Mine Automation and Data Analytics

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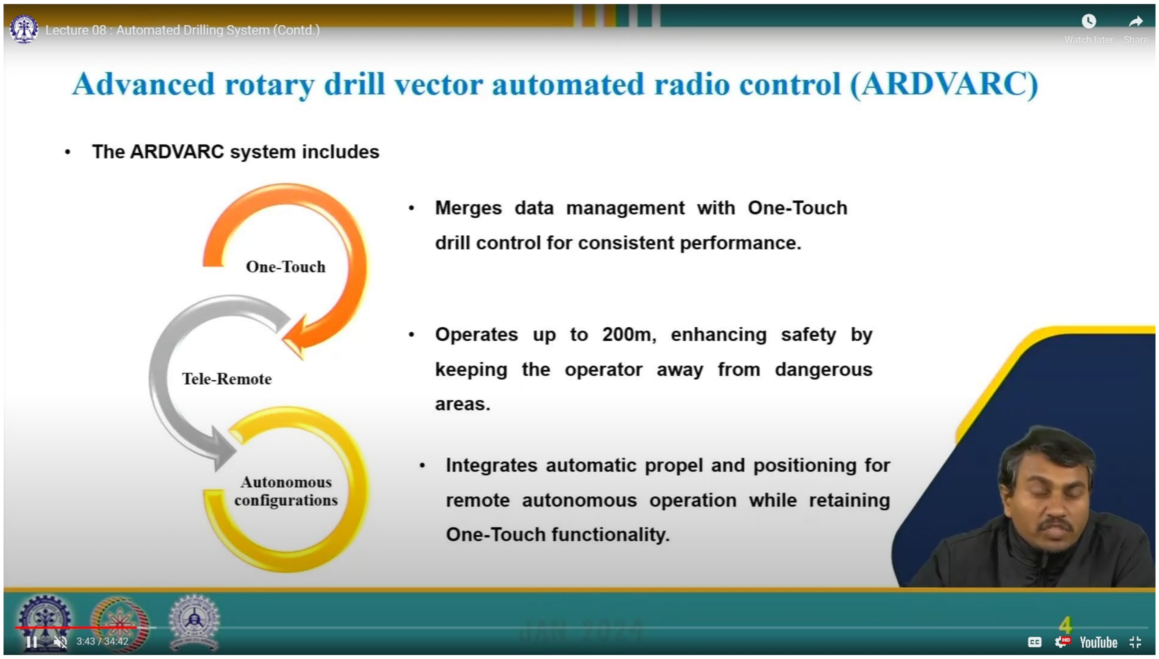
Week-2

Lecture-8

Autonomous Drilling System (Contd.)

Welcome back to my course, Mine Automation and Data Analytics. In today's lesson, we will discuss the part of the automated drilling system. So, in this lesson, the following concepts will be covered: We will discuss the ARDVARC drill control system, in abbreviation, it is called ADS, we will discuss ADS system operating modes, we will discuss ADS system features, we will discuss the detailed overview of autonomous drill rig, and we will also discuss the modes of blast hole drill computerization. We will discuss some of the case studies where autonomous drilling systems were used and some of the summarized results we will discuss here.

So, what is the ARDVARC system? It is an advanced rotary drill vector automated radio control system. So, the major feature of this system is one touch. That is, all the data is managed and merged into the drill control system for consistent performance of the drill system in one touch. So, everything are assembled in one dashboard and from that the control is established over the system. Tele-remote operation-It can handle the drill machine from a 200-meter spot near the mine site, and it substantially reduces the chances or kind of hazard situation for the cabin operator and those who operate the drill machine. So, it basically enhances the safety of the drill system as well. The third important aspect of this ADC system is its autonomous configuration, so, this feature basically integrates the automatic propel and positioning for remote autonomous operation while retaining one-touch functionality.



So, one-touch functionality is the core of the feature, or it is a core feature of the ADS system, and in one touch, all the controls and all the data are merged into one point and one dashboard. So, good control is established by integrating all these mechanisms together. So, this drill within the system interprets the pre-programmed blast design and autonomous drill into rounds with minimal or no human intervention. This system has the capability to anticipate and correct the drilling process during the operation. It also provides comprehensive data on drill performance, its health, strata mapping, and generates customized reports for maintenance and production. This is a very important part. It is the data that is periodically used for analytics and performance evaluation. So, these are the aspects this drill system has on board. So, this is a typical example where this system has been implemented in mine, and we are sharing with you pictures from the published data set.

ARDVARC drill control system operating modes-It can operate in semi-autonomous mode. In semi-automated drilling, the machine operator manually guides the machine to each whole location. Initiating the one-touch drill cycle is as simple as pressing a single button on the operator interface. So, only by pressing one button it basically runs the drill cycle. The one-touch drill cycle involves leveling, collaring, drilling, retracting the drill bit, and deploying jacks. So, this is basically the feature of semi-autonomous drilling mode. After completing the cycle, the operator switches the machine to propel mode and moves to the next whole location, restarting the same process that we have already done in the earlier whole location. So, the operator retains the ability to take control of the autonomous automated drilling process at any time and can return the drill to autonomous mode as well. So, based on the necessity, the operator is in a position to run the machine in autonomous or semi-autonomous mode. So, in a semi-autonomous mode, the driver or operator propels the machine to the next location, so and so forth, and the rest of the operation is controlled by one touch or one button switch. So, the ARDVARC system issues a message if the operator attempts an unauthorized action. So, within the control system, it has the feature that if unauthorized activities observed then it will generate a message, and that message, through the telecommunication mode, will go to the central control system. So, they will be alerted that something unauthorized is being tried on the machine. So, this message explains why functions cannot be completed and provides guidance on corrective actions. So, this message also has the second layer of information that if you want to do this, then you do this, and if you want to do that, then do that like that. So, not only does it issue the alert, it also guides the operator in the right direction and what the operation driller wants to perform.

Fully autonomous mode-The autonomous system provides comprehensive autonomous control, incorporating hazard and obstacle detection, mitigation features, and a remote monitoring station. With this system architecture, the operator can be moved from the machine to a secure location. So, here, the operator can stay a few meters or a few hundred meters away from the system and can teleoperate or telecontrol the machine from a distance. A single operator has the control system, and the operator has the capability to monitor up to eight machines from a remote-control room, only intervening to determine the sequence in which the pattern is drilled. So, from the central control tower, if the drill machine is in the vicinity or in a line of sight that is visible, an operator can control up to eight machines. So, this remote capability becomes particularly useful when drilling is required below an existing high wall or in proximity to the edge of a potentially unstable high wall. This is one of the major features and advantages of this drill machine: we are not deploying human power in the hazardous zone. So, there are chances that on the edge of a high wall, while drilling, some failure may occur. So, in those cases, the operator will be in trouble and in danger. So, without putting the operator in danger, the machine operates, and if something happens, we can rescue the machine later on, but we are saving precious human labor. So, this is one of the major advantages of a fully autonomous mode of drilling operation.

ARDVARC systems incorporate several autonomous features-

Pipe in-hole protection- It prevents the machine from entering propel mode when drill bit is below the safe propel set point. It safeguards the drill string from bending.

Hole quality assurance- Automatically detects the need for hole cleaning during the retraction phase. So, hole quality is a major issue for the drill blasting performance in an open pit production mine, and we all know that a good amount of money is invested in a drilling and blasting operation for the production. So, if the hole quality is not good, then the damage and breakage in the planning phase will not be achieved. So, good quality fragmentation might not be achieved if the hole quality is not good. So, here, hole quality assurance ensures the quality of the hole. It measures the hole to ensure proper depth with each drilling cycle.

Hole collar quality management: hole collar quality is also an important feature that basically protects the hole for a few hours without damaging the collar of its hole. So, it enables dynamic automated collaring to ensure collaring to competent ground.

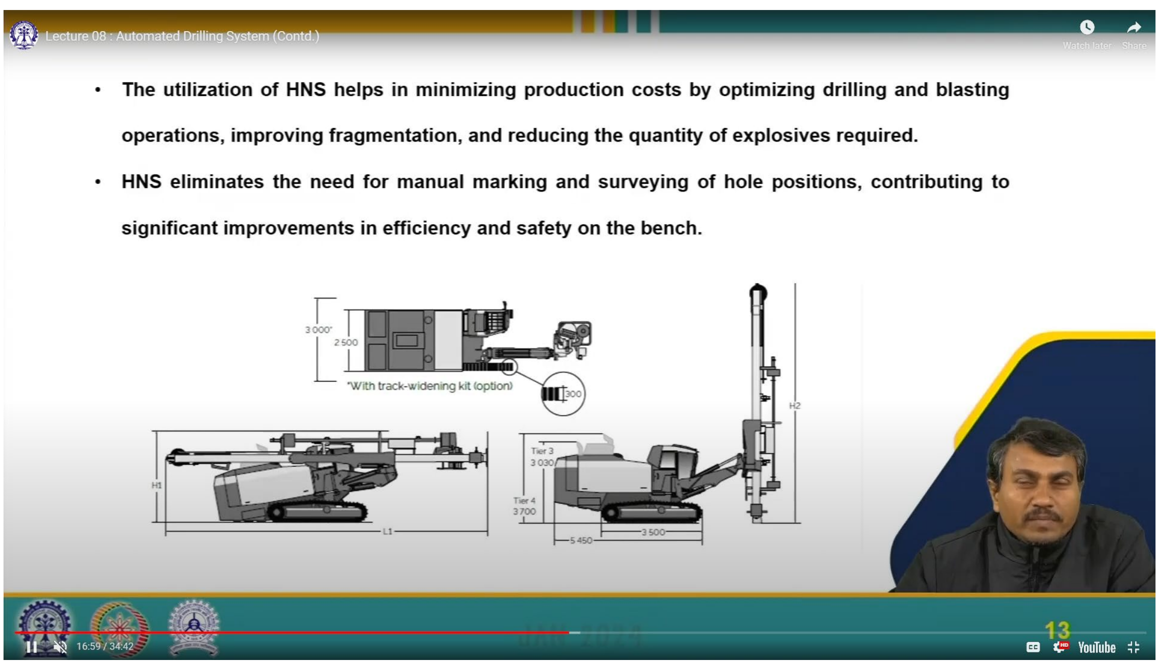
All-stop mode- It is initiated when all machines currently in automated control mode need to be shut down. It is only in an emergency situation that the drill machine is not able to enter an all-stop mode. By that, it basically protects the machine from further damage.

Auto-leveling functionality: This machine automatically levels the machine within plus or minus 0.2 degrees on 90 percent of the hole.

Automatic engines are down- It initiates automatic shutdown in the event of a catastrophic system failure.

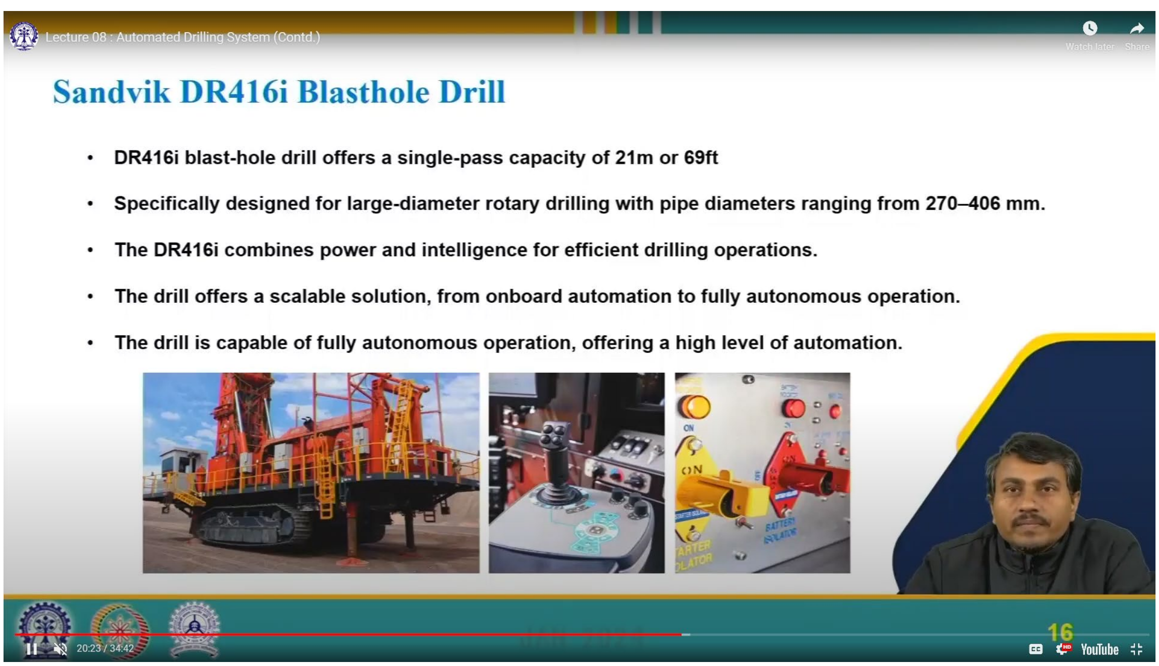
Air compressor control- It regulates the air compressor's air pressure using electronic air regulation. It utilizes air pressure feedback to control bit RPM and pull-down pressure.

Drill energy index- It dynamically adjusts drill parameters such as pulldown and rotation.



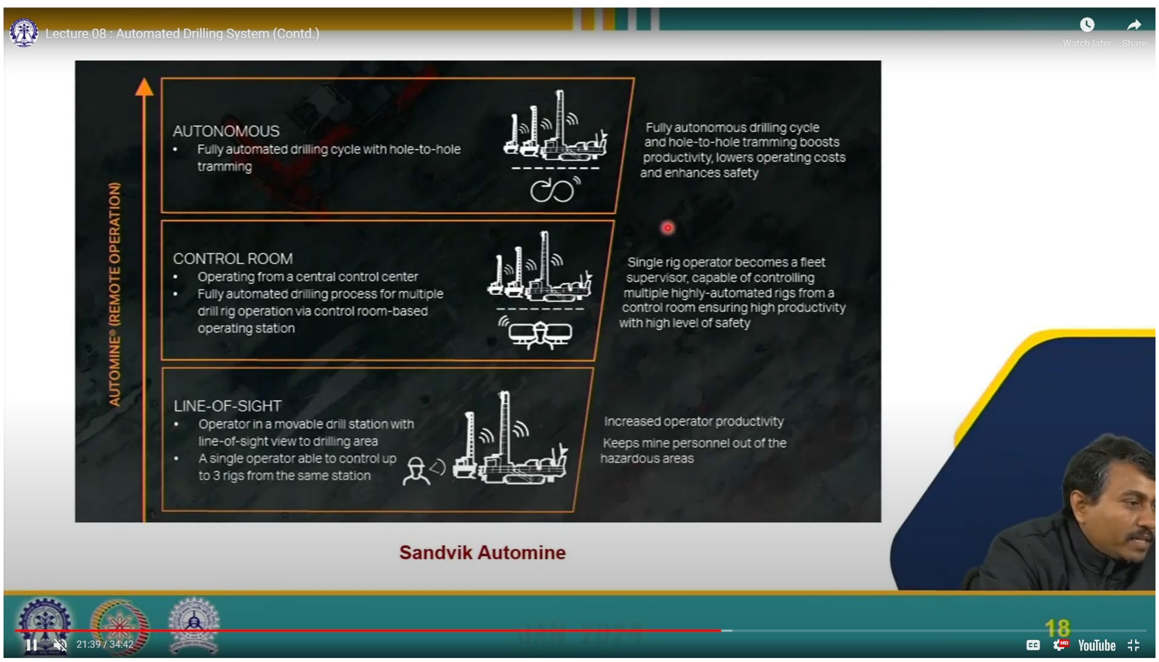
Let us discuss the autonomous drill rigs. We will start with an example of the Epiroc smartROC D65. The smart ROC D65 incorporates cutting-edge automation technology to facilitate drilling in various scenarios, including production blast, pre-split, and buffer holes. The drill offers a reverse circulation option for in-pit grade control as well. The hole navigation system is a key feature that enhances drilling efficiency by enabling faster set-up, allowing for high precision drilling in any weather condition. That is one of the major advantages of this Epiroc smartROC D65 machine. It utilizes the HNS (Hole navigation system) system to minimize production costs by optimizing drilling and blasting operations, improving fragmentation, and reducing the quantity of explosive required in each drill hole. HNS eliminates the need for manual marking and serving the hole positions, contributing to a significant improvement in efficiency and safety on the bench. By that, we are basically reducing the cycle time of all these drilling operations as well. This is a typical example of the smartROC D65 Epiroc drill machine. This is the mast, here, some of the reserve drill is used to control the pipes. So, as and when required, it will insert and go on.

SmartROC D65has several advantages, the most significant of which is reduced fuel consumption. The SmartROC D65integrates an intelligent control system for compressor load and engine RPM, leading to a significant reduction in fuel consumption. This innovative approach ensures optimal energy utilization, promoting cost effectiveness and environmental sustainability. Rugged and efficient design, this smartROC D65 is designed with raggedness and efficiency, having high availability and flexibility and for a good amount of time, it can run continuously. So, that enhances the available time. Consistent productivity through automation: the automated drilling and rod handling features are key elements contributing to the smartROC D65 ability to maintain consistent productivity. By automating these critical processes, the drill minimizes downtime, enhances operational efficiency, and ensures a steady work flow. This automation capability is pivotal in achieving reliable and predictable drilling outcomes.



The Sandvik DR416i blasthole drill offers a single-pass capacity of 21 meters. It is specifically designed for large-diameter rotary drilling with pipe diameters ranging from 270 to 406 mm. The DR416i combines power and intelligence for efficient 21-meter drilling. The drill offers a scalable solution from on-board automation to fully autonomous operations. The drill is capable of fully autonomous operations, offering a high level of automation. This is an example, side view of the machine, this is the control cabin, these are the switches.

Key features: Automation- iDrill performance produces consistently clean precision drill holes, delivering improved fragmentation downstream throughput and asset utilization. iDrill navigation accurately and safely positions the rig in the correct location to produce clean holes, improving blast accuracy, fragmentation, and downstream throughput. Operator environment- full visibility of drilling operations, an ergonomically designed shock-mounted cabin, a function lockout fail-safe programming system, and a touch screen for ease of operation.



This is an example of a sandvik automine system, here these autonomous systems have a drilling cycle and hole-to-wall trimming boost productivity system that basically lowers the operating cost and enhances safety. In the control room, the single-rig operator becomes a fleet supervisor and is capable of controlling multiple highly autonomous rigs from control room, ensuring high productivity with a high level of safety and line of sight. When drill machines are in line of sight, an operator can control up to three drill rigs from the same station.

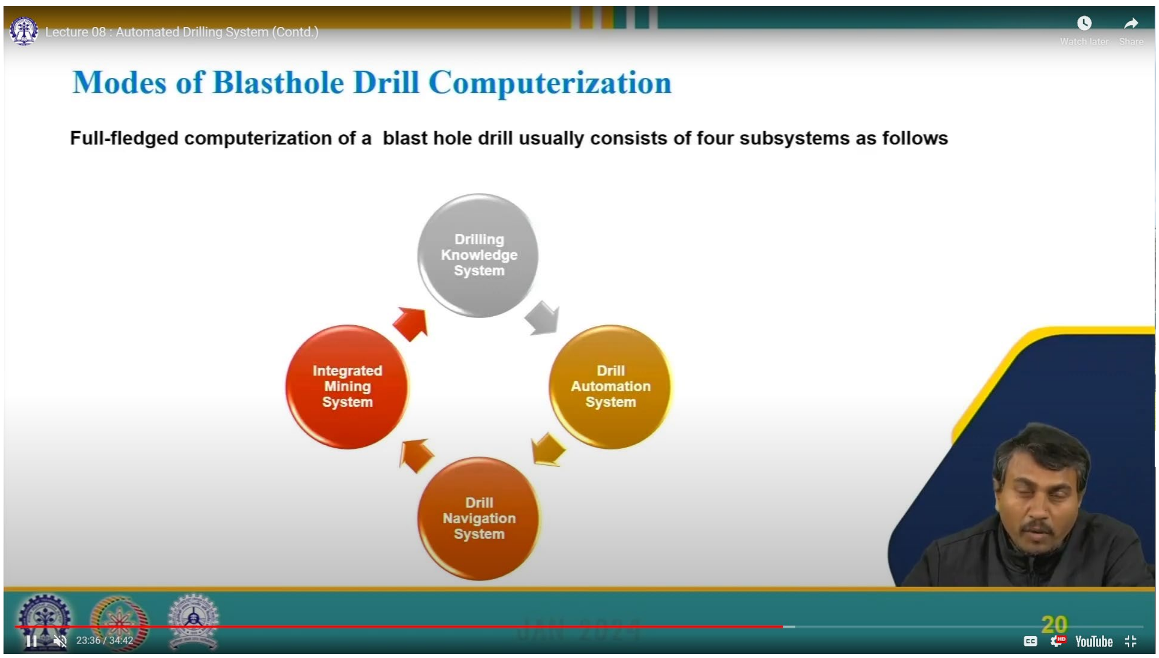
Let us discuss a few questions.

Question 1:

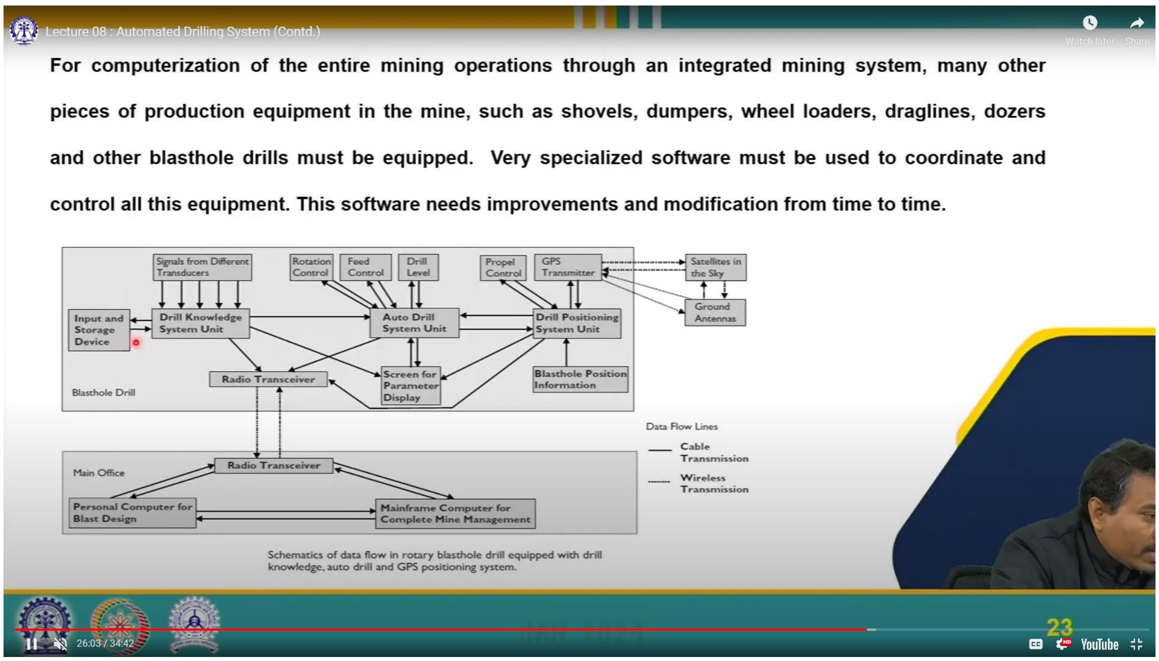
What is the role of hole quality assurance in the ARDVARC system? enabling dynamic collaring, initiating all-stop mode, detecting the need for hole cleaning during retraction, and none of these.

The right answer is detecting the need for hole cleaning during retraction.

Modes of blast hole drill computerization: full-fledged computerization of a blast hole drill usually consists of four subsystems, as follows: First is the drilling knowledge system (DKS), drill automation system (DAS), drill navigation system (DNS), and integrated mining system (IMS).



So, these four operations can work hand in hand in continuous mode, and by that, it enhances the digitalization and computerization of the hole scheme, and by that, we are achieving a very high level of efficiency and safety in the operation. The objective of the drilling knowledge system is to get data about the drilling operation and the material being drilled. The objective of a drill automation system is to introduce automation in various activities to be carried out in a drilling cycle. Means of introducing automation in rod handling, leveling, and drilling have been in existence for a long time. The drill navigation system aims at automating the trimming activity of the drilling cycle. Then the integrated mining system the ultimate objective is to control all operations of all the equipment used in the mine. To achieve this, it is essential to channel some output from drilling activities to the activities of other mining equipment. For computerization of the entire mining operation through an integrated mining system, many other pieces of production equipment in the mine, such as shovels, dumpers, wheel loaders, drag lines, dozers, and other blast hole drills, must be equipped. Very specialized software must be used to coordinate and control all this equipment. This software needs time-to-time improvement, modernization, and upgrading for good functioning and seamless functioning of the whole system.



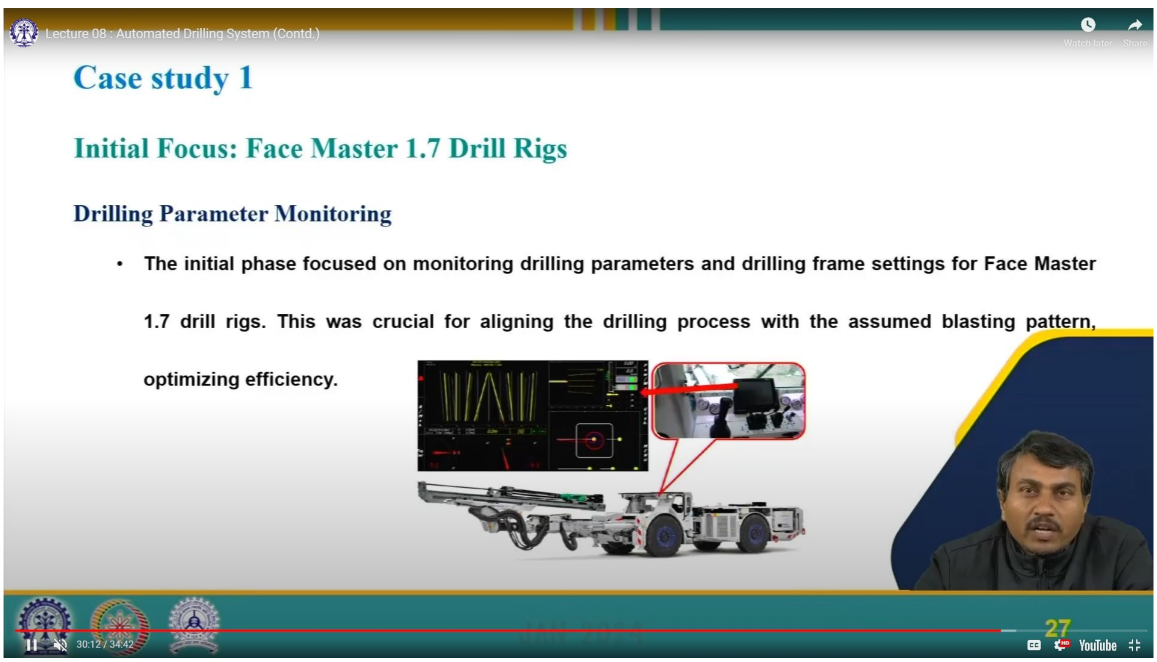
This is a typical example of a blast hole drill equipped with a drill knowledge system. Here are the input and storage devices. This is within the drill hole machine, and here in the drill knowledge system, it basically gets different signals from different transducers and receives data. It is in continuous connection with the auto-drill system unit. It gets data about rotation control, feed control, and drill levels. It also gets data about the parameters, the propel mode control, and the GPS data, and these data are coming from the drill positioning system unit, and by doing so, it also gets data about the blast hole position information. All these inside the machines are wire- and cable-connected, and the machine is in connection with the GPS satellites for the navigation system through wireless mode. In the main office, the operator is in control and in communication with the machine through the wireless transmission system and radio transmitter and receiver system, and here are the personnel who are basically designing the blast holes; they are basically giving commands through the radio transducer and transceiver, and that is executed in the blast hole drills, and here also the main frame computer for complete mine management; here all the data is stored, managed, and monitored for efficient performance of these machines.

Question 2:

What is required for the computerization of the entire mining operation through an integrated mining system? exclusion of certain products and equipment, inclusion of specialized software, limited coordination between equipment, ignoring improvements in software.

The right answer is the inclusion of specialized software.

Let us discuss a few case studies. Case Study 1: This case study was conducted in partnership with the AGH University of Science and Technology and the mine master company. They developed two innovative modular drilling machines and a monitoring system. These systems are the result of their combined expertise, and they aim to significantly enhance productivity in drilling processes.



System development, collaborative effort, and the development of the monitoring systems stem from the collaborative effort between the mine master and AGH University, leveraging their collective experience in drilling process automation. Modular design: the monitoring system is strategically designed with a modular approach, allowing for flexibility and adaptability to different drilling scenarios. Initial focus: face master 1.7 drill rigs, drilling parameters monitoring. The initial phase focused on monitoring drilling parameters and drilling frame settings for face master 1.7 drill rigs. This was crucial for aligning the drilling process with the assumed blasting pattern and optimizing efficiency. This is the typical picture of those face master 1.7 drill rigs.

Diagnostic system implementation, as a natural progression diagnostic system, was integrated to monitor the drive system and hydraulic system of the machine. This step further enhances the overall monitoring capabilities of the drilling systems. Impact on productivity, decisive impact: the monitoring system is specifically designed to have a decisive impact on achieving the assumed productivity levels by providing real-time insight and control. This system contributes to optimizing drilling operations. Comprehensive machine control and the monitoring system offer control over the drilling machine not only during the drilling process but also extend to transportation to and from the workplace. This includes navigation on roads with a slope of up to 15 degrees, ensuring seamless machine operation across various terrains.

Case Study 2: West Angeles Iron Ore Mine

Automating surface blast hole drill rigs have proven to be game changers, delivering superior accuracy and repeatability compared to manual operation, remote supervision enables a single operator to control multiple drills simultaneously. Precision and repeatability: automation ensures drilling accuracy and repeatability, matching manual productivity levels while reducing errors. The trials on an 80-ton Terex SKSS-16 drill equipped with an automated system demonstrated a substantial improvement in accuracy compared to manual operation. Over a 9-week period, the remotely supervised drill utilizing the automated system outperformed manual drilling by completing over 90 percent of all the holes in automation mode. Training efficiency: automating drilling approaches reduces training time for new operators, enabling them to reach proficiency comparable to that of expert drillers. Geological stability: the automated drill maintains stability in varying geological conditions, adapting drilling technique for consistent performance. This is the typical picture of how the automated drill is basically a drill, and it maintains the stable hole collar in different geological conditions by injecting an appropriate amount of water during the drilling process.

These are the references. Let us conclude in a few sentences what we have covered in this lesson. We have introduced the ARDVARC drill control system. We have explored various operating modes of the ARDVARC system. We have highlighted the multiple automation features integrated into the ARDVARC system. We have discussed in detail an overview of autonomous drill rigs, highlighting the technological components and functionality that contribute to their autonomy in drilling operations. We have examined the various modes employed in the computerization of blast hole drills, illustrating the adaptability and versatility of this system in different drilling scenarios. We have discussed two case studies of autonomous drilling systems. Thank you.