ISEN-645

LEAN ENGINEERING

HW4

Lean Cell Engineering and Design

Team - 25
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Question 1:

Description: A lean manufacturing cell has the following design depicted. There are 8 SCAs in the cell. A complete loop would require 8 walks at 3s between workstations.

Station time refers to the time it takes for the operator to unload the machine, check the part, load a new part, and move the completed part to the decoupler between workstations.

a Lean Engineer proposes a 3-loop operator design of

- operator1: (ws1, ws2, ws8)
- operator2: (ws4, ws5, ws6)
- operator3: (ws3, ws7)

[a] Is the loop design feasible according to the cell design axiom regarding operator paths?

<u>Ans.</u>

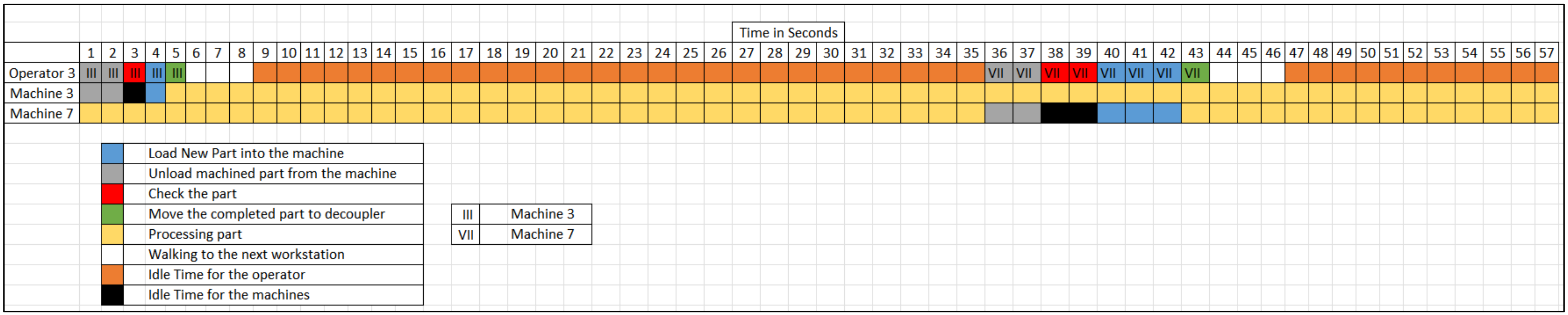
According to the axiomatic design methodology and analyzing the functional, design, and process requirements, we observe that the operator's work cycle does not interfere with each other, enabling parallel processing of the processes. And thus, we can conclude that the loop design is feasible regarding the operator's path.

[b] Assume that SCAs machines are designed to stay in continuous operation if serviced properly by the cell operator. Draw a feasible "worker-machine chart" for the operator and machine timing that depicts one entire loop time for operator3 that would keep the SCAs machines in continuous operation. The diagram should identify what the operator is doing and what the machines are doing.?

Ans.

Below we have visualized the worker-machine chart for operator 3, machine 3, and machine 7 design loop.

- Here the time is in Seconds.
- The average idle time for Operator 3 is 30 Seconds.
- The average idle time for Machine 3 is 1 Second.



[c] Would a rabbit chase strategy work for this machining cell?

Ans.

In the Rabbit chase strategy operators should be trained and capable of executing all the cell task loops. And they should be multi-skilled with an equal level of performance. This would enable the operators to complete all the activities work back-to-back without influencing other operators in other loops. In this case, operation 3 has the highest processing time which will definitely influence all the other operators which in turn leads to the blocking of other workers. So, we conclude that the Rabbit chase strategy would not work very well with the given conditions of station time and processing time.

Question 2:

Description: A lean assembly cell has the times identified. A complete loop by a worker would require 8 walks at 3s between workstations. Station time refers to the time to prepare the workstation for the assembly task. Station + Processing time equals the total time spent at a workstation.
A Lean Engineer wants to use a Rabbit Chase strategy to staff the cell.

[a] What is the cycle time for the cell using A Rabbit Chase with two workers?
<u>Ans.</u>

Operations	Station Time	Processing Time	Travelling Time	Total Time	Cumulative Sum
1	3	42	3	48	48
2	3	26	3	32	80
3	4	53	3	60	140
4	2	20	3	25	165
5	4	18	3	25	190
6	6	30	3	39	229
7	8	34	3	45	274
8	10	47	3	60	334

Cumulative Total Time Taken = 334 secs (For all the 8 operations)
Of Workers = 2 (Condition for this question)
Cycle Time = Total Time Taken/No. of Workers = 334/2 = 167secs

Hence, the cycle time is 167 seconds.

[b] If takt time were identified as 57s, how many operators would you need to meet that requirement?
<u>Ans.</u>
Takt Time = 57 secs (Condition for this question)
Planned Cycle Time = 0.9*57=51.3
Of workers required = Cycle Time / Planned cycle time = 334 / 51.3 = 6.5107 rounding off to 7
Of workers required = 7 Workers

Hence, the number of workers required = 7 workers

[c] Is this cell a good candidate for a Bucket Brigade strategy? why or why not.

<u>Ans:</u>
In the Bucket brigade strategy, the first process should be the longest process (Bottleneck) and there must be shorter cycles following it. The processing time should be from the longest to the shortest. This sequence of processes and operations should fall under a single cell or single skill bucket.

In our question, the first process is not the longest one. so, in this case, **the Bucket brigade strategy may not work effectively**. As the following process are longer and may cause blockages.
Question 3:

1. Calculate Takt time:

Demand = 800 assembled products per day
Available Time = 8hrs - 30 min - 2*20 min break - 1*10min break
Available Time = 480 min - 30 min - 40 min break - 10min break
Available Time = 400 min

$$Takt\ Time = \frac{Available\ Time}{Demand}$$

$$Takt\ Time = \frac{400}{800}$$

$$Takt\ Time = 0.5\ mins\ per\ part$$

$$\boldsymbol{Takt\ Time = 30\ Secs\ per\ part}$$

2. Using 90% of takt to calculate the current number of workers for the (current) ASIS system

Summation of Task Time = 122 Sec
Planned cycle time = 90% of Takt time = 0.9 x 0.5 x 60 = 27 Seconds

$$No. of\ worker = \frac{\sum Task\ Time}{Planned\ cycle\ time}$$

$$No. of\ workers = \frac{122}{27}$$

$$No. of\ workers = 4.51$$

$$\boldsymbol{No. of\ workers = 5\ (Approx.)}$$

3. Classify the activities, identify the waste, identify the re-engineered activities

Summary	Present No.	Present Time	Proposed No.	Proposed Time	Difference No.	Difference Time
Operations						
Handlings						
Transportations						
Inspections						
Delays						
Storages						
Distance Traveled						

Plant: Current

Charted by: Karthikeyan Chandar & Pradeep Manoharan

Date 02/27/2023 Sheet: 1 of 1

MAN		-------------	MATERIAL	

Chart begins: Activity 1

Chart ends: Activity 26

Details of Method

PRESENT		-------------	PROPOSED	

Details of Method	Operation	Handling	Transport	Inspection	Delay	Storage	Distance in	Quantity	Time	What?	Where?	When?	Who?	How?	Notes	Eliminate	Combine	Sequence	Place	Person	Improve
1. Fetch inbound material from raw material storage (every 1 cycle)									4												
2. Walk to the inbound raw material container																					
3. Pick up raw material									2							X					
4. Walk to LHS of weld machine									3								X				
5. Place raw material on LHS of the welding machine									2								X				
6. Walk to the center of the welding machine									2							X					
7. Remove welded part from jig on weld machine									5												X
8. Place welded part in the outbound area									2							X					
9. Walk to LHS of weld machine									3								X				
10. Pick up raw material from LHS of weld machine									3								X				
11. Move raw material to the center of weld machine									2							X					
12. Secure raw material into jig									6												X
13. Start welder									2												
14. Welder cycle									18												
15. Wait for the part to cool									15												X
16. Pick up welded part and jig from weld machine									2												X
17. Perform a visual inspection									6												X
18. Carry part to bushing WIP area (75% of parts)									3												
19. Carry part to deburring area (25% of parts)									4												X
20. Deburr part (25% of parts as noted)									12												X
21. Carry deburred part to the bushing WIP area									2												
22. Fetch bushings container (every 1 cycle)									1												X
23. Pick up bushing									2												
24. Walk to the assembly table									3							X					

25. Assemble the product	○	⬡	⇨	□	D	▽			10	
26. Place assembled product in the FGI area	○	⬡	⇨	□	D	▽			3	

WASTE IDENTIFICATION:

Activity	Description	Therbligs	Wastes in System	Time (sec)	Task Time
A	Fetch inbound material from raw material storage (30 cycles)	NP	T, I	120	4
B	Walk to inbound raw material container	NP	M	5	5
C	Pick up raw material	NP	M,T	2	2
D	Walk to LHS of weld machine	NP	M	3	3
E	Place raw material on LHS of the weld machine	NP	M	2	2
F	Walk to the center of the welding machine	NP	M,T	2	2
G	Remove welded part from the jig on the welding machine	NP	M,T	5	5
H	Place welded part in outbound area	NP	M	2	2
I	Walk to LHS of weld machine	NP	M,T	3	3
J	Pick up raw material from LHS of weld machine	NP	D	3	3
K	Move raw material to the center of the welding machine	NP	OP	2	2
L	Secure raw material into the jig	NP	D,OP,U	6	6
M	Start welder	P	W	2	2
N	Welder cycle	P	M,T	18	18
O	Wait for part to cool	NP	W	15	15
P	Pick up welded part and jig from weld machine	NP	M,T	2	2
Q	Perform visual inspection	P	OP,D	6	6
R	Carry part to bushing WIP area (75% of parts)	NP	M,T	3	3
S	Carry part to deburring area (25% of parts)	NP	M,T	4	4
T	Deburr part (25% of parts as noted)	P	OP,D,U	12	12
U	Carry deburred part to bushing WIP area	NP	M,T	2	2
V	Fetch bushings container (every 200 cycles)	NP	M,T	200	1
W	Pick up bushing	NP	M,T	2	2
X	Walk to assembly table	NP	M,T	3	3
Y	Assemble product	P	OP,D,U	10	10
Z	Place assembled product in FGI area	NP	M,I	3	3
				Total	122

Therbligs: A study of motion economy in the workplace. There are 18 kinds of elemental motions used in this study.

In this Production system, we have classified each and every activity based on the therbligs.

Productive time (P): Inspect, Process, Assemble,

Non-Productive time (NP): Walk, Fetch, Transport, Motion, Move, Carry, Pick

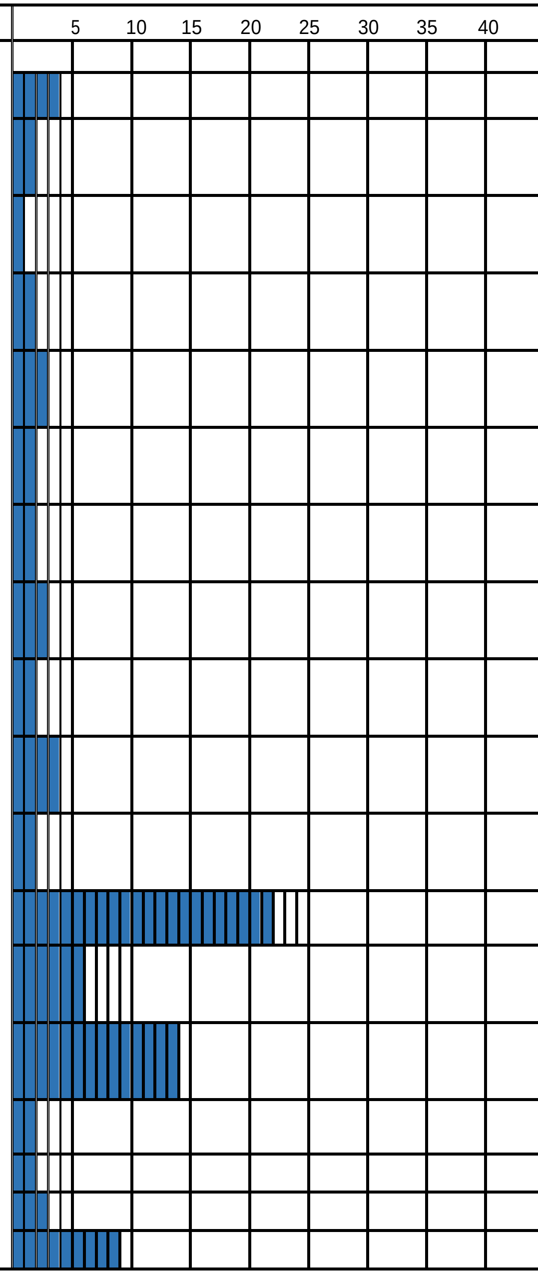
Legends for 8 Wastes	
Defects	D
Over production	O
Waiting	W
Unused Util %	U
Transport	T
Inventory	I
Motion	M
Over processing	OP

Potential Waste Identified in this system: Refer Legends for 8 waste

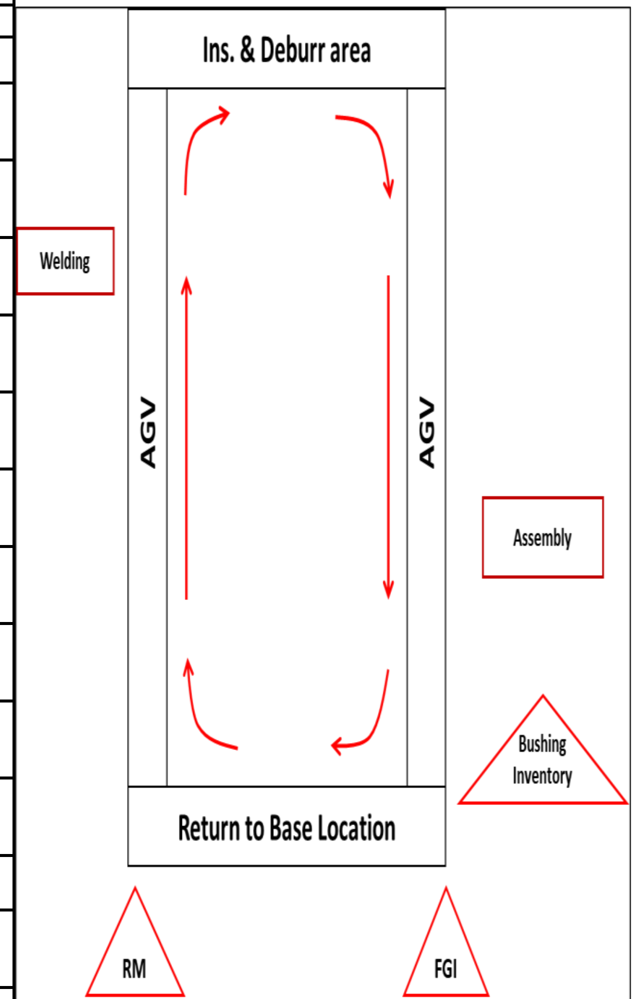
STANDARDIZED WORK

Manual Work
Machine Time
Walking

Ref. Symbol	Cyclical Work Element	Element Time (Sec.) Manual	Machine	Walking
1.	Fetch RM storage	4		
2.	Place RM on Conveyor/ AGV	2		
3.	Pick up bush from RM	1		
4.	Place on conveyor/AGV	2		
5.	Remove welded part from Jig	3		
6.	pick up welded part from jig	2		
7.	Place on conveyor/AGV	2		
8.	pick up RM from AGV/Conveyor	3		
9.	Place RM in jig	2		
10.	secure RM in weld jig		4	
11.	start welder	2		
12.	weld cycle & Cool		22	
13.	perform visual inspection	6		
14.	pick up & deburr part	14		
15.	place in AGV/conveyor	2		
16.	pick up bushing from AGV/Conveyor	2		
17.	walk to assembly area			3
18.	Perform Asembly	9		



LAYOUT SKETCH & WALK PATH



19.	place assembly part in FG area	3															
	Sub-Total	88															
	Total Operator Cycle Time																

No.	Non-Cyclical Work Element	Time		Freq.	Total									
	Total Operator Time													

Notes

Re-designed Assembly line Process

1. AGV's are used for transporting the material with pallets from one station to the other. After welding, the welded parts are placed in the pallets, then transported to the next station.
2. The bottleneck welding station has major modifications to incorporate load leveling and cycle time reduction, where we get an output every 24 seconds. Firstly, the welding station has two jigs, and two operators – one welder and one setter.
3. The setter will do the activities like unscrewing the jig, removing a welded part from jig, picking up the RM, and placing and screwing the part into the jig. We are using two jigs for the operators to work at tandem. As the setter does the pick and place activities, the welder starts the welding. As the welder welds, the setter waits for the component to cool in the other jig and completes the setting activity in the same and the cycle continues.
4. In this way, with minimal investment in introducing an additional jig, we are reducing the cycle time at welding. Also, in addition to this, we are incorporating pneumatic actuation in the jigs, where the screwing and un-screwing take place at a relatively lesser time, at the click of a button. Thus, reducing the time for the setter in the removal process.
5. AGVs are chosen instead of conveyors, again on the cost perspective. With the takt time being 27 seconds, the cell is re-engineered where all activities fall within the limit, as well as maintaining operator efficiency.
6. Operator 1 does the work of fetching the RM/ bushing container and the assembly process. Since, the RM is fetched only once in 30 cycles and bushing container is fetched, once in 200 cycles, we had levelled the requirement based on the output and batch size, so that RM & bushing which are both at one location can be fetched at the same time by the operator 1 for every 50 cycles. By this way, operator 1 is programmed for fetching RM/ bushing every 50 cycles while he is in the process of assembling the parts.

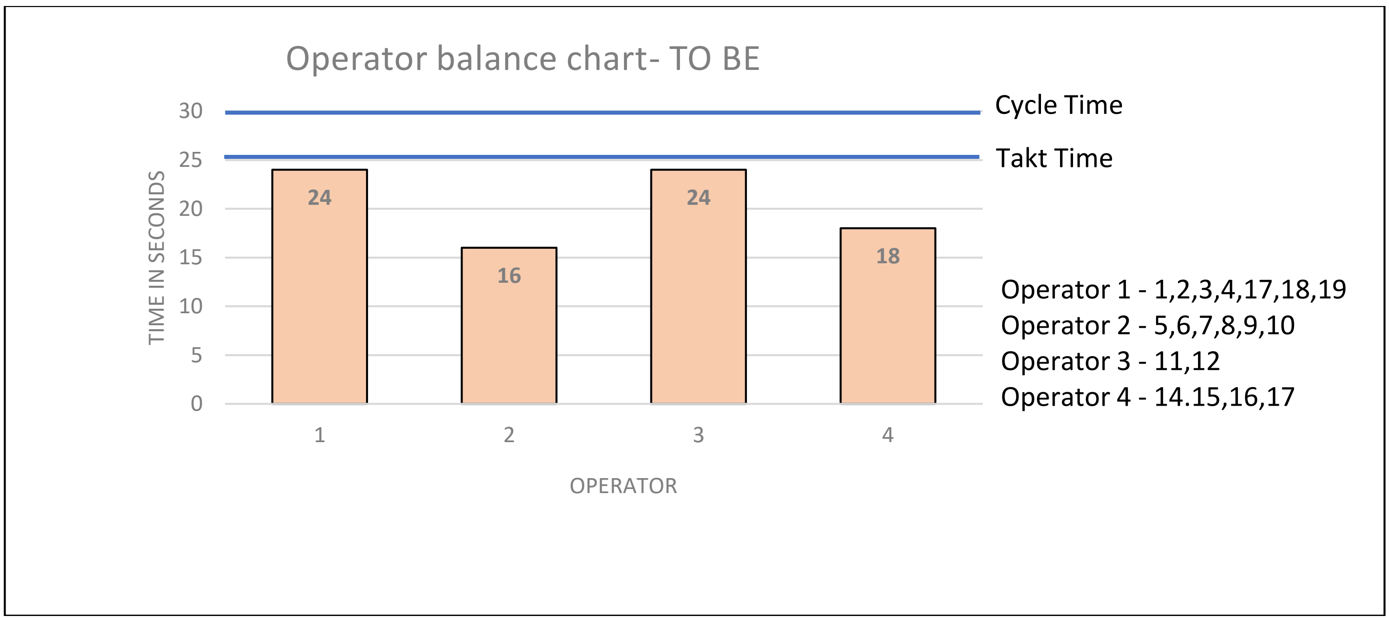
Assumptions

1. The industry we are considering is a tier 2 component manufacturer operating over a thin margin, expecting to grow by leveraging economies of scale. Thus, any capital investment is carefully considered before proceeding.
2. The welded parts are critical to be cooled within the jig in secured clamping's, to avoid any dimensional change due to welding heat dissipation.
3. The AGV's are moved, once the calculated batch size is attained.

Kaizen Events to realize Improvements.

1. Colour coding for the RM,FG & WIP pallets for identification and visual control in the production system.
2. In view of production numbers, 5-axis robo welding can be installed for seamless production consisting of 12 jigs in a single production cell.
3. Use of proper antispatter sprays and guided spray transfer weld machines to further reduce the number of components entering into the de-burring operation.
4. Self – certification of parts through robust process introduction and removal of inspection after the deburr process.
5. The RM is fetched through required cycles through the introduction of Kanban withdrawal cards.
6. Automated loading and un-loading of the pallets in AGV's to reduce the unnecessary movements within the cell.

OPERATOR BALANCE CHART (OBC)



CELL DESIGN CHECKLIST

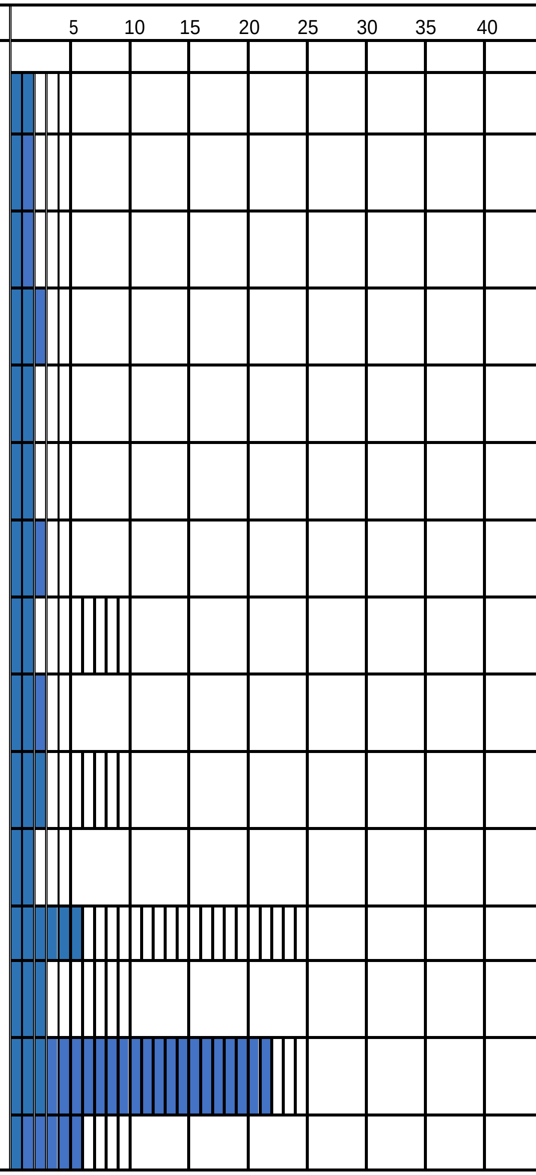
No.	CELL DESIGN CHECKLIST	Status		Remark
		Yes	No	
1	The machinery is arranged on the floor layout in the proper order of action.	X		
2	The unit output (cell) should have level, equitable activities, and follow the established SOPs.	X		
3	The manufacturing line should be generally shaped like a "U"	X		
4	Batch-wise manufacturing ought to be disregarded.	X		
5	Unit manufacturing is strongly advised.	X		
6	Every process relating to quality must be observed.	X		
7	Takt duration ought to be shorter than cycle time.	X		
8	Each assistant is capable of performing several tasks at once.	X		
9	The paths of all the workers should not cross.	X		
10	Based on the following waste that we have established, we have divided labor into profitable and unproductive categories.	X		
11	Charts should be used to plainly visualize all standard tasks.	X		

Question 4: (Operation/Process) - Fabrication of Metallic hood

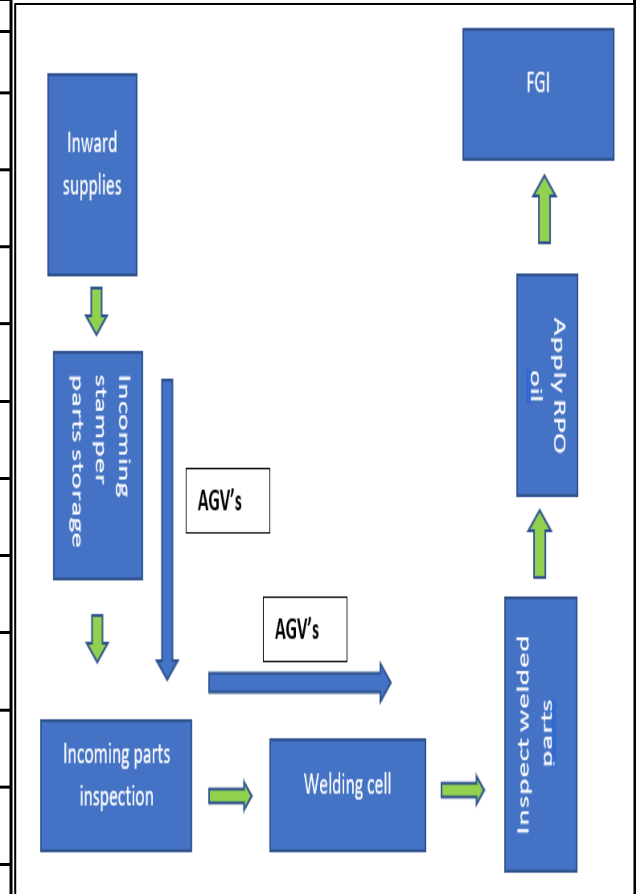
a. WORK STANDARD:

Manual Work
Machine Time
Walking

Ref. Symbol	Cyclical Work Element	Element Time (Sec.) Manual	Machine	Walking
1.	Fetch stamped parts from RM storage	2		
2.	Inspect incoming components (once in every 30 cycles)	2		
3.	Place in AGV's as a batch		2	
4.	Transport to welding area		3	
5.	Place in WIP's	2		
6.	Automated pick up of stamped part		2	
7.	place in robo fixture		3	
8.	automated pick up of stiffeners		2	
9.	place in robo fixture		3	
10.	Walk to the robo cell			3
11.	Switch on the pneumatic actuation	2		
12.	Pneumatic actuation		6	
13.	Start the welding process	3		
14.	Welding cycle		22	
15.	Unload the pneumatic actuation		6	



LAYOUT SKETCH & WALK PATH



16.	Auto pickup of welded component		3		
17.	place in designated pallet		4		
18.	Transport to final inspection area		3		
19.	Perform final Inspection		3		
20.	place in pallet	3			
21.	Transport to RPO area	3			
22.	Apply RPO oil	4			
23.	place in pallet	2			
24.	move the pallet once filled to FGI area	6			
25.	Pickup component	2			
26.	Perform Inspection	8			
27.	place component on AGV	4			
28.	Transport to outbound area		3		
	Sub-Total		111		
	Total Operator Cycle Time				

No.	Non-Cyclical Work Element	Time		Freq.	Total
	Total Operator Time				

Notes

Demand = 800 assembled products per day
Available Time = 8hrs - 30 min - 2*20 min break
Available Time = 480 min - 30 min - 40 min break
Available Time = 410 min

$$Takt\ Time = \frac{Available\ Time}{Demand}$$

$$Takt\ Time = \frac{410}{800}$$

$$Takt\ Time = 0.5125\ mins\ per\ part$$

$$\boldsymbol{Takt\ Time = 31\ secs\ per\ part}$$

B. LEADER STANDARD WORK (LSW) SPECIFICATION:

S.no	Frequency	Activities	Status
1	Daily	Inspect the RM storage area for all safety standards	☑
2	Daily	All forklifters/ AGV's/ handling equipments are functioning	☑
3	Daily	All SOP's are followed for power plant and oven for safety standards	☑
4	Daily	Engage all workers and improve morale o daily basis	☑
5	Daily	Plan the current-day production and discuss any anticipated impediments	☑
6	Daily	Ensure all operators are present and plan contingency for any absence	☑
7	Daily	Ensure all indirect materials are available to ensure seamless production	☑
8	Weekly	Plan for indirect materials and inward the necessary weekly stocks	☑
9	Weekly	Inspect for proper functioning of all machines	☑
10	Weekly	Inspect the welding machine functionality and filling of weld gases like Co2 & Ar	☑
11	Bi -Weekly	Calibrate the robo welding machine and its reach	☑
12	Bi -Weekly	Check the power source for any erratic voltages and correct in welding machine	☑
13	Bi -Weekly	Inspect whether the TPM activities related to machine are performed periodically	☑
14	Monthly	Implement kaizen activities and look for constant improvements	☑
15	Monthly	Replacing of welding nozzle on monthly basis	☑
16	Monthly	Cleaning of machine and proper maintainence as per SOP	☑
17	Monthly	Calibration of robo machine for human machine interface	☑
18	Monthly	Inventory check list and stock taking	☑
19	Monthly	Aggregate planning for all the BOM components	☑