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CMR INSTITUTE OF TECHNOLOGY, BENGALURU.
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Internal Assessment Test 5 – February 2022

Sub	Computer Aided Design & Manufacturing (CADM)				Sub Code:	18ME72	Branch	Mech
Date	07.02.22	Duration	10.15 AM 11.45 AM	Max Marks	50	Sem / Sec	VII/A&B	OBE

Answer All Questions

		MARKS	CO	RBT
1	Explain the following terminology related to Robot (i) Accuracy (ii) Resolution (iii) Repeatability	10	CO4	L2
2	The following data refers to the precedence relationship & element times for a new product (see table below). Using Largest candidate rule method find (i) Construct the precedence diagram. (ii) If the ideal cycle time is 1 min find the no. of work stations required. (iii) Balance delay and Balance efficiency.	10	CO3	L4
3	The following data refers to the precedence relationship & element times for a new product (see table below). Using Kilbridge and Westers method find (i) Construct the precedence diagram. (ii) If the ideal cycle time is 1 min find the no. of work stations required. (iii) Balance delay and Balance efficiency.	10	CO3	L4
4	Explain the different configurations of robot with neat sketches and explain about various applications areas of industrial robots.	10	CO4	L2
5	Explain with a neat sketch the Sheet lamination process & direct energy deposition technique.	10	CO4	L2

Table for Question 2:

Element No	1	2	3	4	5	6	7	8	9	10	11	12
Tc(min)	0.2	0.4	0.7	0.1	0.3	0.11	0.32	0.6	0.27	0.38	0.5	0.12
Precedence	-	-	1	1,2	2	3	3	3,4	6,7,8	5,8	9,10	11

Table for Question 3:

Element No	1	2	3	4	5	6	7	8	9	10	11	12
Tc(min)	0.2	0.4	0.7	0.1	0.3	0.11	0.32	0.6	0.27	0.38	0.5	0.12
Precedence	-	-	1	1,2	2	3	3	3,4	6,7,8	5,8	9,10	11

CI **CCI** **HoD**

1. The precision with which the robot can move the end of its wrist Spatial resolution, Accuracy & Repeatability. Spatial resolution smallest increment of motion at the wrist end that can be controlled by the robot Depends on the position control system, feedback measurement, and mechanical accuracy

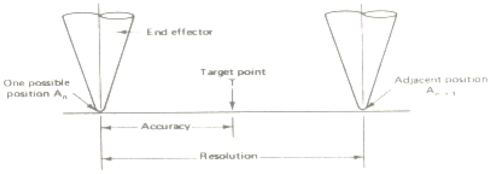


Fig 1.10 Spatial Resolution

Smallest increment of motion

Depends on the control system and feedback

$$\textbf{Control resolution} = \frac{\textbf{range}}{\textbf{Control increments}}$$

Spatial Resolution

Accuracy

Capability to position the wrist at a target point in the work volume

- One half of the distance between two adjacent resolution points
- Affected by mechanical Inaccuracies
- Manufacturers don't provide the accuracy (hard to control)

The ability of a robot to go to the specified position without making a mistake. Closely related to spatial resolution

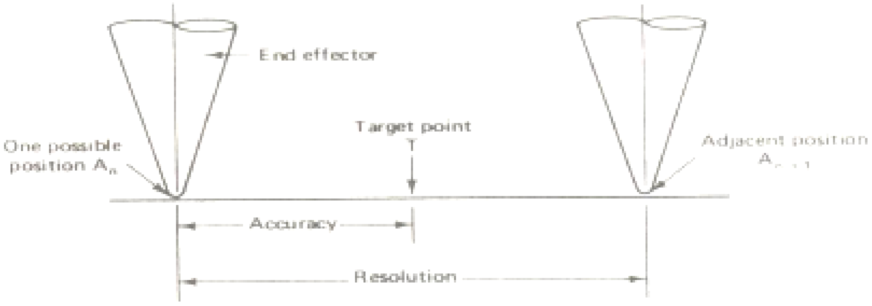


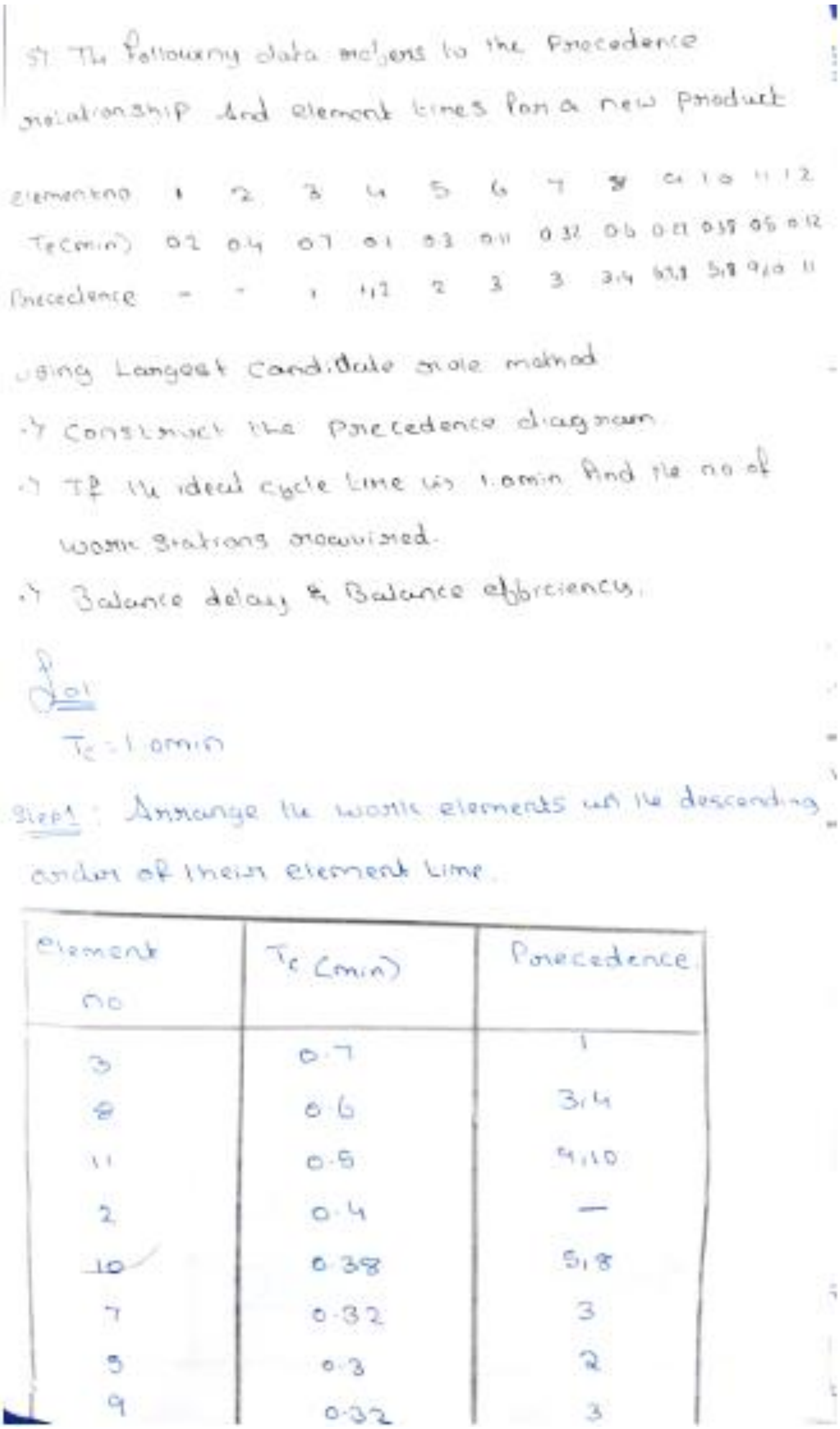
Fig 1.11 Accuracy

Repeatability

Ability to position back to a point that was previously taught

- Repeatability errors form a random variable.
- Mechanical inaccuracies in arm, wrist components
- Larger robots have less precise repeatability values

2.



Q. The following data refers to the precedence relationship and element times for a new product

element no	1	2	3	4	5	6	7	8	9	10	11	12
Te (min)	0.2	0.4	0.7	0.1	0.3	0.11	0.32	0.6	0.27	0.38	0.5	0.12
Precedence	–	–	1	1,2	2	3	3	3,4	6,7,8	5,8	9,10	11

using Largest candidate rule method

- i) Construct the precedence diagram.
- ii) If the ideal cycle time is 1.0 min find the no of work stations required.
- iii) Balance delay & Balance efficiency.

Sol:

$T_c = 1.0 \text{min}$

Step 1: Arrange the work elements in the descending order of their element time.

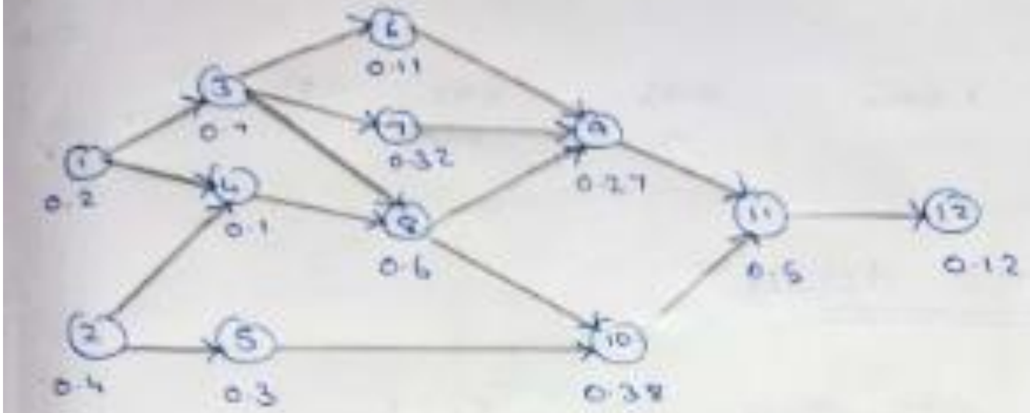
element no	T_e (min)	Precedence
3	0.7	1
8	0.6	3,4
11	0.5	9,10
2	0.4	—
10	0.38	5,8
7	0.32	3
5	0.3	2
9	0.32	3

1	0.2	–
12	0.12	11
6	0.11	3
4	0.1	1,2

Step2 : Assigning the work element to
work Station's [T = 1min]

Element no	Tc (min)	Precedence	Station	Station time
2	0.4	–	I	0.4+0.3+0.2 +0.1=1min
5	0.3	2		
1	0.2	-		
4	0.1	1,2		
3	0.7	1	II	0.7+0.11+0.12 = 0.93 min
12	0.12	11		
6	0.1	3		
8	0.6	3,4	III	0.6+0.32 = 0.92min
7	0.32	3		
10	0.38	5,8	IV	0.38+0.27 = 0.65min
9	0.27	6,7,8		
11	0.5	9,10	V	0.5min

Step 3 : Construct the precedence diagram



Step 5 : Determine the theoretical number of stations required.

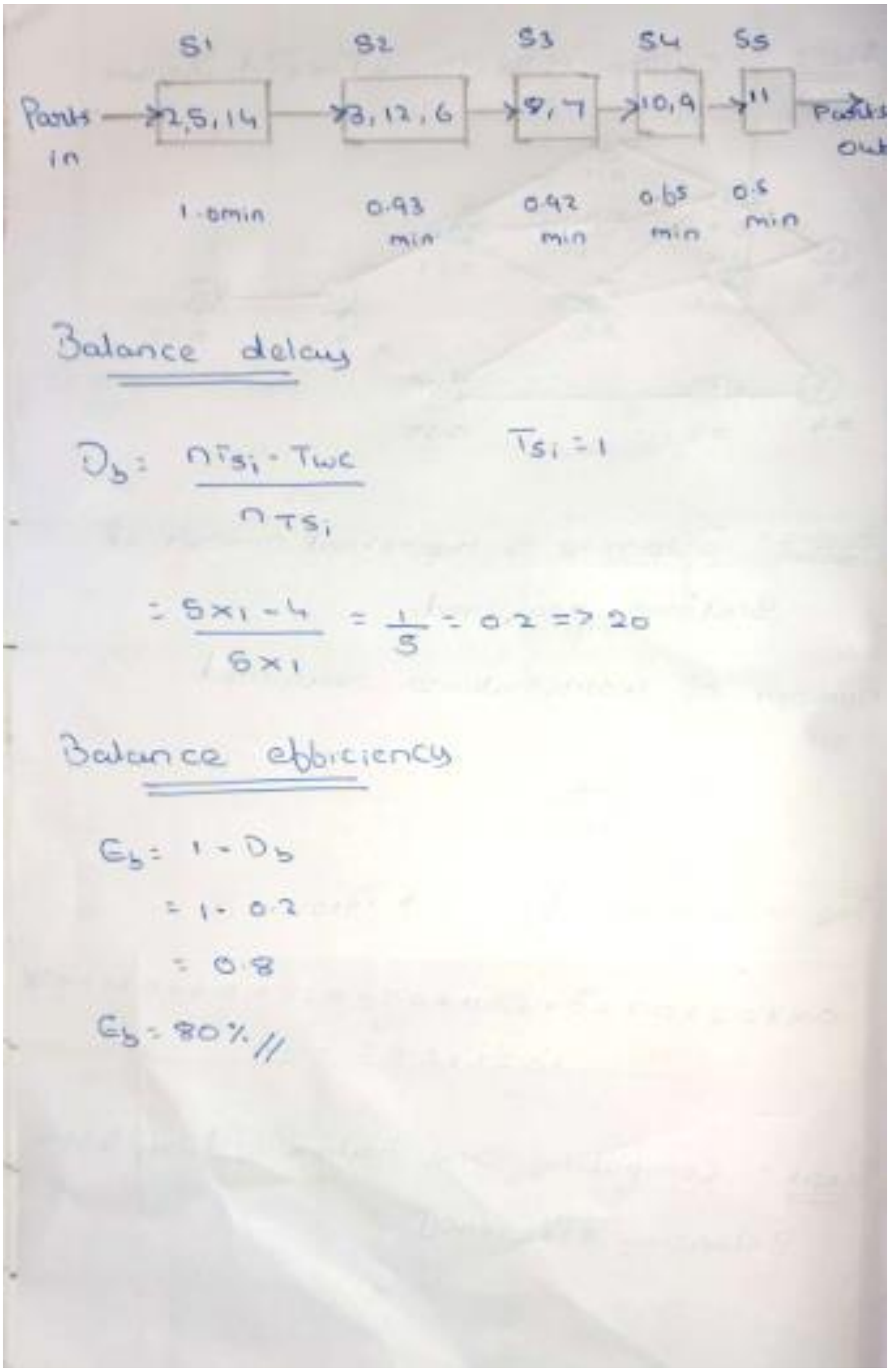
number of workstations required

$$n = \frac{T_{wc}}{T_c}$$

$T_{wc} = T_{e_1} + T_{e_2} + T_{e_3} \cdots + T_{e_{10}}$

$= 0.4 + 0.3 + 0.2 + 0.1 + 0.11 + 0.7 + 0.12 + 0.6 + 0.32 + 0.38$
$+ 0.27 + 0.5 = 4 \text{min}$

Step 6 : Computing Line balancing delay & Line Balancing efficiency.



Balance delay

$$D_b = \frac{nT_{si} - T_{wc}}{nT_{si}} \qquad T_{si} = 1$$

$$= \frac{5\times1 - 4}{5\times1} = \frac{1}{5} = 0.2 \Rightarrow 20$$

Balance efficiency

$$E_b = 1 - D_b$$

$$= 1 - 0.2$$

$$= 0.8$$

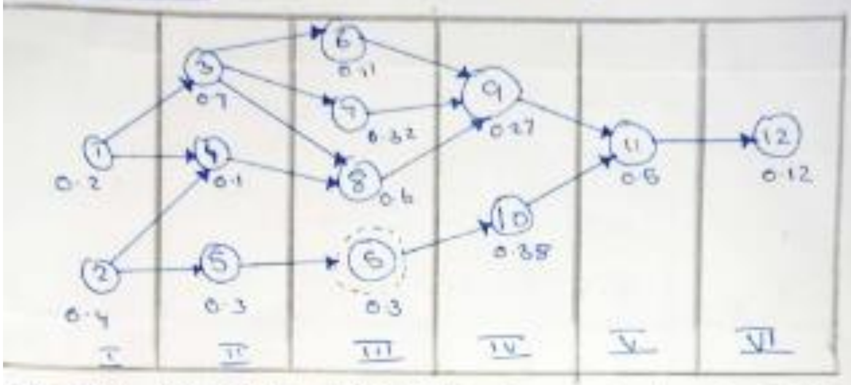
$E_b = 80\%$ //

3.

5th sum

Kilbridge and Westers method

Step 1 : Precedence diagram

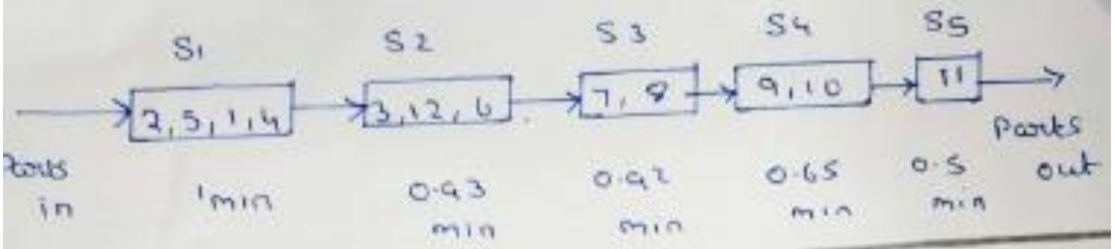


Step2 : List out elements Along column wise & According to element times in the particular column

Work element	Column	Te min	Preceded by
①	I	0.2	—
②	I	0.4	—
③	II	0.7	1
④	II	0.1	1, 2
⑤	II	0.3	2
⑥	III	0.11	3
⑦	III	0.32	3
⑧	III	0.6	3, 4
⑨	III	0.27	6, 7, 8
⑩	IV	0.28	5, 8
⑪	V	0.5	9, 10

Steps : work elements Assigned to the Stations According to kilbrige & westerns method

work element	Column	Tej	Precedence	Station	Total Station time
2	1	0.4	–	I	1min
5	2	0.3	2		
1	1	0.2	–		
4	2	0.1	1,2		
3	2	0.7	1	II	0.93 min
12	6	0.12	11		
6	3	0.11	3		
7	3	0.32	3	III	0.92 min
8	4	0.6	3,4		
9	4	0.27	6,7,8	IV	0.65
10	5	0.38	5,8		
11	6	0.5	9,10	V	0.5



Balance Delay

$n = 5$

$$D_b = \frac{n T_{s_1} - T_{wc}}{n T_{s_1}}$$

$T_{wc} = 4$

$$= \frac{5 \times 1 - 4}{5 \times 1}$$

$$= 0.2$$

Balance efficiency

$E = 1 - D_b$

$E_b = 1 - 0.2$

$E_b = 80\%$

Classification of robots based on robots configuration

Polar Coordinate Body-and-Arm Assembly

Consists of a sliding arm (L joint) actuated relative to the body, which can rotate about both a vertical axis (T joint) and horizontal axis (R joint) Notation TRL:

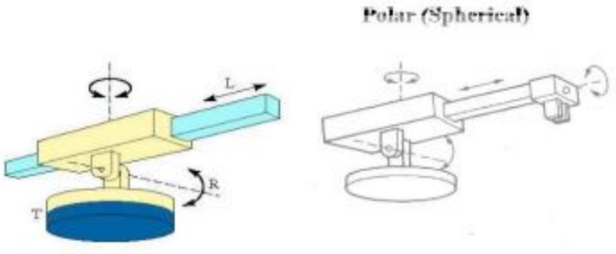


Fig 1.3 Polar Configuration

4.

Cylindrical Body-and-Arm Assembly

Consists of a vertical column, relative to which an arm assembly is moved up or down. The arm can be moved in or out relative to the column Notation TLO:

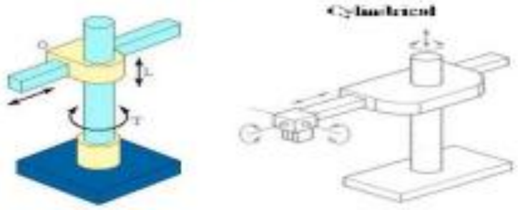


Fig 1.4 Cylindrical Configuration

Cartesian coordinate Body-and-Arm Assembly

Consists of three sliding joints, two of which are orthogonal other names include rectilinear robot and x-y-z robot Notation LOO:

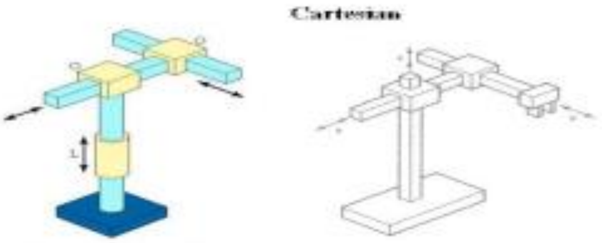


Fig 1.5 Cartesian Configuration

Jointed-Arm Robot

Similar in appearance to human arm Rotated base, shoulder joint, elbow joint, wrist joint.

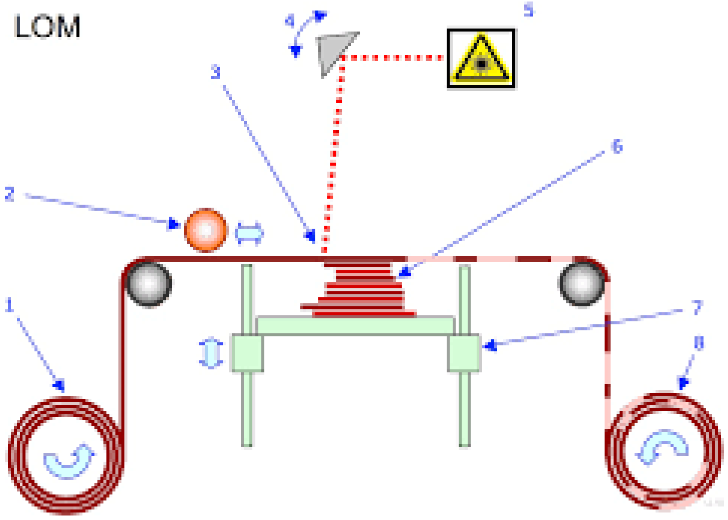
Notation TRR:

Fig 1.6 Jointed Arm Configuration

Application areas of industrial robots has been categorized into the following seven areas.

1. Material Transfer
2. Machine Loading
3. Welding
4. Spray Coating
5. Processing Operations
6. Assembly
7. Inspection

5.



The physical model is formed by stacking layers of sheet
Based on the build material it has two type

- Laminated Object Manufacturing (LOM)
- Ultrasonic Additive Manufacturing (UAM)

LOM uses paper as material and adhesive
UAM used sheets of metal bonded by ultrasonic welding Instead of adhesive

Process steps

1. The sheet and the adhesive is placed on the platform
2. Laser is employed to cut the required shape forms the first layer
3. The spool is rotated for the next layer to position on the first and they are bonded by adhesive heat rolle
4. The required shape is cut by the laser
5. The process repeats till the required thickness is obtained
6. The build is removed to carry the post processing work.

Advantages

1. The process is faster and economical
2. The strength of the part depend on the type of the bond laminated
3. The LOM process does not induce any residual stresses in the finished product

Disadvantages

1. Post processing is required to achieve the desired shape
2. Limitation in variety of material usage
3. This sheet lamination further requires some research

Directed Energy Deposition (DED)

In this process the part is created by melting the Material as it is being deposited

This process is widely used for repair and Maintenance rather than fabricating parts

Laser or electron beam or plasma arc is used As energy source

The metal pool is formed at the when the energy Source is directed over the deposited metal and Solidifies as the beam moves away

Process steps

1. Deposition head is mounted around the fixed object.
2. Material in the wire or powder form deposited by the nozzle
3. Using energy source the material is melted
4. Further material is added layer by layer as it solidifies

Advantages

1. Capable of producing denser parts
2. Utilized effectively for repairing and refurbishing components like turbine blades, crank shafts and bearings

Disadvantages

1. The process is time consuming
2. Components have poor resolution and surface finish
3. Limited material use
4. Further this process requires research