Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture – 49
IIOT Applications: Factories and Assembly line

In this particular module I am going to take you through different case studies, different applications for examples of implementation of IIoT. So, different industries are trying to adopt IoT, IIoT solutions. So, I am going to take you through the collection of different adoptions and the stories behind this adoptions of IIoT technologies by different industries, I am going to do it domain wise.

So, in the first domain we are going to talk about smart manufacturing industries. So, manufacturing industries, the assembly lines and so on is the first one to be considered, smart factory more specifically is what we are going to revisit once again and look at which different industries have in adopting IIoT solutions and how their processes have improved consequently. So, let us look at manufacturing.

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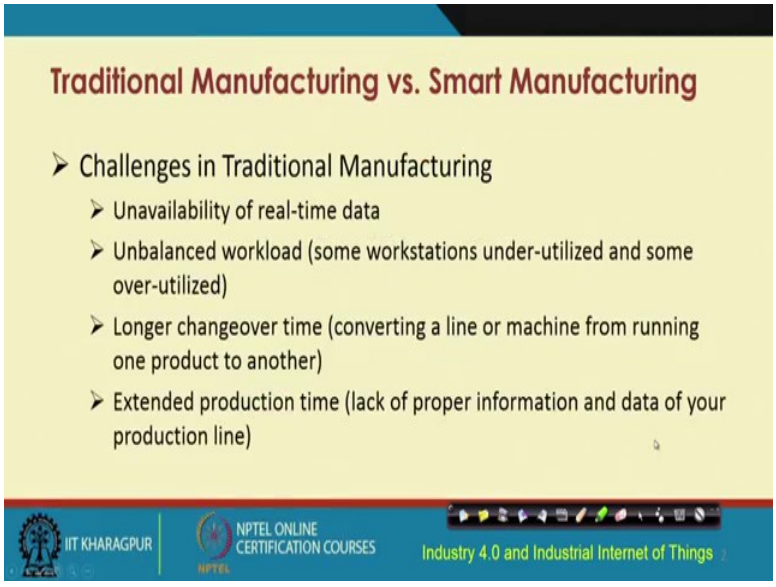

So, whenever we are talking about manufacturing, traditionally there were different challenges, this manufacturing machines deals to work in isolation, these machines were not connected, there were different other challenges such as because these machines were not connected with one another, there was unbalanced work load in this different

machines. So, the work load across the different machines doing the same thing was not balanced.

There were other challenges also, challenges with respect to the availability of data in real time that was also another challenge with traditional manufacturing, with traditional isolated manufacturing machines which were not connected with one another and which were also not connected from one machine to some centralized entity or the controlled station.

There were challenges with respect to longer change over time; that means, converting a line or machine from running one product to another. So, whenever this changeover will have to happen it used to take much longer and so on, that is the traditional manufacturing, the drawbacks of it.

The other challenge with traditional manufacturing was that the production time itself used to be much more extended, this is because of lack of proper information and data of the production line. So, all of these different challenges, the 4 different challenges that I have just mentioned could be overcome with smart manufacturing solutions. So, smart manufacturing, smart factories, factories which integrate IIoT solutions to basically transform them to be smart. So, smart factories smart manufacturing is what we are going to talk about over here.

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So, smart factory: so whenever we are taking about smart factory, smart factory integrates IT and OT. So, you have this traditional machinery, the traditional equipments, the traditional operational technologies and their optimization, self optimization, automation and so on. So, not just having these machines run respectively in isolation, but also to optimize the processes automatically in through the connection of the different data that are coming from this machines about their health conditions and so on and also through the automation overall.

So, self optimization and automation so, benefits of this smart factories are going to be that one can, in real time get lot of data, data about different things particularly the data about the health condition of these different machines. This data will have to be analyzed and based on the analysis, quality control can be done and that is all of these things can be done only in a smart factory.

Smart factory results in reduced change over time, smart factory results in reduced production time and also smart factory has the features of flexibility; flexibility with respect to change over, flexibility with respect to adoption of newer components, newer technologies, integration, integration within and beyond the system and also ease of management. So, all of these are different benefits of a smart factory.

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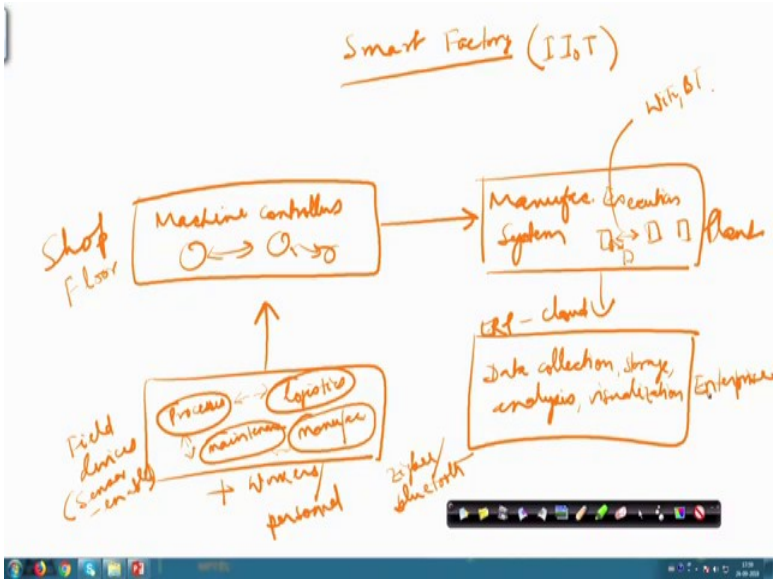

So, before I proceed let me show you some of the different features of a smart factory. So, smart factory is something that I have already discussed in a previous lecture, but let

us try to go over this particular thing in much more detailed because IIoT a good application instance of IIoT is basically the building of smart factories.

So, whenever we are talking about smart factories we are talking about different field devices. So, field devices; these are basically sensor enable devices which will help in execution of different processes in a smart manner. So, different processes running on them the different other things can be done such as the maintenance of these devices, of the system, of the processes, logistics and manufacturing.

So, in other words we could have field devices improve the processes, improve the maintenance, improve logistics, and improve manufacturing holistically. So, these are the different things that can be done with the help of these sensor enabled field devices. So, this field devices are basically sensor enabled. So, let me also tell you that not only these field devices are enabled with the sensors, but these are also you know the sensors are also enabled with the different workers, or the different personnel that are involved.

They also will have different variable sensors which continuously are going to monitor there their work habits, their stress level and so on and so forth. So, all of these so monitoring the health of the different devices, monitoring the health and the working condition of this different workers and the work force the personnel so on, working in a smart factory all of these things are going to be done.

So, there after this data are going to be sent to the shop floor. So, these are like different units. So, if the manufacturing plant has a shop floor, different shop floors are there. So, these are like different units for manufacturing, different units catering to the different requirements within a particular factory. So, shop floor will have different controllers, these are machine controllers that might be there within a shop floor so machine controllers and so on.

So, these machine controllers will again be connected with each other. So, I forgot to mention over here that these different devices taken care of processes, maintenance, logistics, manufacturing and also these components between themselves they are all going to be connected with each other and this is going to happen through the use of different communication mechanisms like ZigBee or Bluetooth or the different communication technologies that I covered in the introductory lecture on IoT.

So, all of these are going to talk to each other. So, this is the shop floor and from this shop floor basically the data are going to be sent to the manufacturing plant. So, the manufacturing plant will have the manufacturing execution system right, manufacturing execution system which will again have different components like controlled rooms, you know sub controlled rooms and so on which will also have to be connected through this different communication mechanisms like may be Wi-Fi, Bluetooth, etcetera. And finally, the data will be sent may be to a system integrator like ERP right.

So, this may be the ERPs which is going to do the data collection, storage and may be analysis and this could be even cloud enabled. So, this could be ERP cloud, cloud enabled ERP not only just analysis, but also visualization is also possible so, all of these different things can be done. So, holistically so this is your enterprise level. So, we started with the field device level, then the next level higher up was the shop floor then the plant and finally, the enterprise level.

So, you know in a smart factory all of these things are going to be interconnected, these different devices throwing in lot of data being processed in the shop floor different controllers, connectivity between them, again sending the data to the manufacturing system and their execution at the plant level. And then at the cloud level the ERP and cloud together could be used for data collection storage analysis and visualization, this is holistically how a smart factory looks like this is the high level block diagram of how these operations go on in a smart factory. So, having understood this thing let us now proceed further and try to, we have already seen that these are the different benefits of having a smart factory.

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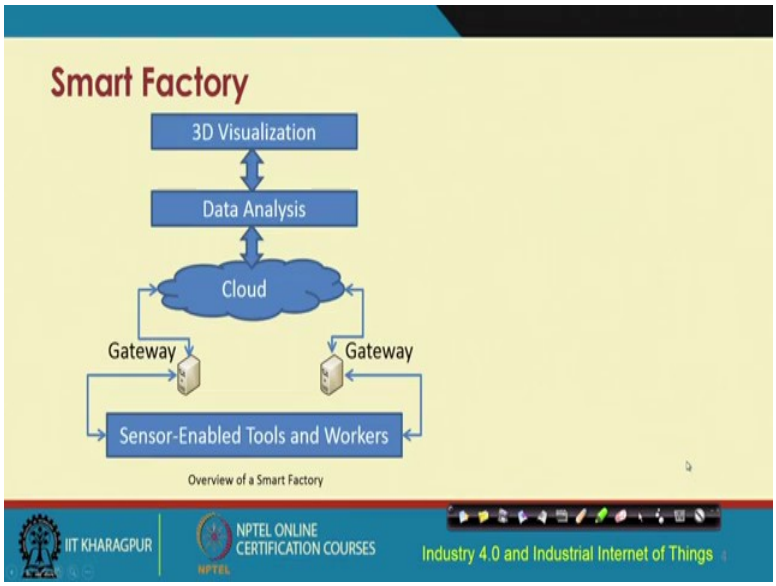

Let us now look at from a different perspective how this smart factory is going to work. So, at the very bottom we will have this sensor enabled tools and workers. So, this is what I was telling you earlier that your devices are going to be sensor enabled this is understood in a manufacturing plant in a factory and so on, but not only these tools and devices, but also the workers are going to be sensor enable.

So, both the tools and this workers are going to be sensor enabled, they are going to through in lot of data which are going to passing through this gateway to the cloud where further data analysis, data visualization, etc. are going to be done and the results are going to be made available to the respective stake holders based on their corresponding policies, their access control mechanisms takes place and so on.

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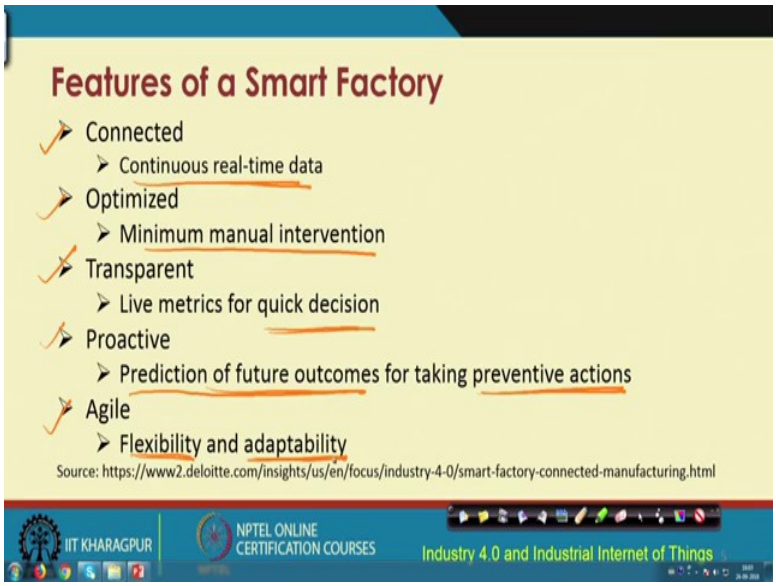

So, in terms of the features of a smart factory these are the some of these different features, in a smart factory we are talking about connected devices which are going to sent lot of data in real time continuously. Optimized components, optimized data without any human intervention or with minimal human intervention is a characteristic of a smart factory.

Smart factory is transparent in the sense that you are going to get lot of data, live data depending on the metrics that are implemented you are going to get all this live data and those data can be used suitably at different levels of management for quicker decision making so, transparency is also promoted in a smart factory.

Proactive feature means that you know proactively we can predict the future outcomes and take preventive actions depending on the situation and what is going on or what is going to happen in the future. So, proactively based on the prediction of future outcomes one can take preventive actions.

And finally, agility with respect to flexibility, flexibility to change adoption of newer systems components changes in terms of the versions etc. So, all of these things are possible in a smart factory.

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Let us now look at some of these case studies right. So, you know I will start with the Airbus Company which has state of the art implementation of IIoT. So, airbus basically has adopted something known as the factory of the future. So, before I talk about the factory of the future let me give you a brief highlight about airbus. So, airbus as you know is a major pair player in the aviation sector and airbus is a German or in general I can tell the it is an European aircraft manufacturer and it applies lot of IoT technologies in its production process.

So, essentially what happens is that consequently during the production; that means, during manufacturing productions so on in the floor of the plants and also after the products are deployed in a real aircraft lot of data can be collected. So, lot of data can be collected at the time of manufacturing production in the floor of the plants, but also additionally lot of data can be collected from the flight recorders, while the flights are in operation.

So, collecting data on flights will help to improve the in flight experience and the workers on the factory floor can use this IoT devices to improve their processes to get an understanding about the different positions in the manufacturing process and so on the I mean how much the manufacturing has processed what are the different gaps etc. in the process and so on. So, all of these things holistically the workers on the factory floor using this IoT enabled devices can get a holistic understanding. So, airbus, they launched

this digital manufacturing initiative which is known as the factory of the future. So, this is how it looks like.

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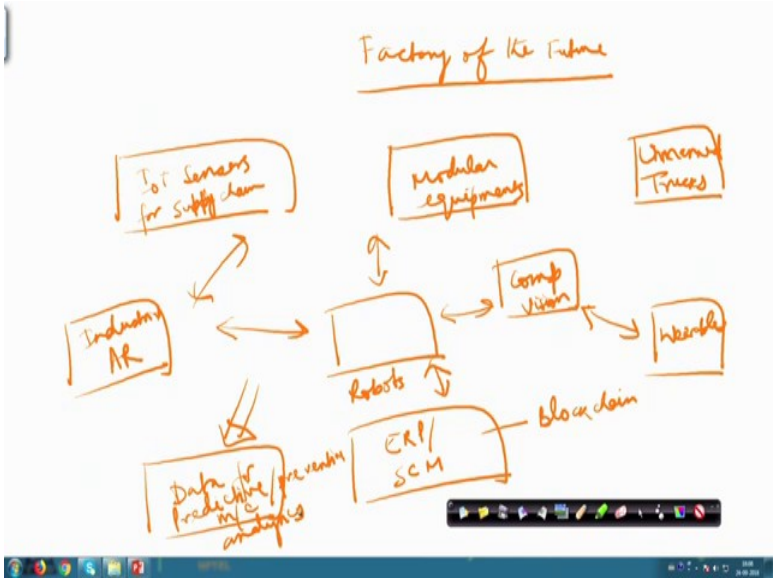

Let us look at this factory of the future. So, in a factory of the future, we are talking about different components; components such as IoT sensors for supply chain management. Then we are talking about modular equipments, use of different robots, robotic arms, etc., use of concepts of industrial augmented reality, use of computer vision, image processing and video processing in real time and so on.

Then use of logistics and trucks and particularly in an autonomous system which is a characteristic of the factory of the future we are typically talking about unmanned trucks and we are talking about workers and these different machines which have wearables. We are talking about ERP, then supply chain management, probably cloud enabled and also may be block-chain implemented, and these basically will be different components; randomly I am connecting them, but basically they are going to work together.

And also what is very important is finally, all of these are going to throwing this data this data will be used for predictive or preventive machine analytics. So, this is typically how it looks like, what it looks like in a factory of the future and as I told you that airbus has already adopted the factory of the future.

So, let us now proceed further and look at this different other implementations that airbus has adopted with respect to the factory of the future.

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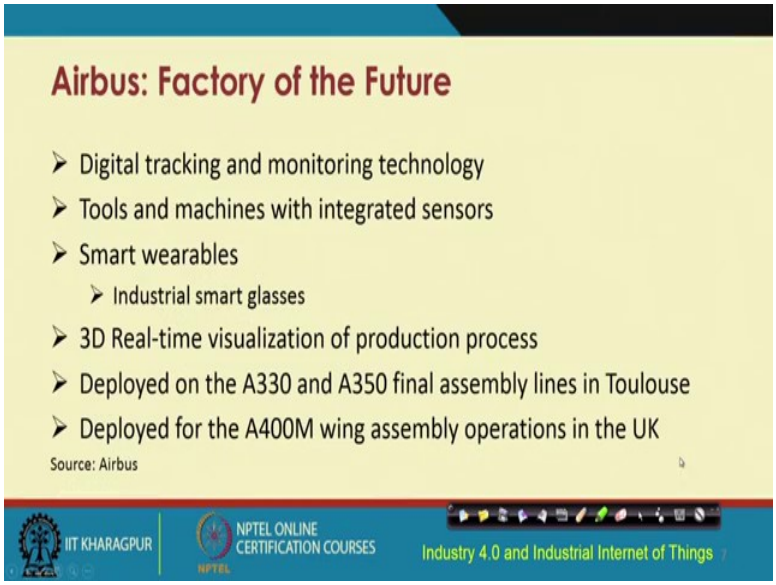

So, with respective the implementation of factory of the future, airbus now has mechanisms for digital tracking and monitoring, tools and machines with wearable sensors, sensors which are integrated to them not only those wearable sensors, but also equipments such as smart glasses can be use the industry grade smart glasses could be used with maybe augmented reality support, so, this smart glasses could be used. So, airbus is using all of these different things for its implementation of factory of the future.

So, 3D real time visualization of the production process is possible and all of these things are also deployed different sensors and all of these things are deployed on the A330 and A350 models and their assembly lines which are there in the Toulouse manufacturing plant and they have also deployed this factory of the future for the A400M model and their assembly operations in the UK.

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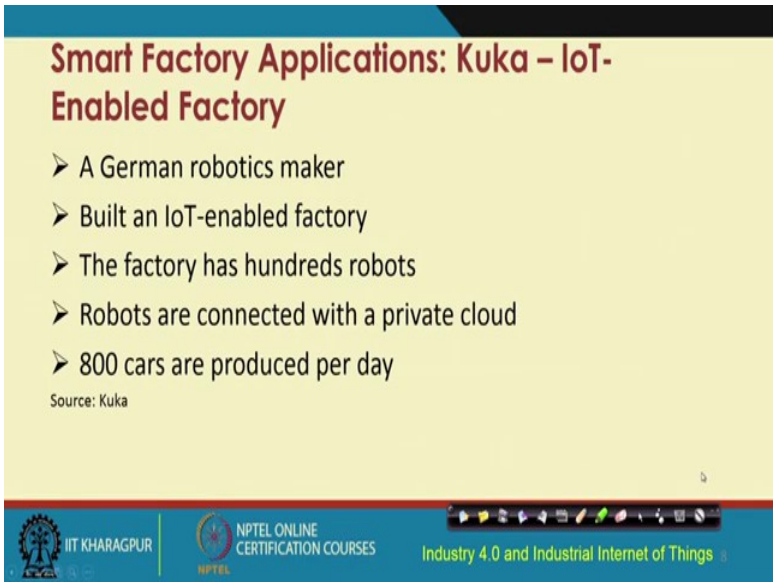

Another company of which is a germen robotics maker; name is Kuka, they have their IoT enabled factory which basically caters to having different robots their manufacturing of the robots and their connectivity between them etc. All of this things have been implemented IoT enabled connectivity between this different devices sensors connectivity and so on. So, all of these things are enabled in Kuka. So, basically these robots are connected with a private cloud and so, Kuka basically produces more than 800 units of these different devices per day.

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So, another application is the construction internet of things. So, by the company DeWalt; DeWalt is the tool manufacturer which launched this initiative of construction IoT. It uses the IoT platform and the Wi-Fi mesh network that tracks the workers and the equipments that they are using. The construction internet of things basically monitors the sites the construction sites which are very large, as large as the NFL football stadium.

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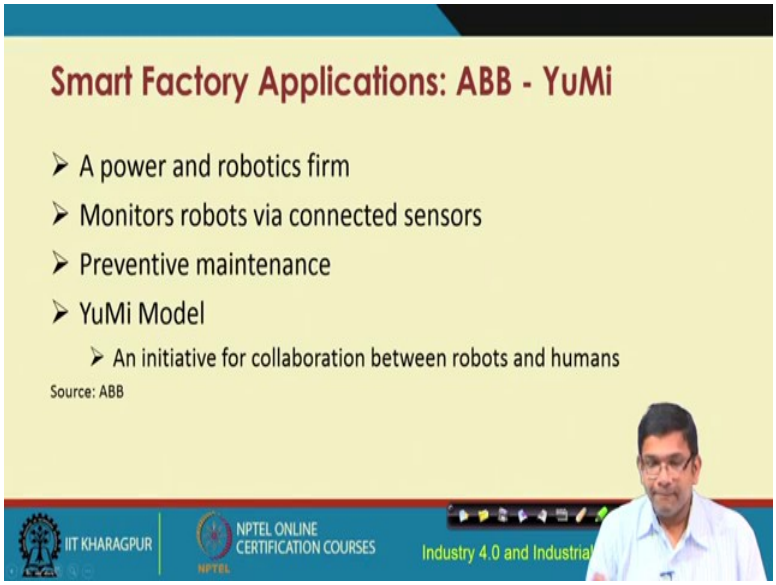

ABB came up with the YuMi model which is basically an initiative for collaboration between different robots, industry skilled robots and the humans YuMi model. And ABB is a power and robotics firm which has sensors and different robotic machinery enabled power systems, for monitoring the conditions of these machines and so on. So, these machines are all sensor enabled and also are connected through robots etc. and this YuMi model can help in the preventive maintenance of the ABBs products.

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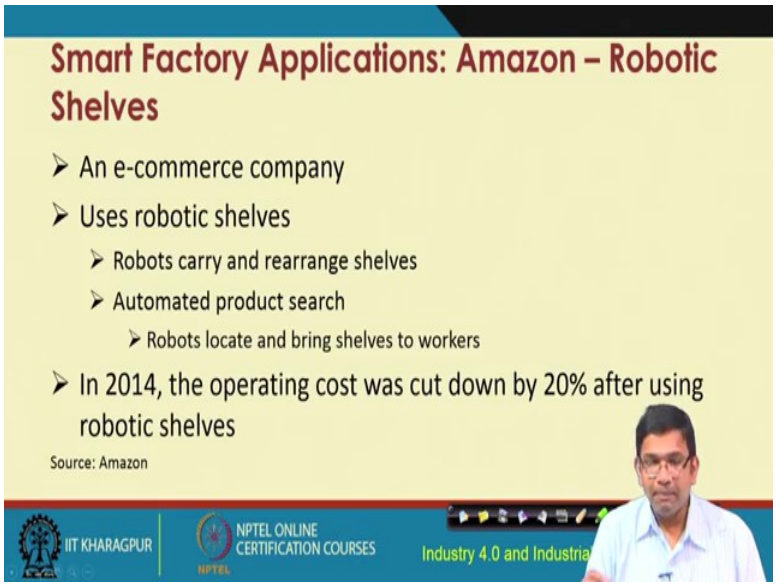

Amazon basically has the robotic shelves and as this name suggests basically Amazon uses different types of robots that will carry this shelves and rearrange this shelves. Amazon basically is the e-commerce company as you know and this shelves and their rearrangement robotically is very important and that basically makes the processes much more autonomous, efficient and so on.

So, the good part of this thing is that because it is an autonomous robotic system; using this system the robots can efficiently locate and search different items from their different shelves. So, basically in 2014 the operating cost was cut down by 20 percent using these robotic shelves by Amazon.

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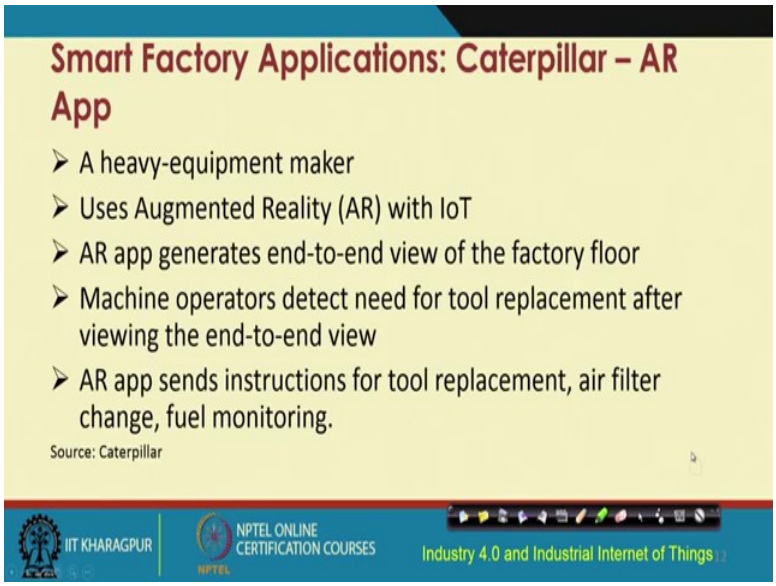

Caterpillar: caterpillar basically has the AR app augmented reality app which is integrated with IoT, caterpillar as you know is a heavy equipment maker and they have come up with the augmented reality app that generates end to end view of the factory floor. So, the machine operators can detect the need for tool replacement whenever it is required after viewing the end to end view through that particular AR app. The AP app basically sends instructions for doing things like tool replacement, air filter change, fuel monitoring and so on.

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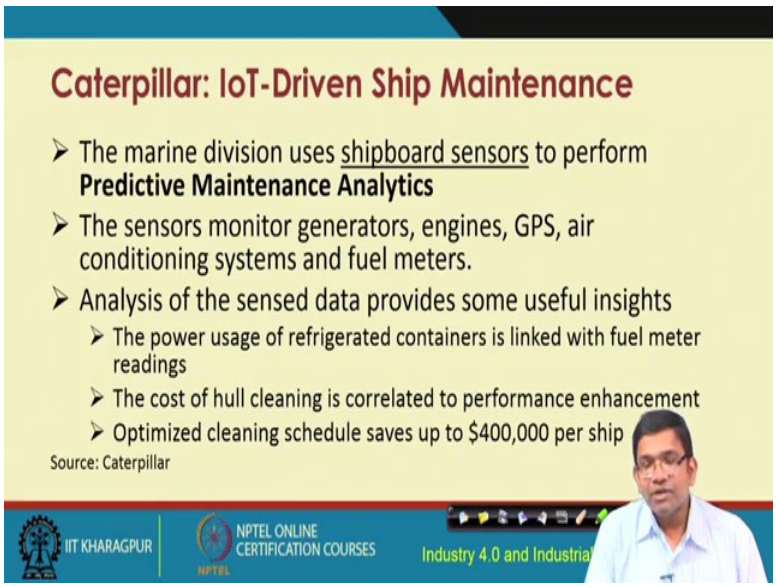

Caterpillar has the IoT driven ship maintenance and that is done by their marine division they use the ship board sensors to perform predictive maintenance analytics. The sensors that are deployed can monitor generators, engines, GPS, air conditioning systems and fuel meters. The analysis of the sensed data provides useful insights with respect to the insights about power usage of refrigerated containers, the cost of hull cleaning and optimized cleaning schedule and their data these are all provided through the analysis of the data that are obtained through these different sensors that are deployed in the onboard devices of the ships.

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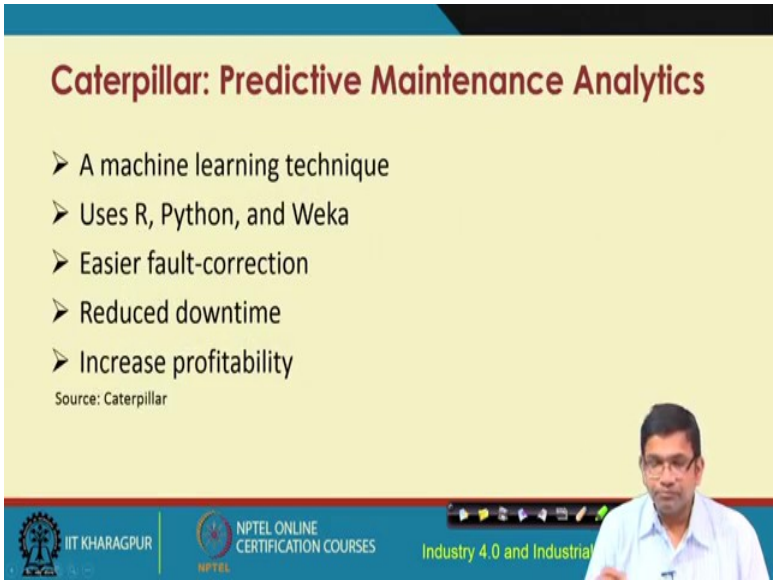

So, preventive maintenance analytics talks about use of all these machine learning techniques that we have discussed in a previous lecture. Tools and techniques like, are Python, Weka could be used to come up with these different analytics predictive analytics and so on. It is used easier to have easier fault correction, reduced downtime, and increased profitability, using the predictive maintenance analytics and this is what caterpillar is doing.

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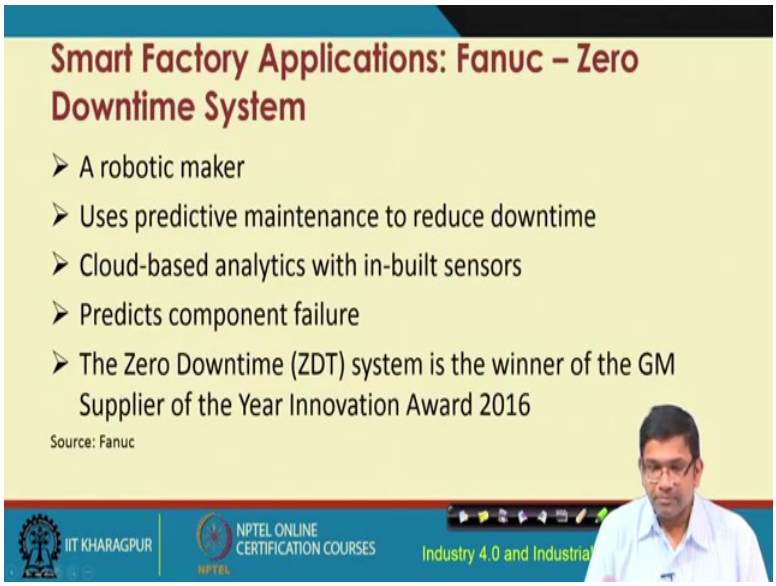

Fanuc is a robotic maker. It has the Zero downtime system, it uses predictive maintenance to reduce the downtime. It uses cloud based analytics with built in sensors, predicts component failure and the zero downtime system that Fanuc has is the winner of the GM supplier of the year innovation award 2016.

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Gehring is in the space of connected manufacturing. It makes honing machines, using cloud based analytics different types of predictive analytics is done with the data that are received from the machines in real time, thereby the productivity of the processes,

productivity in the manufacturing plant of Gehring is improved, the optimization of productivity is done and so on.

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Hitachi has the Lumada system which offers IoT platform comprising of 5 layers, the layers of edge, core, analytics, studio and foundry which are used together in order to improve the manufacturing processes of Hitachi.

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Maersk is in the space of intelligent shipping. Maersk is a container shipping company that tracks the assets and fuel consumption using different sensors. So, this is another

example of smart factory and it is implementation. It uses IoT for preserving refrigerated containers uses blockchain technology for supply chain optimization.

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Magna Steyr has the smart packaging system which uses IoT for tracking assets including tools and vehicle parts. So, smart packaging is enabled with Bluetooth. Bluetooth enabled packaging is there in their system and it tracks the components in the warehouses. In Magna Steyr the employees use wearable technologies in order to have end to end connectivity, improved connectivity, between these different machines, not only between these different machines but also the machines and the humans or the employees that are working in the factory.

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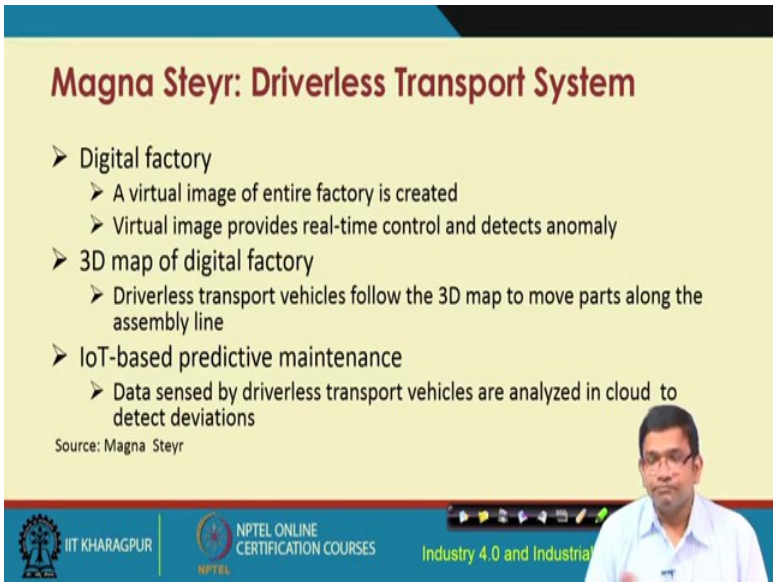

Magna steyr has the driverless transport system, they have the digital factory which offers a virtual image of the entire factory and that is done using advanced technologies this virtual image provides real time control and detects in the anomaly. They create with the help of the data collected, they create the 3D map of the digital factory and that basically helps in doing number of things efficiently including predictive maintenance of their transport vehicles using the data that is stored in the cloud.

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North Star BlueScope Steel uses IoT for worker safety. So, this particular company is a major supplier in the steel industry. It has different smart IoT devices, helmets, wristbands, etc. for the workers and their supervisors so that the supervisors can track the health condition of the different workers. The supervisors can give break for example, to the overloaded workers, the supervisors can monitor the condition of the workers and the working condition in which this workers are working. So, the supervisors can get data about you know the environmental parameters such as whether there is any radiation in the environment in which the worker is working or whether the worker is working in an environment a with different toxic gases.

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So, some other smart factory applications include the implementation of IoT by Rio Tinto for mining. So, Rio Tinto has driverless trucks and trains to pull ore from the mining sites and they also have the autonomous drill technology.

There are different other IoT applications in the power grid sector were IoT has been deployed to make the power systems much more smarter. The company bosch also heavily uses IoT and it basically deploys different IoT equipments in order to improve the working condition of the workers or and also to reduce the number of errors that happen in the work floor by the different workers.

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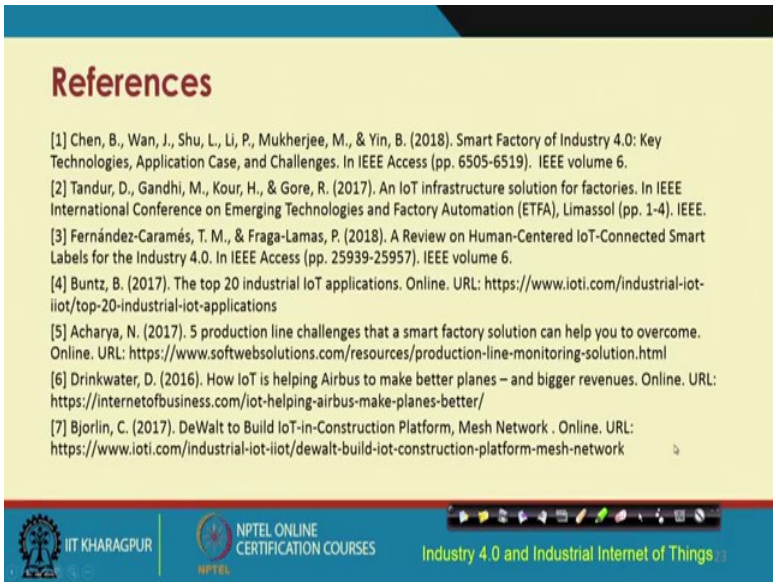

So, these are some of these different references that you could go through in this particular space of the smart factory and also the assembly line in the smart factory IIoT implementation in a smart factory and so on. These are all these different references and including the references talking about these case studies of the companies and their products that I talked about briefly in the last half an hour of lecture.

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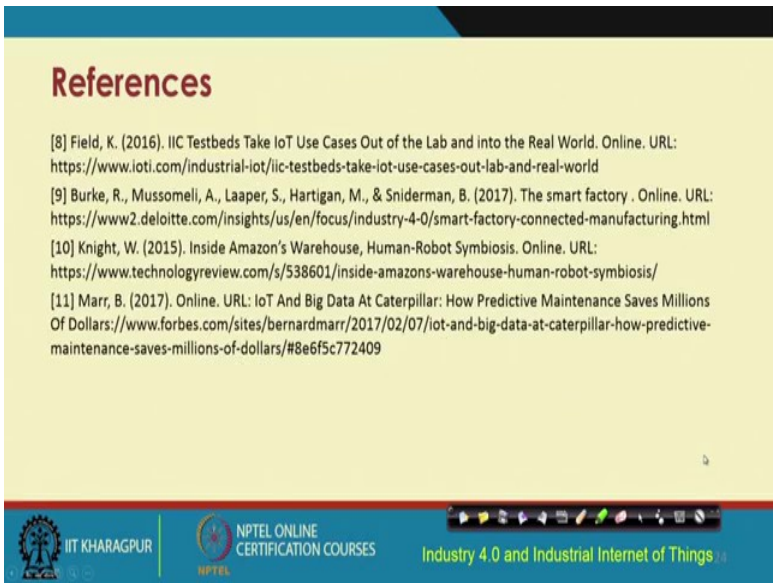

These are all these references for you to go through.

Thank you.