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FROM DRIVING FORCES TO CHALLENGES – IMPLEMENTATION OF VALUE STREAM MAPPING FOR PRODUCTIVITY IMPROVEMENT

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Abstract

In the current increasingly competitive world of work, it is very important to constantly improve, to be efficient and effective, meeting with high-quality standards. Lean Manufacturing tools are one of the most influential & most effective methodologies for eliminating wastes, controlling quality, and improving the overall performance of any process with the assurance of a large profit margin. The Value Stream Mapping (VSM) techniques involve flowcharting the steps, activities, material flows, information flows, and other process elements that are involved with a process of transformation. This thesis presents the current performance of output and capacity of the FEP bogie frame fabrication shop by accurate data collection through time study. In each workstation, the processing time is different and longer time-consuming workstations will be identified as a bottleneck. The identified bottleneck station will be analyzed to reduce the processing time, non-value-added activities, different wastes ultimately which increase production rate in the bogie frame fabrication shop.

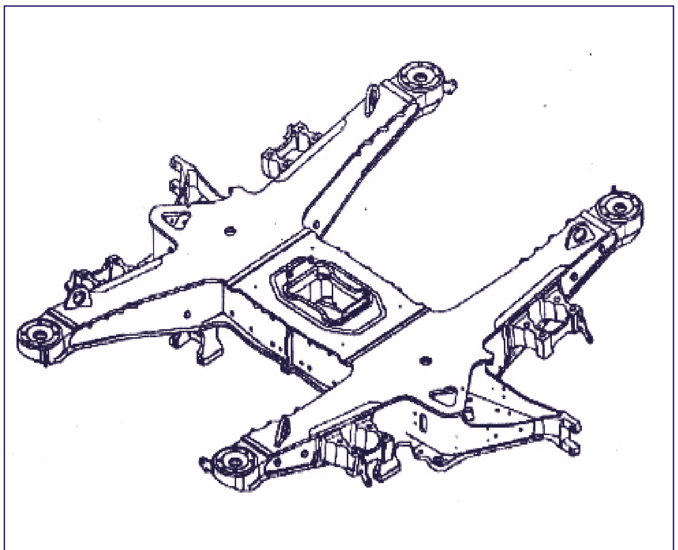
Keywords: FEP Bogie, Lean Tools, Value Stream Mapping (VSM), Productivity Improvement Techniques

INTRODUCTION

Productivity improvement plays a vital role in most of the manufacturing industries as it helps in either removing or minimizing the waste by utilizing lean manufacturing techniques. [1,2].

This paper covers implementing strategies of Lean manufacturing techniques and QC tools to bring down current manufacturing hours in the FEP Frame fabrication project. [3,4] FEP bogie frame mainly consists of three sub-assembly components as shown in fig. 1. It contains side frame LH assembly, side frame RH assembly (Mirror to LH), and transom assembly.

Figure 1. Fabricated FEP Frame



The assembly line of the FEP bogie frame included steps i.e. bottom plate assembly, set up and fitment, external welding, attachment setup, welding, finishing, and measurement. Assembly of side frame includes transom Assembly and final assembly of Side frame LH & RH, Transom Assembly. There are seven types of waste including overproduction, defects, inventory, transportation, waiting, motion, over-processing.

EXPERIMENTAL WORK

Analysis of Wastages using Value Stream Mapping

All the tasks and activities are involved in a process can be divided into two categories: Value Added and Non-Value Activities. [5] A Value Stream comprises all the activities whether value-added or non-value activities that are involved in the conversion of the final product from raw material to the time it reaches the arm of customers. [6, 7] Analyzing the value stream of a product or service gives an idea of the wastages involved in the entire process. Value Stream Mapping is a visual tool used to register all the actions involved required fulfilling the request of the customer. [8] It is a powerful lean tool designed to provide a visual view of what is happening in the process through direct observation. [9] It involves the flow of both materials and information that is required for the conversion of raw material to finished goods. [10]. It differs from a traditional flow chart in the fact that it involves information flow, a critical aspect of the entire process. A Value Stream Mapping (VSM) consists of pre-defined icons and symbols thus creating a common ground for communication. [11]. The VSM as an activity improvement technique to visualize an entire production process, representing information and material flow, to improve the production process by identifying waste and its sources. [12] Value stream maps should imitate what happens rather than what is supposed to happen so that opportunities for improvement can be identified.[13]. A Value stream mapping can be created by tracking the flow of the most time-consuming part of the most valuable past.[14] In the case of FEP frame fabrication, the bogie frame happens to be both; the most time-consuming part as well as the most valuable part. Thus the value stream was mapped by tracking the movement of the Bogie Frame. To understand the flow of the material i.e. the FEP Bogie frame – Process flow chart was created. Figure 2 illustrates the Process Flow Chart (PFC) of FEP Bogie Frame Fabrication. It shows in detail the flow of two side frames and transom assembly followed by full final frame assembly. The process flow chart is created by analyzing the entire production line. This process flow chart aids the workers in understanding the flow of work to be followed. The information flow required in the Value Stream Mapping is created to understand how the orders are placed and how the information for the weekly orders are passed on by the planning department to the production department.

Figure 2: Process Flow Chart (PFC) of FEP Bogie Frame Fabrication.
The first Value Stream Map is illustrated in Figure 3.

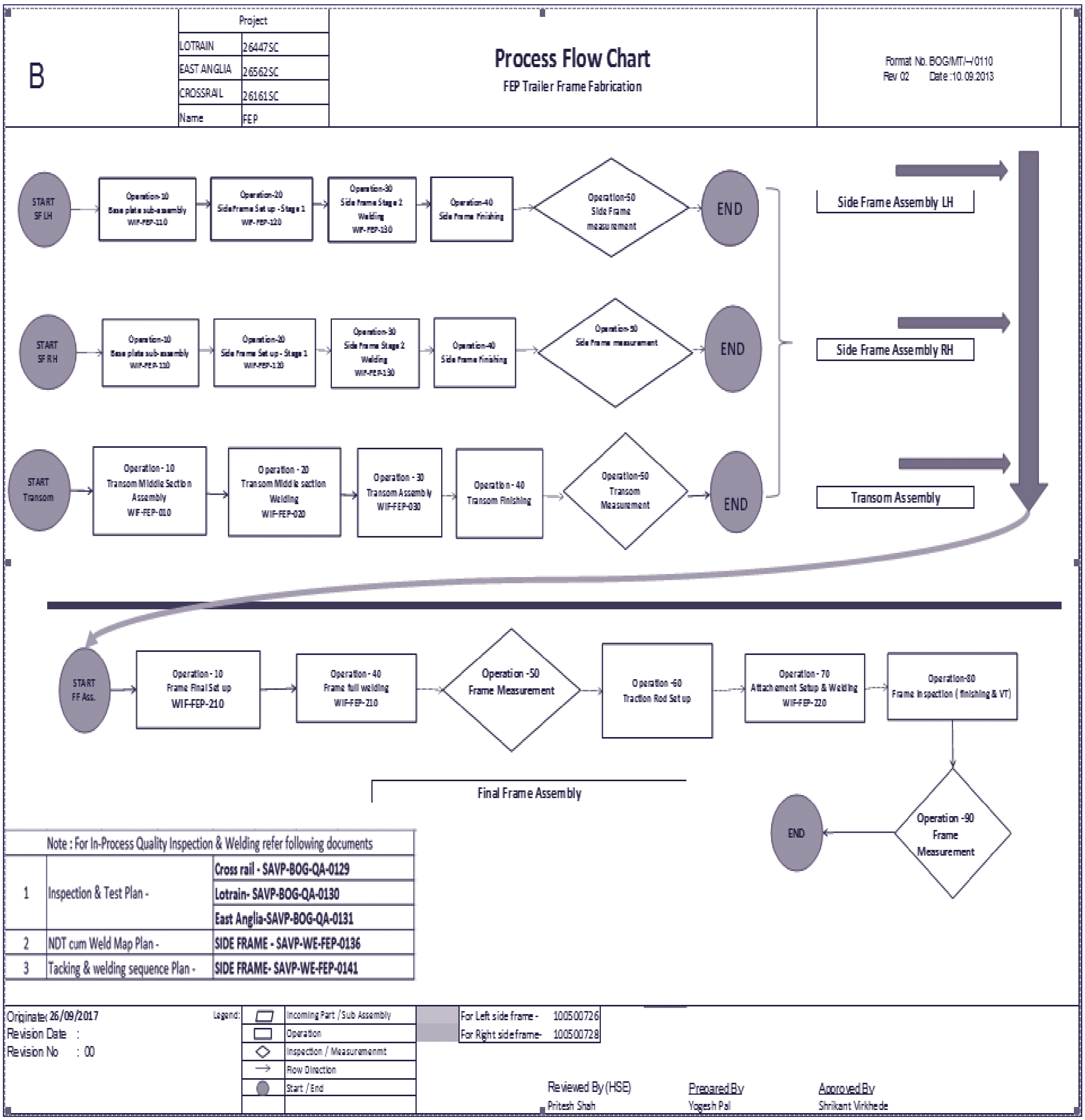
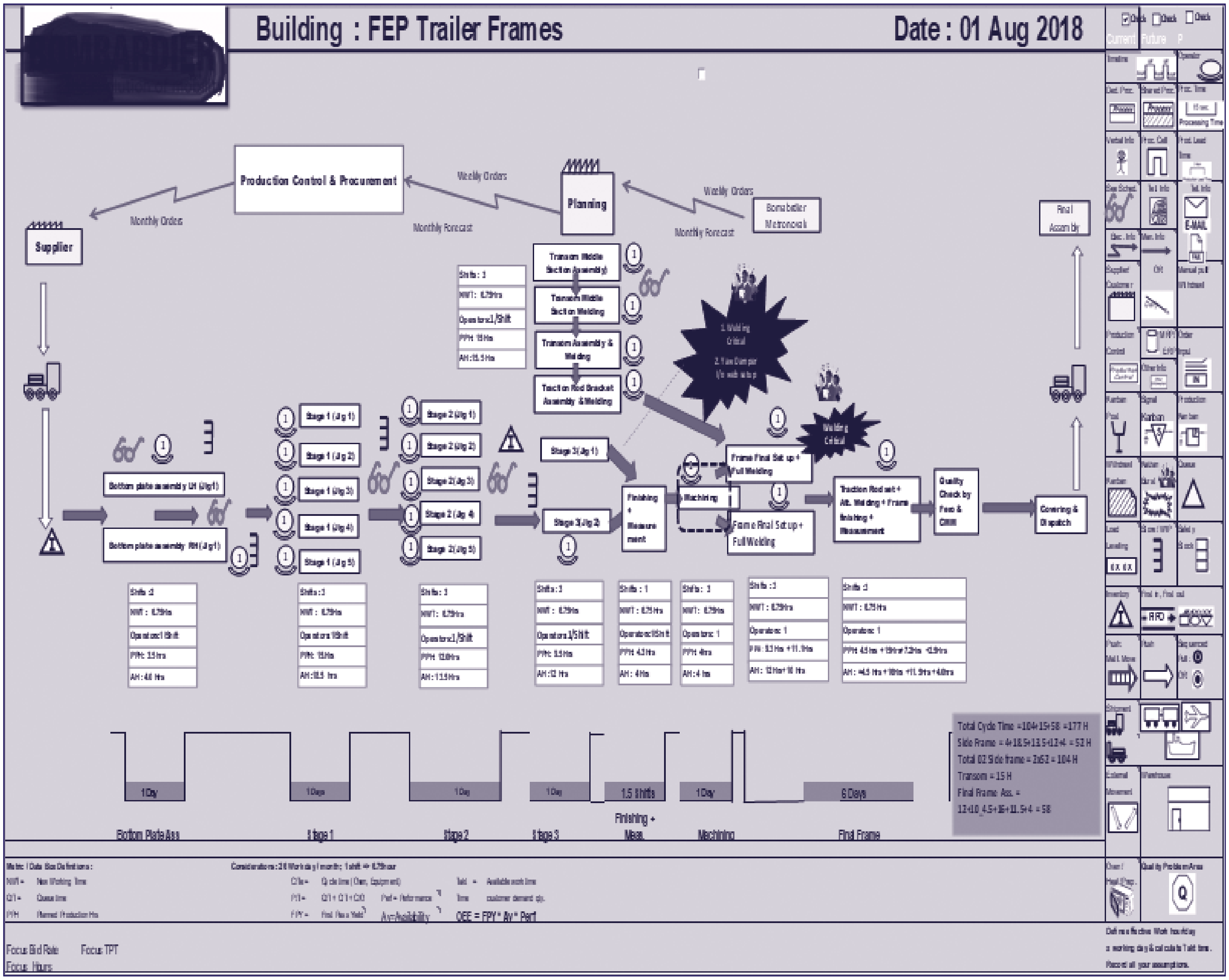


Figure 3: Value Stream Map of FEP Bogie Frame Fabrication – Pre-condition



The organization currently works in three shifts of 8 hours each. The networking time in the shift is defined as the actual time in which the worker is supposed to complete his task. It excludes the Lunch/ Dinner break, tea time, and the time lost in changing of the shift. The Net-working time is generally considered as 85% of the shift time.

Net-working time: Shift hours – Lunch/Dinner time – Tea breaks – Change over time
=9-1-0.25-0.25
=7.5 hours

Cycle Time of Full Frame:

Total Cycle Time = 52 H + 52 H + 15 H + 58 H = 177 Hrs

Side Frame = 4+18.5+13.5+12+4 = 52 Hrs

Total 02 Side frame = 2x52 = 104 Hrs

Transom = 15 Hrs

Final frame assembly = 12+10_4.5+16+11.5+4 = 58 Hrs

MAJOR CONTRIBUTORS TO WASTAGES IN CYCLE TIME

Major contributors to wastages are identified using the Pareto principle. [15, 16, 17] Pareto analysis is a ranked comparison of effects leading to a particular problem, thus it acts as a prioritization tool. Pareto chart bifurcated the factors into vital few and Trivial many thus aiding the identification of certain factors that cause the majority of the problem. The Pareto principle stated that 80% of the problem is caused by 20% of factors, and the remaining 20% of the problem corresponds to the remaining 80% factors. In the case of FEP Side frame fabrication; there is a total of five stages of manufacturing involved. The cycle time as calculated from the Value Stream Mapping is 52 Hours for both LH & RH Side Frame Fabrication; however, the standard time for the same is 44 hours as defined by the Industrial (Method) department. Therefore, there is a wastage of around 8 hours in each side frame. Henceforth, two Side frame assembly is used to one bogie frame – which contributes a total of 16 hours in total.

For Final Frame fabrication the same as the side frame, there is a total of 06 stages of manufacturing involved. The cycle time is calculated from VSM is 58.5 hours whereas the standard hours defined by the Method department are 52 hours. So, total wastages of 6.5 hours observed per frame. Hence in total, 17.5 hours are excess to plan hours which are creating a loss of Productivity. Using Pareto analysis, the major contributors to this wastage can be determined and it's shown in fig. 4 and Table 1.

Figure 4: Wastages in operating activities of Side Frame fabrication each

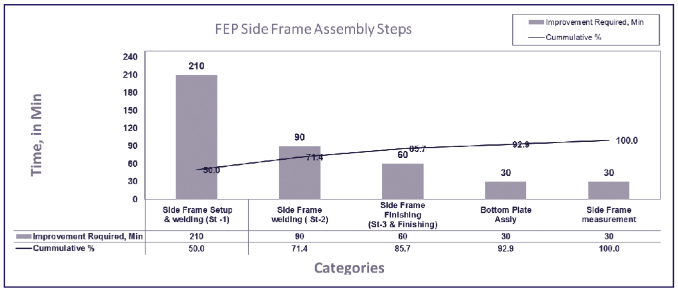


Table 1: Side Frame Fabrication - Actual cycle time Vs Standard cycle time

Description	Actual Time	Plan Hours	Improvement Required, Min	Contibution Percentage	Cummulative %
Side Frame Setup & welding (St - 1)	18.5	15	210	50.0	50.0
Side Frame welding (St-2)	13.5	12	90	21.4	71.4
Side Frame Stage 3 welding & Finishing (St-3 & Finishing)	15	14	60	14.3	85.7
Bottom Plate Assly	4	3.5	30	7.1	92.9
Side Frame Measurement	1	0.5	30	7.1	100.0
	52	45	420	100	

From this Pareto analysis, it is understood that the Side frame set up & Welding (Stage 1), Side Frame welding (Stage 2), and Side frame stage 3 welding & finishing contributing 85.7% wastages in total. Thus a detailed study of these activity stages shall help us to determine the key issues and also necessary action plan. An in-depth analysis of these activities can be obtained by performing a time study of all these stages. The corresponding Pareto chart is shown in fig. 5 and related statistics are given in table 2.

Figure 5: Wastages in operating activities of Final Frame fabrication

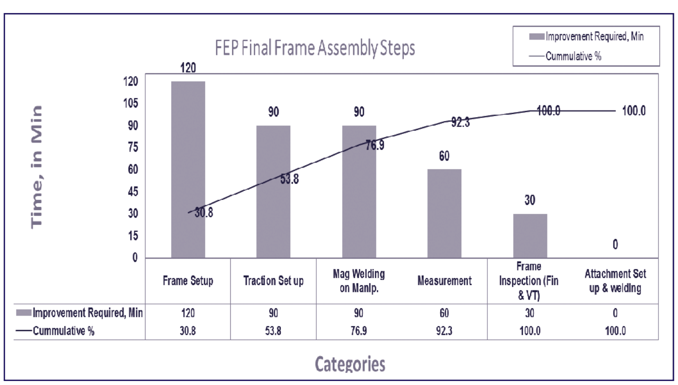


Table 2: Final Frame Fabrication - Actual cycle time Vs Standard cycle time

Description	Actual Time	Plan Hours	Improvement Required, Min	Contibution Percentage	Cummulative %
Frame Setup	12.5	10.5	120	30.8	30.8
Traction Set up	4.5	3	90	23.1	53.8
Mag Welding on Manip.	10	8.5	90	23.1	76.9
Measurement	4	3	60	15.4	92.3
Frame Inspection (Fin & VT)	11.5	11	30	7.7	100.0
Attachment Set up & Welding	16	16	0	0.0	100.0
	58.5	52	390	100	

From the above Pareto analysis, it is understood that the final frame set up, traction rod set up, & Full MAG welding on Manipulators contributing 76.9 % wastages in total. Thus a detailed study of these activity stages shall help us to determine the key issues and also the necessary action plan. An in-depth analysis of these activities can be obtained by performing a time study of all these stages.

TIME STUDY OF IDENTIFIED MANUFACTURING STAGES

Time Study is a direct and continuous observation of a task, using a timekeeping device to record the time taken to accomplish a task given by F.W. Taylor. [18, 19] It is often used when there are repetitive work cycles of short or long duration, a wide variety of dissimilar work or process control elements constitutes a part of the cycle. By performing the time study of the assemblies contributing majority to the wastages we can find out the actual value-added work happening in the actual time the assembly consumes. [20, 21] By keeping a record of the activities performed, the value-added time i.e. the time in which value is added to the process can be calculated. All the other activities which consume time but do not create values are known as Non-Value Added Activities and the time they consume is called Non-Value Added Time. At the industries, the activities are classified into 07 categories i.e. Value Added Activities (VAA), Non-Value Added Activities (NVA), Assignable Ancillary Activities (AAA), Non-assignable Ancillary Activities (NAA), Organizational Losses (OL), Rest and Personal Care (RPC), Irregularities due to Employee (IDE). [22,23,24]. From the analysis of the time study, the time that activity should consume can be determined. Correspondingly an action plan to nullify NVA and IDE, and reduce NAA should be developed with the help of the time study. RPC is to be neglected since it is required by every operator and it ensures the safety and proper work.

TIME STUDY OF SIDE FRAME SET UP & WELDING (STAGE 1)

From the VSM, it was identified that the Side frame set up & welding was consuming about 3.5 hours more than its planned standard hours. To narrow down the analysis, a time study of this stage was carried out. Activities in the process were segregated into the 7 different categories giving us an idea regarding the time-consuming activities are and Non-Value Added activities. The analysis clearly stated the NVA time lost in Tool searching, tool waiting, improper tooling, improper method, and material searching. Using this data, an action plan can be generated to remove the above NVA. The time study duration analysis is given in table 3 with an individual contribution in the form of a pie-chart for better understanding.

Table 3: Side Frame set up & welding (Stage 1) time study – Duration analysis

Activity Classification	Duration, Hours
AAA	3:36
NAA	2:17
NVA	4:29
OL	1:42
RPC	1:35
VAA	4:57
Total Hours	18:36

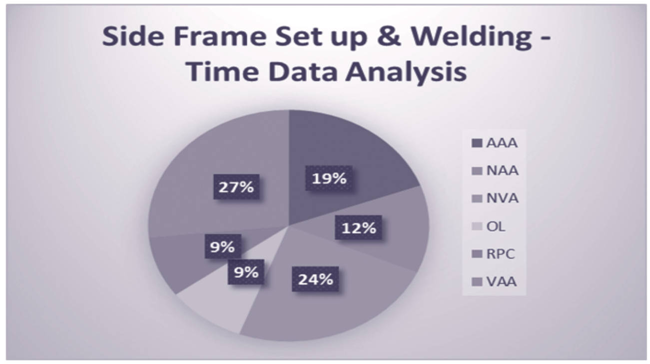


Table 4 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 4: Time Study of Side Frame set up & welding (Stage 1)

Station FEP SF st1	FEP Side Frame (Stage 1)		
	Deepak Patel		
Duration	Activity	Details	Activity
0:09	Lifting	Loading bottom plate assly to fixture	VAA
0:05	Fixing	Belt assly not properly rested due to resting plate	NVA
0:05	Fixing	clamping	AAA
0:13	break	Tea break	RPC
0:02	Documentation	direct hrs punching	NAA
0:02	Waiting	Searching grinder	OL
0:04	Lifting	Brake bkt	VAA
0:04	Setup	Brake bkt (YAW side)	AAA
0:06	Grinding	2MM grinding for root gap as per WPS (YAW side)	NVA
0:02	Marking	marking for grinding (YAW side)	NAA
0:04	Grinding	1MM grinding for root gap as per WPS (YAW side)	NVA
0:05	Setup	Brake bkt (YAW side)	AAA
0:01	Grinding	1MM grinding for root gap as per WPS (YAW side)	NVA
0:05	Setup	marking for grinding (ARB side)	AAA
0:03	Grinding	3MM grinding for root gap as per WPS (ARB side)	NVA
0:07	Setup	Brake bkt (ARB side)	AAA
0:05	Waiting	Searching Heating set	OL
0:06	Tack Welding	Run in / out heating & tack	VAA
0:05	Setup	Brake bkt (Both side)	AAA
0:05	Waiting	Searching Heating set	OL
0:02	Heating	Brake bkt heating	NAA
0:13	Tack Welding	Brake bkt tack welding	VAA
0:04	Heating	Brake bkt heating	NAA
0:02	Welding	Brake bkt welding	VAA
0:04	Grinding	flush grinding at both ends	NVA
0:02	Grinding	chipping & grinding with chipper and belt grinder	NVA
0:02	Movement	Rotating fixture for welding position	NAA
0:01	Heating	Brake bkt heating	NAA
0:02	Welding	Earthing cable clamping & welding torch cleaning	NVA
0:04	Welding	Brake bkt welding	VAA
0:03	Grinding	flush grinding at both ends	NVA
0:02	Grinding	chipping & grinding with chipper and belt grinder	NVA
0:27	Lunch	Lunch	RPC
0:17	Setup	Outer end plate setup	AAA
0:06	Grinding	Outer end plate grinding	NVA
0:03	Setup	Outer end plate setup & marking for grinding	AAA
0:04	Grinding	Outer end plate grinding	NVA
0:13	Setup	Outer end plate setup (ARB side)	AAA
0:04	Grinding	Outer end plate grinding (YAW side)	NVA
0:01	Waiting	searching mechanical jack	NVA

TIME STUDY OF SIDE FRAME STAGE 2 WELDING (STAGE 2)

From the Value Stream Mapping, it was identified that Side frame welding – Stage 2 was consuming about 1.5 Hours more than its planned standard hours. To narrow down the analysis, a time study of the side frame stage 2 welding was performed. Detail data analysis as below. The time study duration analysis is given in table 5 with an individual contribution in the form of a pie-chart for better understanding.

Table 5: Side Frame Stage 2 Welding - time study – Duration analysis

Activity Classification	Duration, Hours
AAA	0:41
NAA	2:42
NVA	3:46
OL	0:23
RPC	1:23
VAA	4:38
Total Hours	13:33

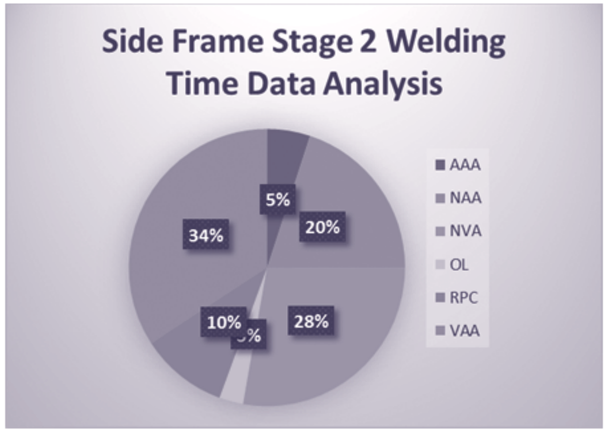


Table 6 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 6: Time Study of Side Frame Stage 2 Welding

Duration	Activity	Details	Activity
0:05	Movement	Loading of frame on fixture	NAA
0:04	Fixing	Clamping frame	AAA
0:01	Preparation	Preperation for welding m/c	NAA
0:16	Preparation	Preperation for gas heating trolley	NAA
0:05	Heating	Pre heating of brake bracket to outer end plate	NAA
0:03	Movement	Gas trolley shifted to other station	NAA
0:08	Welding	TIG Welding of brake bracket to outer end plate	VAA
0:02	Grinding	Filler material(Tungesten) grinding	NVA
0:09	Welding	TIG Welding of brake bracket to outer end plate	VAA
0:02	Waiting	Discussing with other operator	NVA
0:11	Welding	TIG Welding of brake bracket to outer end plate	VAA
0:01	Break	Drinking Energy soft drink	RPC
0:02	Break	Filling water bottel	RPC
0:01	Preparation	Wearing ppes	NAA
0:04	Welding	TIG Welding of brake bracket to outer end plate	VAA
0:01	Waiting	Looking for belt grinder	NVA
0:01	Movement	Fixture rotation	NAA
0:01	Meeting	Discussion with production team member	NVA
0:01	Movement	Fixture rotation	NAA
0:00	Meeting	Discussion with production team member & busy in other activity	NVA
0:04	Waiting	Looking for gas heating set	NAA
0:02	Heating	Heating of top plate & outer side end plate(Both side)	NVA
0:02	Grinding	Manual chipping	NVA
0:05	Welding	TIG Welding of Top plate & outer end plate	VAA
0:02	Meeting	Discussing with other operator	NVA
0:08	Welding	TIG Welding of Top plate & outer end plate	VAA
0:01	Grinding	grinding of weld joint	NVA
0:00	rest	drinking water	RPC
0:02	Cleaning	cleaning	NAA

From the Value Stream Mapping, it was identified that Side frame Stage 3 welding & finishing was consuming about 1 Hour more than its planned standard hours. To narrow down the analysis, a time study of the side frame stage 3 welding & finishing was performed. Detail data analysis as below. The time study duration analysis is given in table 7 with an individual contribution in the form of a pie-chart for better understanding.

Table 7: Side Frame Stage 3 welding & finishing - time study – Duration analysis

Activity Classification	Duration, Hours
AAA	4:42
NAA	0:39
NVA	1:27
OL	0:06
RPC	2:12
VAA	6:04
Total Hours	15:10

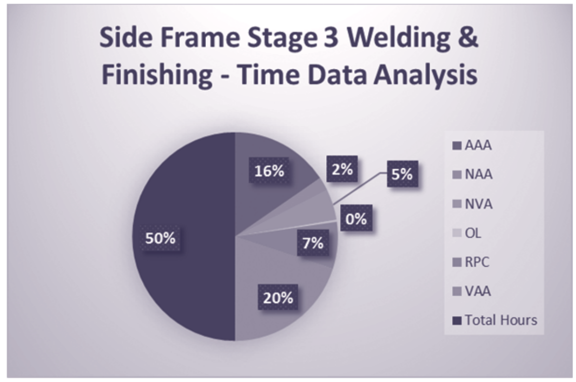


Table 8 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 8: Time Study of Side Frame Stage 3 Welding & Finishing

Duration	Activity	Details	Activity
0:04	RPC	RPC	RPC
0:09	Movement	loading of side frame (operator using craddel for rotating of side frame)	NAA
0:03	Waiting	operator serching for spanner	OL
0:01	Clamping	clamping	AAA
0:02	RPC	operator standing in front of fan	RPC
0:01	Waiting	Operator calls other operator for clamping	NVA
0:01	Movement	Rotating of fixture	AAA
0:02	Clamping	clamping	AAA
0:02	Marking	marking for secondary suspension (operator not knowing setup of sec. susp. Ca	AAA
0:07	Waiting	searching for grinder (operator doing timepass)	NVA
0:01	Grinding	grinding	AAA
0:03	RPC	rpc (operator doing timepass)	RPC
0:35	Waiting	tig machine available but electrical connection not available	NVA
0:02	Welding	tacking of sec. sus brckt	VAA
0:03	Welding	welding of sec. sus. Brckt	VAA
0:01	Waiting	torch tip preparation	OL
0:01	Waiting	filler rod availability	OL
0:01	Movement	fix rotation	AAA
0:04	Welding	welding	VAA
0:01	Waiting	torch tip preparation	OL
0:07	Welding	welding	VAA
0:49	Break	dinner	RPC
0:01	Preparation	wear ppe	NAA
0:02	Waiting	torch tip preparation	NVA
0:01	Movement	fix rotation	AAA
0:07	Welding	welding	VAA
0:16	Cooling	cooling	AAA
0:02	Inspection	vt by welding inspector	AAA
0:02	Movement	fix rotation	AAA
0:05	Welding	welding	VAA
0:03	Grinding	chipping	AAA
0:04	Welding	welding	VAA
0:01	Movement	fix rotation	AAA
0:01	Welding	welding	VAA

TIME STUDY OF FINAL FRAME SET UP ACTIVITIES

From the Value Stream Mapping, it was identified that Final frame Set up activities was utilizing about 2 Hour more than its planned standard hours. To come down the to analysis, a time study of the final frame set up activity was carried out. Detail data analysis as below. The time study duration analysis is given in table 9 with an individual contribution in the form of a pie-chart for better understanding. The time study duration analysis is given in table 9 with an individual contribution in the form of a pie-chart for better understanding.

Table 9: FEP Final frame set up- time study – Duration analysis

Activity Classification	Duration, Hours
AAA	2:28
IDE	1:38
NAA	1:50
OL	1:38
RPC	1:37
VAA	3:22
Total Hours	12:33

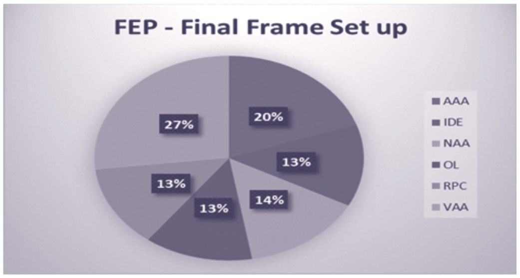


Table 10 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 10: Time Study of FEP Final frame set up

	FEP Final frame setup		
Duration	Activity	Details	Activitie
0:25	Clamping	side frame movement & loading & clamping	AAA
0:27	Movement	Transom movement & loading & clamping	AAA
0:18	Heating	heating for top plate of sf1	VAA
0:02	Setup	jack	AAA
0:01	rest	break for energy drink	RPC
0:05	Heating	heating for bottom plate of sf1	VAA
0:02	Setup	jack	VAA
0:08	Heating	heating for bottom plate of sf2	VAA
0:01	Setup	jack	VAA
0:07	Heating	heating for bottom plate of sf2	VAA
0:01	Setup	jack	VAA
0:06	Heating	heating of top plate sf 1 pre-bended portion	VAA
0:03	Clamping	clamping	VAA
0:10	Heating	heating of top plate sf 2	VAA
0:02	Setup	setup	VAA
0:01	Grinding	grinding of transom bevel side	NAA
0:06	Checking	checking with prescribed dimensions	VAA
0:01	Grinding	grinding of transom bevel side	NAA
0:04	Setup	setup of sf1 with the transom	VAA
0:01	Grinding	grinding of transom for maintaining the dimension	NAA
0:05	Checking	dimension checking	VAA
0:01	Marking	marking for grinding of transom to achieve dimensions	NAA
0:01	Grinding	grinding on transom side	NAA
0:01	Grinding	grinding of top plate sf1	NAA
0:04	Setup	setup of sf1 with the transom	VAA
0:01	Grinding	grinding on transom side	NAA
0:10	Setup	setup	VAA
0:35	Lunch	lunch break	RPC
0:02	Grinding	grinding of transom sf1	NAA

TIME STUDY OF TRACTION ROD SET UP ACTIVITIES

From the Value Stream Mapping, it was identified that Traction rod Set up activities was utilizing about 1.5 Hours more than its planned standard hours. To come down the to analysis, a time study of the traction rod set up activities time study was performed. The time study duration analysis is given in table 11 with an individual contribution in the form of a pie-chart for better understanding.

Table 11: FEP Traction Rod set up- time study – Duration analysis

Activity Classification	Duration, Hours
AAA	1:40
NAA	1:15
OL	1:17
RPC	0:23
VAA	0:04
Total Hours	4:39

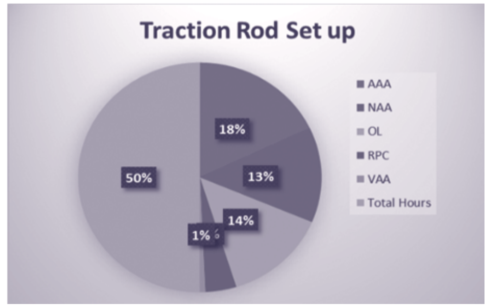


Table 12 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 12: Time Study of FEP Traction Rod set up

	FEP Frame Traction Rod set up		
Duration	Activity	Details	Activity
0:10	Shift end formalitie	shift end formalities	OL
0:06	Lifting	lifting of frame for loading	NAA
0:08	Movement	loading of frame on the measurement fixture	NAA
0:14	Setup	frame setup in "X" & "Y" direction	AAA
0:04	Waiting	operator went to bring height gauge to set frame in Z-direction	ol
0:16	Setup	frame setup in "Z" direction	AAA
0:09	checking	Crosschecking "X" & "Y" dimension after "Z-dimen setting	AAA
0:04	meeting	discussion with supervisor	ol
0:07	Dimension measur	measurement	NAA
0:01	rpc	energy drink	RPC
0:05	marking	marking for traction rod in Y-direction	NAA
0:02	Setup	set up for marking for traction rod in X-direction	AAA
0:10	marking	marking for traction rod in X-direction	NAA
0:10	Shift end formalitie	shift end formalities	OL
0:11	Setup	Frame Z height adjustment	AAA
0:03	Setup	Frame adjustment in Y direction	AAA
0:07	Setup	Frame adjustment in X direction	AAA
0:05	Setup	Frame adjustment in Y direction	AAA
0:03	Setup	Traction rod assly setup	AAA
0:02	Waiting	NO ACTIVITY going on	OL
0:08	Grinding	Traction rod assly grinding	NAA
0:04	meeting	Meeting with other operator	OL

TIME STUDY OF FULL-FRAME WELDING ON MANIPULATOR

After analyzing Value Stream Mapping, it was identified that the final frame full welding activity was utilizing about 1.5 hours more than its planned standard hours. To come down the analysis, a time study of the welding stage was performed. Detail data analysis as below. The time study duration analysis is given in table 13 with an individual contribution in the form of a pie-chart for better understanding.

Table 13: FEP Final Frame full Welding - time study – Duration analysis

Activity Classification	Duration, Hours
AAA	1:50
IDE	0:25
NAA	2:35
OL	1:13
RPC	1:40
VAA	2:31
Total Hours	10:14

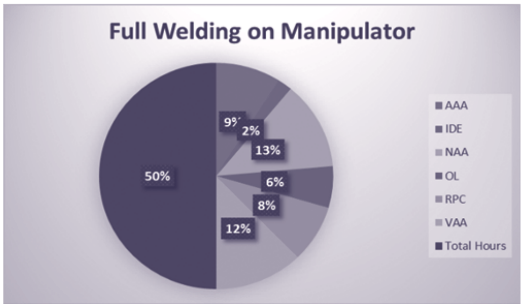


Table 14 represents the time study of side frame set up & welding (stage 1) indicating duration activity type, its detail, and type of activity.

Table 14: Time Study of FEP Final Frame Welding

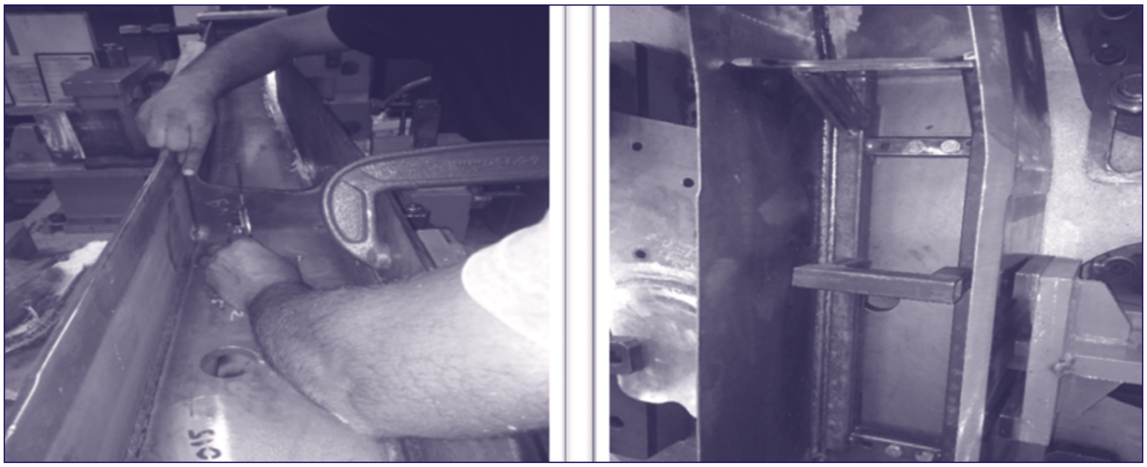
Duration	Activity	Details	Activity
0:04	Lifting	Loading of frame on fixture	naa
0:03	Setup	clamping of frame	AAA
0:09	rest	rpc	rpc
0:01	Movement	jig rotation	naa
0:11	Waiting	serching for template for break bracket rib	ol
0:05	rest	RPC	rpc
0:01	Preparation	setting up of heating set	naa
0:02	Documentation	kronos punch	ol
0:02	Preparation	PPE	naa
0:01	Preparation	torch cleaning	naa
0:03	Discussion with oth	Talking with another operator	IDE
0:02	Heating	heating of traction rod	AAA
0:01	Discussion with oth	Talking with another operator	IDE
0:01	Heating	heating of traction rod	AAA
0:01	Welding	welding	VAA
0:04	Heating	heating of traction rod	AAA
0:02	Welding	welding	VAA
0:01	Discussion with oth	Talking with another operator	IDE
0:02	Heating	heating of traction rod	AAA
0:01	DIScussion with oth	Talking with another operator	IDE
0:01	Welding	welding	VAA
0:04	Heating	heating of traction rod	AAA
0:01	Welding	welding	VAA
0:01	Movement	ladder movement to rotate jig	NAA
0:02	Discussion with oth	Talking with another operator	IDE

IMPLEMENTATION OF ACTIONS

Analysis carried out of details time study of bottleneck stages, it can be concluded that several reasons are leading to exceeding the cycle time against standard cycle time. Major contributing factors are improper tooling, jigs & fixtures, template for setting up activities, shortage of tools and equipment & other resources, poor workplace organization, hazy material delivery at activity stage, Process sequence with additional work in progress material movement, etc. All these causes are analyzed, and a proper action plan prepared with a targeted due date for listed actions for side frame assembly fabrication and final frame fabrication. Realization of improvements tracked and validated with the produced number of the product shown only one for the reference purpose. Fig.6 shows a modification in diaphragm set-up for before and after conditions.

Template for Diaphragm Set up at Side Frame Set Up – Stage

Fig. 6 Modification in diaphragm set-up (Before and after condition)



Other modifications are also performed as mentioned in the list below.

1. Change In Process – Set-Up of Brake Bracket at Side Frame – Stage 1
2. Template for Outer Rib Set Up at Side Frame Set Up – Stage 1
3. Template for Top Plate Set Up at Side Frame Set Up – Stage 1
4. Pre-stressing Unit Made to Achieve Set Up Dimension – Stage 3
5. Work Place Organization (5S & Visualization) – Side Frame Set up - Stage 1
6. Work Place Organization (5S & Visualization) – Side Frame Welding - Stage 2
7. Material Delivery in Cages for Primary Parts – Side Frame Set up - Stage 1
8. The pre-stressing unit made to achieve Spring Pott required Dimension – Stage 2
9. Template for Traction Rod Set Up Checking – POKA YOKE
10. SS Bracket Set Up Template Modification for POKA YOKE– Final Frame Set up
11. Final Visual Testing carried out on Tressle instead of Rotator– Final Frame Welding
12. Process optimization by eliminating process stages – Traction Rod Set up Activity
13. Gas Cylinder Changing Station – Side Frame & Final Frame Welding

RESULT AND DISCUSSION

Current Value Stream Mapping

After implementing the changes, the current value stream could be plotted similarly to the previous value stream. Doing so would give us a better perspective as to how the actions are implemented have led to changes in the cycle time. There are far more factors affecting the change in cycle time apart from the actions implemented such as the guidance of supervisors over the workers, and external pressure to achieve the project goals, acquirement of better skill, and process knowledge by the worker over the project period. Thus, the changes cannot be fully credited to the activities implemented. Figure 7 illustrates the current Value Stream Map after implementing the actions.

Cycle Time of Full Frame:

Total Cycle Time = 45.25 H + 45.25 H + 15 H + 52 H = 157.5 Hrs

Side Frame = 3.5+15+12+14+0.75 = 45.25 Hrs

Total 02 Side frame = 2x45.25 = 90.5 Hrs

Transom = 15 Hrs

Final Frame Ass. = 10.5+3+8.5+3+11+16= 52 Hrs

Time Reduction

After knowing the reduction in cycle time through the value stream, we are concerned as to how many hours are saved in each activity stage. This gives us a brief idea about the activity which can still be optimized further. Depending on that future action plan can be created if the organization wishes to achieve further productivity. Table 15 shows the side frame hours reduction summary and table 16 shows the final frame hours reduction summary.

Table 15 : Side Frame Hours Reduction Summary

Activity No	Description	Standard Hours	Previous Hours	Achieved Hours	Hours Saved
10	Bottom Plate Assly	3.5	4	3.5	0.5
20	Side Frame Setup & welding (Stage -1)	14.5	18.5	15	3.5
30	Side Frame welding (Stage -2)	12	13.5	12	1.5
40	Side Frame Stage 3 welding & Finishing (Stage -3 & Finishing)	13.5	15	14	1
50	Side Frame Measurement	0.5	1	0.75	0.25
	Total	44	52	45.25	6.75

Table 16: Final Frame Hours Reduction Summary

Activity No	Description	Standard Hours	Previous Hours	Achieved Hours	Hours Saved
10	Frame Setup	10.5	12.5	10.5	2
20	Traction Set up	3	4.5	3	1.5
30	Mag Welding on Manip.	8.5	10	8.5	1.5
40	Attachment Set up & Welding	16	16	16	0
50	Frame Inspection (Fin & VT)	11	11.5	11	0.5
60	Frame Measurement	3	4	3.5	0.5
	Total	52	58.5	52.5	6

Figure 7: Value Stream Map of FEP Bogie Frame Fabrication – Postcondition

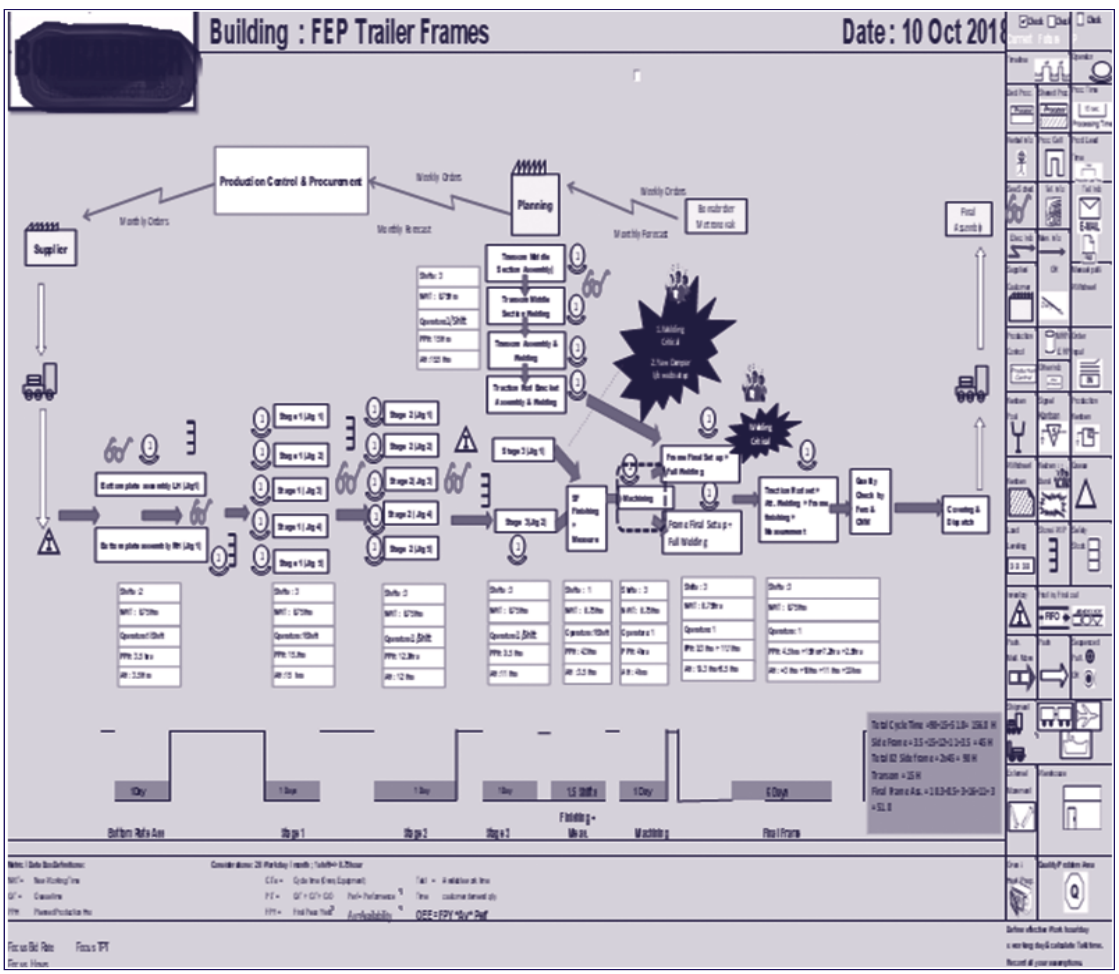
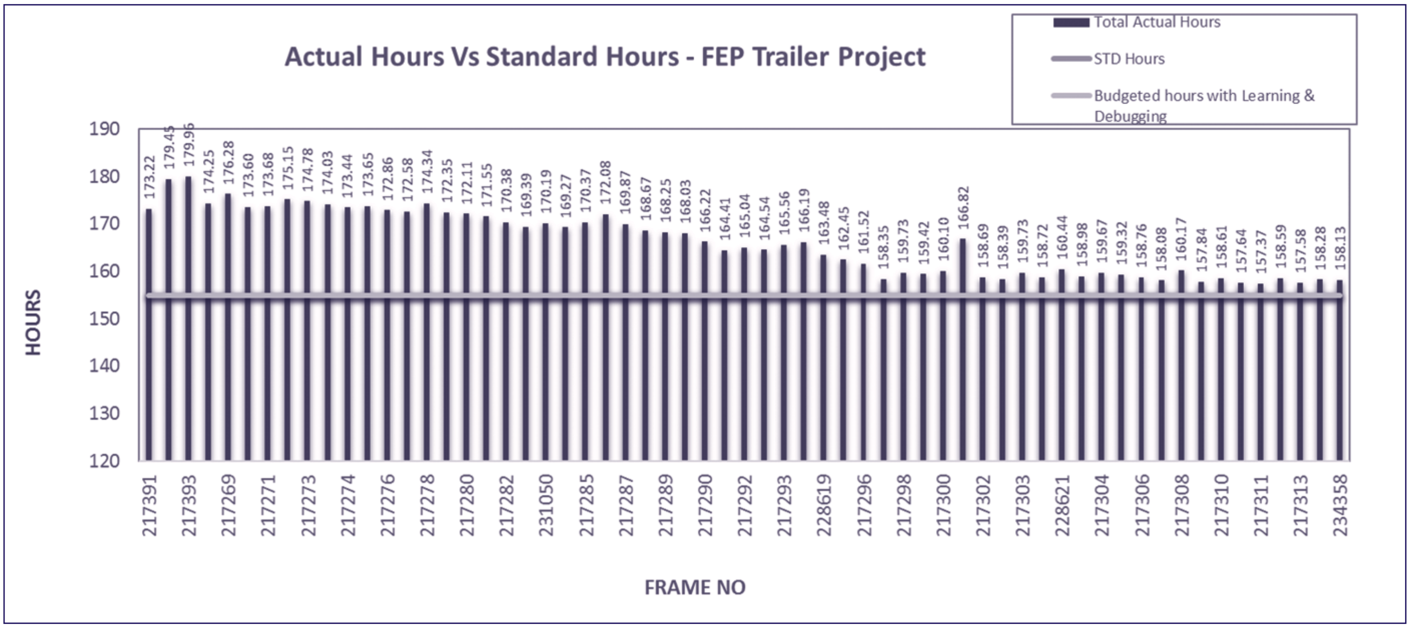


Figure 8 Illustrates the graph of FEP final frame cycle hour trends for different frame nos.

Figure 8: FEP Final Frame Cycle Hours trends



By Analyzing the above graph, trends clearly show a reduction of cycle time from 177 Hours to 157 Hours by implementing the defined action come up through Lean Exercise. [25]

CONCLUSION

From this study, it can be concluded that Lean Manufacturing is an ideal philosophy to reduce wastages in all organizations including the Bogie Frame manufacturing organization. The tools under the Lean principles such as VSM play an important role in exploiting the wastages involved and exposing the area for improvement. Furthermore, tools like Kaizen, Effective 5S, change in process sequence &layout, POKA-YOKE can be used in every firm as these tools give remarkable improvements. If the Lean root is followed by the company in line with its business strategy and is applied systematically, the organization can achieve its ultimate goal of profitability and sustainability with a reduction in wastages.

In our experimental exercise, we achieved cycle time 158 Hours from 177 Hours for in FEP Frame fabrication project by implementing Lean manufacturing techniques. This provides a significant margin to the organization by cost avoidance & saving actions.

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