WEEK 1: INTRODUCTION TO INDUSTRIAL AUTOMATION & ROBOTICS

Consider a paper plate manufacturing industry using manual production changing to automation production. Analyze the advantages of automation process over the manual process.

A doll manufacturing industry switched to automation from manual production. Analyze the advantages of automation process over the manual process.

Manual processes involve human effort and rely on personal skills, while automated processes use technology and machines to complete tasks more efficiently. Advantages of automation process are

Increased Efficiency: Automation can perform tasks faster and more consistently than humans. It eliminates the need for breaks, reduces errors, and operates 24/7 if necessary. This leads to higher productivity and faster task completion.

Cost Savings: While there may be initial setup costs, automation can significantly reduce long-term operational costs. It reduces the need for labor, lowers the risk of errors that can be costly to rectify, and can optimize resource utilization.

Improved Quality: Automated systems can perform tasks with greater accuracy and consistency than manual labor, leading to fewer defects and inconsistencies in the final product.

Increased Flexibility: Automation helps manufacturers to adapt to changing market demands and produce new products more easily, which can be done by reprogramming/reconfiguring a machine which is simple and fast and does not require user training.

Scalability: Automation can be easily scaled up or down to handle varying workloads. Whether you need to process a small number of tasks or a large volume, automation can adapt to the demand without significant manual intervention.

Enhanced Safety: Automated systems can perform tasks that may be dangerous or hazardous for manual labor, such as heavy lifting or working with chemicals. By automating these tasks, manufacturers can help eliminate or reduce workplace hazards associated with manual labor.

Data Analysis: Automated systems can collect, analyze, and report on large volumes of data with precision. This enables the company's to make better decisions.

Competitive Advantage: Businesses that implement automation often gain a competitive edge by delivering products or services faster, with higher quality, and at lower costs than their competitors.

Reduced Downtime: Automated systems can detect and diagnose issues more quickly and accurately than manual labor, enabling manufacturers to take corrective action before a problem causes downtime or a breakdown. Additionally, automated systems can be programmed to perform routine maintenance tasks, which can help prevent equipment failure and reduce the need for unscheduled downtime.

A Laptop manufacturing industry having permanent automation was not able to meet the demands of market supply due to slow production. Explain how the changeover to programmable automation by the Laptop industry could improve its productivity

Ans: Industrial automation is a system that allows manufacturing companies to increase productivity through computerized technologies. Programmable automation is one such automated manufacturing system designed to accommodate batch processes and facilitate changeover of products. Like any Industrial Automation process, Programmable automation features production equipment tooled with computer-controlled devices that control and monitor a sequence of functions and tasks. In this the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program, which is a set of instructions coded so that the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products

Industrial automation systems are systems designed to replace the repetitive and mechanical tasks associated with one person and decisions made by them in the manufacturing process. Intended to operate automatically to achieve output at a higher and consistent level, automated devices can be programmed to control processes, but also have the capability of making decisions during production processes. Programmable automation utilizes an assortment of CNC (Computer Numerical Controlled) machine tools, industrial robotic applications and programmable logic controllers (PLC) that work in real time. Operational efficiency is accomplished through the application of logical programming commands with automation technologies that power equipment and machinery. As an automated process, programmable automation:

- Dramatically increases production and output
- Lowers associated costs
- Improves the work environment for employees by not only intellectually engaging them in production
- Removes humans from performing repetitive or hazardous tasks

A material handling company is changing its automation from permanent to flexible automation structure. Justify whether their decision is correct

A flexible manufacturing system is designed to react and adapt to changes within the production process, including any unexpected issues or problems. With high product line turnover, increased competition, and narrow profit margins plaguing manufacturers, flexible automation is the best solution

Flexible automation refers to robotic devices that can be programmed to perform various tasks and functions and multi-process CNC machines .In flexible automation, articulated robots are programmed to be highly adaptable to adjust automatically to application, process, or product changes.

With today's short product lifespan, investing in equipment that is capable of adapting along the way is invaluable. Manufacturers can expand their product lines since six axis robots can complete many different robotic applications and work with a variety of parts. It is ideal for those with a high mix of products for both high and low production volumes. Product lines also do not need to be grouped together into batches. In addition, there is never any downtime due to reprogramming with flexible automation. Some robots can be reprogrammed offline while still operating with its current process. This keeps uptimes high for reliable productivity rates.

Flexible automation means that the robot used to produce toys can be used for making plastic trucks on one day and action figures on the next. Flexible automation allows manufacturers to diversify their portfolios to adjust their production to the market's demands.

Robots play a very important role in packaging industries. Justify your answer.

Ans: The packaging industry has long taken advantage of the benefits of automation. Robotic packaging systems are an integral component of the packaging process, and they're found in warehouses and on production lines worldwide.

Robotic packaging is the use of automated machinery and robots in order to carry out packaging tasks, often in an industrial setting. Robotic packaging systems allow a range of different packaging tasks, such as picking, placing and palletising, to be carried out safely, efficiently and effectively. Robot packaging equipment may include stand-alone robots, including the popular robotic arm that can be used for picking and placing, or they may be integrated into wider production processes, such as on car assembly lines.

The advantages of automated robotic packaging systems include:

- Increase efficiency in the packaging process
- Reduce the need for monotonous manual tasks
- Improve health and safety in industrial settings
- Lower packaging costs
- Cut down on waste
- Can be run 24/7 without the need for breaks
- Have a versatile number of uses and applications
- Can achieve high levels of accuracy and precision

Robotic packaging systems are incredibly versatile, and they may be used for a large number of different packaging tasks. From sorting sausages into packets to palletising crates in a warehouse, if the task can be automated then robots can do it with accuracy and speed.

The following are the most common tasks that robots undertake in the packaging industry.

i) Pick and Place

Robots are well suited to pick and place tasks in the packaging industry. There are a number of different pick and place tasks they carry out, including assembling packaging parts, placing components or products into packaging, and picking objects off conveyor belts.

ii) Boxing

Products can be quickly boxed into their respective packaging when they have been assembled. In an industrial setting, packaging robots can carry out boxing tasks quickly and accurately.

iii) Depanning

One of the more niche tasks that robots carry out is depanning. This is required when foods, such as mass-produced cakes, need to be depanned after cooking and before being packaged.

iv) Inspection

Robots may be used for product inspection in warehouses and on production lines. They may inspect the final, packaged products or they may inspect the goods themselves prior to being packaged.

v) Palletising

Once products have been packaged, they often need to be palletised for transport. Packaging robots can quickly and safely palletise large numbers of goods, making them ready for the next stage in the distribution chain.

vi) Warehouse Work

Robots may carry out a variety of different warehouse tasks that are essential for the packaging of goods. For example, robots may be used to move goods or pallets around the warehouse, for inspecting and servicing mechanical parts, and for many more industrial tasks.

How robots are revolutionizing medical device manufacturing.

Below are the technology trends that impacting the topic of Robotics in Medicine (2021).

AI:

- • AI technology, especially machine learning, is an integral part of developing intelligent industrial robots that can predict and adapt to specific situations based on the interpretation of data from various sensors.

- • Taking industrial automation and robotics to the next level requires further advances in certain AI technologies such as computer vision, conversational platforms, and context-aware computing.

- • Neuromorphic processors will be an important part of the next generation of robots. They are trained on a basic library of relevant data and learn how to think for themselves by processing sensory input. These processors will eventually use their acquired skills to perform assigned tasks.

Edge computing:

- • Robot operations can be performed from the cloud, but security and latency issues may require the robot to process real-time data about the operating environment and react immediately. Edge computing can improve robot performance due to lower latency. Security is also better because the edge is more secure than the cloud. Edge computing, combined with self-contained "sense-decide- act" firmware loops in robotics, makes cyber-attacks more difficult.

Cyber security:

- • One of the biggest challenges to the widespread implementation of robots is the threat of cyber- attacks. Robots, especially those connected to the internet, are highly vulnerable to hacking. Left unprotected, it can allow unauthorized access to critical applications and systems, resulting in the loss, theft, destruction, or improper use of sensitive information.

Industrial Internet:

- • The Industrial Internet implies a higher level of connectivity between systems and assumes that monitoring and control data will flow beyond factory boundaries and be consumed and managed by cloud-based services. Existing factories, machines, and processes are prime opportunities for the Industrial Internet.

- • The greatest short-term gains come from retrofitting today's industrial infrastructure with advanced communication and management capabilities. By giving industrial equipment manufacturers access to real-time performance data, they can offer new services and support new business models such as predictive maintenance and robotics as a service (RaaS).

Cloud robotics: Advances in AI have enabled the evolution of robots, allowing them to become highly complex products rather than stand-alone, fixed-function machines, with an increasing number of roles that robots can play. Central to this development was the cloud computing. This enables faster, more secure and more scalable management of sensing, computing, and storage. Using the cloud in robotics could change the way we use technology. The RaaS market includes products that integrate cloud-based management and analytics services with physical robots. Major robot manufacturers have implemented cloud connectivity to enable remote monitoring, management and maintenance of their robots.

Robotics centres of excellence (CoEs)

The Robotics CoE is responsible for designing and implementing robotic solutions that are efficient, productive, and address industry needs. The CoE collects, evaluates, and manages information that facilitates the use of robotic solutions. A robotics CoE requires a strong governance model and the right mix of people, including sponsors, leads, project managers, business analysts, architects, developers, and controllers.

Explain permanent automation system in industry.

- Permanent /Fixed automation is a type of automation where the manufacturing process is a fixed sequence of automated processes.
- It is suitable for flow/continuous production, where the products are continuously made.
- It can be expensive to set up initially due to the equipment requirement , but provides high production rates.
- This type of automation is best suited for high demand and generic products that require no change.

- Examples- coca cola use fixed automation for production of large quantities of soft drinks to meet high demands
- Advantages
    - High levels of production
    - Consistent quality in production
    - Low cost per unit produced
- Disadvantages
    - High initial cost
    - Difficult to accommodate changes

NOTE: ANY EXPLANATION /SUITABLE EXAMPLES TO BE CONSIDERED

Illustrate with an example different types of automation industries

1. FIXED AUTOMATION

Fixed automation, also known as hard automation, refers to an automated production facility in which the sequence of processing operations is fixed by the equipment configuration. In effect, the programmed commands are contained in the machines in the form of cams, gears, wiring, and other hardware that is not easily changed over from one product style to another. This form of automation is characterized by high initial investment and high production rates. It is therefore suitable for products that are made in large volumes. Examples of fixed automation include machining transfer lines found in the automotive industry, automatic assembly machines, and certain chemical processes.

2. PROGRAMMABLE AUTOMATION

Programmable automation is a form of automation for producing products in batches. The products are made in batch quantities ranging from several dozen to several thousand units at a time. For each new batch, the production equipment must be reprogrammed and changed over to accommodate the new product style. Production rates in programmable automation are generally lower than in fixed automation, because the equipment is designed to facilitate product changeover. Examples: Numerical control machine, Industrial robots etc.

3. FLEXIBLE AUTOMATION

Flexible automation is an extension of programmable automation. The disadvantage with programmable automation is the time required to reprogram and change over the production equipment for each batch of new product. This is lost production time, which is expensive. In flexible automation, the variety of products is sufficiently limited so that the changeover of the equipment can be done very quickly and automatically. The reprogramming of the equipment in flexible automation is done off-line; that is, the programming is accomplished at a computer terminal without using the production equipment itself. Examples textile manufacturing, food packaging industry, pharmaceutical industry etc.

How does an industry 4.0 technology help to increase productivity of manufacturing sector? Illustrate with an example.

Ans: Industry 4.0 is revolutionizing the way companies manufacture, improve and distribute their products. Manufacturers are integrating new technologies, including Robotics, Internet of Things (IoT), cloud computing and analytics, Large-scale Machine-to-Machine communication (M2M), Artificial Intelligence (AI) and machine learning into their production facilities and throughout their operations. These smart factories are equipped with advanced sensors, embedded software and robotics that collect and analyze data and allow for better decision making. Even higher value is created when data from production operations is combined with operational data from ERP, supply chain, customer service and other enterprise systems to create whole new levels of visibility and insight from previously siloed information.

This digital technologies lead to increased automation, predictive maintenance, self-optimization of process improvements and above all, a new level of efficiencies and responsiveness to customers not previously possible. Developing smart factories provides an incredible opportunity for the manufacturing industry to enter the fourth industrial revolution. Analyzing the large amounts of big data collected from sensors on the factory floor ensures real-time visibility of manufacturing assets and can provide tools for performing predictive maintenance in order to minimize equipment downtime. Industry 4.0 concepts and technologies can be applied across all types of industrial companies, including discrete and process manufacturing, as well as oil and gas, mining and other industrial segments.

Example: How Bosch Automotive benefited from Industry 4.0

- Let's take a look at the business benefits that Bosch Automotive Diesel System factory realized after implementing Industry 4.0 to optimize production processes.
- Bosch was experiencing production failures and losses, leading them to search for a way to identify bottlenecks in their production operations in order to prevent them.
- As combining IIoT and big data is a big part of the digital transformation Bosch is undergoing, they connected their machinery to monitor the overall production process at the core of its plant. By using data analytics to process the data in real-time, they were able to predict production failures, enabling them to prevent future losses from happening before they even occur.
- They saw more than a 10% increase in throughput, and continually improved delivery time and customer satisfaction.
- The implementation of an AI-powered data solution, ultimately allowed for data-driven decision making, resulting in optimized production.

- By leveraging Industry 4.0 technologies, automotive manufacturers can address processes-driven quality and throughput losses in production and assembly processes. For example, surface quality issues, coating issues, paint thickness problems, dashboard assembly issues, interiors and more, can all be mitigated. By doing so, they experience the long term business benefits that translate to increased ROI (Return On Investment).

Illustrate with an example the implementation of Industry 4.0 in any manual/semi manual industry.

Before implementing the Industry 4.0 in Semi-Manual of Corrugation box manufacturing process:

- Raw materials like paper, gum ,stapler pin etc. are purchased.
- The Role of paper are lifted by hand manually and then taken towards the first step.
- In **First step** the Role of paper are cut manually as per the width of the blade settings in the Paper Cutting machine.
- The cut Paper are stored in the tray.
- Then the tray is carried manually to the second step.
- In **Second step** the paper sent to the gumming the paper boards as per the requirement maually/using machines
- Next it is carried to the Rotary section.

- The **Third step** is Rotary, in the rotary step the paper boards are bended as per the shape required using the sides bending machines.
- Next it is carried manually to the Sorting section.
- In sorting section the bended part of the paper board is cut using the machine.
- After sorting they are carried to the stapling machine, where the paper board is stapled using the pins.
- After stapling they are exposed to sunlight to dry the glue.

After implementing the Industry 4.0 in Semi-Manual of Corrugation box manufacturing process:

- The Role of paper are lifted by fork lifter and fixed to the machine.
- The machine takes the paper in as per the input from the HMI and cuts the paper
- It is moved to the second stage on the conveyor.
- If the Photodetector sensor detects the object the conveyor is started.
- The machinery folds the paper to the required shape
- Next the paper is gummed/glued as per the requirement using glue machine.
- By using the preheater in the machine the paper board are dried.
- Next it is carried to the Rotary and sorting section by the conveyor.
- The paper boards are bended as per the shape required using the sides bending machine and by the blades attached in the same machine the paper board are cut.
- The stapling machine staples the paper board using pins.
- The conveyors are controlled by the HMI and PLC using suitable networking protocols.
- At every stage the Visual camera systems are used for verifying the product.

NOTE: ANY MANUAL/SEMI MANUAL INDUSTRY VISITED DURING THE COURSE CAN BE EXPLAINED WITH SUITABLE SUGGESTION TO FULLY AUTOMATE THE SAME.

Mention the role & benefits of automation in Industry 4.0

Analyse the role of Industry 4.0 in enhancing the existing production methodology through automation. Illustrate with an example

The Fourth Industrial Revolution (or Industry 4.0): is the on-going automation of traditional manufacturing and industrial practices, using modern smart technology. Large-scale machine-to-machine communication (M2M) and the internet of things (IoT) are integrated for increased automation, improved communication and self-monitoring, and production of smart machines that can analyse and diagnose issues without the need for human intervention.

The fourth industrial revolution that is unfolding and is mostly based on robotization (with supporting IT structures forming cyber-physical systems), which confers a higher level of flexibility in terms of the locations, the manufacturing processes, the scale and scope of the output, and the customization of the products. Robotization goes beyond mechanization by enabling machines to perform more complex tasks and being able to adapt to a redefinition of these tasks. Machines are therefore getting similar to the flexibility of human labor. They involve more than simple and repetitive tasks but increasingly average skilled and routine tasks. In such of context, the importance of input costs, particularly labor, are rebalanced since labor can be considered close to ubiquitous for manufacturing relying on robotization. The focus, therefore, shifts on global value chains, which are a circular process to gather resources, transform them in parts and products, distribute finished goods to markets and finally make these resources available again through various recycling and reuse strategies. Manufacturing and supply chain management become closely embedded.

Benefits of Automation or Industry 4.0

i. **Reduction in cost**

Industrial automation helps improve productivity, quality and system performance, which in turn reduces the operating expenses. However, the major advantage of an industrial automation system is the **reduction in manufacturing costs**.

Instead of a floor full of workers, a few supervisors and key personnel, can ensure that the systems are running properly. Instead of a pile full of defective products or parts, a streamlined system can be designed to have very few, if any, defective products.

ii. Increase in productivity

These **systems allow continuous mass production which can run 24/7**. In simple words, automation systems will improve productivity because they never have to take a break, go home, or stop running. Another benefit of automation system running is that it free's up humans to do what they do best: **The staff need not have to perform monotonous job**, they have the room to be creative and productive at work.

iii. **Enhances quality**

By means of adaptive control and monitoring in different stages and industrial processes, these industrial automation systems are useful in **eliminating human error**, thus improving the quality of the products offered. If programmed correctly and without any external interruptions,

automated system will behave exactly as intended until the program is changed or the system is turned off. Because there is very little, if any, room for human interference, the chance for error is removed.

iv. Precise results

All solutions help to get detailed data that can be analyzed using data analytics tools to get accurate information to improve industrial processes leading precise results.

v. Promotes industrial safety

Another huge benefit of automation is **improved safety in the workplace**.

Industrial automation keeps workers from going too close to the assembly lines, thereby enhancing the safety of the workers.

Thermal sensors continually check the temperatures in the production area. In some cases, the thermal sensors can identify any spike in temperature and send an alert. Immediately after, certain precautions can be taken to ensure the safety of everyone on the production floor.

vi. **Increase in human efficiency**

The systems that a company implements to automate their services will not only perform the tasks that a human being would do, but these automated systems are capable of performing functions that exceed the capabilities of a real person.

vii. Predictive maintenance

A huge benefit of industrial automation is that it helps in monitoring and predictive maintenance. Production lines and the production floor can be continuously monitored using sensors. These sensors track temperature, acoustics, time, frequency, oil pressure, and other parameters related to the production process. If the sensors detect any change in these parameters, they will immediately send an alert.

When the alert is received, the technicians can immediately identify the cause of the change. If it is noted that the changes in parameters may cause equipment problems or issues in the production process, then immediate service or repairs can be done. Automation can therefore help identify possible issues before they blow up into huge problems that can result in production downtime**.**

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Considering any production industry, illustrate the role of the automation in inventory management. Mention the challenges the industry may have to face if they go for inventory management automation

Ans: Inventory management refers to the supervision of flow of goods and materials from the warehouse to the point of sale. An inventory management system can simplify the process of ordering, storing and using inventory by automating end-to-end production, business management, demand forecasting and accounting. The role of automation is as follows:

1) It makes the existing process of inventory management seamless.

2) It reduces the need for redundant tasks and contributes at several levels in a business.

3) Inventory management helps wholesalers, retailers and ecommerce business owners edit, manage and monitor their inventory in real time by using automated platform

4) The main role of inventory management comes in the cost reduction of the business and making processes seamless so that key stakeholders can focus on more critical decisions for their business rather than just getting involved in minute tasks related to inventory.

The advantages of automation for Inventory management are:

1) Automation helps save time

2) Automation ensures accurate inventory level (Real time data)

3) Automation improves the quality of delivery

4) Automation helps cut down on business costs

5) Automation reduces the risk for human error

The challenges of automation for Inventory management are:

1) Return on Investment (ROI)- Some automated services come with costs, so ROI has to be considered before automating .

2) Complexity – Some tasks that are to be completed on daily basis tasks are complex, so automating them may be difficult

3) Security –There are computer security-related problems like hacking attempts which needs to be considered

4) Integration Compatibility - The platform chosen must be compatible with the existing system in use.