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3. Automation and Robotics in Manufacturing

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ABSTRACT

we discuss the uses of robotic automation in manufacturing. Automation can assist the manufacturing industry by reducing labor costs substantially, increase quantity or generate more output for a given period of time, improve product quality, and mitigate risk. This chapter provides an introduction to the uses of robotic automation in manufacturing. It begins by describing what robots are. Robotic automation is applicable to virtually any industry imaginable. It is used in manufacturing to change the industry landscape by increasing productivity, repeatability, and precision while protecting employees from unsafe working environments. This paper provides an introduction on the uses of robotic automation in manufacturing. In this paper we will discuss. Automation and Robotics in Manufacturing.

KEYWORDS

Automation, Robotics, Manufacturing, Reducing Labor Costs, Computer Software, Software Automation, Industrial Automation, Increased Efficiency, Improved Quality Control, Increased Safety, Collaborative Robots, Autonomous Mobile Robots, Industrial Robot Arms, Robotic Blacksmithing.

Introduction:

Automation:

Automation is the use of computer software, machines or other technology to carry out tasks that would otherwise be done by a human. There are several types of automation, which can include both virtual and physical tasks.

Automation in manufacturing refers to the use of technology and machinery to perform tasks that were previously done by humans. This technology ranges from simple machines that perform repetitive tasks, to advanced robotics and artificial intelligence that can perform complex tasks with minimal human intervention.

The goal of automation in manufacturing is to increase efficiency, productivity, and quality while reducing labor costs and improving safety. Automation in manufacturing can be classified into three categories: fixed automation, programmable automation, and flexible automation. [1]

1. Software Automation:

This is the automation of tasks usually performed by humans using computer programs. This area includes business process automation (BPA), using software to formalise and streamline business processes, robotic process automation (RPA), which uses 'software robots' to mimic humans using computer programs, and intelligent process automation (IPA), which involves the use of artificial intelligence to learn how people perform tasks using a computer program.

2. Industrial Automation:

This is the control of physical processes with machines and control systems to automate industrial processes. Robots are used in this type of physical automation but so are other non-robotic machines, such as CNC machines. [2]

Importance of Automation in Manufacturing:

- Automation plays a crucial role in modern manufacturing, providing numerous benefits to businesses and consumers alike. Some of the key reasons why automation is important in manufacturing include:
- Increased Efficiency and Productivity: Automation allows manufacturers to produce goods at a faster rate and with fewer errors. This results in increased productivity and lower costs per unit, allowing businesses to remain competitive in the global market.
- Improved Quality Control: Automation reduces the likelihood of human error, resulting in improved quality control and consistency of product quality.
- Reduction in Labor Costs: Automation reduces the need for manual labor, resulting in reduced labor costs for businesses.
- Increased Safety: Automation can perform dangerous tasks, reducing the risk of injury to human workers and improving overall workplace safety.
- Higher Customer Satisfaction: Automation can enable manufacturers to produce products with higher precision and accuracy, resulting in higher customer satisfaction and improved brand reputation.

Robots in Manufacturing:

This area of engineering uses multiple disciplines to design, build, program and use robots. Robots are programmable machines that use sensors and actuators to interact with the physical world and perform actions autonomously or semi-autonomously. Because they can be reprogrammed, robots are more flexible than single-function machines. Collaborative robots are designed to complete tasks in a similar manner to humans, while traditional industrial robots tend to complete tasks more efficiently than humans.

Automation and robotics have areas where they cross, such as the use of robots to automate physical tasks, as with car assembly lines. However, not all automation uses physical robots and not all areas of robotics are associated with automation. Today most robots are used in manufacturing operations; the applications can be divided into three categories: (1) material handling, (2) processing operations, and (3) assembly and inspection.

Material-handling applications include material transfer and machine loading and unloading. Material-transfer applications require the robot to move materials or work parts from one location to another. Many of these tasks are relatively simple, requiring robots to pick up parts from one conveyor and place them on another. Other transfer operations are more complex, such as placing parts onto pallets in an arrangement that must be calculated by the robot.

In robotic processing operations, the robot manipulates a tool to perform a process on the work part. Examples of such applications include spot welding, continuous arc welding, and spray painting. Spot welding of automobile bodies is one of the most common applications of industrial robots in the United States. The robot positions a spot welder against the automobile panels and frames to complete the assembly of the basic car body. Arc welding is a continuous process in which the robot moves the welding rod along the seam to be welded. Spray painting involves the manipulation of a spray-painting gun over the surface of the object to be coated. Other operations in this category include grinding, polishing, and routing, in which a rotating spindle serves as the robot's tool. [3]

History of Robotics in Manufacturing:

The roots of industrial robots can be traced back to the 1950s, although the first true industrial robot was created out of the model construction system Meccano in 1930. George Devol, an American engineer, brought to life the world's first industrial robot in 1962, pioneering a revolution in the manufacturing sector.

These early robots were essentially programmable machines that perform simple tasks. The 70s marked a significant shift as the development of industrial robots became more advanced, and more manufacturers entered the robotics market. [4]

Types of Robots Used in Manufacturing:

There are several different types of industrial robots that are reshaping the manufacturing process. Here are a few examples:

- **Collaborative Robots:** These are specially designed to work alongside people in factories. Their primary function is to carry out tasks that require human supervision, where using typical manufacturing robots would be too dangerous or impractical.
- Examples of applications include using mechanical arms to move pieces from storage to the workplace. Due to collaborative robots working so closely with humans, they possess unique safety features such as sensors that can detect if a person is in the way and trigger an emergency stop.

- **Autonomous Mobile Robots (ARMs):** ARMs are factory robots that can move through work environments without any human input. They use artificial intelligence to "see" their surroundings to avoid obstacles and workers' movement. They're fundamentally used for moving items, often being programmed to move heavy loads that would usually require multiple workers or heavy-duty equipment to shift.
- **Industrial Robot Arms:** Robot arms are one of the most common types of flexible automation because they can be programmed to perform several different tasks on an assembly line, for example screwing bolts, welding, or painting. They're commonly used in factories that manufacture large goods, like vehicles. They're also commonly used to move heavy items from one plant to another or hold up products for inspection. They use a system that generates compressed air and sends it to an actuator, or motor, to control the arm's motion.
- **Robotic Blacksmithing:** Robotic blacksmithing is a new form of automation that could be a replacement for other production methods like traditional machining or 3D printing. It uses special tools, robotic arms and sensors to shape metals and other material. The sensors help the robot detect the shape, and the lasers are used to reshape the entire component. The main benefit of using robotic blacksmithing is that it is more sustainable and resource efficient.
- **Robots with Machine Vision:** Machine vision technology enables other types of robots to perform routine inspections. Quality control can be one of the most tedious steps in the manufacturing process, and robots with machine vision such as quality control robots can help automate this task. Quality control robots use AI to detect issues and inspect parts, freeing up the human workforce for more complex issues.

Manufacturing Applications of Automation and Robotics:

One of the most important application areas for automation technology is manufacturing. To many people, automation means manufacturing automation. In this section, the types of automation are defined, and examples of automated systems used in manufacturing are described.

Three types of automation in production can be distinguished:

1) fixed automation,
2) programmable automation, and
3) flexible 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.

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. This reprogramming and changeover take time to accomplish, and there is a period of nonproductive time followed by a production run for each new batch. Production rates in programmable automation are generally lower than in fixed automation, because the equipment is designed to facilitate

product changeover rather than for product specialization. A numerical-control machine tool is a good example of programmable 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. [5]

Review of Literature:

Automation and robotics have revolutionized industrial processes, making them more efficient, precise, and flexible. The integration of automation and robotics into manufacturing and production has been a pivotal driver of industrial advancements. The ability to improve quality, reduce human error, and increase production speed has made these concepts indispensable for various industries. Moreover, automation and robotics are becoming particularly relevant in the era of Industry 4.0, where smart manufacturing and mechatronics play a crucial role. In this Editorial, the state of the art in automation and robotics, their applications, current limitations, and future perspectives within the context of improvements in the industrial process are explored. (Gupta, A, 2009) [6]

The journey from conventional industrial robots to the deployment of cutting-edge robotic systems, incorporating artificial intelligence (AI) and machine learning algorithms, has revolutionized the manufacturing landscape. These advancements have not only propelled the industry towards unprecedented levels of precision and productivity but have also paved the way for adaptive and autonomous decision-making by robotic systems. From traditional robotic arms executing repetitive tasks to collaborative robots (cobots) working alongside human operators, the spectrum of robotic applications in manufacturing has expanded exponentially. This review explores case studies and real-world applications, offering insights into how robotics has been harnessed across diverse industries to optimize manufacturing processes. From automotive assembly lines to intricate electronics manufacturing, robotics has become synonymous with enhanced operational efficiency and heightened production capabilities (Javaid et al., 2022). [7]

Robotics goes beyond automation by introducing physical machines that can perform tasks with a high degree of autonomy. These machines are equipped with sensor and actuator systems that enable them to interact with their environment. Robotics plays a significant role in flexible production, particularly when tasks require precision and adaptability. Robotics has become increasingly prevalent across diverse industrial applications. While various definitions of robots exist, the ISO 8373 standard characterizes a robot as a reprogrammable and multifunctional manipulator, controlled in position, with one or multiple degrees of freedom, capable of manipulating objects using programmed movements to execute various functions. Industrial robots typically comprise three key components: the manipulator (robot), a controller, and a user interface (programming console). The robot is equipped with sensors and actuators, which are the senses and muscles of robotic systems. Sensors provide data about the robot's surroundings, including information about temperature, humidity, light, and object detection. (Neythalath, N, 2021) [8]

Objectives:

- Robotics in Manufacturing
- Automation in Manufacturing
- Examples of automation in manufacturing
- Future Trends & Technology in Automation

Research Methodology:

The overall design of this study was exploratory. The research paper is an effort that is based on secondary data that was gathered from credible publications, the internet, articles, textbooks, and newspapers. The study's research design is primarily descriptive in nature.

Result and Discussion:

Robotics in Manufacturing:

Automation has become synonymous with using robotics and machines to reduce or replace work traditionally done by employees. But robotics is only one part of how automation works in the manufacturing industry. Robotics like three- or six-axis robotic arms can be used for material handling and pick-and-place tasks, completing them faster and more efficiently than through labor alone. These industrial robotic applications can improve high-volume, repeatable processes, such as orienting a part on a conveyor belt and lifting heavy objects. Controls engineers can program robotics to do the same task the same way every time, or, using more advanced technology, they can program them to be more flexible. [9]

Figure 1: Robotics in Manufacturing

Examples of Automation in Manufacturing:

Automation in manufacturing comes in a variety of shapes and sizes, from quickening ordinary processes to a complete overhaul of your logistical systems.

Below are some examples of common ways automation can be used in manufacturing.

Use of robots:

There are more than three million industrial robots on factory floors around the world. They are pre-programmed to carry out repetitive or tedious tasks that would be prone to error if carried out by humans.

Manufacturing tasks that can be performed by robots include:

- Stacking
- Painting
- Welding
- Polishing
- Labelling
- Assembly

The use of robots decreases the cost of production and increases the precision and speed of output.

Major companies that use robots on their factory floors include Tesla, which uses industrial arm robots for its production line among others uses, and Amazon, which leans on robots for inventory management and other requirements. [10]

Figure 2: Robots can aid in manufacturing by automating your manual factory processes such as stacking, labelling, and assembly.

3D printing:

This refers to printing various production parts with a 3D printing machine, which follows a computer design to print certain materials such as plastic in thin layers until the design has been recreated in physical form.

3D printing negates the need for traditional manufacturing processes to be used to create or order that particular part. Companies that use 3D printing on their factory floors include Volkswagen, L'Oreal, and Aldi.

CNC Machining:

CNC machines are those which use computer software to direct and control certain automated processes that may be more complex than those handled by robots.This type of automation is used in industries like aerospace, due to its high levels of precision and rapid production abilities.

Robotics in Manufacturing Types:

Here are five types of robotic technology that have changed and will keep changing the manufacturing industry:

1. Collaborative Robots
2. Autonomous Mobile Robots
3. Industrial Robots
4. Robots with Machine Vision
5. Robotic Blacksmithing

Robots are used in manufacturing for the following reasons:

1. To create efficiencies all the way from raw material handling to finished product packing.
2. They can be programmed to operate 24/7 in lights-out situations for continuous production.
3. Robotic equipment is highly flexible and can be customized to perform even complex functions.
4. Manufacturers increasingly need to use robotic automation to boost productivity and stay competitive.
5. Robotic automation can be highly cost-effective for nearly every size of company.
6. Any repetitive task is a candidate for robotic manufacturing. Robots protect workers from repetitive, mundane, and dangerous tasks,
7. Robots handle tiny parts too small for human eyes and never make mistakes.
8. Robots' free up manpower to let companies maximize workers' skills in other areas of the business. They create more desirable jobs, such as engineering, programming, management, and maintenance.

Robots used in manufacturing to perform different functions. The most common areas were robots performing their jobs in the manufacturing process include

1. Material Handling: Robots are being used to handle materials that require dangerous product that could risk contamination if in contact with humans.

2. Welding: The process of joining metal pieces is a dangerous and requires exact precision. Robots are becoming a popular choice for welding jobs. Welding robots are shown in Figure 3 [11]

Figure 3: Welding robots

3. Assembly: Having to assemble product parts is a long, repetitive job. By replacing such a system with a robot significantly reduce error.

4. Dispensing: For processes which require glue, paint, or sprays, dispensing robots are placed at a strategic point near the path of the product.

5. Processing: There are certain products that have to undergo a specific type of processing, such as carving, polishing, or sawing, before being released. This task is done by robots with varying degrees of autonomy.

Future Trends & Technology in Automation:

Automation and robotics solutions in manufacturing are expanding and will continue to change the manufacturing plant. Manufacturers have realized that connecting their machines with networking and using that data to make decisions improves their business. And that is just the start of Industry 4.0. [12]

Conclusion:

The review of advances in robotics in manufacturing underscores the transformative impact of automation on industrial processes and the workforce. From traditional industrial robots to collaborative robots and the integration of artificial intelligence, the manufacturing landscape is undergoing a profound evolution. However, this transformation is not without its challenges and implications for the workforce. robotics automation is revolutionizing manufacturing operations, driving efficiency, and improving workplace safety. By leveraging robotics technology, manufacturers can achieve higher levels of productivity, quality, and agility while creating safer working environments for their employees.

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