Mine Automation and Data Analytics

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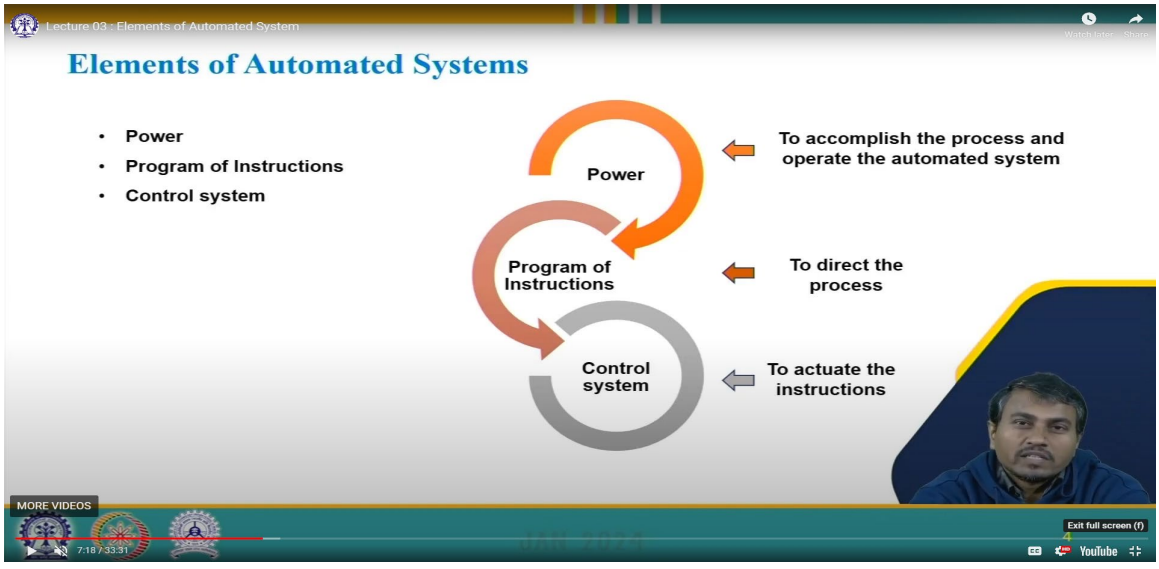
Week-1

Lecture-3

Elements of an Automated System

Good morning, welcome back to my course, mine Automation and Data Analytics. We've already covered the introduction to automation and its principles. Today, we are going to focus on the elements of an automated system. So here, we are going to cover the following: First of all, we will discuss the basics of automated systems. What are the components of an automated system? How are they working on integration and synchronization? Then, we will discuss the mine production system in automation. Then, we will discuss the sequence of information processing activities at different stages of processing in an industrial process. So that is very important for automation to be successful in the industrial process. Then, we will discuss the opportunities for automation and computerization in the context of the mining industry, or more particularly, the mine production system.

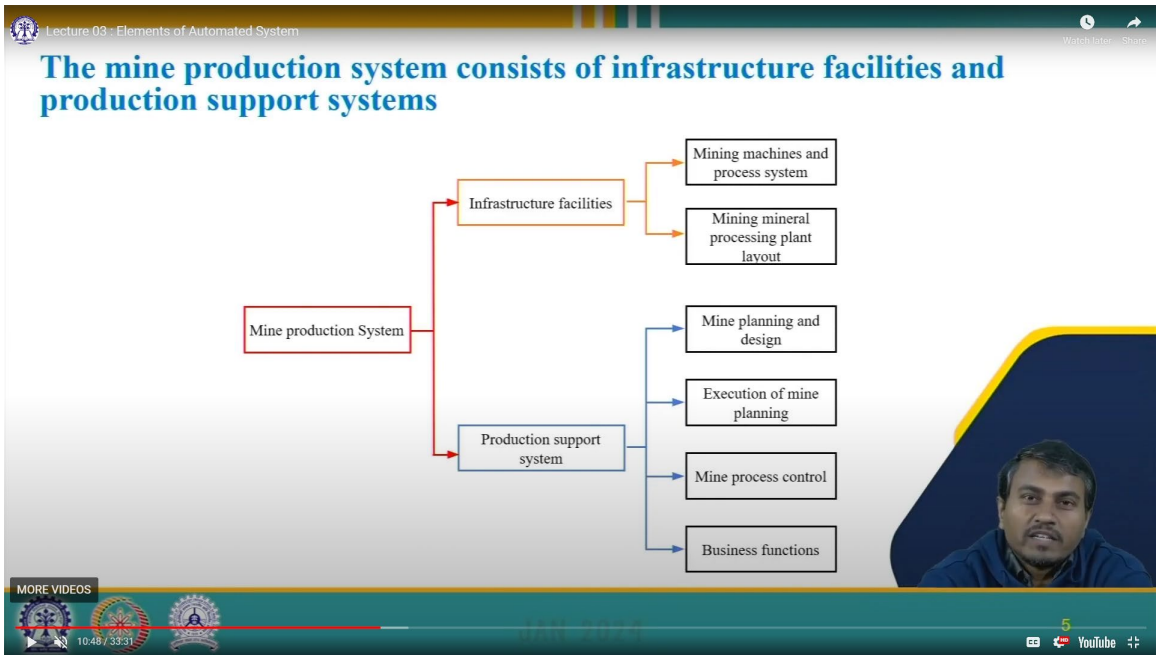
So, let us discuss the elements of an automated system. What are the components? The most vital component in these elements of an automated system is power. Power basically supports everything of the control system, everything about actuating the work, about sensing, and about the data transmission of the automated system. So, power is the vital one here in the automated system.



The second most important part is program of instruction, in an automated system, there are sequences of programming commands that aim at executing some specific tasks based on the requirements for which it has been designed and tested. So, the program of instruction is a very important part of the elements of an automated system and also, before we go to the control system, this program of instructions is in the language that the machine can understand and that is very important.

The next part is the control system, The control system is very important in an automated system because it executes the work seamlessly, synchronizing everything on board with total control over the process, it knows where to intervene and where not to, and by that, it basically enhances efficiency. For example, we discussed in the last lecture the autonomous haul truck system. In this autonomous haul truck system, the control system is synchronized in such a way that it has been manipulated, devised, and recognized based on the necessity that what should be the speed of the vehicle, what should be the speed of the haul truck. In the particular terrain, it is operating and as a result of that, it reduces the necessity of using the brake in the process. So, by that, it basically saves a good amount of energy, by saving that, it basically saves a good amount of money. So, the control system is very important in the automated system to make the automation successful in the industry. So, the power program of instruction and the control system are interconnected with each other and they are working in tandem; they are working synchronously and seamlessly, as and when power is required for the program of instructions, power is supplied. When a control system is required, power is connected. So, everything is connected, and everything is optimized ultimately. So, this power is all about accomplishing the process and operating the automated system. So, basically, it is one of the most important components of a successful automation system. Next is the program of instruction; it directs the process in which direction to go, what to execute, what not to do, where to intervene, and where not to do it. Then the control system will actuate the instructions on what to do.

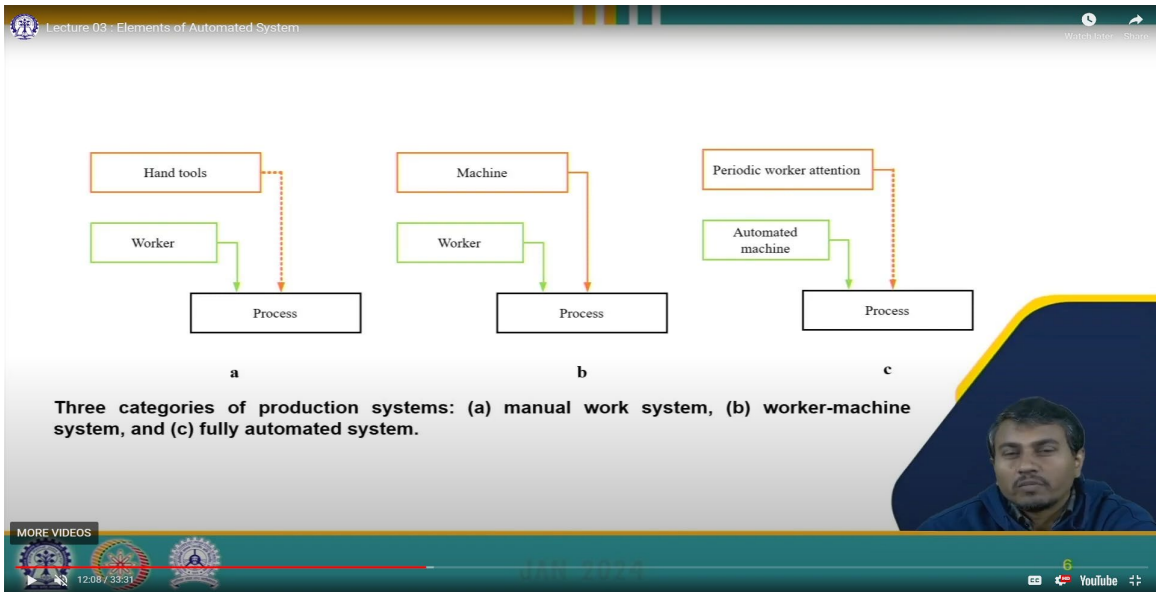
Now, we will discuss the mine production system in light of infrastructural facilities and the production support system. We all know that any mining activity is a huge infrastructural investment. It requires huge infrastructural support as well as a large production system to make the mining industry successful and profitable, and it must run in a sustained way. So, let us see the components one by one. The mine production system and its part infrastructural facility are the most vital facilities to support the production facilities. In the infrastructural facilities, we require mining machines and process systems, and here we require a good amount of investment to make mining successful and we also required very efficient machines to make the mining successful, and for that, we also required a good amount of investment in the mining. We also required to make the mining product marketable; we required a good mining mineral



processing plant in the vicinity of the mine so that the quality grade ore, when there is a demand in the market, can be supplied without compromising the quality.

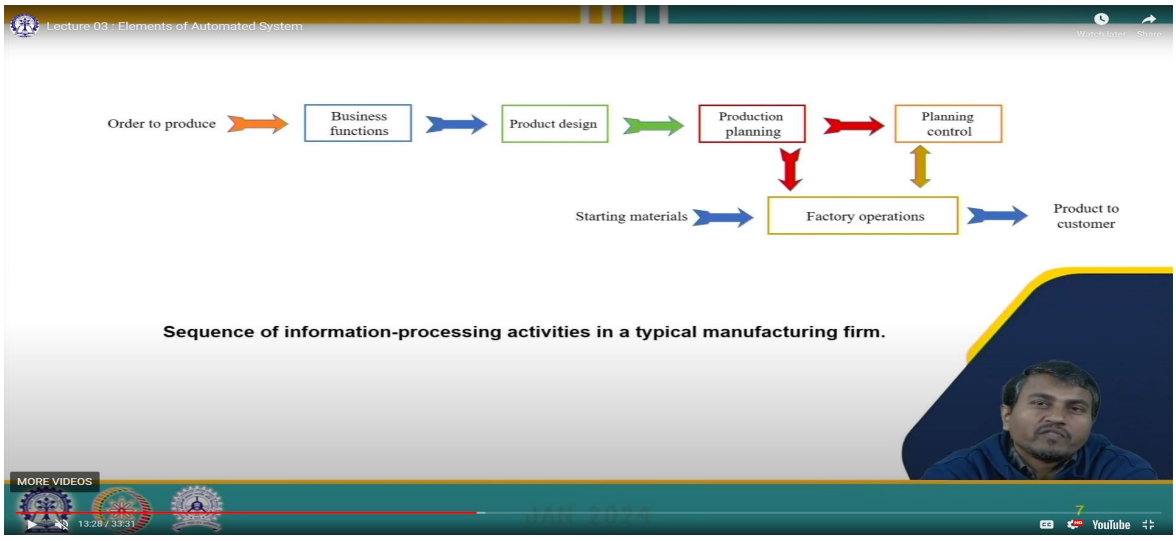
The next stage is the production support system: The production support system must be supported by good mine planning and design any mining industry can be successful if its planning and design are very good. It plans and designs according to necessity and according to the geological conditions. Then it would be very useful, and it would be very effective. The second part is the execution of the mine planning, that is the role of the enterprise level to execute the mine planning efficiently at the grassroots level of the mining operation. The third is mine process control. Overall mining process control needs to be established so that production is going smoothly, as we require, as demand is rising, and as production is also rising like that. So there is a good relationship between the production process and the market that is there for the mineral industry.

The next is the business function: All these processes will be sustainable if they are sustainable in terms of business. Efficient business function is also an integral part of the production support system. So let us see the definition with respect to the technique, the process, and the method of the process. So, a process can be accomplished by hand tools and the intervention of human labor. The process can also be done with the machine or with labor. The process can be done by an automated workstation or automated machine where a very low amount of worker attention or periodic worker attention is required. So, processes can be defined in the context of the development of technology, such as automation technology. So, these are the alternative definitions of process. So, one is a

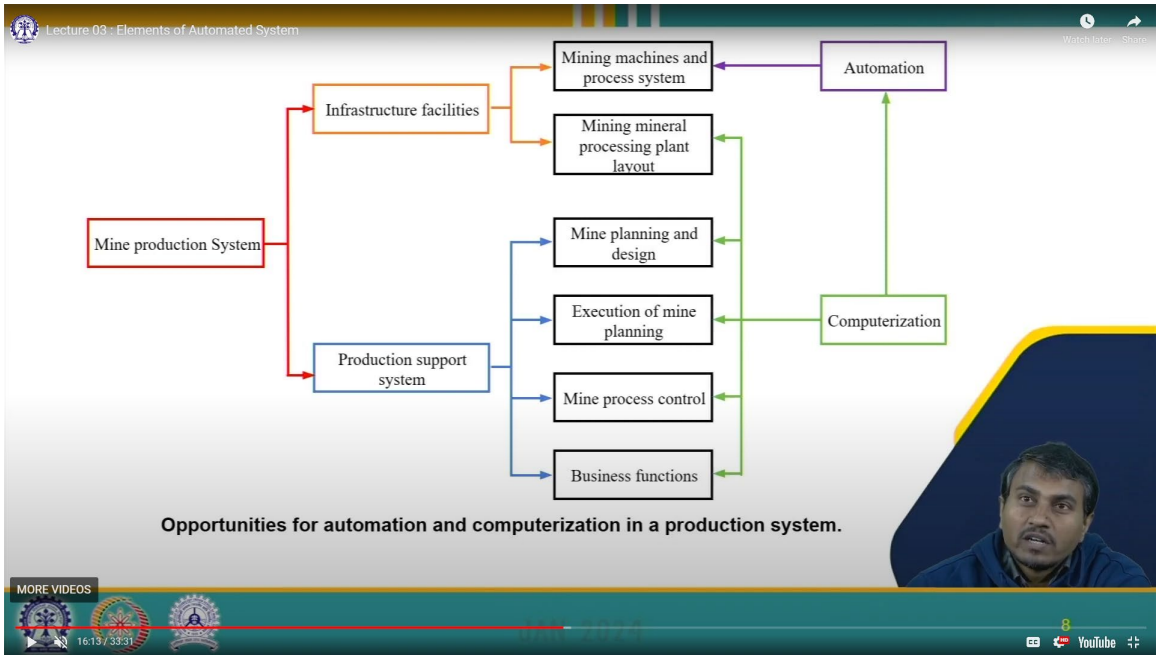


manual work system, the second is a worker machine system, and the third is a fully automated system. Now let us see the process in the production chain. There is a requirement to produce something. So first, there should be some viability studies from the business perspective to determine whether this project will be sustainable and whether it is profitable in terms of all these conditions. Then, if it is successful in that context, it will go to the next level for product design. Then it will go for the production planning mass production planning. Mass production planning is required to make the system run at a lower unit cost. Then we require planning control over the system, so using this planning control and production planning, a factory must be set up, and factory operations should start with the input material; it will supply the product to the customer.

So, these are basically the different stages of information processing activities in a typical manufacturing firm.

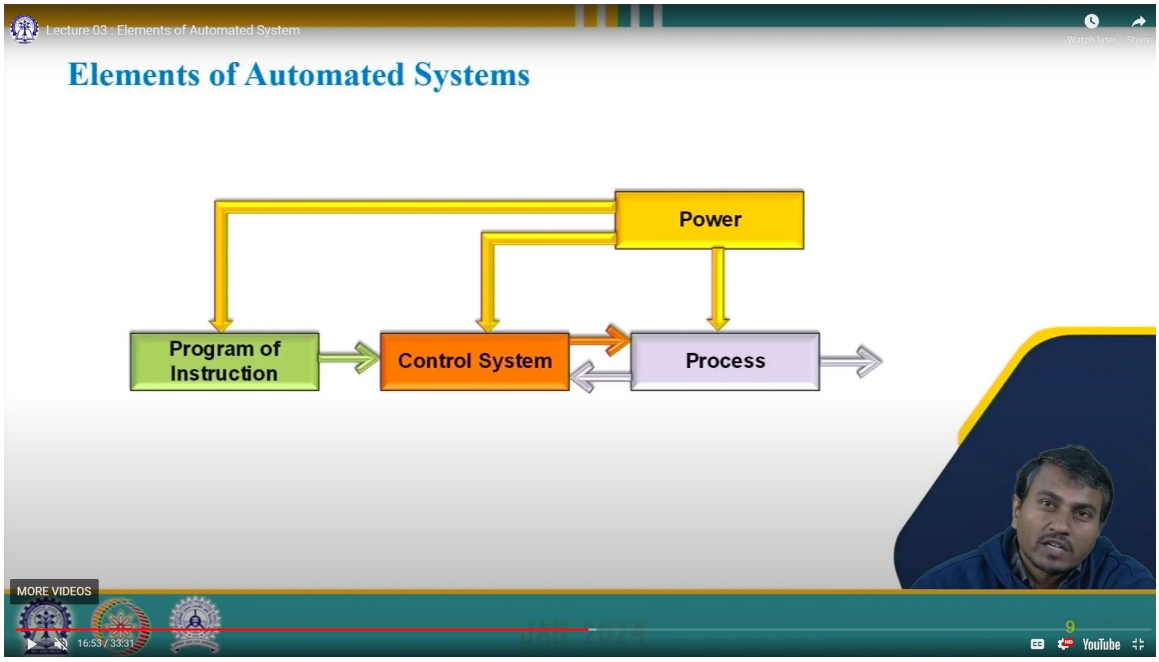


Now I will discuss the possible opportunities of automation and computerization in a production system. We have already discussed the production system broadly composed of the infrastructural facilities and the production support system, and each has a separate segment of unit operation, for example, mining, machines, process systems, mining, mineral processing, plant layout and mine planning design, execution of mine planning, mine process control, and business functions. Now where is the opportunity for automating the process or computerizing the production system? So let us see the schematic possibilities. We have identified that these are the areas starting from the mineral processing plant: mine planning, design, execution, control, and business functions that can be computerized.



This computerization is aiming at that different level, the different kind of data that is generated. So, all the data in different formats is basically practiced in different kinds of systems. So, in digitalization and automation, we are looking for a kind of conformal data format. So, this conformal data format will be supported all across the system. So that the data from the processing plant can be utilized in mine process control, mine planning, design, and business functions as well. As well as in the business function, data can be utilized in the mineral processing plant, and so forth. So all across these industrial unit operations, a conformal data format is required so that this kind of connection, this kind of networking, and this kind of computerization will be helpful and will add benefit towards making it an automation system. This automation system will be successful in connecting all these industrial unit operations with automation in mining machines and process systems. There are other possibilities as well, such as that the mineral processing plant can also be automated to some extent. So as a result, this whole process of the mine

production system can be automated with the stress of computerization, digitalization, and automating these processes.



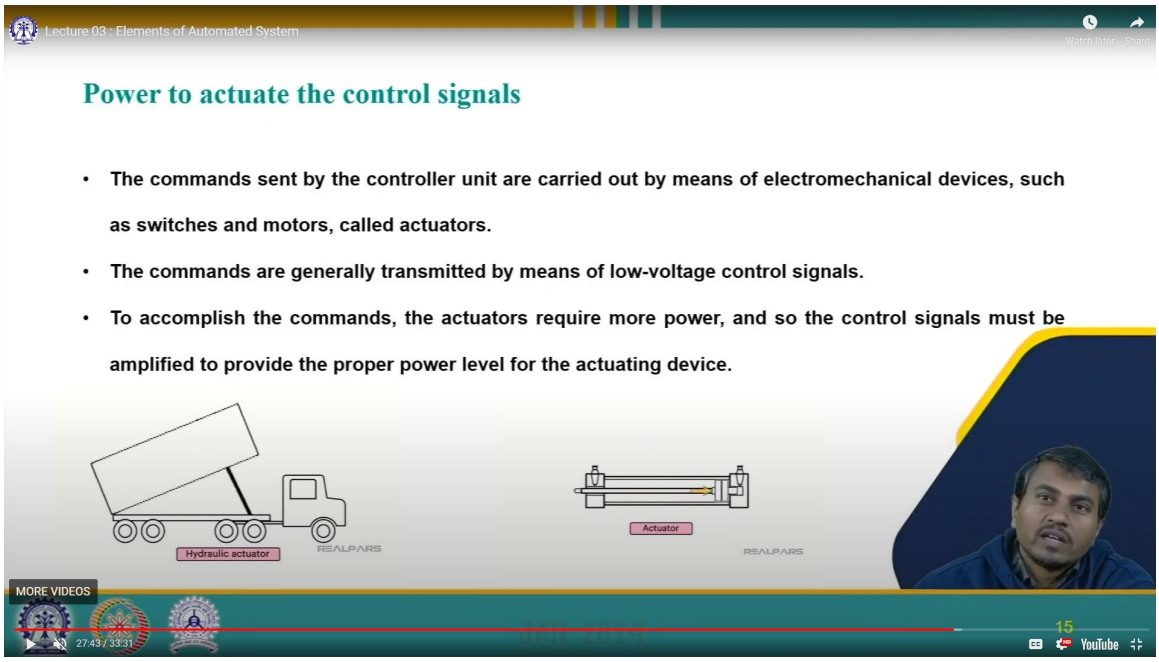
Now let us see in another aspect the elements of an automated system. Here, the power is connected with the program of instruction, the control system, and the process. So power is required for all these operations to execute the automated system work, to execute the required program of instructions, and also to make the automated system successful. Now, power to accomplish the automated system. First of all, we have to ensure that electrical power is available across the industry because electrical power is required for this automated system. Because in many parts of this system, we require electrical energy. So, we require affordable electrical power all across the industry, all across the mining industry, because different mines are located in remote locations. So, we have to make sure that affordable electrical power is available at these sites as well. The advantage of electrical energy is that it has flexibility and can easily be transformed into other forms of energy, such as mechanical, thermal, light, acoustic, hydraulic, and pneumatic. That is basically the advantage of electrical power. So that is why we are looking at making sure that affordable electrical power is available all across the industry. All future equipment and devices that are fitted into the autonomous system, or those that are integrated into the automation process, basically operate on electrical power. Low-level electrical power basically performs functions like signal transmission, information processing, data storage, and communication. In this particular aspect, data storage and communication are very important for making use of AI in automation. Because these are the data at different levels generated by the automated system, AI techniques and AI modules are used to further optimize the process. Another advantage

of electrical energy is that it can be stored in batteries, so it suits remote locations as well. Another aspect is alternative power sources like fossil fuels, solar energy, water, and wind. These are rarely used in automated systems and are often used to drive processes while electrical power controls the automation. For example, a furnace is heated by fossil fuels, but temperature and time cycle control are electrical, which means the sensory system is operated by the electrical power and the control system as well. So, some cases involve converting the alternative source of energy to electrical power for both processes and automation. So, ultimately, the energy has to be transferred in the form of electrical energy so that it would be useful for the automated system.

So, power is required for the process, and the process in production covers the entire manufacturing operation on a specific work unit. It served as the driving force propelling each stage of the manufacturing operation.

Power for automation, power is required for the controller, Power is required to activate the control signal, power for the data acquisition system and information processing. So, these are the sectors in automation where we require power and this is where data acquisition and information processing are very important because this is the portion where we will get the data. These data will be utilized by different AI tools for further optimizing the process. Also, this kind of data will be used to monitor the health of the system. Different people, groups, and researcher groups are working on this. They are acquiring data about the system, and based on that, they are basically diagnosing the health of the system as well. So, these are very useful, and this is very much required in the context of making automation more successful.

So, let us see the controller unit. So, all modern industrial controllers operate on digital computer technology and the essential function of these controllers relies on a consistent supply of electrical power. Here also, we require electrical power. So, this power is crucial for tasks such as reading program instructions, performing complex control calculations, and executing commands to activate devices. Basically, this controller unit is actuating the work to be done. The role of industrial controllers extends to automation, contributing to increased efficiency, accuracy, and overall system reliability. In most control systems, data must be collected from the process and used as input to the control algorithm. Additionally, process requirements may include keeping records of process performance or product quality. Here also, we have the further opportunity to keep these records for analyzing the performance of the process and the product quality for further optimizing the process. The functions of data acquisition and record-keeping in the control system require power, albeit in modest amounts, yes data acquisition required a very small amount of power, but it was a vital unit in the automation strategy. We require this data acquisition system because it is basically the storehouse of different kinds of information. This kind of information will be used for further processing using the data analytics tool.



So, the commands sent by the controller unit are carried out by means of electromechanical devices such as switches and motors called actuators. So, the actuator basically actuates the work required. The commands are generally transmitted via low-voltage control signals. So, actuating some work and giving commands to actuate some work also require some energy and some power and this is basically the control signal that requires low voltage and low energy as well. To accomplish the command, the actuator requires more power. So, the control signal must be amplified to provide the proper power level for the actuating device. When the work is heavy, it requires a good amount of power. So, the system should be ready so that increased demand for power can be supplied in time, there is no gap, and that is to be ensured. So, let us see the hydraulic actuator here: a dump truck with an automated unloading system, and this automated unloading system is actuated by the hydraulic actuator. So, this is basically an example of how the actuator works. Some portion is responsible, and some portion is actually executing the work.

Program of instructions: Automated processes are guided by a program of instructions and logic. Manufacturing operations, regardless of production scale, involve unique processing steps for each part of the product. Every part of the product undergoes one or more specific processing steps during the operation. These processing steps are carried out within a defined work cycle. So, this work cycle is very vital. The details of the work cycle, including the specific processing steps, are outlined in a work cycle program, also referred to as a part program. We will discuss the work cycle. So, let us discuss the questions.

Question number 1: In an automated system, the program of instruction is responsible. providing energy to operate the system, directing the process and task, monitoring system status, Regulating feedback loops. The right answer is directing the process and task.

Question number 2: Which element ensures the capability to accomplish the process and operate the automated system? Control system, program of instructions, Power, Feedback loop. The right answer is Power. Because power supports the process and operates the automated system.

Question number 3: Explain the importance of seamless integration between power, programs of instruction, and control systems for the overall reliability of an automated system. We have shown you that power, programs of instruction, and control systems are integrated together. So, what is the importance of this integration and seamless integration, in particular? The significance is that it basically synchronizes the operation, and by synchronizing the operation, it basically prevents disruptions in the process. So seamlessly, the process executes the same task without any disruption. That is very important for the automated process to be successful and also, this integration is basically to dynamically adjust the power requirement based on necessity and demands so that it can optimize the overall performance of the system. That is why an integrated and seamless connection is required between these components of the automated system.

So, the work cycle program: In the simplest automated process, the work cycle consists of essentially one step, which is to maintain a single process parameter at a defined level. In a complicated system, the process comprises a work cycle with multiple steps that repeat consistently from one cycle to the next. This category predominantly includes discrete-part manufacturing operations. A simplified sequence of steps typically involves loading the part into the production machine, executing the process, and unloading the part.

So, these are the references. So, let us now conclude in a few sentences what we covered in this lecture. We have covered the fundamental aspects of automated systems and explored the principles and constituent elements. We have also seen the automated system in the context of the mining industry and the interrelationship between the infrastructural facilities as well as the production support system. We have seen the different categories of manufacturing systems, and this lecture has also explored the vast opportunities of automation and computerization across the mining industry. Thank you.