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LEAD TIME REDUCTION AND LINE BALANCING OF CUTTING TORCH ASSEMBLY

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Abstract:

This Paper is about lead time reduction & line balancing by application of Lean Techniques to improve productivity in a cutting torch (Gas cutter) assembly. Lean tools and techniques are widely used in industry for identifying and eliminating Non Value added activity, there by effective utilization of resources and increase the productivity. The detail process flow is analyzed by using spaghetti diagram and time study is conducted for individual processes. The detailed analysis of process flow and layout is conducted and proposed an alternate layout. The new proposed layout is for effective work flow and meeting future production requirement. Kanban storage is introduced for minimizing the material movement and reduce work in progress inventory. Line balancing is done by using rank position method for optimum allocation the resource according to the takt time. The result is validated by using arena software.

Key Words: Lean Techniques, Spaghetti Diagram, Line Balancing, Kanban Storage, Time Study & Cellular Layout

1. Introduction:

Lean manufacturing is a Management technique from product development and procurement through manufacturing and delivery of goods for providing customers precisely what they want and when they want it while minimizing the resources, costs and materials to make that happen. The project is done at a reputed cutting equipment manufacturing industry. The Company has developed a new production line for cutting torch assembly. Currentlyit is not meeting the production target and line is not stabilized. The objective is to reduce the lead time of Cutting Torch Assembly by at least 12% and Increase the productivity by 25% by using Lean Techniques such as Cellular Layout, Kanban Storage, Line Balancing and validate the process using simulation software Arena.

2. Literature Review:

Lean manufacturing concept with a systematic approach to identify and eliminate waste through continuous and sustained improvements by manufacturing the product at the pull of the customer in pursuit of perfection. Lean Line Design is a method for implementing manufacturing industries principles like process orientation, perfect quality, standardization, flexibility, waste elimination, transparent process, associate involvement [1].

The fragility and the lack of flexibility are still the main problems of the lean production system. Elimination of buffers (JIT): The philosophy of lean interprets buffers as a sign of mismanagement. The main factors of the JIT concept, which weaken the system reliability, are concentration of only one main supplier. There is a high risk involved with this strategy.

Second factor is making thesystem unstable. Is the philosophy of minimal resources propagates that rework resources are not required; it is a challenging task, which needs a highly developed infrastructure. The analysis of the concept of lean shows that not only the problems within the implementation phase are potential causes for the failure of the lean system, but also the concept itself contains drawbacks, which is predominantly associated to a lack of reliability [2].

Lean manufacturing is a set of tools and methodologies that aims for increased productivity; cycle time reduction and continuous elimination of all waste in the production process. Lean manufacturing is a technique that allows work to be performed without bottlenecks or delays. Lean manufacturing is a culture in which all employees continuously look for ways to improve processes [3].

According to Womack Jones, and Roos, lean manufacturing uses less of everything compared to mass production, half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product [4].The efficiency of the production planning and control department is mainly influenced by unplanned occurrences, like machine failures or order changes. Based on these occurrences the continuous adaptation and optimization of the production processes and the assembly system is necessary. The overall approach of the research aims at the development of the Method for situation-based Modeling and Simulation of Assembly Systems, which is based on five pillars these are the Assembly System Base Model, the modeling Language, the modeling Procedure, the Resource Library and the Manufacturing Capability [5].Assembly is an important manufacturing process for cost effective product variety. Lean Manufacturing also called Lean Production.

Methodologies that aims for the continuous elimination of all waste in the production process. The mainbenefits of this are lower production costs; increased output and shorter production lead times [6].

Cellular Layout:

This type of layout helps in arranging common equipment in a modular/cellular format to provide flexibility and minimize process labor travelling distances [7].

Spaghetti Diagram:

Spaghetti diagram is a visual representation using a continuous flow line tracing the path of an activity through a process [8].

Takt Time:

Takt Time is the rate at which your customer buys a product. It is often called the heartbeat of production figures and tables [9]

Line Balancing:

Assembly line balancing is the problem of assigning various tasks to workstations, while optimizing one or more objective without violating any restrictions imposed on the line [10]

Algorithm used for Arena Simulation:

- List down the All Process & Collect the Data for all Processes.
- Arrange the Process in Descending Order.
- List the Number of Resources Available.
- Find out Total Lead Time.
- Find out Maximum time should be allocated to Individual Resources (Total Lead Time/No of Resources)
- Allocate Individual Process to Resources Based on Highest Time Taking Process First.
- Balance the Process according to the Operator Convenience.
- Input the Data into the Arena Software.
- Get output and validate the Process.
- Improve the Process and Follow the Steps Again. [11] [12]

Lean Cell Measurement:

In this measurement are few and their focus on the issue of lean manufacturing providing motivation toward the company lean goals. Information is gathered and used in the cell and is presented visually and units. [13]

Day by the hour Report:

- The Most Fundamental Measurement of Lean Performance is Day by the Hour Report.
- Lean cells are designed to achieve predetermined cycle time for Product to be manufactured. Cycle time of cell is determined by the takt time required by customer.
- The Day by the hour Report Track cells ability to achieve takt time and provide fast feedback when Problems arise.
- The Day by the hour Report information usually reported on a white board within the cell and shows the production quantities needed each hour to support customer takt time.
- At the end of the each hour one member from the cell team writes up the actual quantity achieved that hour and Cumulative quantity achieved that shift or that Day.

Methodology:

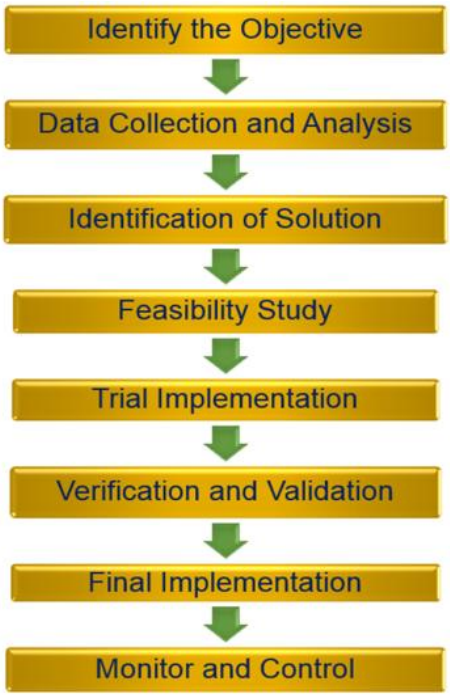

Figure 1: Methodology for project work

Methodology for the project work is mentioned in fig 1; the detail description is as follows

Identify the Objective:

Initial study has to be conducted and select the project

Data Collection and Analysis:

Make a data collection plan and collect the data according to the schedule. Stratify the data and analyze the data.

Identification of Solution:

Based on the data collection and analysis identify the key area where improvement is needed. Brainstorm and find out the all possible solution for the problem.

Feasibility Study:

Based on the identified solution feasibility study should be conducted and find out the possibility of implementation, action plan has to be created for difficulty in implementation of best possible solution or choose alternate solution.

Trial Implementation:

The Trail run has to be conducted and identify the practical difficulties for actual implementation.

Verification and Validation:

The verify & validate the solution by simulation using ARENA or Witness software

Final Implementation:

After trial implementation plan for final implementation and allocate the resource according to requirement.

Monitor and Control:

After final implementation monitor and control the process by using control chart, Day by hour Report, Overall Equipment Effectiveness etc.

3. Data Collection and Analysis:

Spaghetti Diagram:

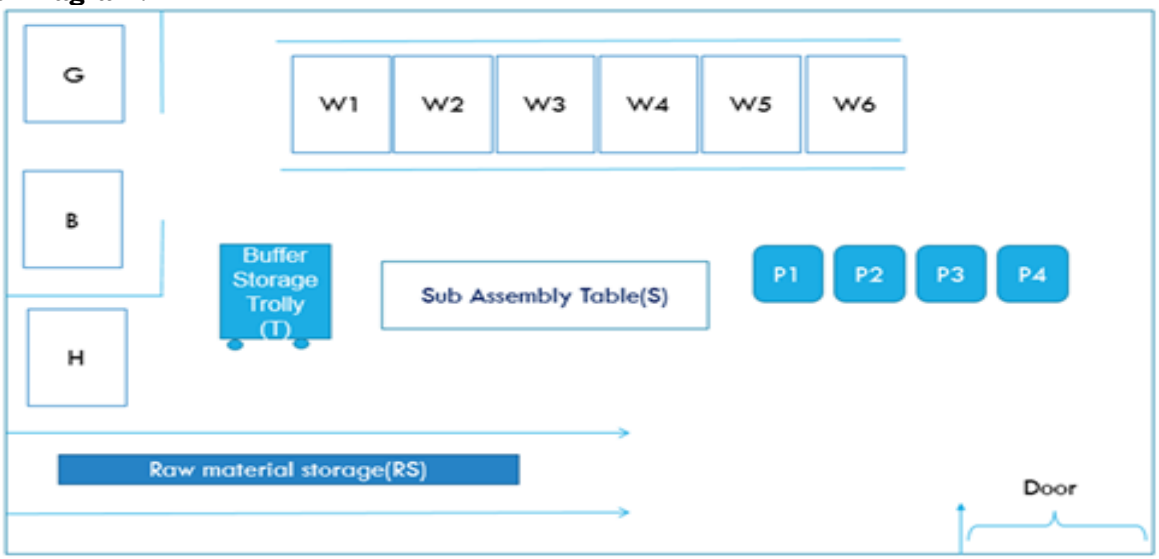

Figure 2: Schematic diagram of current layout

The schematic diagram of layout of torch assembly is as shown in figure 2. The total work area is 100.5 square meters. Thedetail description as explained below.

- G-Glass Beading
- B-Buffing
- H-Hot Water Cleaning
- W1-Brazing
- W2-Stage1 Assembly
- W3-Main Assembly
- W4-Leak Testing
- W4-Reaming, Flame Testing
- W5-Final Assembly, Packing
- RS-Raw Material Storage
- S-Sub Assembly, Cleaning
- T-Buffer Storage Trolly
- P1-Assembled Component (Pallet)
- P2-Ready for Flame Testing (Pallet)
- P3-Ready for Leak Testing (Pallet)
- P4-Ready for Despatch (Pallet)

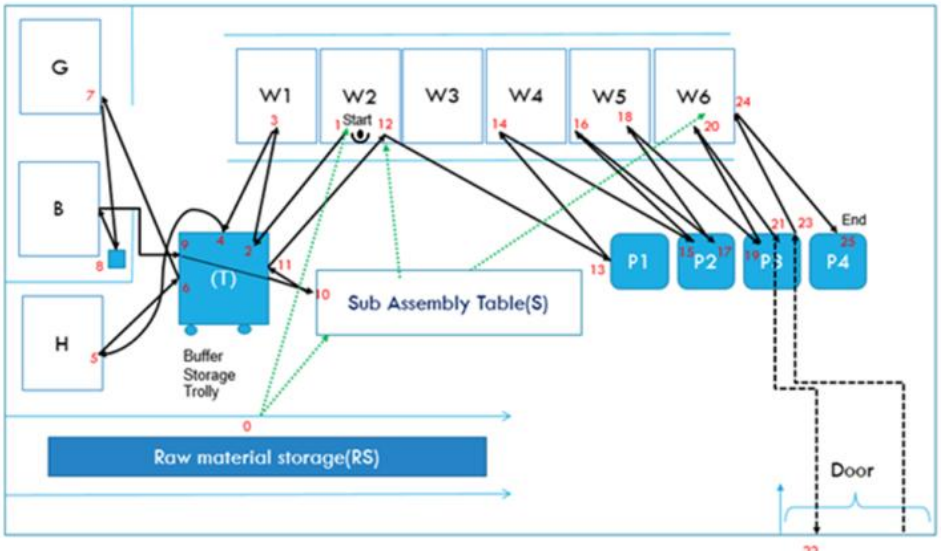

Figure 3: Process Flow of Torch Assembly

In figure 3 described about the spaghetti diagram of current production process. Material movement between the workstation is shown in the diagram.

Table 1a: Material movement between workstation in meters

Operation No		Activities	Distance (in Metre)
0	1	Raw Material Storage to Work Table 2	
1		Sub Assembly for Brazing	
1	2	W2 to Trolley	2.75
2	3	Trolley to W1	2
2		Brazing	
3	4	W1 to Trolley	2
4	5	Trolley to Hotwater Cleaning	2.2
5		Hot Water Cleaning	
5	6	Move to Trolley	2.25
6	7	Trolley to Glass Beading	3
		Glass Beading	
7	8	Move to Temperorary Storage	2.5
8		Buffing	
8	9	Move to Trolley	3.5
9	10	Trolley to Sub Assembly Table	2.5
10		Scratch sheet Cleaning	
10	11	Move to Trolley	2.5
11	12	Trolley to Main Assembly (W2) Table	3.75
11		Main Assembly	
11	12	Move to Pallet 1	3
12	13	Pallet 1 to Leak Testing (W4)	2
13		Leak Testing	
13	14	Move to Pallet 2	1.75
14	15	Pallet 2 to Reaming Station(W5)	2
15		Reaming	
15	16	Move to Pallet 3	2
16	17	Pallet 3 to Flame Testing(W4)	2
17		Flame Testing	
17	18	Flame Testing to Pallet 3	2
18	19	Pallet 3 to Final Assembly Table W5	2
19		Final Assembly	
19	20	Final Assembly to Pallet 4	2
20	21	Pallet 4 to Pin Marking Area	28
21		Pin Marking	
21	22	Pin Marking Area to Torch Assembly Area	28
22	23	Pallet 4 to W6 for Packaging	2
23		Packaging	
23	24	W6 To Pallet 4 fot Despatch	2

Table 1: Shows the total distance travelled between material movements between individual workstation. Total distance is summarized as 107.7 meters.

Time Study:

Time study has been conducted for all the process between 1st to 15th, January 2016. Stop watch is used for study and allowances given are Process allowances 5 %, Rest allowances 5% and contingency allowances 5 % [14]

Table 2: Time study Summary

Process	Time (Minutes)	
Brazing (Including Sub Assembly)	09:21	
Heat water Treatment	03:16	
Glass Beading	08:58	
Buffing	03:43	
Cleaning	03:36	
Sub Assembly	02:04	
Main Assembly	09:43	
Leak Testing	05:59	
Reaming	04:51	
Flame Testing	05:58	
Final Assembly	05:54	
Buffing Torch Head(Optional)	01:30	
Pin Marking	00:58	
Packaging	02:46	
Normal Time	58	Minutes
Standard Time	69	Minutes

The Time study is summarised in table.2. From Time study it us summarized the Normal time as58 minutes and standard time as 69 minutes.

Plan vs Actual Production:

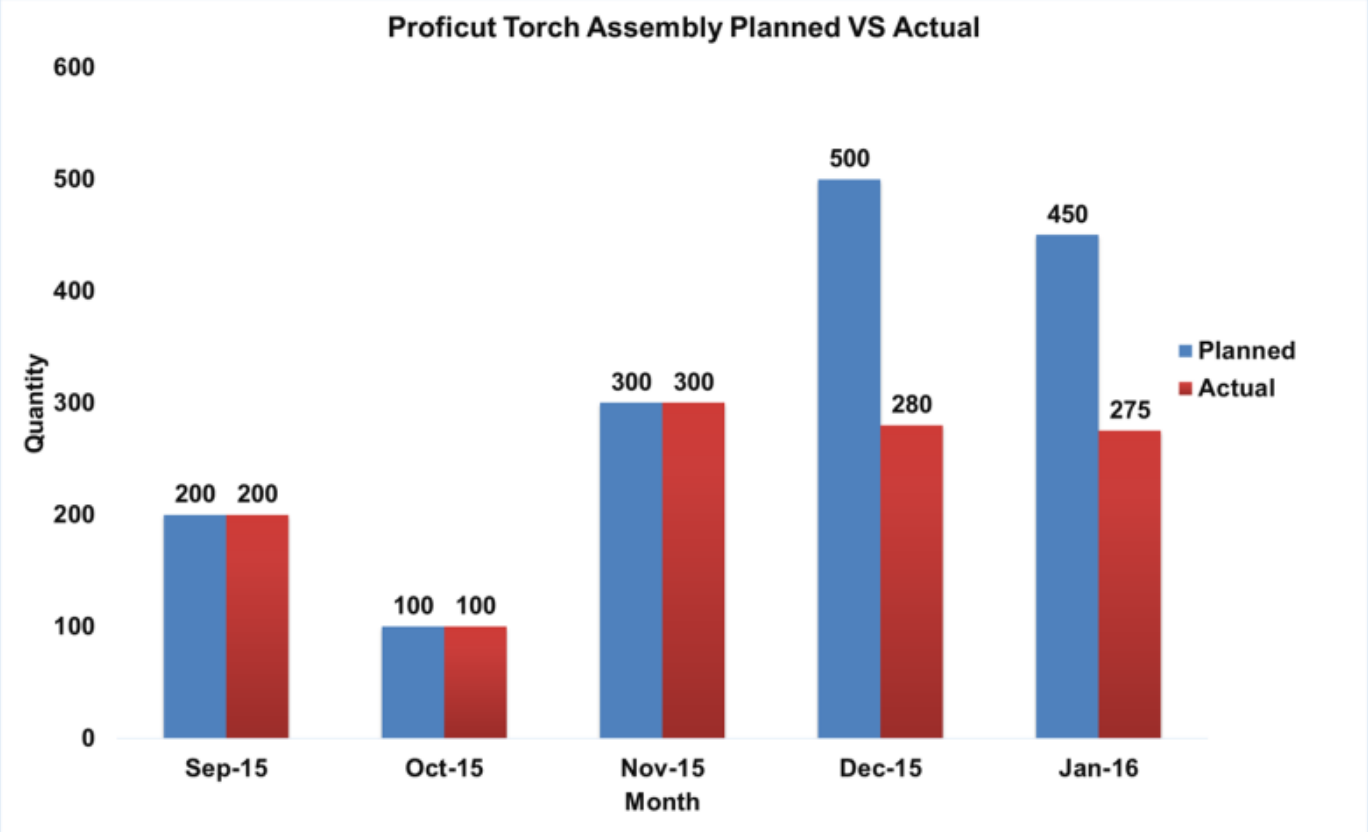

Figure 4: Plan vs Actual production of cutting torch assembly

The figure 4 shows plan versus Actual production of torch assembly.

Fishbone Diagram:

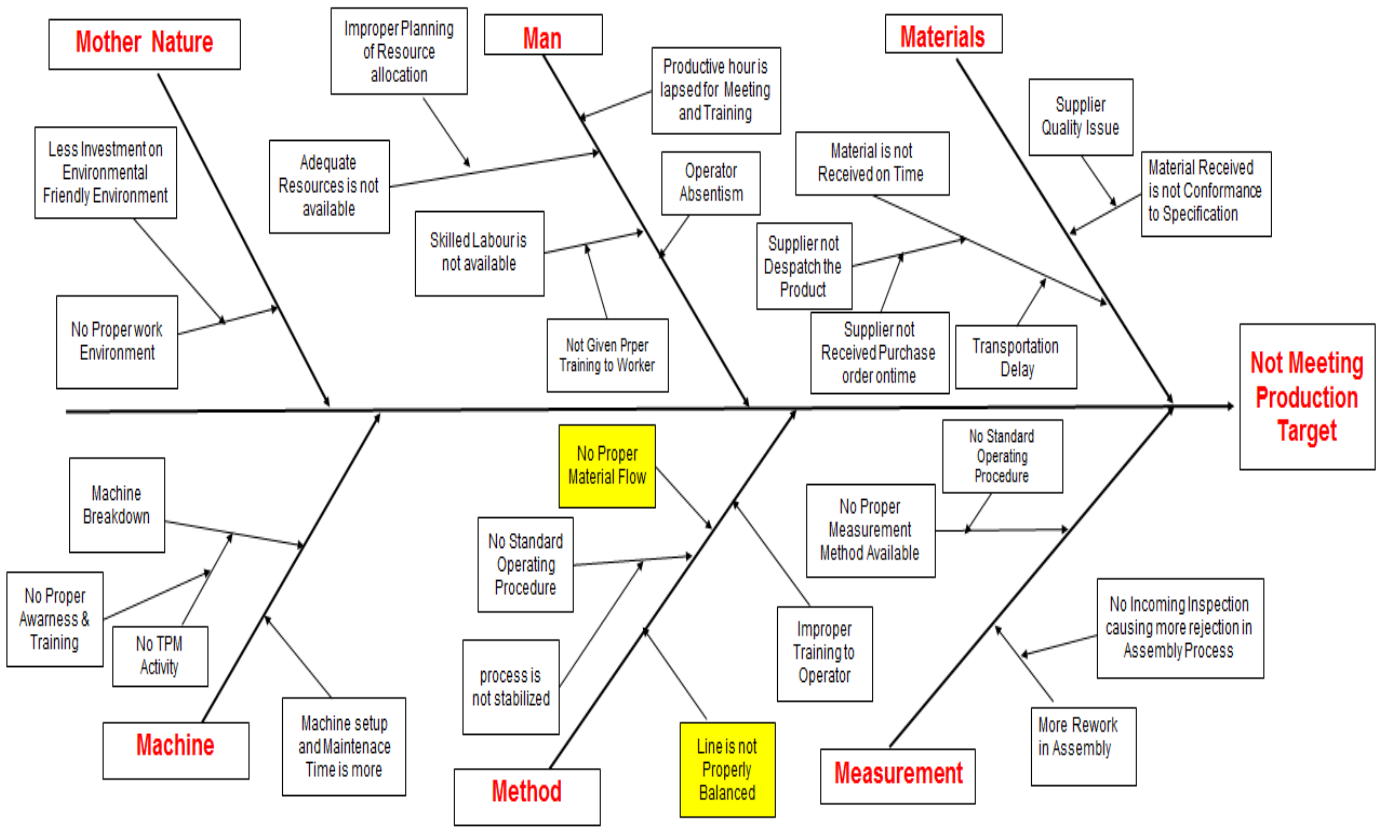

Figure 5: Fishbone Diagram for not meeting Production Target

The Fishbone diagram is drawn for initial analysis of 'not meeting production target' as. From fishbone diagram (Figure 5) major cause obtained for not meeting production target are 'No Proper Material flow ' and 'Line is not properly balanced'.

4. Identification of Solution and Validation:

Layout Optimization:

In the Current State Layout Total Material Movement is 107.6 metre for producing one Cutting Torch. Major Time is wasted due to additional movement of operator for Material Storage in a Trolley. This can be improved by introducing Kanban Storage (as shown in fig 6) which can be reduce additional movement.

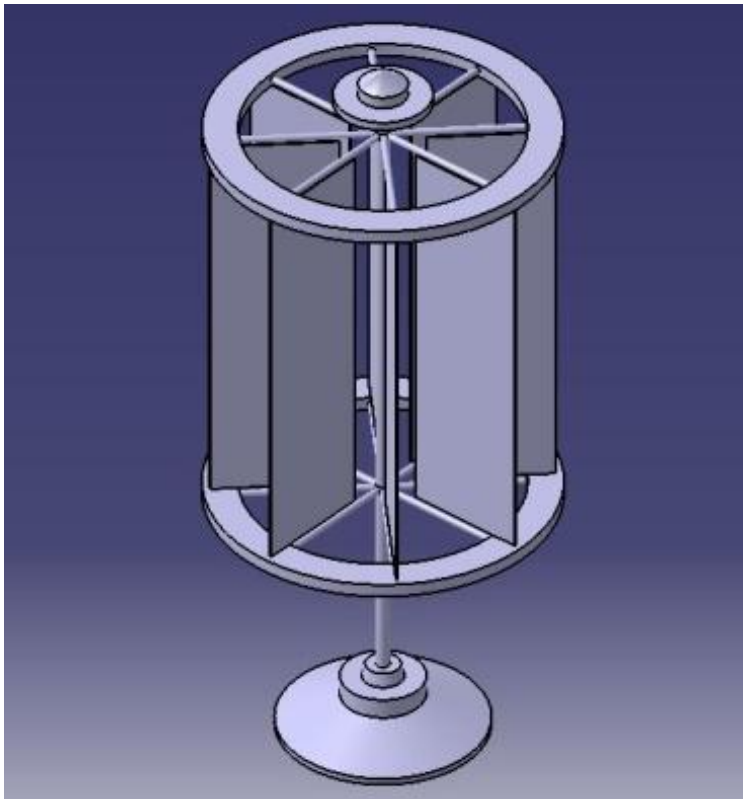

Figure 6: Kanban Storage for torch assembly

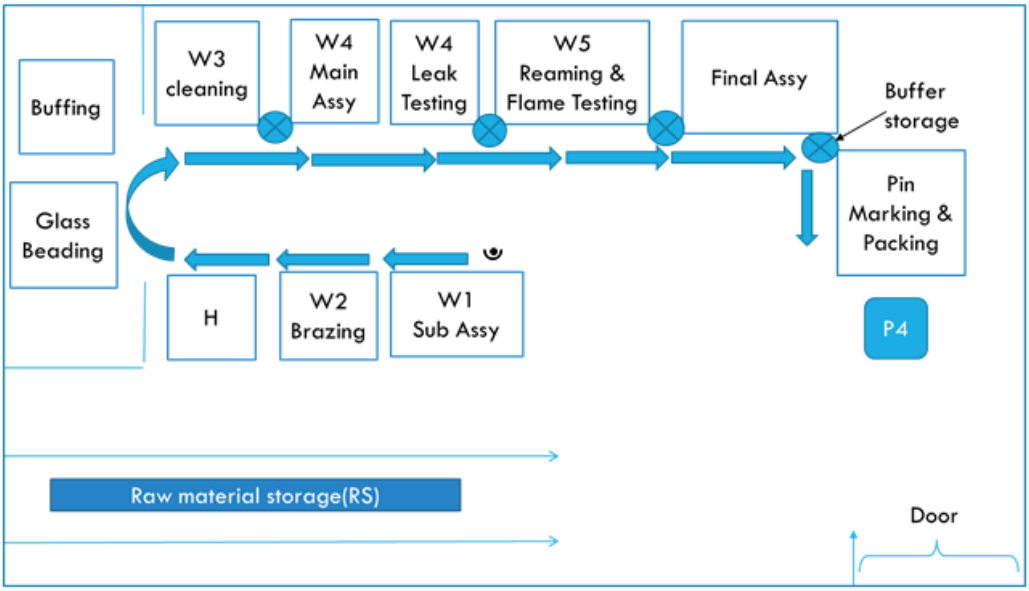

Figure 7: Schematic Diagram of proposed layout

The Schematic diagram of proposed layout is as shown in figure 7. The proposed layout will reduce the total distance travelled during the process flow. Advantages of Proposed Layout

- Reduction of Material movement from 107.7 meters to 17 meters (approx. 84 % Reduction).
- Work flow will be smoother and which lead to reduce the Lead Time Significantly.
- It is easier to allocate resources according to Takt Time.

Takt Time Calculation:

Daily Productive hours: 8 hrs
Total working Days: 25
Sample Calculation

$$\text{Takt Time} = \frac{\text{Total Working hour}}{\text{Number of Customer Order}}$$

For 800 Parts/Month

$$\text{Takt Time} = \frac{25*8*60}{800} = 15 \text{ minutes}$$

Takt Time is calculated for various quantities of torches from 500 to 200 are mentioned in detail at Table 3.

This will helps in resource allocation and identifying individual process which need to improve for meeting target as per the requirement.

Table 3: Takt time according to number of quantity to produced

Number of Parts to be Produced/ Month	Takt Time
500	24.00
600	20.00
700	17.14
800	15.00
1000	12.00
1250	9.60
1500	8.00
1750	6.86
2000	6.00

Cutting Torch assembly current capacity of production based on Time study Data:

- Number of Dedicated Resources in the Current Torch Assembly:3 Numbers
- Total Lead Time of current Product: 69 minutes
- Resource1 is doing Brazing and Main assembly
- Total Time Taken by Resource1: 18.64 minutes

Resource 2 & 3 work equally Distributed $= \frac{480}{25.18} = 25.18$ minutes/operators

Number of products can produce per day: $\frac{480}{25.18} = 19.06$

Total Products can be Produced/Month: 19.06*25= 476 Nos*

If assuming work is equally distributed to 3 Resources. Number of Products can be produced:

$$\frac{480}{25.18} * 23 = 521$$

Action Plan for Improvement:

Process	Improvement can be made	Proposed Time
Brazing (Including Sub Assembly		09:21
Heat water Treatment	Process can be elimintaed by directly placing the Product in the heater after brazing'	00:25
Glass Beading	Can be reduce the time by using Push type bush instead of current thread tightening	07:58
Buffing		03:04
Cleaning	To find the possibility of using thinner & also reduce the process of cleaning area which is not visible after final assembly	02:00
Sub Assembly		02:04
Main Assembly	Can be see the possibility of using torque wrench for tighthening	09:00
Leak Testing		05:59
Reaming	Already improvement process is going on by using driller	02:00
Flame Testing		05:58

Figure 8: Improvement Action Plan

Figure 8 is the action plan for improvementexpected Lead Time after Improvement approx. 60 Minutes

Recommendation for producing 1000 Products/Month:

Target /Month: 1000 Torches
Takt Time=12000/1000=12 minutes
Expecting a lead time reduction by 9 minutes by layout Process improvement
Number of resource required=60/12=5 Dedicated Operator
Allocation of work distribution to '5' resources in a Cutting Torch Assembly

Analysis & Recommendation for producing 2000 Products/Month:

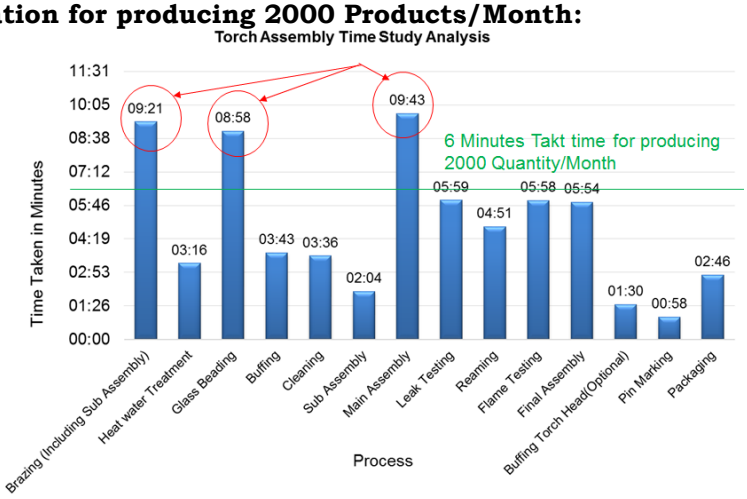

Figure 10: Bottleneck Analysis for producig 2000 torches/month

Bottleneck processes identified are (figure 10)

- Main Assembly.
- Brazing.
- Glass Beading.

Arena Simulation Output:

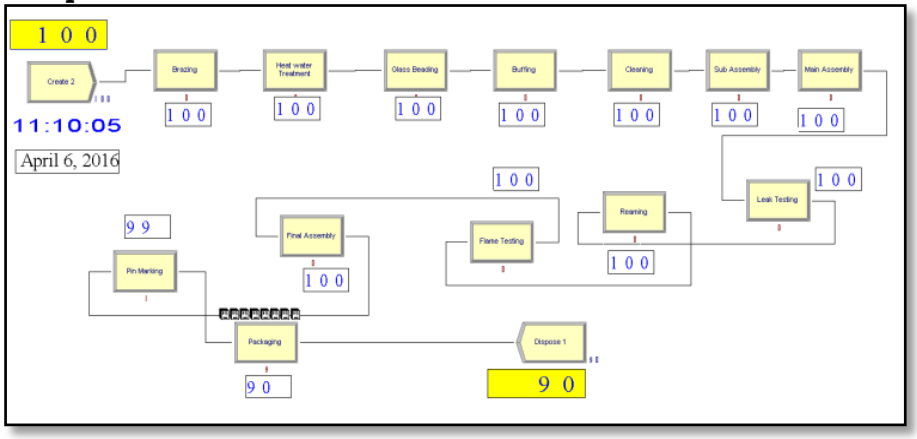

Figure 11: Simulation output for proposed layout for current setup for 1 week production.

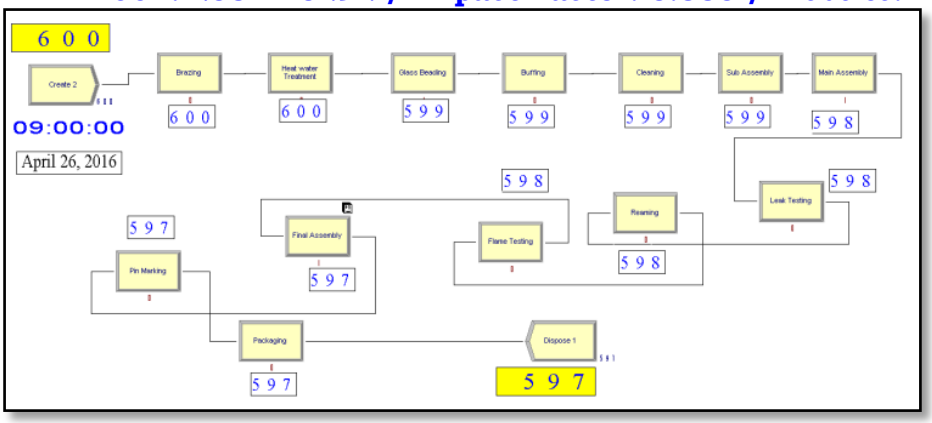

Figure 12: Simulation output for proposed layout by using 3 resources for 1 month product

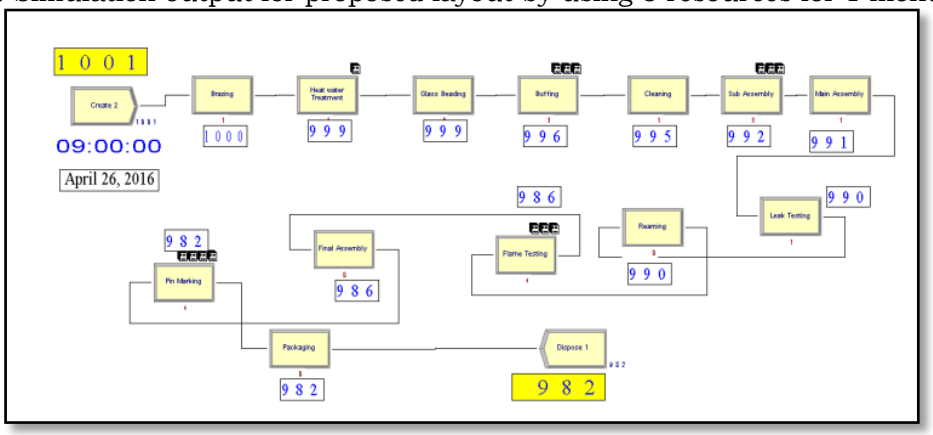

Figure 13: Simulation output for proposed layout by using 5 resources for 1 month production.

By using Arena [15] it is successfully validated (figure 11, figure 12 and figure 13) the proposed layout change and proposed resource allocation. Which is matching with the manually calculated data? Resource utilization also improved to above 95 % from 70 to 80% in current setup.

Results & Discussion:

Item	Current Status	With Layout change and Process Improvement	For Producing 1000 Quantity	For Producing 2000 Quantity
No of Dedicated Resources	3	3	5	7 to 8 Approx.
Capacity/ Month	480	600	1000	2000
Lead Time	69	60	60	42 to 48
Major Improvement Needed		Change of current Layout into Cellular Layout	Separate Resources for Brazing and Main Assembly	Bottleneck Process Brazing, Main Assembly and Glass Beading Should be reduces to 6 Minutes

Figure 14: Summary of Torch assembly

Figure 14 shows the detail summary of cutting torch assembly, it shows no of resource requirement as per the expected lead time to meet the required demand.

5. Conclusion:

The Detail study of cutting torch assembly is conducted and the time study and material movement data is collected for all individual process. The detail analysis is done for the all collected data. Then find out all possible solution for reducing lead-time of the torch assembly

Four possible layouts are proposed for reducing the the material movement from 107 metres to 17 meters which helps in reduce the lead time of the process.

Modified Rank Position method is used for line balancing, which will helps in effective resource allocation for the process. The proposed solution is validated by using Arena software.

Based on the proposal there will be 25 % increase in production can be achieved from current process. The recommendation is made according to the of future targets based on Takt time requirement.

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