to talk about anything new drastically. But I am going to expose you to some of the requirements that are specific to these industries oil chemical and pharmaceutical and how these specific sensors and their interconnectivity can help address the issues that these industry space face.

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IoT and the Industry

- Industries add extensive value by integrating IoT strategies for transforming the business
- Industries need to become more efficient and reliable
- Maximize profit by the predictions
- IoT cloud slash cost

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So, let us look at these issues in detail, but before we do that I would like to have a recap because this is going to be the last application that I am going to expose you to in this particular section on applications. I am going to take you through a recap of the you know the issues that are there and the advantages that can be obtained from IoT implementations in the industry. In other words, in a nutshell; let us talk about the specificities of industrial IoT once again. We have looked at it in different levels of detail earlier, but now I am going to expose you to the summary of the different requirements that are there.

So, we want to industries have been operating in their respective fashions since ages; whether we are talking about the oil industry; whether we are talking about the chemical, pharmaceutical or manufacturing industries; things have been going on since ages, since decades, things have been carried on using traditional methodologies. But only now we are talking about the use of IoT or IIOT solutions and we are doing that in order to improve certain things..

We want to improve the efficiency; we want to improve the overall cost effectiveness operations and so on and so forth. In other words, what we want to do is that we want to add value; we want to add value to the products and the processes that are already there, the traditional ones. We want to add value by integrating IoT strategies, IoT solutions to these products and services.

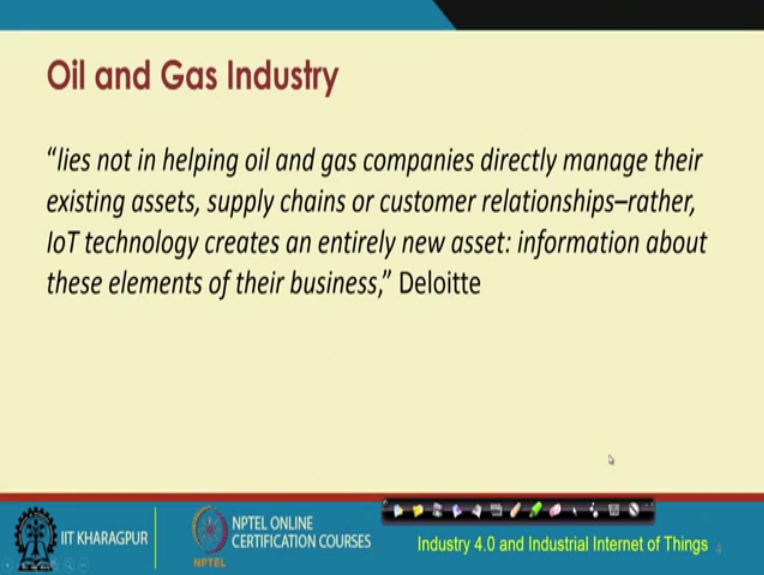
So, value addition should come out through this incorporation or integration of IoT solutions. Essentially, what is going to happen? We are going to improve efficiency; we are going to increase the reliability, safety, security; maximize the profit, maximize production and at the same time, we are going to slash the cost; the cost of production, the cost of manufacturing, the cost of the goods in turn. So, improving the productivity, reducing the cost is essentially in a nutshell we can say that are the benefits of integration of IoT solutions in the industry sector.

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Now, let us come to the specificities in terms of Oil and Gas Industry.

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Oil and Gas Industry

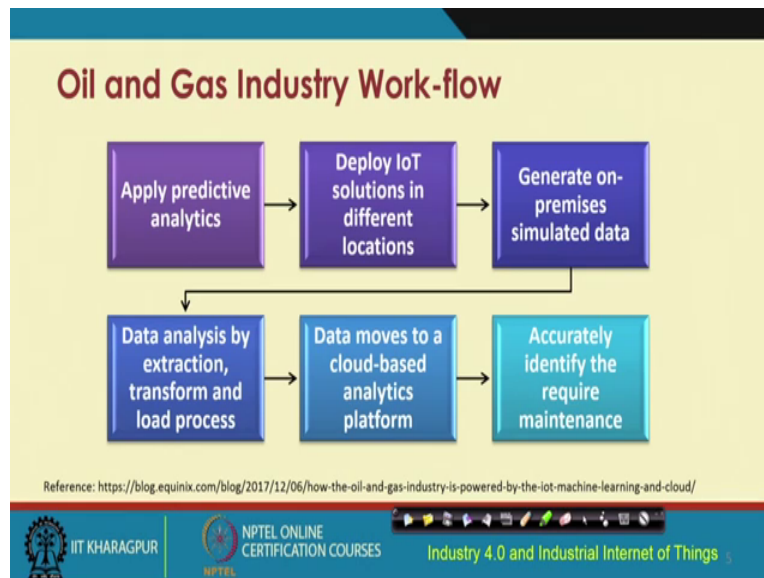
"lies not in helping oil and gas companies directly manage their existing assets, supply chains or customer relationships—rather, IoT technology creates an entirely new asset: information about these elements of their business," Deloitte

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So, there are different efforts globally that are going on in this particular industry domain oil and gas industry domain; lot of efforts are going on, lot of these different industries operating in these spheres. They are talking about having solutions where integration of IoT with their existing processes, machinery etcetera are going to happen. The benefits is something that, I have already told you at the outset, but what is going to happen is through the integration the oil and gas companies would be able to directly manage their existing assets, supply chains or customer relationships and that basically will help the business overall..

The productivity of the business is going to improve, the customer relationship is going to improve, the asset management is going to improve, the cost reduction is going to happen and so on. So, overall this is what is going to happen in the oil and gas industry through the integration of IoT solutions. This is a quote that I have taken from a Deloitte literature.

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So, this is something that you are already familiar with. We have looked at it, relooked at it in different different ways, but essentially as I told you earlier everything remains the same. The only thing that changes is basically the industry domain specific requirements, but from a technology point of view, from an IoT deployment point of view and IoT solution point of view things are essentially the same. But still for completeness sake for getting a bit of idea about implementation issues in different different domains, let us still have a relook at the entire process of integration of IoT.

So, ultimately, what we need? We need data, we need data; we need data for doing different things, we need data for predicting something that might happen in the future, miss happenings in the future events and miss events that are going to occur in the future. So, this is what might happen..

We need data about different parts of the process, we need data about the health condition of the machines, we need data about the workforce the employees that are working and so on. So, we need data. We need data to do predictive analytics. So, depending on what analytics, we would like to do the specific objectives that we have, we means the specific industry that is implementing the oil and gas industry that is implementing this solution, they would have some specific analytics objective.

So, based on that objective different IoT devices are going to be deployed; sensors, actuators etcetera are going to be deployed in different locations. Different locations in the plant within the plant also in different machines that are going to be involved in the process, in the supply chain and so on. So, different IoT devices are going to be deployed. Thereafter, these devices would generate lot of data. These data could be even augmented with certain simulated data as well. Those data the real ones plus the simulated ones could be together used to analyze, they could be used, they could be analyzed a priori to extract transform and load the processes, the etl processes could be implemented thereafter.

The data thereafter can be moved after this basic processing etl processing the data could be moved to the cloud based platform where in depth analytics is going to be performed and these analytic solutions are going to be commensurate with the analytics objectives that were set at the outset. And finally, based on the results of the analytics, requisite actions are going to be taken. For example, the devices that need future maintenance would be identified. Also the devices which would need immediate maintenance, they would be identified.

The segregation of the data, segregation of the machinery consequently based on different criteria are going to happen. So, this is overall the entire lifecycle of IoT deployment till you know control of machinery this is over all the lifecycle. The workflow that is going to be implemented and this is going to be implemented in the oil and gas industry and this is what is already happening, this is what is already happening, there are existing works, initiatives that are focusing on implementation of this kind of solution in the oil and gas industry.

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Improve operational Excellence

- Predictive maintenance
- Location Intelligence
- Pipeline and equipment monitoring
- Monitor
 - Sensor integration
 - Real time machines
 - Fleet operations

Reference: <https://dzone.com/articles/usage-of-iiot-in-oils-and-gas>

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So, overall we want to improve the operations. Different attributes such as predictive maintenance, location intelligence, pipeline monitoring, equipment monitoring, monitoring of the different sensors that are integrated to the pipelines through the machines etcetera. Real time machines taking part in these industries in the different processes their execution and so on and fleet operations all of these their operations and so on the performance overall could be improved with the incorporation or integration of IoT solutions.

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IoT increases customer loyalty

- Connects business and car
- Smart application
- Energy consumption profiles

Reference: <https://www.allerin.com/blog/whats-iot-doing-in-oil-gas>

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IoT not only does what I just told you, but IoT is also capable of increasing the customer loyalty. Connecting the business, connecting different businesses and different other components, smart applications energy consumption profiles and so on. So, all of these things could be improved and could be made handy and available to the IoT to the customers that are there in these different industries..

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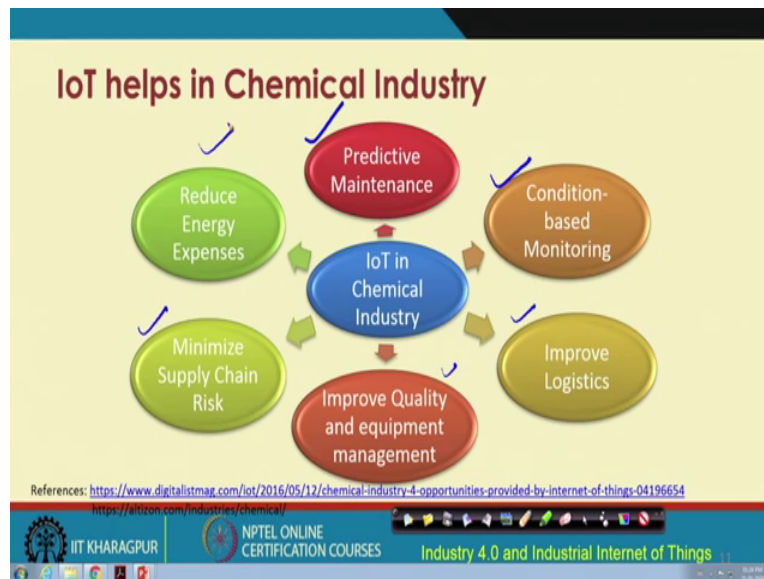
Benefits of using IoT in Oil and Gas Industries

- Increase production efficiency
- Save cost and time
- Improve asset maintenance
- Enhance
 - Production
 - Work safety
 - Supply chain planning

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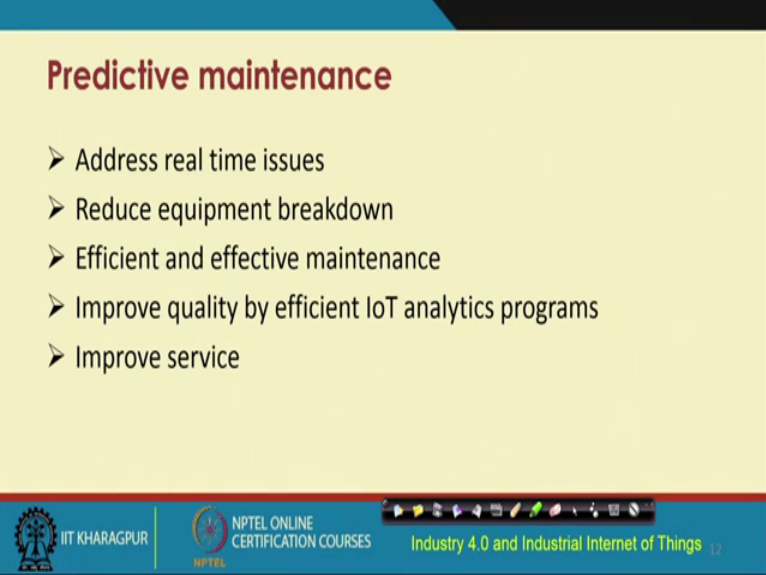
So, the benefits of using IoT in oil and gas industries is already quite apparent, but essentially let us recap and try to summarize what are the different benefits. Benefits include increase in production efficiency, saving on costs, saving on the time, improving asset maintenance, enhancing product productivity, work safety, supply chain planning and so on.

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In the chemical industry likewise IoT could be used for improving the overall processes, productivity reducing costs and so on and so forth. So, in the chemical industry once again, let us have a look at these different benefits. We can have predictive maintenance; we can have condition based monitoring of different machinery that are taking part in these industries to carry out different processes to execute them and so on; improvement of logistics could also be done; improvement of the quality; improvement of the management of the different equipments in these industries; minimizing the supply chain risk and reduction of energy expenses, these are the different benefits that could be achieved through IoT integration in the chemical industry.

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Predictive maintenance

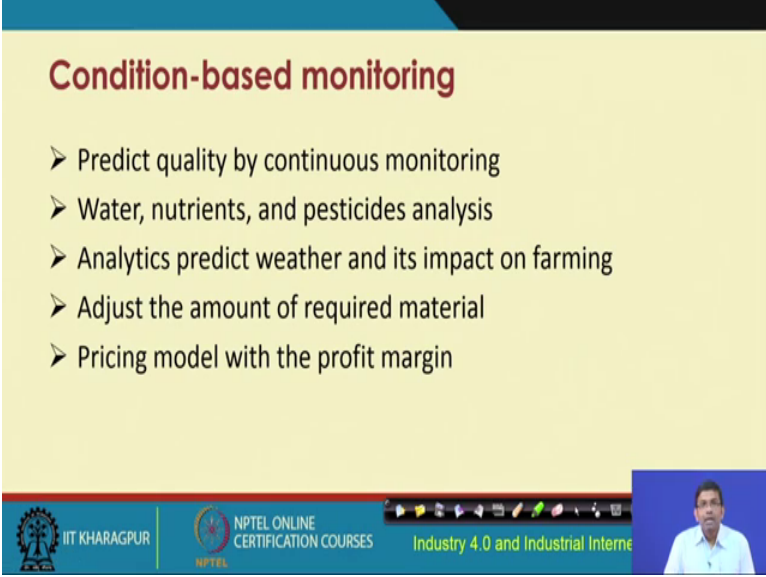
- Address real time issues
- Reduce equipment breakdown
- Efficient and effective maintenance
- Improve quality by efficient IoT analytics programs
- Improve service

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Predictive maintenance such as addressing different issues, that are going to happen in real time in the future now and also in the future. So, seconds later two minutes later two hours later things that can happen. So, predicting those in advance is what predictive maintenance concerns. Reducing the equipment down breakdown and downtime is what is going to be the benefit out of predictive maintenance.

So, what is required is through appropriate predictive maintenance through IoT integration, we are going to have efficient and effective maintenance and improvement of quality by efficient IoT analytics programs and in turn improving the overall services that are delivered.

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Condition-based monitoring

- Predict quality by continuous monitoring
- Water, nutrients, and pesticides analysis
- Analytics predict weather and its impact on farming
- Adjust the amount of required material
- Pricing model with the profit margin

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So, condition based monitoring is going to be possible. It is going to be possible to predict the quality by continuous monitoring, water, nutrients, pesticides, their analysis and analysis in real time is going to happen through the integration of IoT solutions. Analytics predicting weather and their impact on farming and adjusting the amount of required material, pricing models with profit margin; these are the different attributes of condition based monitoring which are going to be implemented through the integration of IoT solutions.

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Improve Logistics

- Ensure product location through sensors or RFID tags
- Track assets to prevent loss
- Detection of contamination or attacks
- Alert notification
- Warehouse monitoring

Improving logistics, ensuring product location through sensors or RFID tags tracking of assets to prevent loss. Detection of contamination or attacks, alert notification warehouse monitoring are the different different things that can help improve the logistics.

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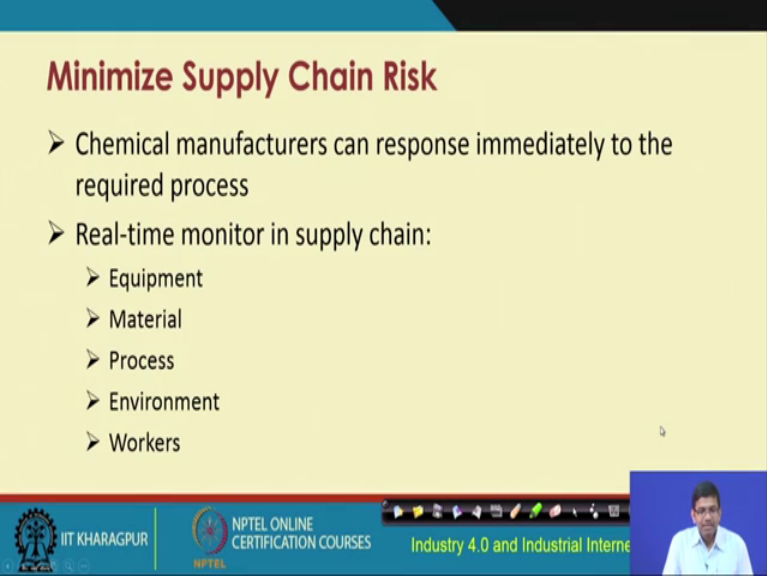
Reduce Energy Expenses

- Energy usage and regulatory control
- Analyze real time data
- Improve
 - Usage pattern
 - Inefficiency

Reducing energy expenses, energy usage, regulatory control. Analyzing real time data, improving the usage pattern, behavioral pattern of users inefficiency, reduction of inefficiency.

So, these are the different you know different characteristic different things about the energy expenses and reduction of energy expenses is of concern.

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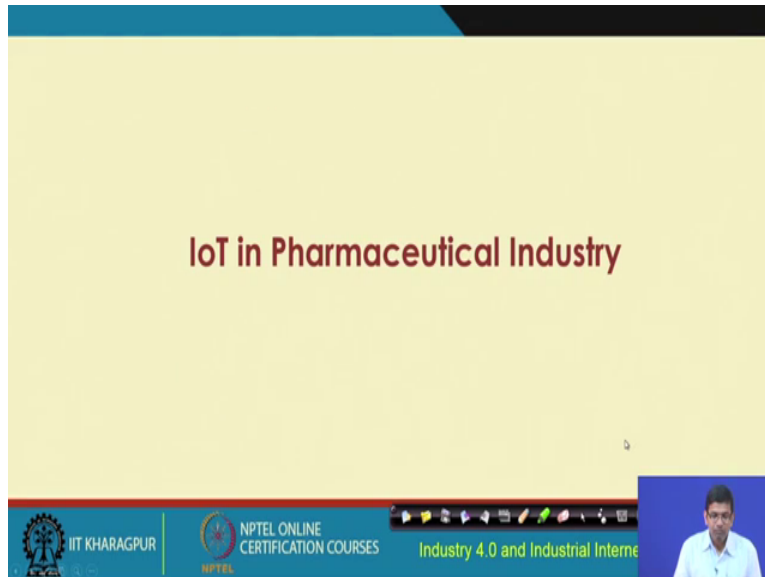
Minimize Supply Chain Risk

- Chemical manufacturers can respond immediately to the required process
- Real-time monitor in supply chain:
 - Equipment
 - Material
 - Process
 - Environment
 - Workers

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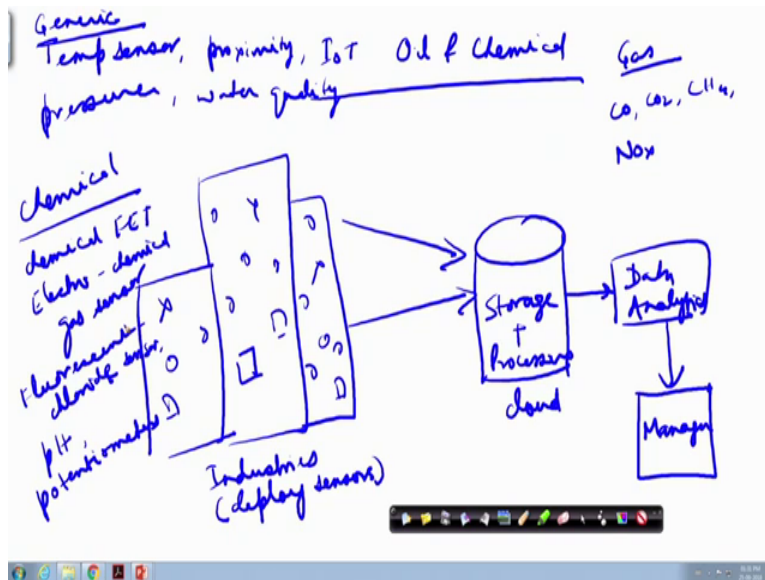
Minimizing supply chain risk. Chemical manufacturers can respond immediately to the required process whenever it is required as and when it is required based on the specific requirements that might be there. Real time monitoring in the supply chain of equipment, materials being used, raw materials, finished products, finished goods processes, workers environment, everything in real time, monitoring in real time of the entire supply chain and the participants in the supply chain; be it the humans, the workers the laborers and so on or be it the different machinery, everything is going to be possible to be monitored in everything in the supply chain is going to be possible to be monitored in real time.

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So, before I talk about IoT in pharmaceutical industry, let me see whether we understand this in detail enough. So, let us try to look at this particular thing. Let us say that we have, so we want IoT implementation in the oil and chemical industry right.

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So, we are essentially talking about what we are talking about different industries right, different industries etcetera in this domain. These are let us say the industries that would deploy different

sensors; different sensors in these different parts of these industries in the different industrial floor, the fields the field equipment and so on. So, all of these different sensors are going to be deployed. So, these data are finally, going to reach some server or some cloud service let us say which has storage plus processing capability and this data would be analyzed and would be made available to let us say the manager.

So, manager at a high level I am mentioning. So, it could be any type of manager. Whoever needs access to that data so, this is holistically how it is going to happen and so, for chemical and oil industry these different sensors you know I have given different levels for different sensors that could be used..

The different sensors that could be used could be your traditional ones, the common ones like your temperature sensor, different other sensors like proximity sensor, pressure sensor maybe water quality sensor, water quality sensor. So, these are these different types of sensors and also some you know specific chemical sensors could also be used. So, some these are the generic ones generic sensors.

And some chemical sensors could be used. For example,. So, we could have the chemical field effect transistors. We could have you know electrochemical electro chemical gas sensors or different other types of gas sensors also, fluorescent chloride sensors, fluorescent chloride sensors pH sensor is a very common one. Then, potentiometers, potentiometer sensors, potentiometers. So, these are the chemical sensors likewise gas sensors could be any of the gas sensors like carbon monoxide, carbon dioxide, methane, gas sensor; there is those nox gas sensors and so on.

So, there are different different sensors. So these are some of these different sensors, the chemical domain and the gas domain that I have mentioned. If you recall, when we talked about sensors in the industry scale, we also talked about the development of a gas cells sensor and I had shown you one of the facilities in our institute which basically deals with the gas sensor fabrication and how gas sensors can help in monitoring the concentration of different gases right. So, we have talked about that.

So, those gas sensors are actually also applicable in these different industries; oil and gas industries right. So, they could be used and for oil and gas industry, what also happens is typically from the point the oil and gas are procured or may be generated typically you will find that there are different ways of transporting that oil and gas right. So, there are different gas pipes; big big big thick gas pipes of large diameters that can help in carrying the gas from one point to another. These are quite common right. So, particularly the big oil industry is the back big gas companies, they deploy these gas pipes for carrying the gas for carrying oil from one point to another.

So, one of the common problems with these gas lines the distribution lines is leakage. So, gas leakage, pipeline leakage or even the oil leakage might happen in any of the points in these transmission lines and so, leakage detection, leakage monitoring is also very important..

So, basically the deployment of appropriate sensors for gas pipe monitoring is a is a very well-known problem and that is an application of IoT to improve the production, the transmission, the generation and so on. So, this is just an example like this different different sensors could be used to solve different problems in the oil and gas industry. So, let us now take a brief look at IoT in the pharmaceutical industry, this is also very similar.

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Use of IoT sensors in Pharmaceutical Industry

- Deployed in production areas
- Access huge data of different manufacturing departments
- Real time monitoring
- Able to control the areas remotely
- Proper utilization of equipment
- Reduce
 - ✓ Production cost
 - ✓ Wastage

The slide is part of a video lecture. The bottom of the slide features a blue banner with the IIT Kharagpur logo, the text 'NPTEL ONLINE CERTIFICATION COURSES', and the course title 'Industry 4.0 and Industrial Internet of Things'. A small video window in the bottom right corner shows a male presenter.

So, the thing is that there are in the pharmaceutical industry, you have different plants which are making different drugs and so on. These drugs are also used for you know the drugs and their monitoring of the drugs on different subjects, different animals and so on is also quite often done. So, IoT can help, IoT can help in doing these trials for the production process of the different you know drugs and so on monitoring those in a much more efficient manner. For example, production of a vaccine, you know it goes through different different steps right so and finally, it goes through certain trials if different sorts of trials happen.

So, these pharmaceutical companies, these pharmaceutical companies. They take these different drugs through different equipments, these drugs are tried out in different phases you know they are manufactured in different phases and finally, tried out in through different subjects and so on before these drugs are released in the market. So, for this entire production process, in this entire production process the supply chain and so on, sensors and IoT solutions could be deployed in order to improve the processes to monitor the quality of the drugs, the intermediate steps monitoring the quality of these intermediate steps and so on.

So, everything could be done in a much more efficient and precise manner. So, IoT sensors could be deployed in production areas could help in getting huge you know huge data from these manufacturing departments in these pharmaceutical industries can help in real time monitoring, can help in controlling these areas remotely, can improve the utilization of the equipments the machinery etcetera. And can help in reducing the production cost and wastage. So, these are some of these uses of IoT sensors in the pharmaceutical industries..

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IoT Application in Pharmaceutical Industry

- Examine drugs
- Detect:
 - Adverse Drugs Reaction (ADR)
 - Effects of pharmaceutical excipients
 - Allergies
 - Other complications

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So, IoT applications in pharmaceutical industry includes examination of the drugs and not just the final drugs, but also the intermediate ones through which the processes that are incurred in between in order to transform these raw materials into the final drugs. So, you know throughout from the raw materials to the final drugs, examining the quality, the quantity etcetera also monitoring the different chemical reactions that are required in order to transform one part of the chemical to another part and so on.

So, all of these basically in this entire process, IoT solutions could be deployed. IoT solutions could be also deployed in order to detect adverse drug reactions effects of pharmaceutical excipients, you know detecting allergies, other complications that might be meant might be effort might be happening. So, all of these drug reactions and allergies etcetera etcetera you know monitoring those, detecting those everything could be done in the pharmaceutical industry. These are being done with the help of different appropriate sensors.

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IoT Application in pharmaceutical Industry (Contd..)

- Quality control by real-time monitoring
- Safe and secure drug delivery
- Deploy to connect different technologies:
 - Manufacturing
 - Monitoring
 - Controlling
 - Distribution

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So, Quality control by real-time monitoring; safe and secure drug delivery deployment of different solutions to have you know improved manufacturing, improved monitoring, controlling, distribution. These are the different other requirements in the pharmaceutical industry.

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Improve logistics

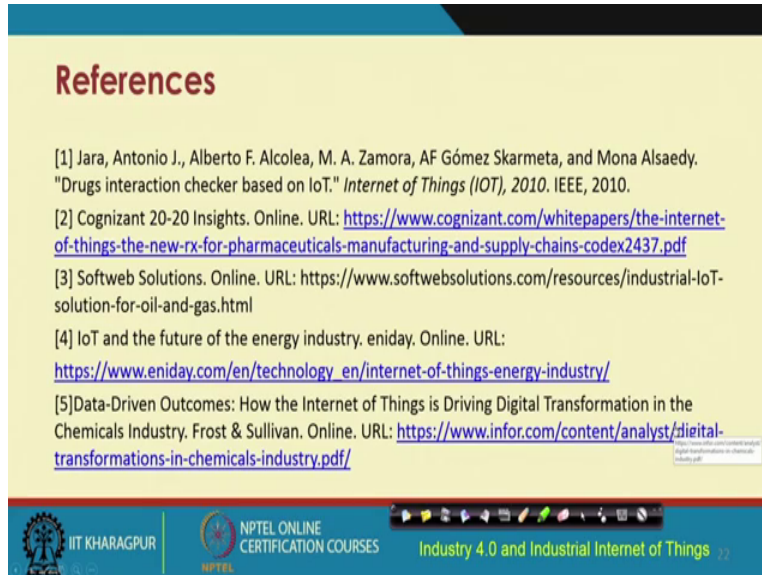
- Track the movement of pharmaceutical goods
- Improve warehousing
- Optimize routing
- Maintenance of machines and equipment
- Inspects the maintenance of medicine and vaccines

Reference: <https://www.entrepreneur.com/article/305272>

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Improving logistics; tracking the movement of pharmaceutical goods. Improving warehousing, Optimizing routing, Maintenance of machines and equipment, Inspecting the machines of medicines and vaccines. These are also going to improve with the incorporation or integration of II of IoT in the pharmaceutical industry.

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[3] Softweb Solutions. Online. URL: <https://www.softwebsolutions.com/resources/industrial-IoT-solution-for-oil-and-gas.html>

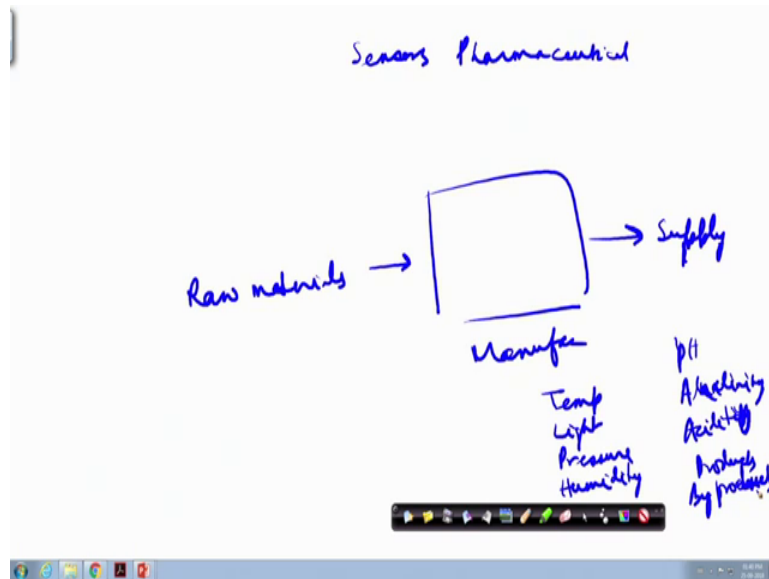
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Before I end, I would like to list these different types of sensors that we are going to use in the pharmaceutical industry.

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So, for the pharmaceutical industry also for you know first of all what happens is let us say that a pharmaceutical industry makes certain drugs right. So, there would be different raw materials. So, raw materials are going to be used. These raw materials are going to be taken through certain manufacturing process, manufacturing process and finally, the final products are going to be supplied right..

So, these are going to be delivered through trucks and other logistic means etcetera etcetera. So, these raw materials undergo different types of processing. These raw materials we would be subjected to different chemical treatment. These raw materials are going to be subjected through different pressure, under certain pressure condition, temperature condition, in certain humidity condition and so on.

Performing different reactions with different agents reagents under certain temperature humidity lighting condition and so on. So, all of these things are going to happen. So, what sensors are going to be used? In addition to certain chemical, specific chemical detection, specific chemicals, specific sensors other sensors such as temperature sensor, because you need to conduct a certain reaction or maybe a titration under certain temperature settings in a certain lighting condition,, light sensors, temperature sensor light sensor, pressure sensor in a certain pressure condition

these reactions have to happen. So, pressure sensors. Like this there are different different other sensors that would also be used in the pharmaceutical industry.

So, let me just right. So, the names of some of these sensors, temperature sensor, light sensors, then you have pressure sensors, maybe humidity sensor and if you have some kind of chemical reactions these different chemicals chemical sensors for detecting maybe the pH level right. So, pH level. So, you could have the pH sensors; detect the alkalinity, alkalinity or the acidity of the different products or the byproducts in the chemical reaction. And the transformation process right. So, these are these different sensors some of these different sensors that could be used.

So, finally, we come to an end or in this lecture and as usual these are these different references. I would encourage you to go through these different references. There are lots of videos that you could also use to you know get better understanding of these the applications of IoT in this different industry; even in the oil industry, gas industry, pharmaceutical industry, there are a lot of different videos. You could try it out in different open media such as YouTube etcetera lot of different videos exist. So, these are these references and finally, we come to an end.

Thank you.