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Review article

REVIEW ON THE ROBOTICS AND THEIR APPLICATIONS IN PHARMACEUTICAL INDUSTRY

Avinash Swami, Jiwan Lavande*, Pradip Landge, Vishweshwar Dharashive

Department of Pharmaceutics, Shivlingeshwar College of Pharmacy, Almala, Ta. ausa, Dist. Latur, 413520 Latur, Maharashra, India.

ABSTRACT

Robotics is the science and technology of robots, and their design, manufacture, and applications. Cartesian, Selective Compliance Articulated Robot Arm (SCARA), and articulated robots are the three most prevalent types of industrial robots. These robots can be used in sterile production, laboratories, packaging, and a variety of other pharmaceutical applications. Roboticists also study electronics, mechanics and software. In the world of pharmaceuticals, there is a vital role for robotics to play in the complicated processes of research and development, production, and packaging. Justification for robots ranges from improved worker safety to improved quality. Speeding up the drug discovery process is another benefit of robotics. A number of robot manufacturers have products specifically designed for this industry. This article intends to provide information on robots used in pharmaceutical industry, as well as to gather and analyse data from previous years relating to the deployment of industrial robots in the market and their impact on worker employment or jobs. According to the study, the number of installations is growing year after year, and many companies are contemplating pharmaceutical robots because of their numerous pharmaceutical applications, benefits, flexibility, and capacity to securely collaborate with people. It is expected that in the near future, robotics will play an important role in the pharmaceutical industry.

Key Words: - Robot, SCARA, Pharmacy, Automation.

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Corresponding Author

Jiwan Lavande

Department of Pharmaceutics, Shivlingeshwar College of Pharmacy, Almala, Ta. ausa, Dist. Latur, 413520 Latur, Maharashra, India.

E-mail: drjplavande@gmail.com

INTRODUCTION

Robotics is the branch of technology that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing.[1] Robots can carry out pharmaceutical manufacturing tasks faster, more consistently and more cost-effectively than manual labour.[2] Pharmaceutical manufacturing is increasingly relying on automation, including automated inspection, and packing. Some robots are remote controlled; some are semi-autonomous while some are fully automatic robots. A remote control robot falls under the category of semi-autonomous robots through shared human and machine control. The primary mode of interaction in it is teleoperation which happens via a transmitter and receiver system and directly in nature. Human beings control the machine by sending signals which are transmitted through a remote.

- Application of remote controlled are Space probes placed in solar system usually employ sophisticated remote-controlled robots.
- Remote control robots empower us to perform intricate mission with accuracy and precision.
- These are prominently integrated on military and combat operations.
- These are employed in different kind of safety measures.
- These are very useful in hazardous atmospheres like Deep sea exploration, Space research etc.[3]

These robots function in potentially hazardous settings in proximity to biological dangers, the threat of radioactive contamination, and toxic chemotherapy compounds.[1]

This article gives a broad overview of robotics in the pharmaceutical industry, focusing on the different types, applications, benefits, and overall installation and price data of industrial robots. Adopting these new technologies has become an urgent necessity in order to provide high-quality products while also supporting research, development, and production. Because, a lack of knowledge about these new upcoming technologies can be a barrier to innovation and development in the pharmaceutical industry. As a result, efforts have been made to disseminate necessary information and encourage the use of robotics technology.[3,4]

Robotics:

Robotics is a technical branch concerned with the design and development of robots. It is a widely spreading and evolving branch in technology as the use of robotics is increasing day by day. It drives the development of robots for its use in various areas such as hospitals, pharmacies, pharmaceutical industries, factories, etc[3,5]

Robots:

A robot is a machine that can be programmed to perform specific tasks. A robot can be autonomous or non-autonomous, intelligent, or non-intelligent. Autonomous robots can operate and complete tasks without human interaction and make their own decisions.[4,5]

Types of robots:

In pharmaceutical manufacturing, there are three categories of industrial robots:

1. Cartesian robot.
2. SCARA robot.
3. Articulated robot.

1. **Cartesian robot:**

In their simplest form, cartesian robots consist of two linear slides placed at 90-degree angles to each other, with a motorised unit that moves horizontally along the slides in the x- and y-axes. A metal rod called a quill can be added as a third axis (z), which moves up and down in the vertical plane. The quill holds the robot's end-effector, such as a gripper. A fourth axis (t or theta) allows the quill to rotate in the horizontal plane. The main advantage of Cartesian robots is that they are less expensive, although their restricted range of motion has a limiting effect on their range. They're frequently used in automated systems or devices that specialise in a certain task, such as assay testing.[6]

2. Selective Compliance Articulated Robot Arm (SCARA) robots:

SCARA stands for selective compliance articulated robot arm. This refersto the fact that a SCARA's arm segments, or links are - compliant,‖ that is, they can move freely, but only in a single geometrical plane. Most SCARAs have four axes. Even though three- and five-axis SCARAs are also found. A SCARA has first two links that swivel left and right in the horizontal plane around the first two axes. In SCARA robot quill is the third link, which moves up and down along the third axis in the vertical plane. The quill rotates horizontally in the fourth axis but is unable to tilt at a vertical angle. Some SCARAs have a metal shaft that is a hollow air balance cylinder.[3,6]

Determining the type of robot needed.

The first step in automating a process with a robot is to establish the process parameters, including.

1. The required type and size of end-effector, or end-of-arm tooling.
2. SCARA robots are capable of very fast cycle times.
3. Repeatability,
4. Reach and
5. Payload capacity.[7]

4. **Articulated robots:**

Articulated robots provide increased freedom of movement as they have both vertical and horizontal joints. They also have more joints than SCARAs. For articulated robot the work envelope is spherical and for cartesian robot and SCARA robot the work envelope is cube shape and cylindrical shape respectively. Articulated robots show movement with greater flexibility and can perform tasks similar to the tasks performed by human hand or human arm. The most common articulate robot has six axes. The first link rotates in a plane that is horizontal like a SCARA while the other two links (second) rotate in a plane that is verticle. Six axis articulated robots performs movements same as the human arm (forearm and wrist). Because of the presence of a vertically rotating wrist joint and also a vertically rotating forearm which allows increased movements. The human like forearm and wrist joint of six axis articulated robots allows them to pick up an any material or object or packaged boxes off the horizontal plane irrespective of its orientation.[6]

ROBOTIC PHARMACIES:

Due to the potential hazards and high volumes, some hospitals and larger health care clinics utilize robotics to dispense medication. Robotic pharmacies are expanding rapidly within the hospitals and clinics. Several companies are servicing that market and the interest level will only increase. On the retail level, robotics in local pharmacies will be a challenge. The technology is available but regulation will pace the growth of robotic pharmacies more than the technology. Hospital pharmacies used to be centralized, but the model is increasingly opening up. Larger hospitals have hundreds of beds and numerous divisions, and all the complexity basically means it can be difficult to keep track of medication's flow from pharmacy to patient.[1]

Advantages Of Industrial Robots:[9-10]

Safety Advantage:

Robots protect the integrity of pharmaceutical products and the health of employees and patients. With industrial robots, toxic chemicals can be mixed safely. These particular robot models are designed to work in clean room settings. Sealed arm construction and decontamination with Hydrogen Peroxide Vapor (HPV) keep these models from ever contaminating product. Low payload picks and place jobs that would prove tedious for human workers are now the responsibility of tireless robots.

Reliability:

The Food and Drug Administration (FDA) requires all medication to be tracked and traced throughout the production process. Industrial robots make it easier for pharmaceutical companies to comply with these requirements. Along similar lines, robots minimize accidents and wasted material. Robots can work 24 hours a day, seven days a week without stopping or tiring.

Tirelessness:

A robot can complete a 96-hour project in ten hours with greater consistency and higher quality results.

Affordability:

With the advancements in technology and affordable robotics becoming available at less cost, more pick and place robotic cells are being installed for automation applications.

Accuracy:

Robotic systems are more accurate and consistent than their human counterparts. Robotic systems outperform humans in terms of accuracy and consistency.

Return on investment (ROI):

Return on investment has a quick turnaround. Furthermore, as quality and application speed improve the benefits of increased production possibilities become available.

Design Benefit:

In the pharmaceutical business, slim, rapid, and flexible robots are suitable for pick-and-place and assembly tasks. Industrial robots can construct blood sugar kits and other custom orders thanks to vision technology.

Quality:

Robots have the capacity to dramatically improve product quality. Applications are performed with precision and high repeatability every time. This level of consistency can be hard to achieve any other way.

Production:

With robots, throughput speeds increase, which directly impacts production. Because robots have the ability to work at a constant speed without pausing for breaks, sleep, vacations, they have the potential to produce more than a human worker.

Flexibility:

Packaging applications can be diverse. Robots are simple to reprogram. Changes in End of Arm Tooling (EOAT) development and vision technology have expanded packaging robots' application-specific capabilities.

Safety:

Robots increase workplace safety. Workers are moved to supervisory roles, so they no longer have to perform dangerous applications in hazardous settings.

Savings:

Greater worker safety leads to financial savings. There are fewer healthcare and insurance concerns for employers. Robots also offer untiring performance which saves valuable time. Their movements are always exact, so less material is wasted.

Speed:

Robots work quickly and efficiently, wasting neither movement nor time. Robots can change productivity by increasing throughput without taking breaks or pauses.

Reduced chances of contamination:

Removing people from the screening process reduces the potential for contamination and the potential for dropped samples when handling them in laboratories. Robotics performs these tasks much faster with more precision and accuracy.

Cost:

Payback periods for robotic equipment purchases in the pharmaceutical industry, given the relatively high hourly labour rates paid to employees, the number of production shifts, and the low cost of capital. The cost of a conventional robot installation, including all attachments, safety barriers, conveyors, and labour, might be approximately $200,000. If that robot were to replace four manual workers, each earning approximately $30,000 per year, the robot would be paid for in less than a year and a half through salary savings alone.

Increase Efficiency:

Robotics can increase efficiency, which means the price of the drug itself will become more competitive. When it comes to pharmaceutical production, people are not as efficient as robots, especially when they are wearing a protective suit. People in protective suits also require more room to work in.

Disadvantages of industrial robots:[10,11]

Dangers and fears:

Although current robots are not believed to have developed to the stage where they pose any threat or danger to society, fears and concerns about robots have been repeatedly expressed in a wide range of books and films. The principal theme is the robots' intelligence and ability to act could exceed that of humans, that they could develop a conscience and a motivation to take over or destroy the human race.

Expense:

The initial investment of robots is significant, especially when business owners are limiting their purchases to new robotic equipment. The cost of automation should be calculated in light of a business' greater financial budget. Regular maintenance needs can have a financial toll as well.

Return on investment (ROI):

Incorporating industrial robots does not guarantee results. Without planning, companies can have difficulty achieving their goals.

Expertise:

Employees will require training in programming and interacting with the new robotic equipment. This normally takes time and financial output.

Safety:

Robots may protect workers from some hazards, but in the meantime, their very presence can create other safety problems. These new dangers must be taken into consideration.

Application of robots in pharmaceutical industry:

Pharmaceutical industry consists of various sectors. In such industries, cost, speed, quality, and flexibility. Quality is a statutory requirement in the pharmaceutical sector, while the main drivers have traditionally been lower upfront costs and increased speed. Machine, system, and facility flexibility will become more crucial in the future, as uncertainty and complexity in products, volumes, and markets will necessitate making quick adjustments while retaining excellent manufacturing flexibility. Continuous manufacturing is gaining traction at the system level, with robotics/automation being applied to oral medicinal products and alternate drying technologies.[11]

Laboratory Robotics:

Pharmaceutical development is rapidly using laboratory robotics to help satisfy the needs of boosting productivity, shortening drug development time, and lowering costs. Cartesian (three mutually perpendicular axes), cylindrical (parallel action arm pivoted around a central point), and anthropomorphic are three of the most prevalent geometries for laboratory robots.[18,19]

Robotics in Sterile Manufacturing:

The ability to handle sterilised components and ingredients without recontamination is defined as robust aseptic processing, which necessitates active process risk management. The most effective way to limit the risk of contamination is to reduce or eliminate the possibility of it happening in the first place, and to make the process seamless in a continuous workflow. During aseptic processing, a rigorous sterility assurance strategy focused on contamination control should restrict or eliminate human interaction while making the process faster and more consistent. Robotics are used to overcome the difficulty of removing the human element from aseptic processing. Another benefit is that particle contamination from traditional prescription product fill finish manufacturing is avoided. A clean room organised into modular process blocks can be envisioned as one form of robotic aseptic processing. The isolator technology can provide air with the proper pressure cascade to support process design and regulatory needs. Under the continuous manufacturing paradigm, this example also highlights the ability to customise and design a flexible, agile end-to-end process that can de-nest various ready-to-use container closures (e.g. vials, syringes, cartridges) as well as assist with different processing stages.[12-16]

Research and Development (R&D):

Robots are already playing an increasingly important role in the creation of novel pharmaceuticals. Millions of chemicals are evaluated in high throughput screening to see which ones could become new medications. The employment of robotics to test these millions of chemicals is required. Robotics, like any other procedure in which a robot substitutes a person performing a repetitive duty, can dramatically speed up this process.[17]

Sterilization and Clean Rooms:

Robotics can be modified to work in sterile conditions. The features of clean room robots prevent the sterile environment from infection. Low flake coatings on the robotic arm, stainless steel fasteners, specific seal materials, and enclosed cables are among these qualities. Robots in clean rooms save money by automating tasks such as inspection, picking and placement, and loading and unloading process tools.

The following are some of the advantages of using a robot in a clean room:

1. Robots help to reduce contamination-related scrap.
2. Robots cut down on the need for clean room consumables like bunny suits.
3. Robots reduce scrap by reducing the number of pieces that are mishandled or dropped.
4. Clean room protocol enforcement and training expenditures are kept to a minimum.
5. Robots save money on clean room area by removing lanes and access points that are traditionally required for human clean room workers.[10]

Packaging Operations:

Packaging activities, like other pharmaceutical operations, benefit from automation's speed and consistency. Robotics, in particular, offers versatility and precision. Robotics can also outperform specialist machines in some packaging applications, such as carton loading. Pharmaceutical packaging machines are frequently designed to accommodate specific product configurations, such as vials.[10]

Advantages over Traditional Automatic Packaging Machines:

Unlike packaging machines, which stop automatically if too much product accumulates at the discharge, robotic loaders and unloaders meet or exceed the in feed and discharge rates required by packaging machines. This capability enables the robot to maintain full production capacity throughout the packaging process.

Advantages of Robotic Automation of Packaging:

1) **Speed** - Robots work quickly and efficiently, without wasting movement or time. Robots can change productivity by increasing throughput without taking breaks or pauses.

2)**Versatility** - Packaging applications can vary. Robots are simple to reprogram. Changes in end-of-arm tooling (EOAT) development and vision technology have expanded packaging robots' application-specific capabilities.

Flexible Feeding:

Robots are also superior to hard automation at flexible feeding, a task that requires handling multiple types of products or packages with varying orientations. High-speed, automated bowl feeders that vibrate parts and feed them to fillers, labellers, or product-transfer mechanisms have traditionally been used on packaging lines. Bowl feeders, on the other hand, cannot always handle a variety of products at the same time, and their vibration can damage fragile parts.

Status of robotics in pharmaceutical industry:

Various tasks in pharmaceutical industries, laboratories are performed by robots. These robots work in dangerous or hazardous environments in vicinity of toxic chemotherapy compounds, biological hazards and in the risk of radioactive contaminants. Robotics are used in packaging too, to assemble and package a number of implants and medical devices. Robotics are also used in making prescriptions for mail order pharmacies and hospitals. Robots are also used for picking and placing of objects in case if the objects are flexible, quick and slim. Customized orders are also placed by robots and tasks like assembling blood sugar kits are also performed by robots. Robotics is beneficial in packaging, handling of test tubes and for drug discovery jobs. Medication errors occurring during packaging and dispensing in hospitals can be eliminated by use of Pill Pick which is a pharmacy automated system that can be used to increase patient safety.

Robotics is also being used in laboratories to provide efficient working. Many pharmaceutical industries are looking for improved sustainability in their operations and for achieving this many manufacturers had to conserve energy by reducing waste and pollution. Robots can work out on these goals as the gearboxes, motor and drives that run them have proved to be 95% energy efficient.[20]

Figure 1: Cartesian robot showing x, y and z axes.

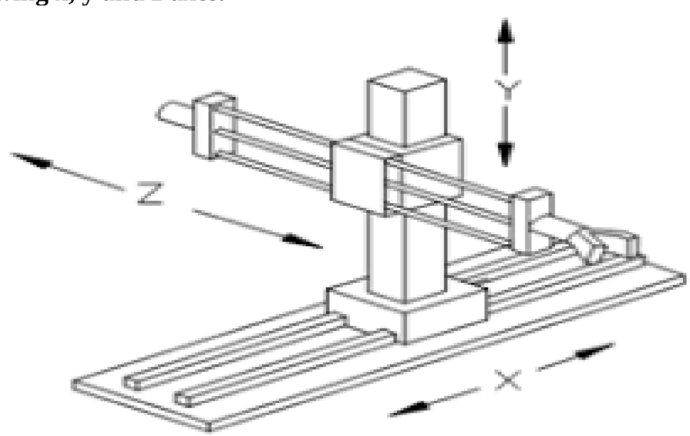


Figure 2: SCARA robot.

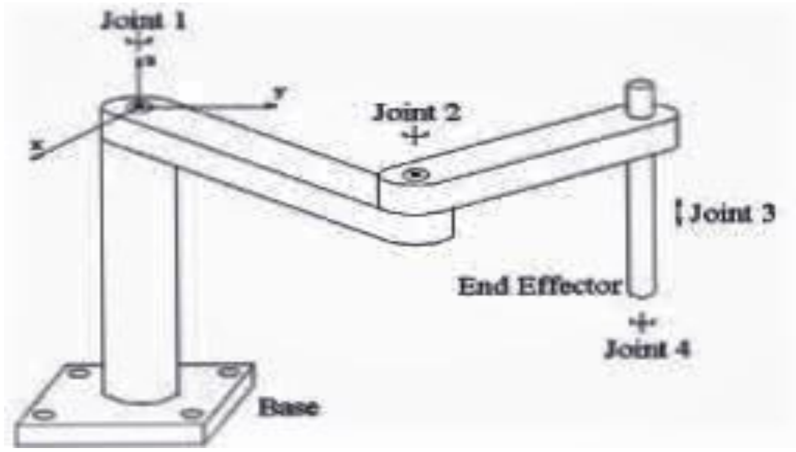
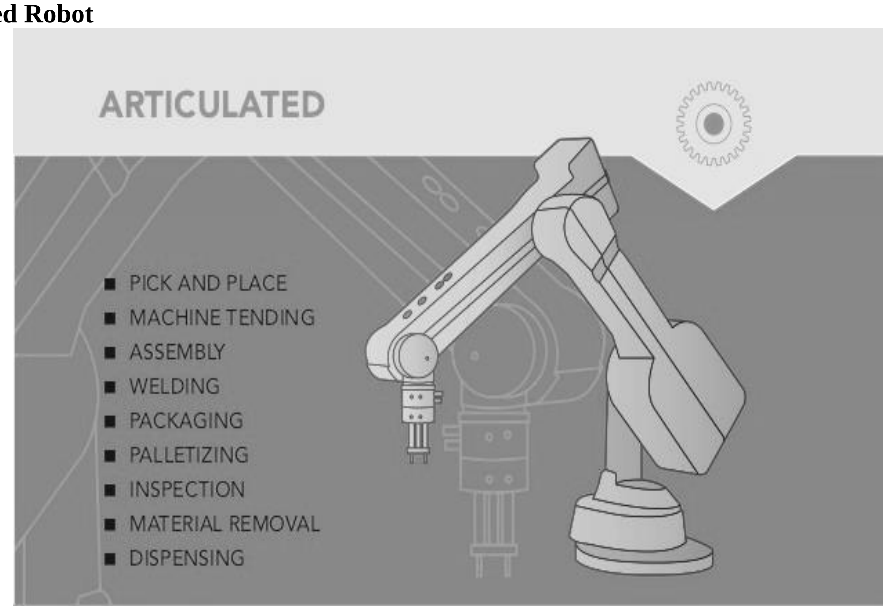


Figure3: Articulated Robot



CONCLUSION:

It has proven to be beneficial for incorporating robots into pharmaceutical day-to-day processes. Robots can work 24 hours a day and perform tasks three to four times faster than humans. As a result, robots can efficiently provide large quantities of products. Employees are freed from performing simple, repetitive tasks as a result of the availability of robots, allowing them to focus on developing new pharmaceutical products. Pharmaceutical robots have been discovered to be useful in a variety of fields, including research and development, pharmaceutical laboratories, picking and placing, packaging, filling, and so on. The use of robots in various sectors of pharmacy is rapidly increasing due to their extensive use. Pharmaceutical companies' ultimate goal is to produce high quality products while increasing efficiency and lowering costs. Thus, robots can be of great assistance to businesses in terms of speed, flexibility, repeatability, precision, and accuracy. Furthermore, the use of industrial robots is growing by the day. According to the analysis, the number of installations is increasing year after year, and many organizations are considering pharmaceutical robots as a way to boost productivity, accuracy, and reliability. This is because, the costs of robots are falling, and even small manufacturing industries are now stepping forward to improve product quality by adopting the new robotics technology.

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