Mine Automation and Data Analytics

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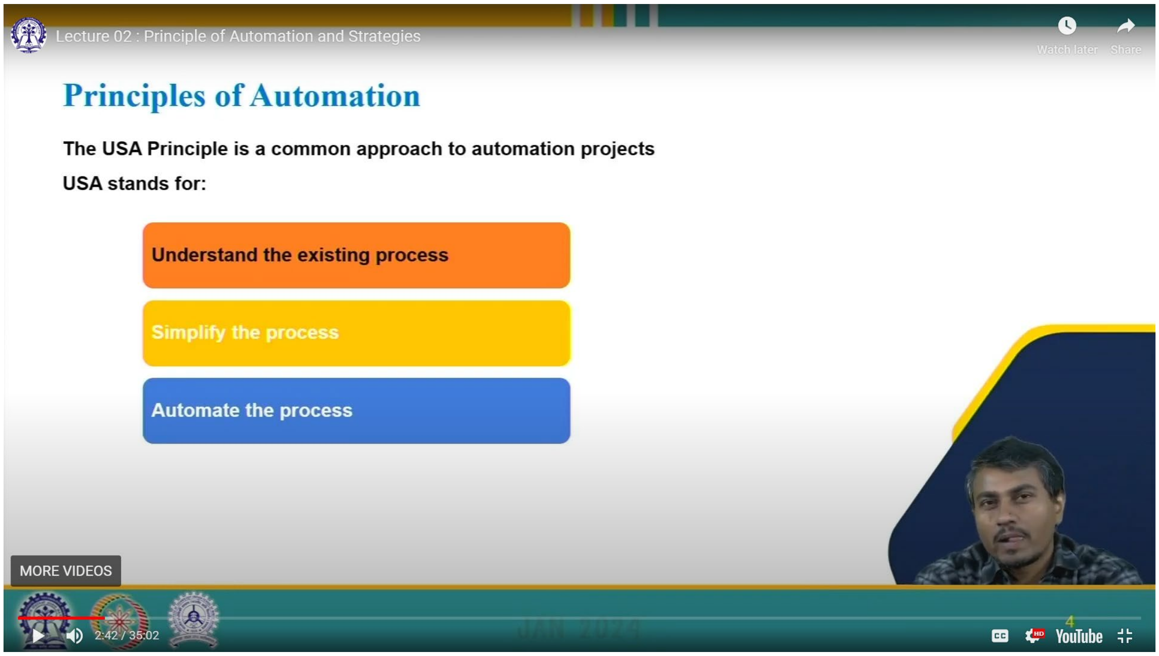
Week-1

Lecture-2

Principle of Automation and Strategies

Good morning, welcome to my course on automation and data analytics. In this lecture, we will discuss the principles of automation and strategies. So, in this lecture, we will cover the following: The principle of automation, then we will cover the different strategies for automation, in particular in the mining industry. Then comes the automation migration strategy. Then we will discuss the engineering design management framework.

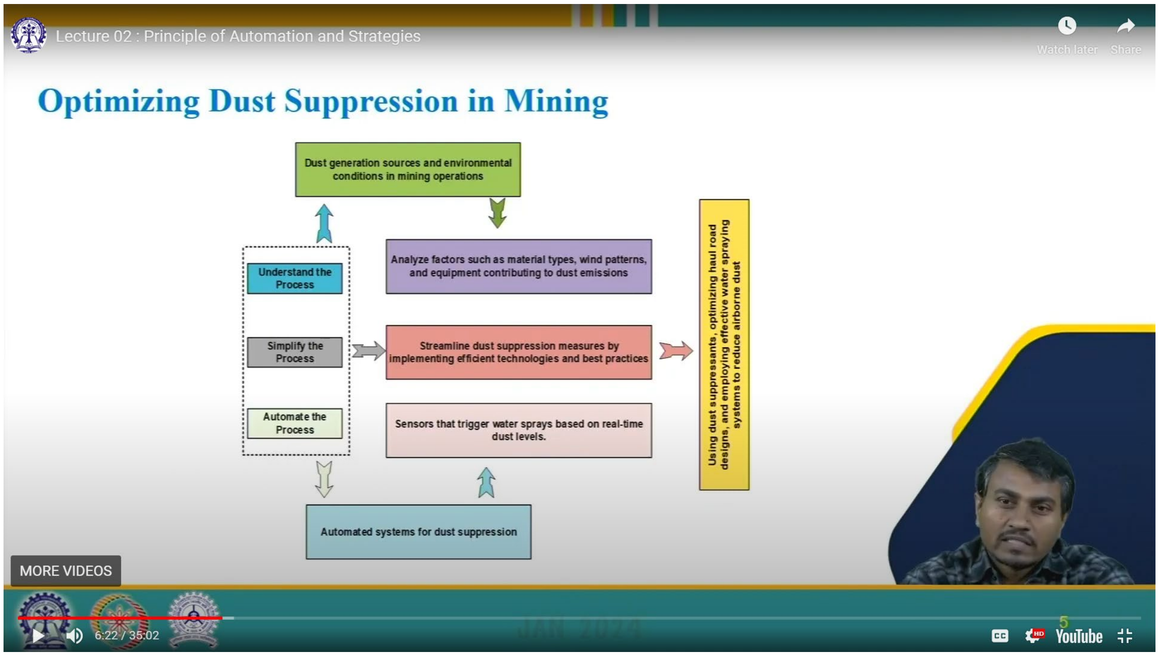
So, what is the principle of automation? The famous principle is the USA principle in the automation approach. In the USA, U stands for understanding the existing process. So, in all automation projects across all the industrial processes, implementing automation is very well linked with the understanding of the existing process, and without understanding the existing process, its limitations, its lacuna, its disadvantages, and its current limiting conditions, the automation will not be successful. So, understanding in detail about the existing process is very much required.



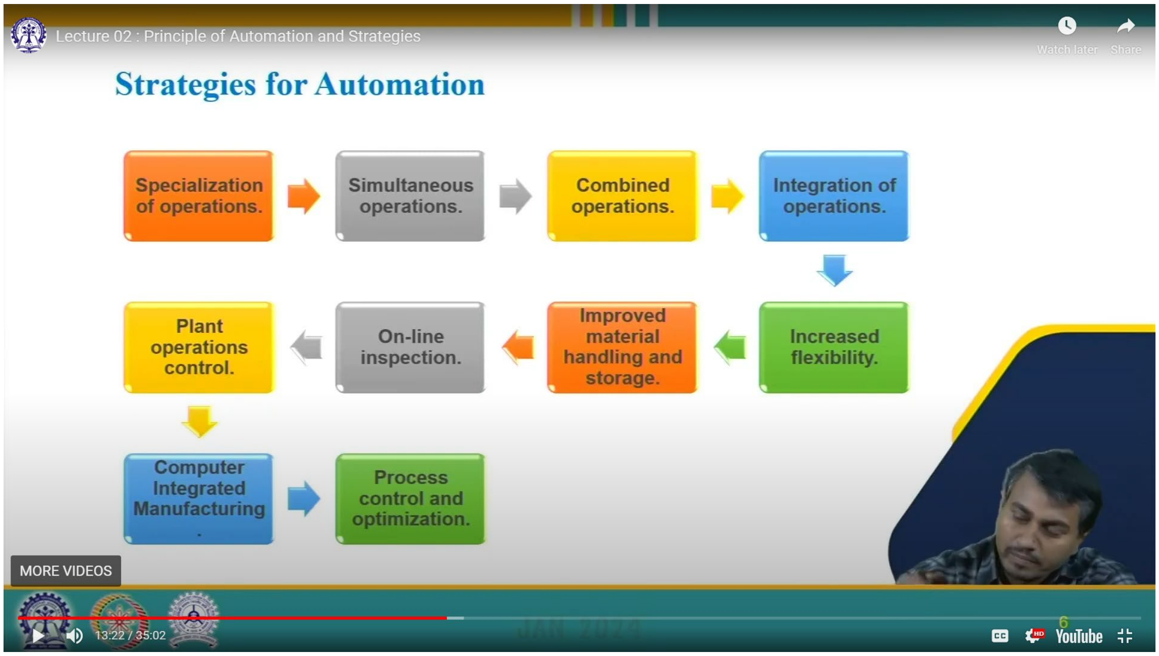
Then the S stands for simplifying the process. It is the inherent principle of the of the success of all automation strategies that they simplify the process for different unit operations and different unit processes. So, the simplification of the process is a very vital part of the automation strategy in the industry.

Then the third, which is A, stands for automate the process. Here, the role of the sensor is very important. Here, using the sensing technology, we are getting ambient and environmental data. We are comprehending that data, and based on that, we are basically actuating some kind of control over the process. So, the last stage, which is automating the process, is very vital in the automation strategies.

So, let us discuss this in light of the dust suppression system adopted in mining. This is a schematic diagram that shows how the USA principle is well connected in the dust suppression system, the automatic dust suppression system in mining.



So, first of all, to make the dust suppression system successful, it is very much required to identify the source of dust. Where from this dust is coming? Is it due to the environmental condition? Is it due to the material condition in the mines? Is it due to the vehicles that are operating on the mine and the emissions from these vehicles? Is this dust in the mine? So, we have to identify the source from which this dust is coming. So, here is the USA principle U that is understanding the system; here we have to understand the source of the dust generation points and based on that, we have to analyze, in the simplification process, what the potential is for dust generation from the material type. What is the connection between this dust generation and the wind pattern, as well as how much emission is contributed to the dust in the air by the equipment. So, we have to identify. Then we have to simplify the dust suppression measures by implementing different technologies and best practices. Here also, we have to specialize in some operations. Suppose if we want to utilize the water spray and it is found that the water spray system in this particular system is very effective, then we have to adopt that system and then the next stage is basically the sensing system. Based on the sensing system, we are sensing the dust level data in real time and based on that, it basically triggers the water spray as and when required. So, by this sensing system, the whole system basically automates the dust suppression mechanism. This dust suppression mechanism's optimum performance basically helps to maintain the haul road very well. By suppressing the dust on the haul road, we basically increase the visibility of the vehicle that is plying and they can see long distances. So, basically, we can reduce the chances of collisions or accidents on the haul road. So, the optimum performance of this dust suppression mechanism or system is also linked to the mining process chain. So, the success of this system lies in the efficient execution of the requirement of sensing the dust level and actuating the water spray from time to time so that dust level or airborne dust is reduced.



Now, let us focus on the strategies for automation. What are the strategies to be adopted to make automation successful in the industry? The first component that is very important is basically the specialization of operation. Anything that we want to replace on the existing one must be very special equipment. It must perform the task very efficiently. It has the specialization of operating or executing that work to the highest level. So, that specialization in operation is very much required. Then the second important strategy of automation is basically simultaneous operation. By simultaneous operation, we meant that in a whole process chain, there are a number of tasks that are performed one by one. One work is complete, then another is coming. So, there are there in between the process, there are gaps. So, if some work is performed during the performance or during the running of another work, we are basically reducing the cycle time. So, this simultaneous operation is looking at reducing the cycle time, and by that, we are basically looking at enhancing the productivity in the system and we are also effectively utilizing the time. Then the next strategy is basically combined operations. In different mine areas, it is found that two-three machines are working for two-three purposes. So, if with a single machine the work can be performed, then effectively we can reduce the waiting time between the machines because if the work of one machine is related to that of another machine, until one machine finishes that job, another machine cannot take that job. So, by combining the operations, we are looking at a further level of reduction in the cycle time, and we are basically aiming at increasing the productivity in the system.

Then the next strategy is the integration of operations. Particularly in mine area, different work is going on at different locations and different sites. So, by integrating these different operations, we are looking at enhancing the efficiency of the whole process and one of the important features of this automation is its increased flexibility. We have to allow some degree of flexibility in the system because mining is all about working in very complex conditions. So, anytime some more complexity may come, we must be ready, and the system must be well adapted to adjust those kinds of changes and under that condition, the system can perform with a very high level of efficiency. That flexibility is required in the automation.

Then another strategy is improved material handling and storage. Any automation project can only be successful if there are some good material handling and storage systems and success lies there. Then another important part is the online inspection. This part basically removes the possibility of producing any faulty product in the system. Inspection is related, or inspection is a thing that we often do after the completion of some task. So, by virtue of the online inspection system, we are basically aiming at checking the quality during the process itself and by that, we are basically minimizing the deviation of the production or any defect in the production.

Then another strategy that is required in the automation project is plant operation and control. In mine also, there are some processing plants, mineral processing plants. There also, we have to establish control over different processes that are running in the processing plant.

Then the computer integrated manufacturing by doing so, we are looking to integrate all the facilities on the mine site. Different unit operation performed in different particular site through network and computers and the database are communicated in between. So that everything is visible at every level, optimization in the process is achieved.

Finally, the process control and optimization of the whole process that is running all over the mining industry. So, what do we mean by the specialization of operation? The first strategy that is involved in the specialization operation is that we use special-purpose equipment designed to perform one operation with the greatest possible efficiency. This is analogous to the specialization of labor, which is employed to improve labor productivity and the example that we have discussed is the automated water sprinkling system. This is basically a specialized system for controlling the release of water into the particular environmental conditions, and dust levels, by doing so, it effectively mitigates the airborne dust particles and improves the overall air quality in the mining area. So, this is basically the example that we have already discussed with the figures and flowcharts.

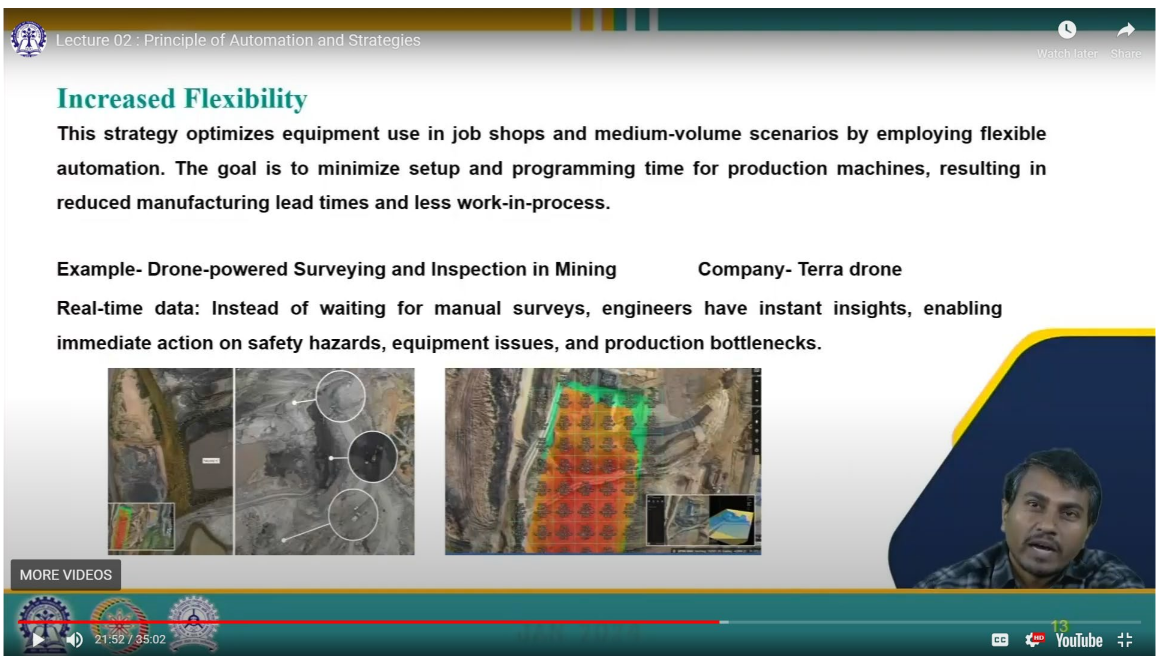
The simultaneous operation extending the combined operation strategy involves simultaneously executing the combined operation at one workstation. The result is a reduction in total processing time, enhancing efficiency in the manufacturing process. An example is fragmentation analysis. We all know that in a mining operation involving drilling and blasting, several factors contribute to the production of material, including overhandling and the production of both ore and overburden. In these cases, the drilling and blasting costs are significantly high, often ranging from 20-25% or more. So, the fragmentation analysis is very important. Blast IQ Frag Track, which is a fragmentation control solution, we are aiming at capturing and reporting the fragmentation data in mining operations very quickly and we are basically going to improve the overall process efficiency. The method on which it is based is automatic picture collection and high-quality image collection, and based on that, it processes the image, identifies the size, and analyzes the fragmentation analysis. It can be analyzed in the conveyor belt and the dig phase of a mark pile as well.

So, let us see some examples of this simultaneous operation. Here, we have cited one example when unloading is going in a crusher. During that time, using some scanner, we are basically analyzing the size of the boulder or ore, and we are basically calculating the efficiency of the blasting process. Then, in another setup, it is basically in a designated place on the haul road, and a scanner is installed. So, during the movement of the vehicle itself, the scanner captures the data, and based on that, it assesses the quality of the blast operation in the mines. This is another example. The material is transported through a conveyor belt, and a camera is set in a designated area to capture the data and, based on that, analyze the size of the rock present on the conveyor belt, which is basically conveyed through that particular belt conveyor system. Another example is that during the loading of the material at the mine site, there is a scanner that scans the material and captures the image, and based on that, it basically analyzes the size and, by that, the blast performance.

Combined operations in which production is a series of operations with complex parts that often require numerous processing steps. The combined operations strategy aims to minimize distinct machines or workstations, consolidating operations on a single machine. And performing multiple operations on one machine reduces the need for separate machines, saving setup time. This strategy results in reducing material handling effort, non-operation time, waiting time, and overall manufacturing lead time. An example of combined operation is real-time ore sorting in the Saloro's tungsten mine, Barruecopardo, Spain. Tomora XRT technology has been utilized here; it can identify and differentiate between valuable minerals and waste rock based on their atomic density. This allows for real-time sorting on the conveyor belt itself, thereby maximizing the recovery of valuable minerals like copper, gold, and tungsten while minimizing waste, this is the setup of these particular mines.

Integration of operations this strategy entails connecting multiple workstations into a unified mechanism. Automated work handling devices facilitate part transfer between stations, minimizing the need for separate work centers. Multiple workstations enable simultaneous processing of several parts, leading to enhanced overall system output. Automated systems like conveyor belts streamline mineral transfer between processing stations in mining, reducing work centers. This enables the simultaneous processing of various ores, enhancing overall mining efficiency and output.

Increased flexibility this strategy optimized equipment uses in jobs and medium-volume scenarios by employing flexible automation. The goal is to minimize setup and programming time for production machines, resulting in reduced manufacturing lead time and less work in progress. An example is drone power surveying and inspection at the mining, company-Terra drone. Real-time data is collected instead of waiting for manual surveys. Engineers have instant insight, enabling immediate action on safety hazards, equipment issues, and production bottlenecks. This is basically the few images. If we have some time, we will discuss the further utility of this kind of drone in the mine for automating various tasks in the mine. By image processing and utilizing different kinds of AI technology, the work can be done with very high efficiency.



In improved material handling and storage, the great opportunity for reducing non-productive time exists in the use of automated material handling and storage systems. Typical benefits include reduced work in progress, shorter manufacturing lead times, and lower labor costs. Example automated haulage system: AHS Rio Tinto. Here, they have utilized the driverless truck, and these trucks use GPS and lidar technology extensively to navigate mine haul roads autonomously, eliminating the need for human drivers and thereby reducing the risk of accidents. The benefits are that it reduces accidents, eliminates the human driver in the process, increases efficiency, and improves the safety of other workers as well. As I discussed in the last lecture, few mines operate with this kind of automated haul truck system, and for the last 10 years, there have been no reportable accidents.

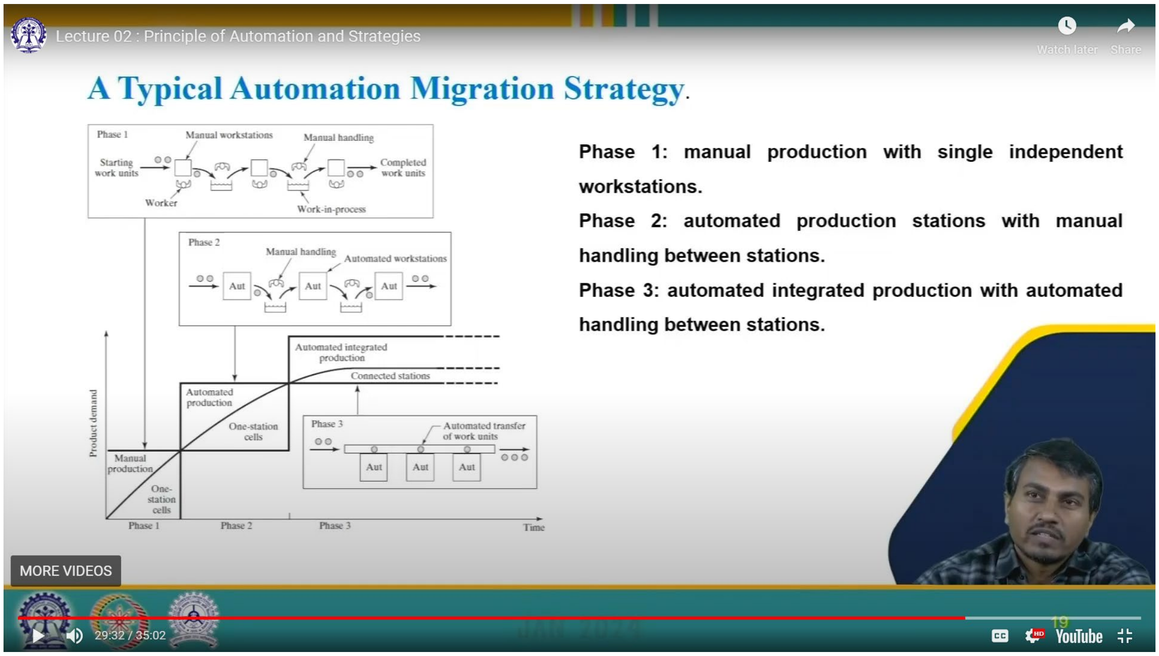
Let us discuss the questions. Question number 1. How does the utilization of specialized equipment in mining operations enhance overall efficiency and productivity? The utilization of specialized equipment in mining operations enhances efficiency and productivity by tailoring machinery to specific tasks and this targeted approach minimizes downtime, optimizes resource use, and streamlines the process, ultimately contributing to overall operational effectiveness. Question 2: In what way does linking workstations align with technological advancements in mining? by resisting innovation, by discouraging automation, by leveraging automation and smart technologies, and by promoting manual intervention. The right answer is by leveraging automation and smart technologies.

Online inspection-Traditional quality inspection occurs after the completion of the process. Hereby, we are looking at online inspections during the manufacturing process itself in real time. So, in the existing system, the traditional inspection system, there is some possibility that poor-quality items may be detected after the process. So, by using an using an online inspection system, we are looking at reducing these possibilities, minimizing scrap, and improving the overall quality of the product design as per the specification.

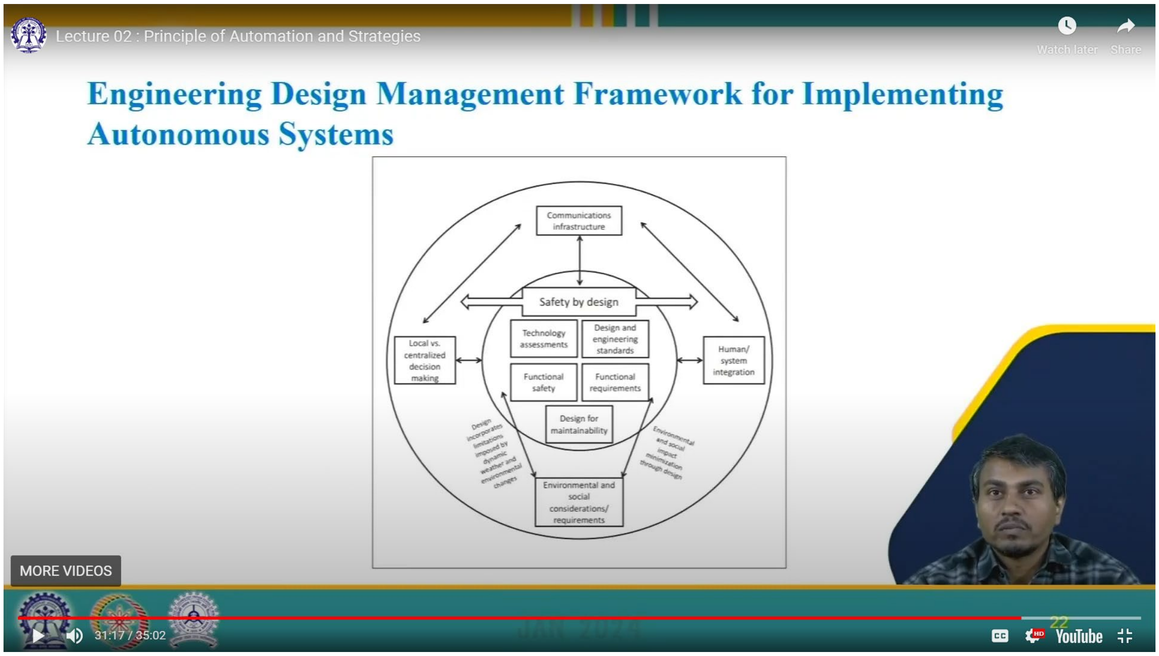
Plant operations control - It controls individual manufacturing processes in the processing plant. It focuses on plant-level control for efficient coordination of aggregate operations. Implementation involves extensive computer networking within the factory.

Computer integrated manufacturing - It involves extensive use of computer systems, databases, and networks and integration spans the entire enterprise. It aims to unify the factory operation and business functions.

Process control and optimization - This includes a wide range of control schemes intended to operate individual processes and associated equipment more efficiently. By using this strategy, individual process times can be reduced and product quality can be improved. Example: the bucket wheel excavator, the advanced control system in the bucket wheel excavator can optimize digging time in real time and it can reduce cycle time, improving material extraction efficiency. It will ensure equipment longevity. That is very important because these are very costly machines. So, if the longevity of the machines is improved, then it would benefit the industry. It has integrated safety features as well, which basically enhance the overall operational safety.



A typical automation migration strategy. Here we have three phases. If we look at these pictures, phase 1, here work starts at a manual workstation, then it is transferred to another, then another manual workstation, then complete unit operation, then final product. So, basically, it cannot supply a large product demand because it operates manually and that is one of the limitations. The phase 2 is basically some of the processes automatize or automatic or the process is automated. But in between the processes, the automated finished product is transferred to manual handling, then again to another automated system, then again manual handling, then automated system, then final product. So, it can supply a good demand for the product and it has a capability. But it can be enhanced further if the automated system, then transfers the product to the next automated system, and then it transfers to the next automated system; it has been streamlined. There is no role of the human handling system or a very role of the overall inspection that can have the possibility of picking the production size. So, it can supply the large production demand. So, phase 1 is all about manual production with a single independent workstation. Phase 2 is basically automated production system stations with manual handling between stations. And the third is automated integrated production with automated handling between the stations. Question 3: What does the term integrated production imply in the context of phase 3 of the automation migration strategy? Independent workstations, automated handling between stations, fully manual productions, No interaction between workstations. The right answer is automated handling between stations.



So, let us discuss the engineering design management framework. A strong design management framework improves overall equipment effectiveness and it enables safe, predictable production results by reducing safety risks and resulting delays. Embedding safety control failed to ensure a safe level of operation. It maximizes asset availability, minimizing breakdowns and failures, and allowing maintenance activity to be conducted within the planned hours. Ensuring equipment utilization conforms to the plan, minimizing production delays, and ensuring the mining equipment performs and delivers to production targets.

Let us see the design management framework for implementing the autonomous system. With this system, we are looking at addressing all these issues. First of all, the design must be safe. It must assess the technology. It must address functional safety. It must address the functional requirement. It must conform to the design and engineering standards. It must conform to the design for maintainability. So, circling around these six parameters, there is some connectivity in between them and also, the environment and social considerations are connected with these functional safety and functional requirements. The local versus centralized decision mining is also included here on the left side, human-to-system integration is on the right side and the communication infrastructure between the systems is also integrated. So, the management framework connects all the stakeholders, all the environmental parameters, all the functional safety parameters, all the functional requirements, and all the design requirements together and basically works to the optimum level possible in this current scenario.

So, the design management plan: A design management plan must be developed and agreed upon by all stakeholders upfront, including the autonomous system supplier, and should include acceptance and performance criteria, agreement on how the design will be verified and approved (that is, the verification approach and quality management plans), a risk assessment approach, and a document deliverable list with both internal and external stakeholders. Configuration management of this system. A comprehensive configuration management system must be employed for changes that are introduced through the implementation of an autonomous system, including operational and maintenance practices, design specifications, system changes, that is software updates, upgrade parameters that affect mine design, data collection and integration, and end-of-life or obsolescence considerations for long-term installation. The last is the risk transformation.

These are the references. So, let me conclude again in a few sentences. In this lesson, we have covered an overview of the fundamental principles of automation in the mining industry. We have explained that using some live examples of mines operating with autonomous systems, and we have explored the various strategies employed in automated mining operations. Here, we are looking at reducing the human risk due to accidents. Here, we are looking at increasing the accuracy. And we have also discussed the different phases involved in transitioning between different automated mining processes. We have also identified and discussed the challenges that may arise during the implementation of automation in mining. Thank you.