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Productivity Improvement in Manufacturing Industry Using Lean tools

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Abstract - Assembly line balancing along with the associated operation analysis assists in constructing an assembly line. Which is the key step in improving the overall performance of an assembly line.Thus paper reveals to improve the line efficiency and productivity of component. When data were observed in production line which were needed to focus. Eliminating the bottleneck on this workstation the solution was to increase line efficiency. Minimization of transportation cost of handling material line as well as number of workers reduction. The concept describe in line balancing to overcome the bottleneck the result obtained were satisfactory. The actual performance and after improving performance measured and observed that productivity improved with considerable reduction in transportation time, manpower reduction and space saving at line

Key Words*: *Productivity, Line balancing, Eliminating wastage, Travel chart, multiple activity chart, TIMWOOD.

1. INTRODUCTION

The concept productivity is used to determine efficiency and effectiveness of processes conducted in an economy business. To increase productivity the systemic plant layout is good and an advantageous arrangement of operating workstation, storage space, material handling equipment and other services to facilitate the design the product. The plant can be design by using line balancing, due to line balancing concept the transportation time reduces and also gives the one piece flow process, reduces the idle time of man and machines.

To design and assess the performance, bottleneck identification, reduction in bottleneck cycle time, minimizing line imbalance, workstation organization, reduction in man power and space saving. Increasing man power and space utilization of industrial production assembly line is discussed. We use systematic layout planning approach to improve existing layout of company. The detail study of plant layout such as time study operation process chart, flow of material and activity relationship chart has be examine.

2. Methodology

For increasing production, productivity improvement techniques have been chosen are as follows.

2.1. Cycle time

First of all to know the status of production capacity of each and every workstation, detailed cycle time study at each workstation can be taken. The 15 Repetitive cycles was taken for three different shifts, and from this average time is taken for improving productivity. Then activity cycle time are classified in value added and non-value added time activity. Non-value added activities are reduced to improve the throughput time.

2.2. Lean manufacturing

For all the workstation time study is carried out, 7 waste tools "TIMWOOD" are visualized at every workstation. Also line efficiency calculated for current state which is 35.20 % which is shown in table no.2.

2.3. Flow Process

For the current state of assembly line the material flow can be identified by using multiple activity and travel activity chart.

3. Observation

Table no.1 shows the cycle time of product which sorted in value added and non-value added time before improvement.

Table -1: Cycle time before improvement

Sr.No.	Cycle time before	VD(sec)	NVD(SEC)
1	55.82	54.65	1.16
2	86.95	85.82	1.12
3	89.95	88.08	1
4	127.55	126.42	1.12
5	123.59	122.42	1.16
6	3.82	2.82	1
7	32.28	31.28	
8	0	0	1
9	21.31	20.31	1
10	71.46	70.41	1.04
11	13.18	12.09	1.08
12	197.24	150.07	47.16
13	80.15	30.23	49.91
14	193.06	143.22	49.83
15	45.29	44.16	1.12
16	27.17	26.17	1
17	26.78	25.73	1.04
18	95	94	1
19	27.48	26.43	1.04
TOTAL	1319.21	1154.37	163.83

The initial state of connecting rod assembly line having 19 workstations and 20 number of operators are shown in table no .2

Table -2: Initial state of line

Number of workstation	19
Throughput time	1319.21 sec
Maximum cycle time	197.24 sec
Takt time	96 sec
Number of operator	20
Line efficiency	35.20 %
Space required	135 ft

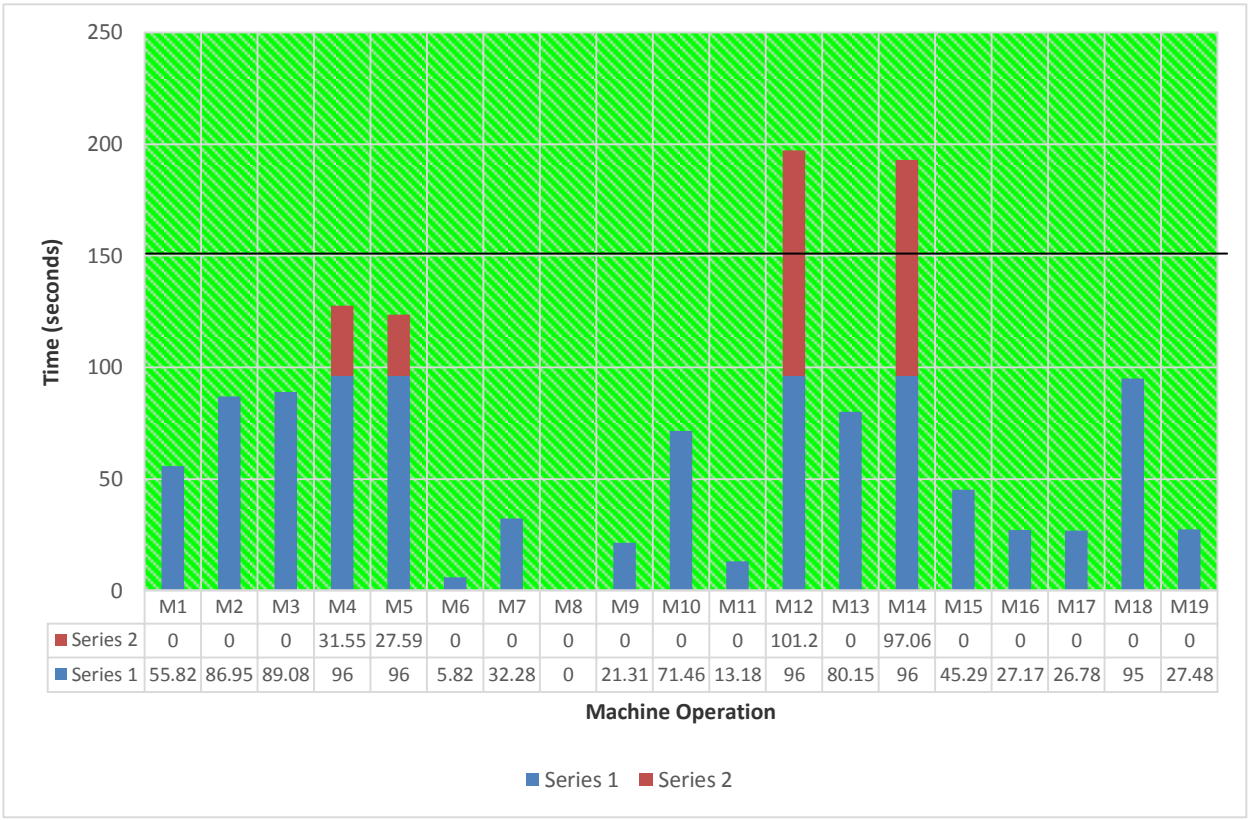
4. Bottleneck Identification

4.1. Side and profile milling and number marking

By using the fifteen repetitive cycle time study measurement can be taken. The takt time was 96 seconds for required production demand as shown in graph no. 1 and machine number 4 has total cycle time is 127.55sec, Out of which cycle time 31.55sec is above takt time and this is above bottleneck operation which is essential to reduce for improve productivity.

4.2. Bolt hole drilling

As shown in graph no 1 machine number 5 has the total cycle time 123.59sec. Out of which cycle time 27.59sec is above takt time and this is above bottleneck operation which is essential to reduce for improve productivity.



Graph-1: Machine operation vs. Cycle time

4.3. Small End and Big End bore and side milling on both side

As shown in graph no. 1 machine number 12 has total cycle time is 197.24sec. Out of which cycle time 101.24sec is above takt time and this is above bottleneck operation which is essential to reduce for improve productivity.

4.4. Big End chamfer

As shown in graph no. 1 machine number 14 has total cycle time 193.06sec. Out of which cycle time 97.06sec is above takt time and this is above bottleneck operation which is essential to reduce for improve productivity.

5. Travel activity chart before

A travel chart is a tabular record for presenting quantitative data i.e. movement and distance. About the movements of material, workers, material handling devices between number of places over a stipulated period of time.

All departments or workstation are listed in row and column with same sequence. Each intersecting box presents the data for the movements of the object from one location to other.

6. Multiple activity charts

Multiple activity charts are the process charts using a time scale. It usually comes in picture when work study man wants to record the activities of one subject with respect to other on a single chart. Subject may be the worker, machine or equipment. Multiple activity charts are a very useful tool for understanding the flow of work in a cyclical process and as a result understanding which resource is controlling the overall progress of the work.

From

TO / M/c No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1																			
2			#																
3	#																		
4																			
5																			
6																#			
7																			#
8						#													
9								#											
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11										#									
12											#								
13												#			#				
14																			
15													#				#		
16																			
17							#												
18				#															
19																		#	

Chart-1: From –To chart

FLOW PROCESS CHART										
CHART NO.1	SHEET NO.1 OF 1			SUMMARY						
SUBJECT CHARTED:				ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation				OPERATION	9					
				TRANSPORT	2					
ACTIVITY:				DELAY						
machine operation				INSPECTION						
				STORAGE	1					
METHOD:-Present				DISTANCE (ft.)	14.5					
LOCATION: Shop Floor				TIME (sec)	127.6					
OPERATIVE(S):				COST						
				LABOUR	1					
CHARTED BY:	DATE:			MATERIAL						
APPROVED BY:	DATE:			TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS	
				O	→	D	□	▼		
Machine No:4(side &profile milling and number marking)										
Taking job from machine no 3		14.5	4(4)						1 labour	
Open the door			1						1 labour	
Clean the fixture			3						1 labour	
Fix the job on fixture			2						1 labour	
Close the door			1						1 labour	
Load the programe			110.55						1 labour	
Open the door			1						1 labour	
Remove the job from fixture			2						1 labour	
Put on table			1						1 labour	
Load the next job									1 labour	
Check the quality of first job			5						1 labour	

Chart -2: Machine No 4

FLOW PROCESS CHART										
CHART NO.2	SHEET NO. OF 2			SUMMARY						
SUBJECT CHARTED:				ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation				OPERATION	9					
				TRANSPORT	2					
ACTIVITY:				DELAY						
machine operation				INSPECTION						
				STORAGE	1					
METHOD:-Present				DISTANCE (ft.)	4.5					
LOCATION: Shop Floor				TIME (sec)	123.59					
OPERATIVE(S):				COST						
				LABOUR	1					
CHARTED BY:	DATE:			MATERIAL						
APPROVED BY:	DATE:			TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS	
				O	→	D	□	▼		
Machine No:5 (Bolt Hole Drilling)										
Taking job from M/C no 4		4.5	4(4)						1 labour	
Open the door			2						1 labour	
Clean the fixture			4						1 labour	
Fix the job on fixture			2						1 labour	
Close the door			1						1 labour	
Load the programe			103.59						1 labour	
Open the door			1						1 labour	
Remove the job from fixture			2						1 labour	
Put on table			1						1 labour	
Load the next job									1 labour	
Check the quality of first job			6						1 labour	

Chart -3: Machine No 5

FLOW PROCESS CHART									
CHART NO.3	SHEET NO.1	OF 3	SUMMARY						
SUBJECT CHARTED:			ACTIVITY	PRESENT	PROPOSED	SAVINGS			
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
			DISTANCE (ft.)	6					
LOCATION: Shop Floor			TIME (sec)	197.24					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:12 (SE & BE bore and side milling)									
Taking job from M/C no 11		6	47(1)						1 labour
Open the door			1						1 labour
Clean the fixture			2						1 labour
Fix the job on fixture			2						1 labour
Close the door			1						1 labour
Load the programe			135.24						1 labour
Open the door			1						1 labour
Remove the job from fixture			2						1 labour
Put on table			2						1 labour
Load the next job									1 labour
Check the quality of first job			4						1 labour

Chart -4: Machine No 12

FLOW PROCESS CHART									
CHART NO.4	SHEET NO.1	OF 4	SUMMARY						
SUBJECT CHARTED:			ACTIVITY	PRESENT	PROPOSED	SAVINGS			
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
METHOD:-Present			DISTANCE (ft.)	5.5					
LOCATION: Shop Floor			TIME (sec)	198.66					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:14 (Big end chamfer)									
Taking job from M/C no 13		5.5	50(1)						1 labour
Open the door			1						1 labour
Clean the fixture			2						1 labour
Fix the job on fixture			2						1 labour
Close the door			1						1 labour
Load the programe			129.06						1 labour
Open the door			1						1 labour
Remove the job from fixture			2						1 labour
Put on table			1						1 labour
Load the next job									1 labour
Check the quality of first job			4						1 labour

Chart -5: Machine No 14

7. TIMWOOD

To avoid the unnecessary non-value added time 7 waste tool were used

- **T**-Transportation,
- **I**-Inventory,
- **M**-motion,
- **W**-Waiting,
- **O**-Overproduction,
- **O**-Over processing,
- **D**-Defect

Out of which transportation waste indicated non-value added time, according to chart (chart no. 2, 3, 4, 5.).

7.1. Systematic layout planning

The systematic layout planning is concept used to arrange a workplace in plant by locating workstations in a proper way to make one piece flow production. This helps to reduces transportation waste, man power (by 1) and increases production rates. The material handling and plant layout cannot be treated separately. They are inter-related to each other. Fig 1 shows the inter-relation between material handling and plant layout. The product to be manufactured determines the sequence of operations required. Depending upon the quantity of machine, equipment and production quantity required can be estimated which can determines the flow of material. This enables to work out the space required and arrangement of machine and equipment i.e. plant layout.

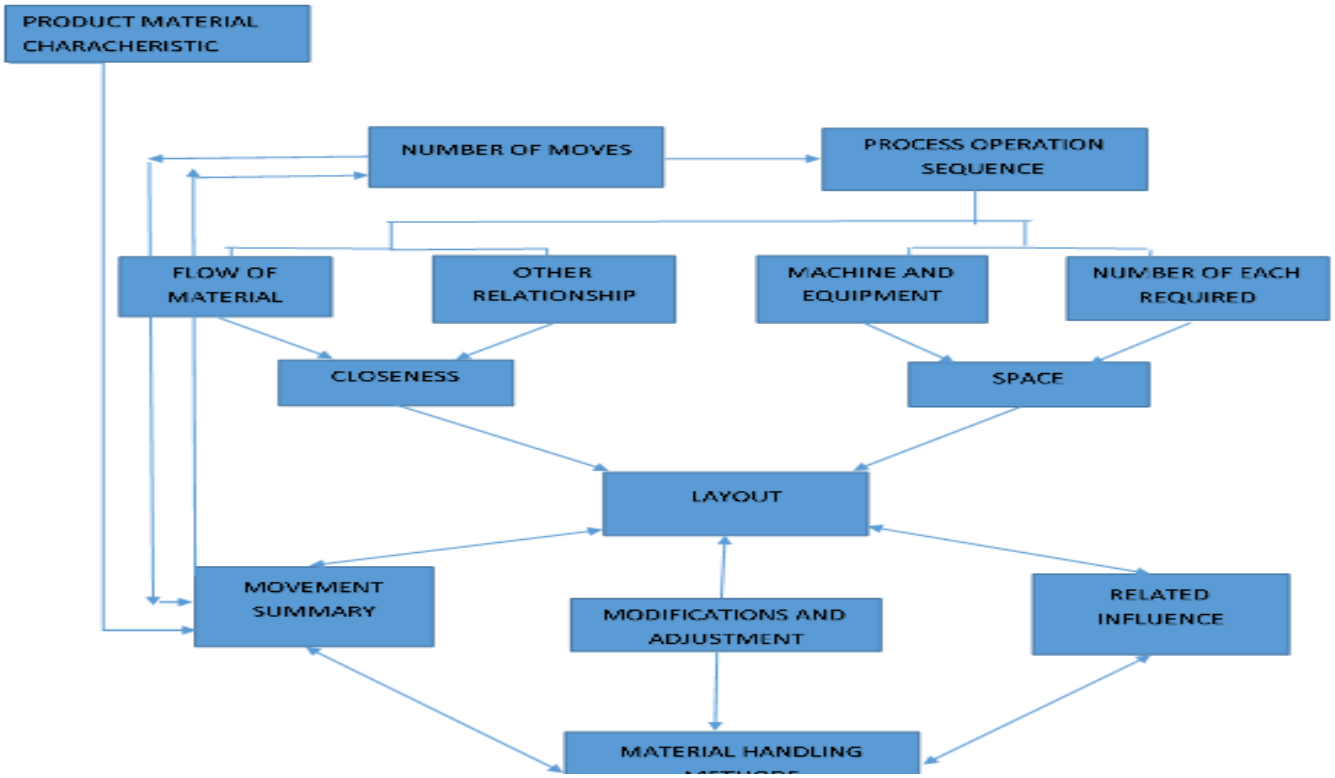


Fig -1: Relationship between plant layout and material handling

7.2. Man Machine Chart

By clubbing workstation no.14 (Big end chamfer) which required 143.2268 sec and workstation no.15 (big end chamfer on both side) which required 44.1654 sec. After clubbing of workstation the man power reduced by 1. Clubbing of workstation does not affect the cycle time and product quality.

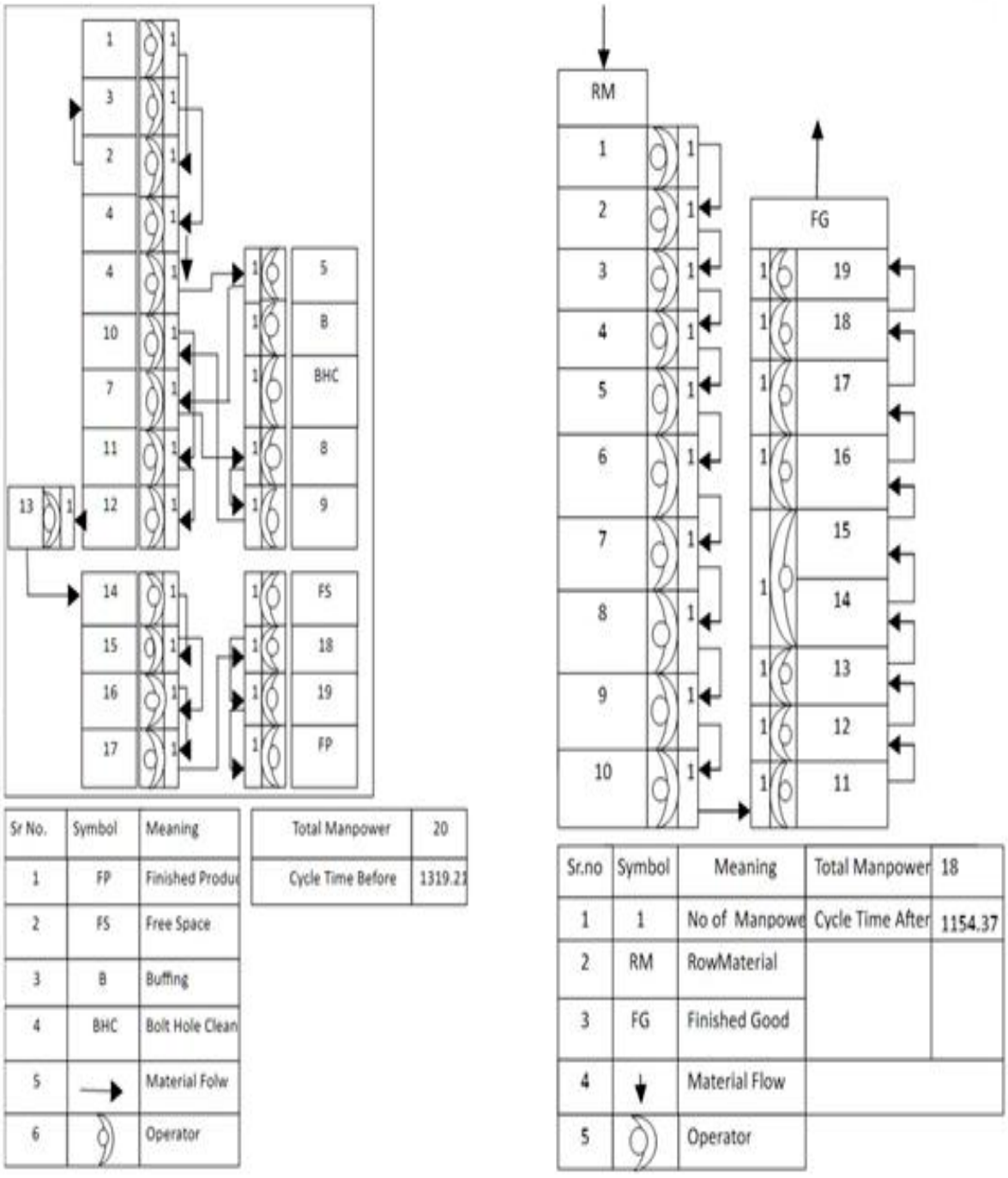
Symbol	
Idle	Working

Activity	Time in sec	Operator	M/C 14	M/C 15
Load on M/C 14	4			
M/C 14	137.22			
Unload	2			
Load on M/C 15	3			
M/C 15	49.165			
Unload	2			

Chart -6: Man machine chart

7.2. Space Saving

The current state of assembly line required more floor space (189ft). By using U-Shape layout balance efficiency increases and save floor space.



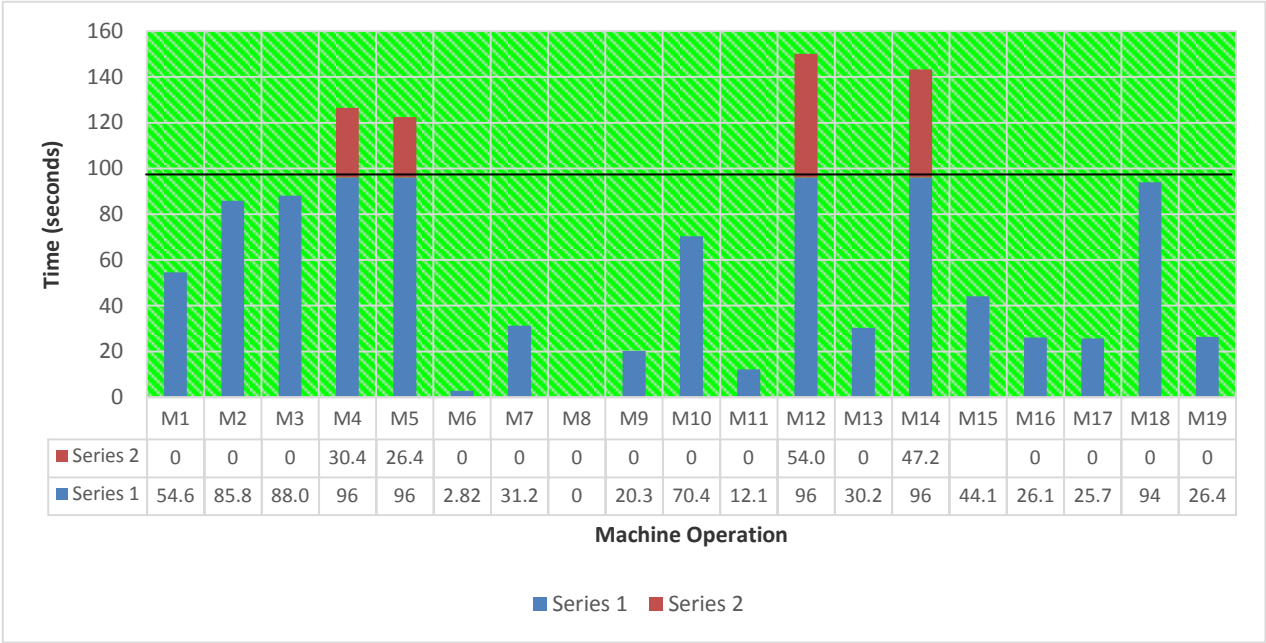
Before After

Fig -2: Plant layout

8. Result

8.1. Bottleneck operation after improvement

After improvement in plant layout, the cycle time reduced by elimination of non value added and improving material handling processes. For 19 number of workstation, the tabulated data is shown in graph no. 2.



Graph-2: Machine operation vs. Cycle time

Table -3: State of line after

Number of workstation	19
Throughput time	1154.3778sec
Maximum cycle time	150.0735sec
Takt time	96 sec
Number of operator	18
Line efficiency	40.5127 %
Space required	124 ft

8.2. Travel activity chart (After Improvement)

Travel chart shows quantitative data on material flow by recording movement between two machines. The Chart 1 shows movement between two machines in zigzag way, but after U-shape line balancing Chart 7 shows movement between two machines in straight way. After U-shape line balancing the one piece flow production is obtained and one piece flow helps to reduce non-value added time, lead time and increases the production with minimum waste. Travel chart are useful to determine degree of closeness necessary between two machines.

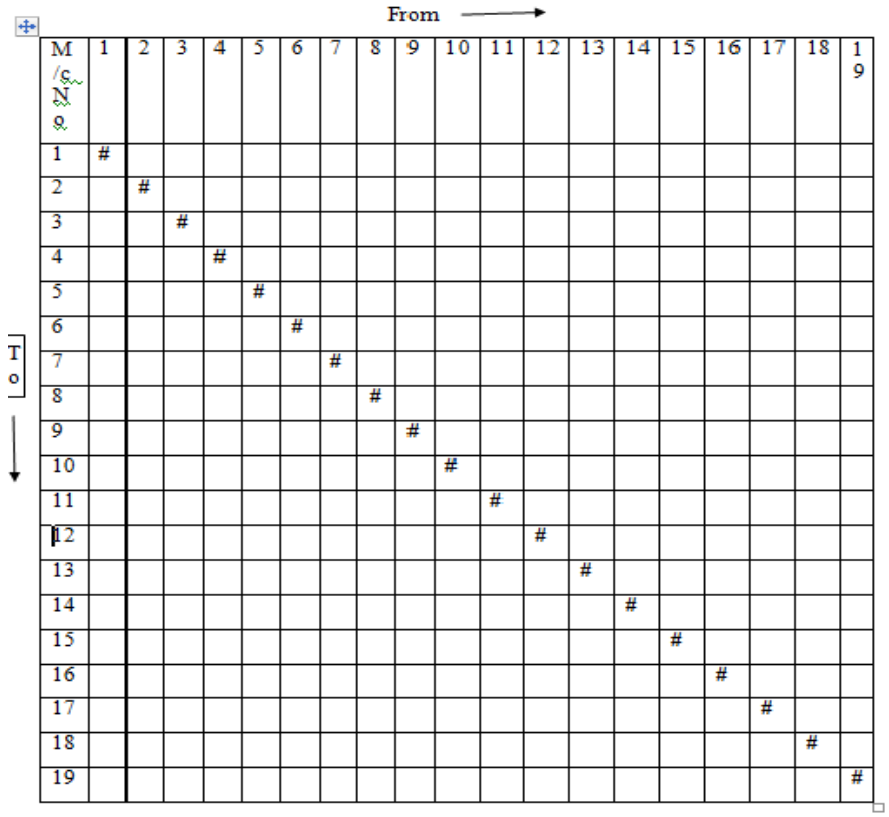


Chart -7: Travel activity chart

8.3. Multiple activity chart (After Improvement)

FLOW PROCESS CHART									
CHART NO.1	SHEET NO.1	OF 1	SUMMARY						
SUBJECT CHARTED:			ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
METHOD:-Present			DISTANCE (ft.)	7.5					
LOCATION: Shop Floor			TIME (sec)	124.18					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:4(side &profile milling and number marking)								.	
Taking job from machine no 3		7.5	0.7875(1)		.				1 labour
Open the door			1	.					1 labour
Clean the fixture			3	.					1 labour
Fix the job on fixture			2	.					1 labour
Close the door			1	.					1 labour
Load the programe			110.55	.					1 labour
Open the door			1	.					1 labour
Remove the job from fixture			2	.					1 labour
Put on table			1		.				1 labour
Load the next job				.					1 labour
Check the quality of first job			5	.					1 labour
Summery :for 1 job (before transportation time - after transportation time by layout)=save time									
1(1.125-0.7875)=0.3375=0.3375*4=1.35									

Chart -8: Machine No 4

FLOW PROCESS CHART									
CHART NO.2	SHEET NO.1 OF 2			SUMMARY					
SUBJECT CHARTED:			ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
METHOD:-Present			DISTANCE (ft.)	7.5					
LOCATION: Shop Floor			TIME (sec)	123.416					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:5 (Bolt Hole Drilling)									
Taking job from M/C no 4		7.5	0.81665(1)						1 labour
Open the door			2						1 labour
Clean the fixture			4						1 labour
Fix the job on fixture			2						1 labour
Close the door			1						1 labour
Load the programe			103.59						1 labour
Open the door			1						1 labour
Remove the job from fixture			2						1 labour
Put on table			1						1 labour
Load the next job									1 labour
Check the quality of first job			6						1 labour
Summery :for 1 job (before transportation time - after transportation time by layout)=save time									
1(1.1665-0.81665)=0.3498=0.3498*4=0.6999									

Chart -9: Machine No 5

FLOW PROCESS CHART									
CHART NO.3	SHEET NO.1 OF 3			SUMMARY					
SUBJECT CHARTED:			ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
			DISTANCE (ft.)	4.5					
LOCATION: Shop Floor			TIME (sec)	183.22					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:12 (SE & BE bore and side milling)									
Taking job from M/C no 11		4.5	33.0166(1)						1 labour
Open the door			1						1 labour
Clean the fixture			2						1 labour
Fix the job on fixture			2						1 labour
Close the door			1						1 labour
Load the programe			135.24						1 labour
Open the door			1						1 labour
Remove the job from fixture			2						1 labour
Put on table			2						1 labour
Load the next job									1 labour
Check the quality of first job			4						1 labour
Summery :for 1 job (before transportation time - after transportation time by layout)=save time									
1(47.1666-33.0166)=14.1499									

Chart -10: Machine No 12

FLOW PROCESS CHART									
CHART NO.4	SHEET NO.1 OF 4		SUMMARY						
SUBJECT CHARTED:			ACTIVITY	PRESENT		PROPOSED		SAVINGS	
Transportation			OPERATION	9					
			TRANSPORT	2					
ACTIVITY:			DELAY						
machine operation			INSPECTION						
			STORAGE	1					
METHOD:-Present			DISTANCE (ft.)	7.5					
LOCATION: Shop Floor			TIME (sec)	158.05					
OPERATIVE(S):			COST						
			LABOUR	1					
CHARTED BY:	DATE:		MATERIAL						
APPROVED BY:	DATE:		TOTAL						
DESCRIPTION	QUANTITY	DISTANCE (ft.)	TIME (sec)	SYMBOL					REMARKS
				O	→	D	□	▼	
Machine No:14 (Big end chamfer)									
Taking job from M/C no 13		7.5	14.95(1)						1 labour
Open the door			1						1 labour
Clean the fixture			2						1 labour
Fix the job on fixture			2						1 labour
Close the door			1						1 labour
Load the programe			129.06						1 labour
Open the door			1						1 labour
Remove the job from fixture			2						1 labour
Put on table			1						1 labour
Load the next job									1 labour
Check the quality of first job			4						1 labour
Summery :for 1 job (before transportation time - after transportation time by layout)=save time									
1(49.8333-34.8833)=14.95=14.95*2=29.8999									

Chart -11: Machine No 14

After improvement in plant layout and material handling due to closeness of workstation the non value added time reduced. It improves the production rate and line efficiency.

Table -4: After Improvement

Sr.No.	Improvement	Before	After	Saving	%Improvement
1	Maximum cycle time (sec)	197.24	150.0735	37.1665	23.9132
2	Total cycle time (sec)	1319.21	1154.3778	164.83	12.4947
3	No. of workstation	19	18	1	5.27
4	Space saving	189	176	13	6.87
5	Man power	20	18	2	10
6	Production rate /hrs	33	38	5	15.15

9. Conclusion

By using systematic layout planning to the assembly line of company we have get the following result

- Majorly reduces the material handling by reducing transportation due to closeness of machine.
- Improve the line efficiency from 35.20% to 40.517%
- The production rates increase to 38 per hour from per hour.
- We successfully completed the work to minimize the material handling times, labour cost and transportation cost for same workstation.

10. Future scope

- Increase line productivity by using all remaining 6 waste tool.
- Increase assets of company.
- Reduces the inventory cost and manpower by clubbing of more workstation.

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