Control System, Robot Programming and Work Cell Control

Robot Drive System

- The robot's capacity to move its body, arm and wrist is provided by drive system used to power the robot.
- The drive system provides its speed of operation, load carrying capacity and its dynamic performance.

Types of Drive Systems

- Hydraulic Drive.
- Electric Drive.
- Pneumatic Drive.

Characteristics of Drive System

- Speed of operation
- Load Carrying Capacity
- Power Consumption
- Positional Accuracy/Repeatability
- Cost

Hydraulic Drive

Hydraulic Drive

- Hydraulic drive is generally associated with large robots.
- It provides the robot with greater speed and strength.
- Hydraulic fluids are the main requirement of any hydraulic system. Leakage of these fluids will create environmental problems and safety issues.
- To actuate linear joints & rotary joints.
- Hydraulic drive Systems can be designed to actuate either rotational joints or linear joints.

Hydraulic Drive

- Advantages
  - For larger robots
  - Greater speed
  - High strength
- Drawbacks
  - Needs more floor space
  - Oil leakage

Electric Drive

- Do not provide as much speed or power as hydraulic systems.
- Accuracy and repeatablility of electric drive are usually better.
- Electric robot tend to be smaller, requiring less floor space.
- Applications tend toward more precise work such as assembly.
- Electric Drive robots are actuated by dc stepping motors or dc servo motors.

Electric Drive

- Utilize hydraulic drive on large robots and electric drive on small motors.
- Cost of the electric motors is much more proportional to its size as compared to hydraulic systems.

Pneumatic drive

- Pneumatic drive used for smaller robots.
- Limited to pick and place operations with fast cycles.
- Leakage will lead to failure

Control System

- A robot must have a *control system* which is used to move the arm, wrist, and body of a robot at various paths. When different industrial robots are compared with their control system, they can be divided into four major types.

They are:

- Limited Sequence Robots
- Playback Robots with Point – Point Control
- Playback Robots with Continuous Path Control
- Intelligent Robots

Limited Sequence Robots

- The limited sequence robots are incorporated with the *mechanical stops* and *limit switches* for determining the finishing points of its joints.

- These robots do not require any sort of programming. As a result, every joint can only travel to the intense limits.

- It is considered as the smallest level of controlling, and it will be best for simple operations like pick & place process.

Playback Robots

- The playback robots are capable of performing a task by *teaching* the position. These positions are stored in the memory, and done frequently by the robot. Generally, these playback robots are employed with a *complicated* control system.

It can be divided into two important types, namely:

- Point to Point control robots
- Continuous Path control robots

Playback Robots with Point – Point Control

- The point to point robots are shortly called as *PTP*.
- The desired paths are taught and stored in the control unit memory. These robots do not move from the desired location for controlling its path.
- It can be moved in a *small distance* only with the help of programming.
- This type of robots can be used for spot welding, loading & unloading, and drilling operations.
- Records work cycle as a sequence of points, then plays back the sequence during program execution.

Playback Robots with Continuous Path Control

- The continuous path control is also known as *CP* control.
- These robots commonly move in the *straight line*.
- The initial and final point is first described by the programmer, and the control unit defines the individual joints. This helps the robot to travel in a straight line
- It can also move in a *curved path* by moving its arm at the desired points.
- Greater memory capacity and capability to execute paths (in addition to points).

Intelligent Robots

- The intelligent robots can play back the defined motion, and can also work according to their environment.
- The sensor is incorporated in these robots for receiving the information during the process.
- This kind of robots is capable of communicating with the programmers in the work volume. It will be best for assembly purposes.

Robot Programming

- Leadthrough programming
  - Work cycle is taught to robot by moving the manipulator through the required motion cycle and simultaneously entering the program into controller memory for later playback
- Robot programming languages
  - Textual programming language to enter commands into robot controller
- Simulation and off-line programming
  - Program is prepared at a remote computer terminal and downloaded to robot controller for execution without need for leadthrough methods

Work Cell Control

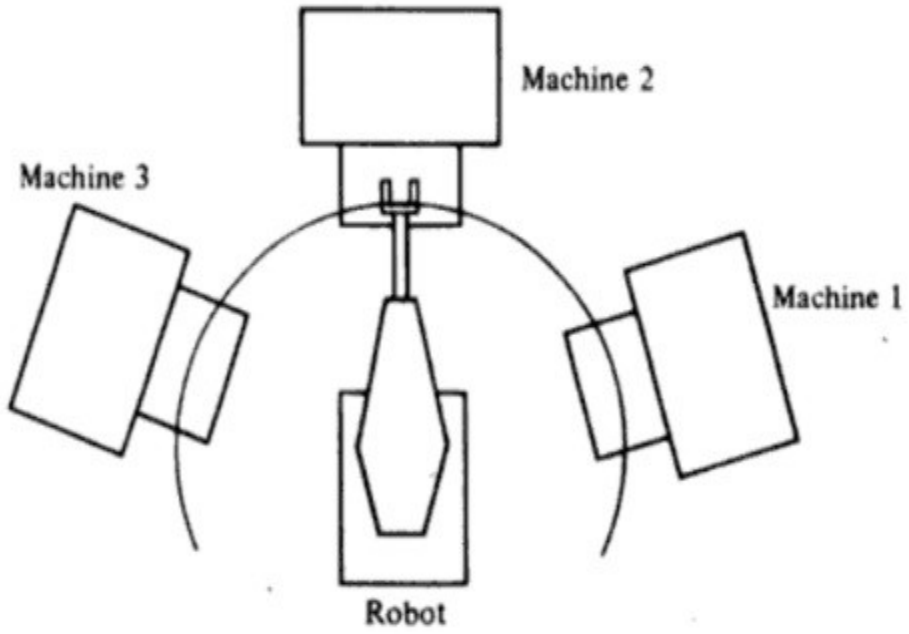
- The robot workcell or simply cell is a defined area of space through which a robot can move. It is also known as the work envelope.

ROBOT WORKCELL LAYOUTS

- Robot cells can be arranged into various arrangements or layouts. The layouts are:
  - Robot-centered cell
  - In-line robot cell
  - Mobile robot cell

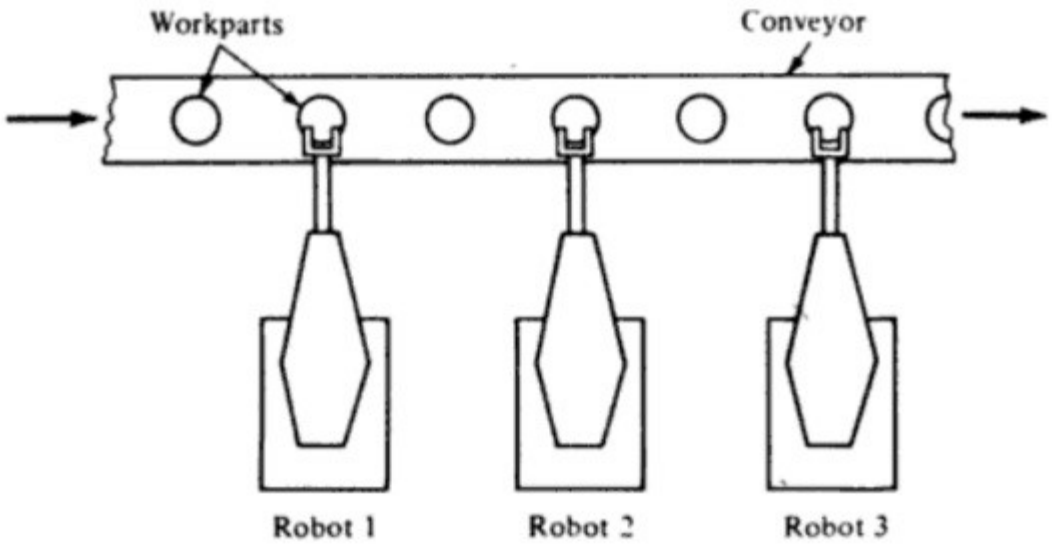
ROBOT-CENTERED CELL

- In robot-centered cell, the robot is located at the center of the cell and the equipment is arranged in a partial circle around it.
- During 1960s, one robot used to perform a single operation, either serving a single production machine, or performing a single production operation. This was causing the low utilization of the robot.
- To increase the utilization, the workcell concept was developed in which one robot services several machines as shown in the figure.
- This type of layout is used for the operations like arc welding.



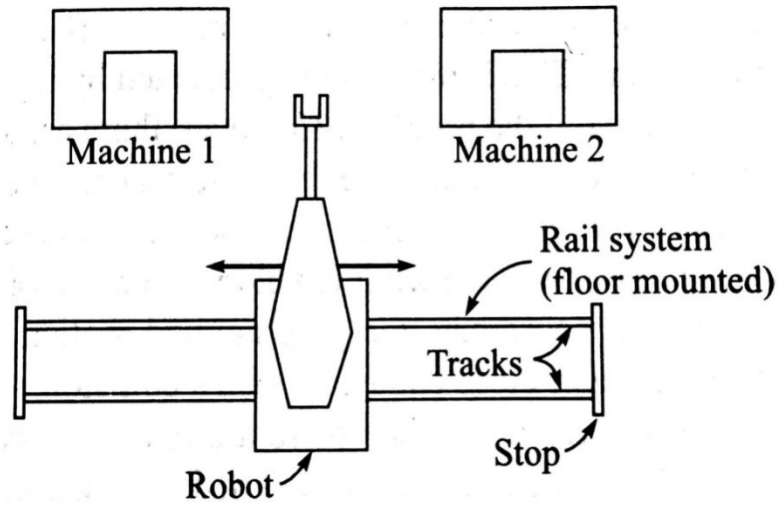
IN-LINE ROBOT CELL

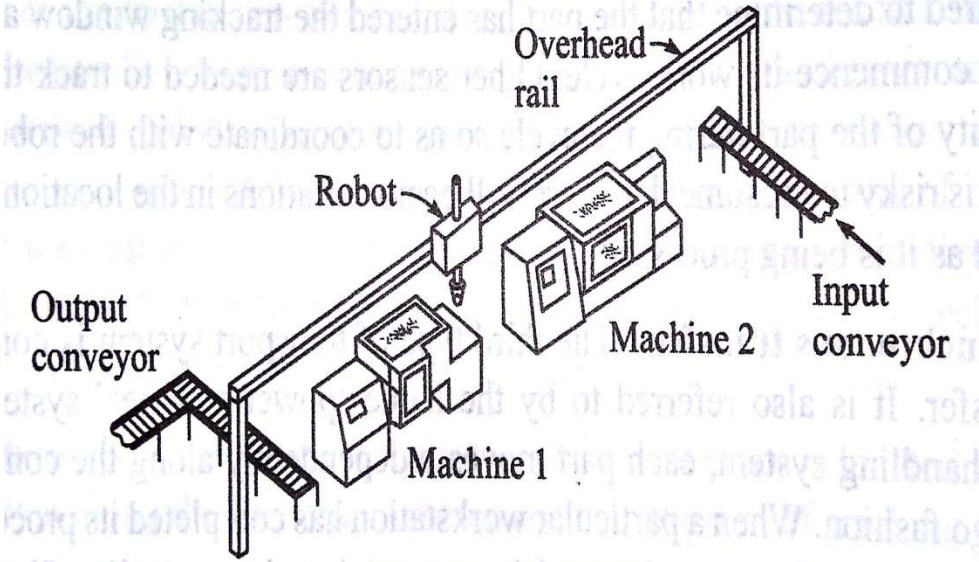
- In this layout, the robot is situated along a moving conveyor and performs a task on the product as it travels past on the conveyer belt.
- Here, more than one robot is placed along the moving line. This layout finds its application in a car body assembly plant.



MOBILE ROBOT CELLS

- The mobile robot cell is the one in which the robot is capable of moving to the various machines within its workcell.
- This can be accomplished by mounting the robot on a mobile base rail system. The rail system may be either the tracks fastened to the floor or an overhead rail system as shown in the figures.
- The overhead rail system has an advantage over the floor-mounted track system that it occupies less floor area. Meanwhile, it has a disadvantage of high capital investment for its construction.





WORKCELL CONTROL

- There are various activities which occur sequentially and simultaneously in the robot cell. To coordinate and control these activities, we use a device called the **workcell controller** or **workstation controller.**
- The functions performed by a workcell controller can be divided into three categories:
  1. Sequence control
  2. Operator interface
  3. Safety monitoring
- If the control requirements to operate the cell are simple and easy, the robot controller is employed to perform these activities.
- If the control requirements to operate the cell are complicated, a higher-level control device, such as a programmable logic controller (PLC), is employed to perform these activities.

SEQUENCE CONTROL

- The workcell controller performs **the sequence control function** during the regular automatic operation of the workcell. It comprises the following control functions:
  1. Control of sequential activities in the workcell.
  2. Control of simultaneous activities in the workcell.
  3. Making decisions to proceed with the work cycle based on the events that occur in the workcell.
  4. Making decisions to stop or delay the work cycle based on events that occur in the workcell.

OPERATOR INTERFACE

- The operator interface provides a means of interaction between the human workers and workcell operation. It is required in some of the important situations like:
  1. The human is an integral part of the workcell.
  2. Emergency stop conditions.
  3. Program editing by the operator.
  4. Data input by the operator.
- In a robot workplace, the human operators will have various works to be done along, the robot like part loading and unloading, and more. At this time, the start and stop controls may be used by the workers in order to protect them from physical damages.

SAFETY MONITORING

- Sometimes, the human workers may be injured severely while performing too close with the robots. To overcome this problem, several safety steps are studied by implementing sensors. Moreover, a workcell controller should have the ability to monitor its individual function for hazardous situations. It is known as hazard or safety monitoring.

INTERLOCKS

- An interlock is a method which prevents the continuation of the work cycle sequences until a certain condition or set of conditions are satisfied.
- It is a feature of workcell control which plays a vital role in regulating the sequence in which the various elements of the work cycle are processed.
- It can be used for the following purposes:
  1. To ensure that a raw workpart was at the pick up location on the conveyor or not before the robot tried to grasp the part.
  2. To determine when the machining cycle was completed before the robot attempts to load the part into the fixture.
  3. To indicate that the part has been successfully loaded, so that the automatic machining cycle can begin.

TYPES OF INTERLOCKS

- Interlocks can be divided into two basic categories:

1. **Output interlock:** An output interlock uses a signal sent from the workcell controller to one of the machines or other devices in the workcell to commence the automatic cycle. It corresponds to the SIGNAL programming statement.
2. **Input interlock:** An input interlock uses a signal sent from the one of the machines or other devices in the workcell to the workcell controller to indicate that a certain condition or set of conditions have been satisfied and the work cycle sequence can continue. It corresponds to the WAIT programming statement

USES OF INTERLOCKS

- The interlocks are used not only to prevent the workpart from **inaccurate positioning,** but also to protect the components in the workcell from **being damaged**.
- In addition, the interlocks also consider **the failures and irregularities** that occur in the cell. If a malfunction takes place in a robot workcell, the application engineer must find out a technique to recognize the malfunction and should take a suitable action for the solution.
- Subsequently, interlocks are used to obtain the **series control** and **safety monitoring** in both irregular and regular work cycles.
- Moreover, advanced type sensors can be used to gain more accurate performance in the work cycle.