



Selecting Robots for Use in Pharmaceutical Manufacturing

What Are the Essential Things to Know?

Pharmaceutical manufacturing, with its need for speed, repeatability and verification, is ideally suited to benefit from robot automation. It is therefore not surprising that robots have been at the forefront of automation developments in the pharmaceutical industry.

Benefits of Robots in Pharmaceutical Manufacturing

Robots are ideal for pharmaceutical manufacturing because they provide verifiability.

Robots can carry out pharmaceutical manufacturing tasks faster, more consistently and more cost-effectively than manual labor. As significant as these benefits are, however, they are far outweighed by the fact that every activity that a robot performs is verifiable. Not only does the robot perform its tasks exactly as it is told to, everything it does can be thoroughly documented.

When a human technician places a drug sample into an oven, sets the oven's temperature to a particular temperature, sets a timer for so many minutes, then removes the sample, questions can always remain: Was the temperature correctly set? Was the timer correctly set? Was the sample actually removed at the specified time?

With a robot, not only are such tasks carried out with an extremely high degree of repeatability, but every parameter in the process can be automatically monitored, recorded and verified.

Choosing the Right Equipment

In order to choose a robot that will benefit them most, those involved in the selection process have to be familiar with certain basic concepts in robot technology.

The success of any automation project depends first of all on choosing the right equipment. This paper will discuss key relevant aspects of robot technology, along with the most important things to consider when choosing a robot.

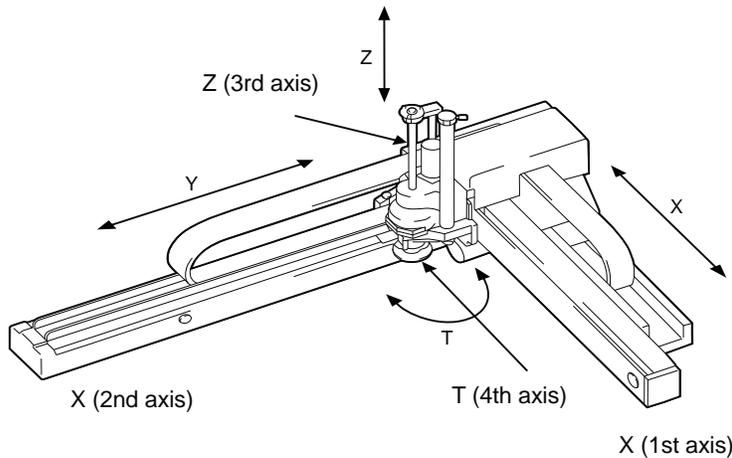
Types of Robots

There are three types of industrial robots most commonly used in pharmaceutical manufacturing: (1) Cartesian, (2) SCARA and (3) articulated.

Cartesian Robots

In their simplest form, Cartesian robots consist of two linear slides placed at 90-degree angles to each other, with a motorized unit that moves horizontally along the slides in the

Low-cost Cartesian robots are often incorporated into single-purpose automation subsystems or dedicated machines.



Four-axis Cartesian robot

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 chief advantage of Cartesian robots is their low cost, although their restricted range of motion limits their usage. They are often incorporated into automation subsystems or machines dedicated to a single purpose, such as assay testing.

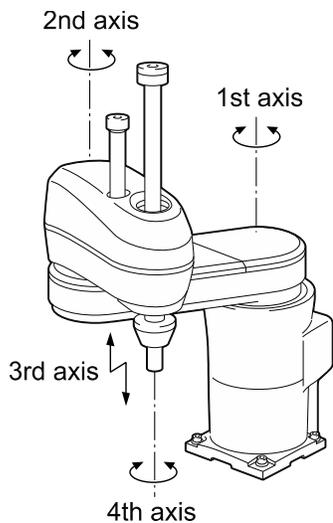
SCARA Robots

**Four-axis
SCARA robots
are especially
well-suited for
high-speed pick
and place.**

SCARA stands for “selective compliance articulated robot arm.” This refers to 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, the terms “SCARA” and “four-axis robot” are often used interchangeably to refer to a four-axis SCARA. The term “SCARA robot,” which is actually redundant, is also commonly used.

The first two links of a SCARA swivel left and right around the first two axes in the horizontal plane. The third link is the



Four-axis SCARA robot

quill, which moves up and down in the vertical plane along the third axis. The quill also rotates horizontally in the fourth axis, but cannot tilt at a vertical angle.

Some SCARAs have a metal shaft that might be mistaken for a second quill, but is actually a hollow air-balance cylinder. The function of this cylinder is to counterbalance the weight of the end-effector and payload and thus reduce settling time—the time the robot has to wait after it moves to a given point before it can carry out its next movement. Faster settling times result in faster cycle times.

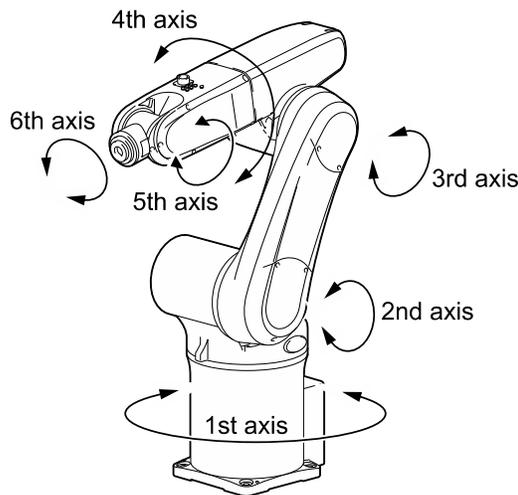
The unique design of SCARAs gives them a high degree of rigidity, which in turn allows them to move very fast and with precise repeatability. SCARAs excel at high-speed pick-and-place and other material-handling tasks.

Articulated Robots

Six-axis articulated robots offer added flexibility of movement, similar to that of a human arm and hand.

Articulated robots not only have more joints than SCARAs, they have both horizontal and vertical joints, giving them increased freedom of movement. Whereas a Cartesian robot has a cube-shaped work envelope and a SCARA has a cylindrically shaped one, the work envelope of an articulated robot is spherical.

With their greater flexibility of movement, articulated robots can perform almost any task that can be performed by a human arm and hand.



Six-axis articulated robot

The most common articulated robots have six axes. The first link rotates in the horizontal plane like a SCARA, while the second two links rotate in the vertical plane. In addition, six-axis articulated robots have a vertically rotating “forearm” and two vertically rotating “wrist” joints, which let them perform many of the same types of movements as a human forearm and wrist.

The forearm and wrist joints of six-axis articulated robots allow them to pick up an object no matter how it is oriented off the horizontal plane, then place it at any angle of approach that might be required. They also allow the robot to perform many other tasks that would otherwise call for the dexterity of a human operator.

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 (EOAT), (2) cycle time, (3) repeatability, (4) reach and (5) payload capacity. Taken together, these will usually determine whether a Cartesian, SCARA or articulated robot is necessary.

Another essential consideration is the environment in which the robot will be operating. Robot models are available for use in cleanrooms, and in applications where biocontamination control is required, aseptic models have special seals, outer coatings and other construction features that allow them to be cleaned with hydrogen peroxide.

Robot Integration

After a robot is selected, it needs to be integrated into the process.

Robots are usually mounted in an enclosed automation workcell. The robot and any other associated equipment are bolted to the cell's steel base or, in the case of an overhead mounting, from a steel superstructure. The upper walls of the cell are generally made of aluminum-framed, shatterproof clear plastic or see-through, metal-mesh screening. This keeps operators safely separated from the robot while still allowing them to observe the cell's activity.

As a safety precaution, opening the cell's access door automatically stops all robot motion. In cases where the robot is not enclosed in a cell, light curtains or pressure-sensitive floor mats can also provide automatic safety shutoff.

The robot's computerized controller, which contains the electronic circuits that run the robot and interfaces to external equipment through a variety of network inputs and outputs, is usually situated on a platform underneath the cell.

Programming the robot is accomplished by means of either a teaching pendant—a handheld interface device that communicates with the controller—or by a computer. Most robot manufacturers offer user-friendly programming software that does not require specialized engineering skills. Some robot controllers can also interface with third-party software such as National Instruments LabVIEW, which allows the user to program the robot without having to learn a new programming language.

The teaching pendant allows an operator to move the robot from one point to another and instruct it what to do at each location, thus “teaching” it the desired routine.

With available software, robots can also be programmed offline on a remote computer, saving development time. A virtual, simulated 3-D environment lets the user configure the

Integrating a robot into a pharmaceutical manufacturing process is relatively uncomplicated.

robot and any peripheral devices without having to actually operate them.

10 Things to Consider When Choosing a Robot

When choosing a robot from a specific manufacturer, here are ten important things to consider:

Knowing what to look for is essential when comparing and evaluating robots from different manufacturers.

1. Experience and reputation of the manufacturer: Look for a manufacturer who has established itself as an industry leader and whose robots have stood the test of time.

2. Documented MTBF: Robots, which are often required to operate two or three shifts per day, every day of the year, must above all be reliable. Manufacturers who stand behind their robots' reliability will be happy to furnish documentation of their mean time between failures (MTBF).

3. High maximum allowable moment of inertia: Look for a robot with a high maximum allowable moment of inertia, a measure of how much force it can exert. The higher the maximum allowable moment of inertia, the more easily the robot can lift and move a given size of payload, putting less strain on the robot's motors and resulting in a longer working life.

4. Continuous-duty cycle time: When comparing robot cycle times, be sure to ask whether the figures given are for continuous duty or only shorter bursts of an hour or less. If the latter, the robot will have to operate at a slower speed in normal operation.

5. Compact, efficient robot design: A compact robot design with slim arms and a small footprint makes integration easier and saves valuable factory floor space. In addition, designs with concealed air and electrical lines keep the lines from interfering with other equipment, as well as protecting them from wear and damage, thus reducing overall costs.

6. Robot controller features: Desirable features to look for in robot controllers include compact size and light weight; fast processing speed; modular expandability, to accommodate additional peripheral equipment without having to purchase a new controller; ease of integration with a vision system, PLC or other devices; and ease of servicing.

Selecting Robots for Pharmaceutical Manufacturing

7. Affordable offline programming software: Be sure that the offline programming software being offered does not include expensive, advanced features that are unnecessary for your needs.

8. Low energy consumption: Ask about the robot's energy consumption. Efficiently designed, slim and lightweight robot arms require less power, so their motors draw less electrical current. This can result in significant long-term cost-savings.

9. Safety codes: To protect employees and limit your company's liability, verify that the robot meets or exceeds all current safety codes.

10. Short training: Ask about the length of required training. Unnecessarily long training can result in excessive unproductive employee time and travel costs.

About DENSO Robotics

As one of the world's largest automotive parts manufacturers, DENSO Corporation has been a pioneer and industry leader in robot design and manufacturing since the 1960s. DENSO is also the world's largest user of small assembly robots, employing more than 16,000 robots in its own manufacturing facilities. Other companies use more than 60,000 additional DENSO robots worldwide.

DENSO Robotics offers a wide range of compact four-axis SCARA and five- and six-axis articulated robots for payloads of up to 20 kg, with reaches from 350 to 1,300 mm and repeatability to within ± 0.015 mm. Available configurations include (IP40), dust- and mistproof (IP65), dust- and splashproof (IP67), cleanroom (ISO 3, 4 and 5) and aseptic (H_2O_2 - and UV-light resistant). ANSI and CE compliance enables global deployment. UL-listed models are available for both the U.S. and Canada.

Easy-to-use programming software, controllers and teaching pendants are also offered. The company's offline programming software, which features 3-D simulation, also allows remote monitoring of robot operations.

DENSO robots are extensively used in pharmaceutical manufacturing as well as a wide variety of other applications, such as assembly, dispensing, inspection, machining, machine tending, material handling, material removal, pick and place, test handling and ultrasonic welding.

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Industries served include appliances, automotive, chemical, consumer products, disk drives, electronics, food and beverage, general manufacturing, machine tools, medical devices, pharmaceuticals, plastics and semiconductors.

For more information, visit the DENSO Robotics website at www.densorobotics.com.

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