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RESEARCH ARTICLE OPEN ACCESS

Reduction of assembly time in ball valve manufacturing using DMAIC methodology

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ABSTRACT
In this present scenario the reduction of cycle time and lead time of a component is essential to uplift the business and to satisfy the customer. The case study was taken in the assembly section of ball valve manufacturing, during the study and observation it was found that more time is consumed to assemble a single ball valve. Hence the DMAIC methodology was applied to investigate the causes to get the solution to overcome it. The various tools and techniques such as SIPOC tool, time study, brain storming, 5S have been applied under DMAIC phases. The reasons are arrived through TIMWOOD method of waste identification and solutions are suggested. The synergic approach of DMAIC and 5S have results a good solution. Finally, the time taken to assemble one ball valve i.e.2.4 min is reduced to 1.8 min and this in turn reduced the lead time of 30 days to 26 days to produce 6000 valves.
Keywords: DMAIC Methodology, SIPOC tool, 5S, Cycle Time, Lead Time.

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I. INTRODUCTION

DMAIC methodology helps to make a continuous improvement process by identifying the non-value added activities involved in the assembly. In this project 5S is used in the improve phase mainly first 2s i.e. sorting & set in order. Ultimately, improving the assembly time leads to decrease in lead time of the two-piece ball valve and also making the company to concentrate in other types of valve production.

- The current assembly time of two-piece ball valve is found to be higher. In detail the maximum production of ball valve is two-piece ball valve of 80class,5A type material. The company has the demand as monthly target of 6000 valves of two-piece that has to be delivered to the customer.
- The current lead time of producing 6000 valves of two-piece is 30 days. At the same time keeping more focus in this production alone becomes a tragedy in producing other types of valves.
- So this project involves finding of non-value added activities in assembly section and eliminating those. Thus the assembly time get reduced & leads to reduction in lead time. The first three stages shown below in the fig is finished in UNIT-1 itself. Remaining 3 stages are only accompanied in current plant.

Stages	Duration	
1. Raw material from vendor	15 days	UNIT-I
2. Inward inspection (1 batch)	45 min	
3. Machining process(1 batch)	9 hrs	
4. Assembly (1 batch)	60 min	CURRENT UNIT-II
5. Valve leakage test	55min	
6. Final inspection	1.5hrs	

Fig 1: Stage of ball valve manufacturing

II. METHODOLOGY

DMAIC methodology is going to be followed in this project which includes various tools & phases.

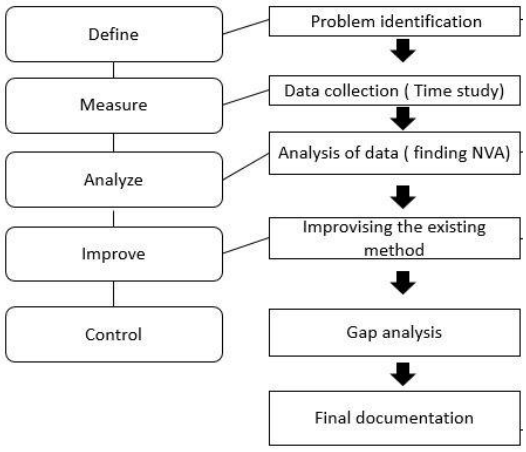
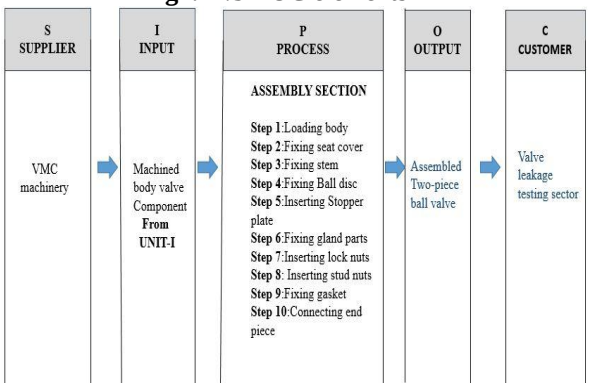


Fig 2: DMAIC Methodology

A. DEFINE PHASE

SIPOC is a tool that summarizes the inputs and outputs of one or more processes in table form. It's an acronym that stands for Suppliers, Inputs, Process, Outputs, and Customers.

Fig2. A.SIPOC elements



We can learn about the overall process carried out for manufacturing ball valve from the above table. In this case a machined body valve component from unit-1 is entered to current plant as input. The initial process of the current assembly section is to assemble all the sub-parts necessary for making ball valve. Then the assembled valves are sent to valve leakage testing sector and at last to inspection zone.

B. MEASURE PHASE

Measuring is important throughout the project's life. In this phase, the time study is used to check the present time needed to complete the assembly of one ball valve. The total capacity of the assembly table to load valves is 25 numbers.

Fig2. B. Time study-1

TIME STUDY FORM												
Type: Two piece ball valve		**Model**: 80 class-5A				**Date**:19-10-2019			**Observed by** : Vimal raj			
S.NO	**STAGES**	**Observation time (sec)**										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Avg OT
1	Loading body	8	7	8	6	8	6	7	8	7	9	7.4
2	Fixing seat cover	13	13	12	15	14	14	13	12	14	11	13.1
3	Fixing stem	23	24	23	22	21	21	22	23	22	24	22.5
4	Fixing Ball disc	29	27	28	27	26	25	28	27	26	28	27.1
5	Inserting Stopper plate	17	19	15	18	19	18	18	17	19	16	17.6
6	Fixing gland parts	20	20	18	19	19	21	21	22	21	22	20.3
7	Inserting lock nuts	11	9	13	9	12	12	11	10	9	10	10.6
8	Inserting stud nuts	9	11	13	10	11	12	13	9	12	9	10.9
9	Fixing gasket	6	7	9	9	8	9	6	8	7	7	7.6
10	Connecting end piece	8	7	5	8	5	6	5	8	7	8	6.7
											Total avg OT	143.8

From this table, we can conclude that the average time required to assemble 1 valve is 143.8 sec i.e. 2.4 min/valve.

C. ANALYSE PHASE

In this phase, we are going to identify the different types of non-value added activity that currently exists in the system.

Brainstorming is a process where an individual or team develops as many ideas concerning a topic as they can, using various creativity techniques or methods.

We are very familiar with the 7 type of wastes available in an organization like transportation waste, inventory waste, motion waste, waiting waste, over-production waste, over processing waste & defects as waste. Ongoing with brain storming with the staffs, the list of non-value added activities are noted below table

Fig 2.C. TIMWOOD WASTES

Transport	Inventory	Motion	Waiting	Over production	Over processing	Defects
		•	•			

The above table helps as to find where the NVA's occurrence is predominantly more. It shows that Motion waste & Waiting waste are the major involvement during the process. Motion waste occurs in two forms namely; Workers are in motion unnecessarily for picking up the sub-assembly parts then & there. This lead to huge time loss when assembly operation is ongoing.

Sometime workers will search for empty bins to load the assembled components. Waiting waste observed is that workers are tend to remain in queue to get sub-assembly parts from store once the stock gets over. But when compare to motion waste it occurs rarely. From the observation the most problematic area found is that there is no proper area to keep sub-assembly parts as shown in figure below.

Fig 3.C. View of assembly table

D. IMPROVE & CONTROL

To make the work area more efficient, the best tool that we can proceed is through 5S - Housekeeping technique. Therefore, in this phase we are going to incorporate any form of 'S' which is more suitable for current progress. In discussion with the company executives we got the permission to place an extra table in the space available near assembly section so that all sub-assembly parts can be placed above on it. Improvisation done to improve the existing area is shown below. A new table has been kept in the existing area to arrange

sub-parts. All sub parts are **sorted down (1S)** and **set in order (2s)**, so that workers can easily pick up the assembly parts.

Fig 2.D. New setup for arranging sub-assembly parts

The remaining 3S i.e. shine, standardize & sustain are in the hands of working employees in this zone. They have refill the spare parts once get over & make other to follow as a routine job. So this the control phase of this project so sustain the growth.

To check the performance of the improvement made we have to calculate the current timing of ball valve assembly. Therefore, once again the time study should be taken to calculate the change in average time.

Fig 2.E. Time study-2

TIME STUDY FORM-2												
Type: Two piece ball valve		**Model:** 80 class-5A				**Date**:03-03-2020			**Observed by** : Vimal raj R			
		Observation time (sec)										
S.NO	**STAGES**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Avg O**
1	Loading body	8	7	8	6	8	6	7	8	7	9	7.4
2	Fixing seat cover	6	8	7	9	8	7	7	9	8	9	7.8
3	Fixing stem	18	21	18	21	19	19	21	18	19	20	19.4
4	Fixing Ball disc	23	24	22	23	26	21	23	24	22	23	23.1
5	Inserting Stopper plate	10	11	13	15	14	13	11	10	9	10	11.6
6	Fixing gland parts	9	13	10	11	12	10	11	12	9	10	10.7
7	Inserting lock nuts	8	7	8	8	9	7	8	9	7	8	7.9
8	Inserting stud nuts	9	7	9	7	8	7	8	8	7	8	7.8
9	Fixing gasket	6	7	9	9	8	9	6	8	7	7	7.6
10	Connecting endpiece	5	5	5	6	5	5	7	6	5	7	5.6
										Total avg OT		108.9

From the table, it is observed that the total average time taken to assemble one ball valve is decreased from **143.8 sec** to **108.9 sec**. this result will surely reflects in the lead time of the component.

III. CALCULATION OF TIME REDUCTION

PREVIOUS STAGE:

1 valve = 2.4 min (143 sec)
1 batch = 25×2.4
= 60 min
Production per day = 8 batches

CURRENT STAGE:

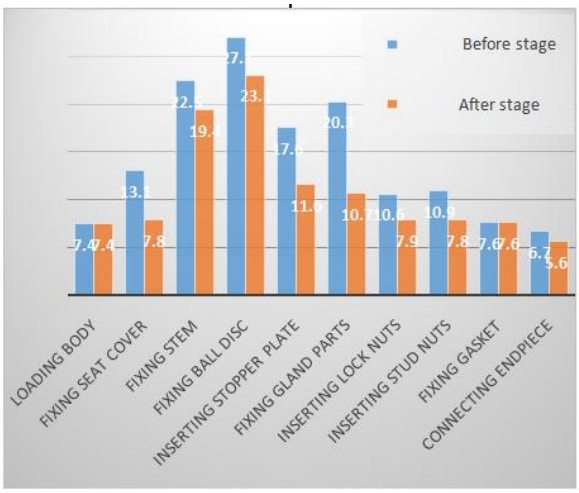
1 valve = 1.8 min (108 sec)
1 batch = 25×1.8
= 45 min

Therefore, the new production status has got a major difference when compared to before.

NEW PRODUCTION STATUS:

480÷45 = 10.4
= 10 batches / day

Fig 3. Comparison chart of before & after result



IV. RESULT & CONCLUSION

The following table helps us to know about the lead time reduction & other status.

Fig 4. Comparison details

Content	Production / day(valves)	Batches	Time / valve(min)	Target (valves)	Lead time(days)
Previous stage	200	8	2.4	6000	30
Present stage	250	10	1.8	6000	24

Due to the gradual decrease in assembly timing it helps to decrease in lead time of two-piece ball. The daily production is also seen to be increased from 200 valves to 250 valves per day. Now the customer can get the valves from 6 days as earlier before & this makes the workers to focus on remaining types of valve production.

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