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Waste Elimination at Diesel Engine Production Plant Using SWCT Tool

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***Abstract*—** The automotive industry always has been under pressure of competitive environment and trying too hard to enhance productivity of plant, reduce product cost and waste. Lean manufacturing concept is being used by most of the companies to minimize waste; better consumption of resources to survive effectively in competitive market. Productivity Improvement requires strong change management, communication and engagement skills. Numerous tools and techniques have been developed to reduce or eliminate waste and carry out Lean concepts in manufacturing. However, in practice, organizations experiences difficulties in identifying the weaknesses of existing system in order to approach them. The ultimate goal is to increase productivity by speeding up the process through proper utilization of man and machine. Many factors like material handling systems, manufacturing process and layout decide the production rate of production line. Selection and implementation of appropriate Lean strategies is very important in order to make achieve desired result.

This project will aim to identify and eliminate the wastes in the total production process using Standard Work Combination Table (SWCT) tool, which will directly give the clarification about auto, manual and walk time of worker's motion.

Keyword **-** Standardized Work Combination Table, Cycle Time, Maynard Operational Sequence Technique, Work In Process,. Sub assembly, Standard Operating Procedure, Process Flow Chart. Gear Train Housing

I INTRODUCTION

Any organization whether manufacturing or service has some kind of waste in its process and therefore it is very important for any organization to Identify, Reduce & Eliminate waste in order to become Lean. There are many components of competitiveness, continual improvement of the Material and Information flow via waste elimination is one of the most important components. Waste elimination is an effective way to increase profitability. Mahindra Heavy Engines Pvt. Ltd. (MHEPL) was formed in 2007 in 22.6 acres at Chakan, Pune (Maharashtra)**,** to produce diesel engines for medium and heavy commercial vehicles in India. MHEPL is a technology leader in diesel engines market; its aim is to integrate the best of theirs expertise to bring in India durable and cleaner engines.

MHEPL's first engine, the six cylinder, 207 HP m Power engine, is already powering 25 and 31 ton Mahindra Trucks. The m Power platform consists of 4 and 6 cylinder medium speed engines with power range from 100 HP to 260 HP. These engines are available in both mechanical and electronic fuel injection system variants. The electronic common-rail Generation 3 version is the most advanced engine available on Indian roads. At the core of Mahindra trucks' high performance is the m-Power engine. In terms of product configuration and component technology, the m-Power engines are some of the most modern engines in the HCV segment in India. But, there's a lot more than just modern components that make m-Power best in the class. With four valves per cylinder, the engine has been designed for better fuel efficiency, higher power, and better performance. The engine has proven its integrity with local components in tests lasting a total of 15000 hrs

Key Specifications	
Specifications	6.12TCA
Emission compliance	BS III Compliant
Configuration	6 Cylinder, In line
Valves/ Cylinder	4
Displacement (cc)	7118
Bore (mm)	105
Stroke (mm)	137
Combustion System	Direct Injection
Injection System	VE Mechanical
Aspiration	Turbo Intercooler
Max Power output Kw (HP) @ rpm	151 (202) @ 2200
Peak Torque N-m @ rpm	920@1250
Compression Ratio	16.1:1

2. PROBLEM DEFINITIONS

Indian market and economy is continuously growing and India is becoming hub for manufacturing activity now a days. This growth is supported by Construction, automobile, mining and alternate energy generators industries. For this there is requirement of Diesel engines, which is why there is a growth in demand of fuel efficient diesel engines. Main business of MHEPL is to manufacture and deliver diesel engines for heavy transport trucks, generators and earth moving equipment etc. All the required parts, subparts etc. for this manufacturing are collected from localized venders/suppliers. Then these parts are assembled together on various stations to complete engine assembly process. In whole production system engine assembly is bottleneck process, and is determining the number of engines produced per day or shift by the company. Currently MHEPL is producing 21 engines per shift, but due to increase in demand company wants to increase their productivity. MHEPL is targeting for 25 engines per shift to fulfil customer's demands. For the study purpose we selected Mechanical Auto engine, as the demand compared to other types of engine is 80:20. So for achieving the customer demand we concentrated only on the Auto engine for SWCT studies

		Productivity index/worker
Current production	21 engines/ shift	1.2352
MHEPL Target	25 engines/shift	1.4705

2.1 Motivation

In today's era of competition, lagging in targeted production influences organization and every individual in organization negatively. Improving productivity to get advantage in this competitive market has always been a major issue for most manufacturing organization. It is very important to maximize production rate to stand in competition. Production improvement increases the production rate as well as drives company to the better future. By reducing waste, productivity can be enhanced.

2.2 Objective Of Work

Ultimate objective of this project is to identify the wastes in the assembly and testing process and to eliminate them. Reducing waste of motion and increasing productivity of system is main aim of this project; this can be achieved by implementing Standardized work combination table (SWCT) technique. In particular this project will determine following for assembly and testing for Diesel engine manufacturing:

1. Activity details
2. Manual Time
3. Machine Time (Auto)
4. Walking Time
5. Waiting Time
6. Total Work Content
7. Workforce requirements
8. Work distributions at every station
9. % utilization of Associate.
10. Current operating procedure
11. Comparison between SOP and actual operating procedure.

3. LITERATURE REVIEW

What is standardized work?

Standardized work is an important tool for manufacturing high-quality products with fewer work processes. It concentrates on human movements, setting up the best work sequence for each production and assembly process. Once the most efficient sequence has been determined, it is always repeated in exactly the same way, so that workers can always avoid unnecessary motion and wasted effort. And besides maintaining quality and efficiency, Standardized work guarantees safety, and prevents equipment damage.

The standardized work combination table (SWCT) provides the time combination of manual work, walk, and machine processing (Auto) for each operation in a production sequence. This form is a more precise process design tool than the Operator Balance Chart. It can be very helpful to identify the waste of waiting and overburden, and to confirm standard work in process (WIP).

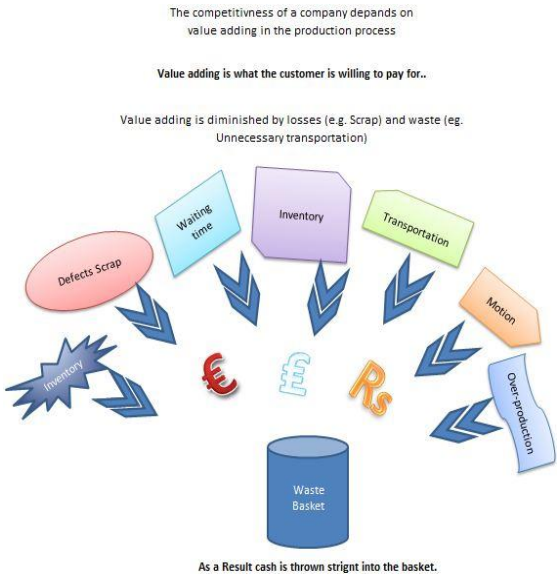
The SWCT is one of three basic forms for creating standardized work, along with the standardized work chart and job instruction sheet. The purpose of standardized work, according to Kaizen Express from which this form is taken, is to provide a basis for continuous improvement through kaizen.

Standardization has an effect on each of following

- Safety
- Quality

- Efficiency
- Productivity.

If we deviate from the standard, safety could be jeopardized; quality could be affected because we did not follow the standard, which in turn, affects efficiency and productivity.



- Overproduction - Example would be producing 500 when the customer needs 450, or running components at a much faster rate than the assembly, if the component line supports only that assembly line.

Number of Active Asso.	17
Supporting Asso.	01
Total Asso.	18
Number of total stations	28
Number of active stations	25
Buffer Stations	03
Sub assembly stations	13
Time in shift(Min)	480
Tea Brake (5*2) (Min)	10
Total Available time for productions(Min)	470
Overall Equipment Efficiency (OEE)	90%
Manning	3 stage
Conveyor speed(3 stage manning)	0.15 m/min
Distance between two stations on conveyor	2.75 meters
Current Production	21Engines/shift

- Correction - premium freight, rework, scrap
- Material Movement / Transportation - extra fork trucks, drivers have unbalanced work schedule, multiple storage areas.
- Excess Processing - excessive approvals, redundant processes, reports with too much information, reports that you don't use.
- Inventory – stagnated material flow, fish instead of fifo, massive rework campaigns when problems surface, long lead times, slow response to changes in customer demands.
- Waiting - man waiting for machine, man waiting on man, machine waiting for man, unbalanced operations (work), unplanned downtime.
- Motion - excessive walk time, tools not in easy reach or not stored at equipment, unpacking and rearranging of parts by the operator, container too large for worksite.
- Lack of Employee Involvement, no suggestion scheme, not listening to the ideas of the employees.

4. METHODOLOGY

For preparing the SWCT first thing to do is to list out various activities in each stations. The sequence of activities should be as follows:

1.
bserve current method
2.
ocument current method
3.
dentify improvements (steps to eliminate)
4.
mplement improvements
5.
alidate quality and productivity of new method
6.
tandardize new method
7.
ocument "Before" and "After" conditions
8.
ecognize achievements
9.
ook for next improvement

In the starting we observed the current process of assembly, Testing and post test for 4 days to get familiar with the operations, terminology used, processes, stations, sub assemblies and part names. Then detailed study of PFC, SOP, and combination matrix chart is done. By this way the current method is understood in detail. Depending upon the huge data collected as per requirements of SWCT following observations we got:

Initially for loading and station number 1 data is collected directly from the line. For completing only one stations it required 1 months. Also assembly line is running only twice or thrice a week. So to follow and achieve the time line video recording of the activities is performed. This helped in the way that there is no requirement of standing continuously on the line, time of the activity can be easily noted down directly from time of video so no need of stopwatch. If some activity is missed than it can be identified again by rewinding the video.

For getting the accurate reading 5 times video of each station is taken and the average value is considered for the calculation purpose. From the videos activities are listed out first, then they are classified into manual (can't performed without human contact), Auto (Machine work) Walk (Walking between the activities), Waiting (Waitng for activity to finish). Timing of each activity is noted down from the video and grouped in respective type. Here is the examples of activity listing and timing readings for station no 5-II, Piston Conrod S/A, rigging in testing and Post test activities.

ti	OP n	Proces	Element	Cate	RD	RD	RD	RD	RD	Avg	Man	Au	Wa
Station 5-II													
5-II	1170b	Assemble Piston-Conrod in block	Pick liner clamping bolts from kit tray and e	Manual	21.00	26.00	33.00	25.00	28.00	26.60	26.60		
			Tight the clamping bolts using pneumatic	Manual	19.00	15.00	18.00	17.00	16.00	17.00	17.00		
			Bring Conrod cap tightening gun to block	Manual	9.00	4.00	4.00	6.00	6.00	5.80	5.80		
			Tight conrod cap bolts	Manual	25.00	20.00	19.00	20.00	25.00	21.80	21.80		
			Keep the Tightening gun back	Manual	7.00	4.00	6.00	4.00	3.00	4.80	4.80		
			Rotate crank by 120°	Manual	2.00	2.00	2.00	3.00	2.00	2.20	2.20		
			Repeat above 4 steps twice	Manual	86.00	60.00	62.00	66.00	72.00	69.20	69.20		
			Inspection using torch and clearance gauge	Manual	30.00	17.00	15.00	17.00	28.00	21.40	21.40		
	1180	Piston-projection checking,	Rotate the pallet	Manual	12.00	11.00	17.00	16.00	12.00	13.60	13.60		
			Walk to tool post and pick dial gauge	Walk	10.00	6.00	7.00	7.00	6.00	7.20			7.20
			Walk back to pallet	Walk	5.00	3.00	3.00	3.00	6.00	4.00			4.00
			Checking and filling route card	Manual	84.00	94.00	90.00	93.00	85.00	89.20	89.20		
			Walk to tool post and put back dial gauge	Walk	4.00	8.00	4.00	5.00	4.00	5.00			5.00
			Enter data into protrusion testing software	Manual	24.00	24.00	19.00	23.00	23.00	22.60	22.60		
			Walk back to pallet	Walk	6.00	5.00	7.00	8.00	5.00	6.20			6.20
			Take TDC setting fixture and walk to next j	Walk	22.00	14.00	16.00	10.00	16.00	15.60			15.60
			Fix TDC setting fixture on next job	Manual	13.00	8.00	10.00	10.00	13.00	10.80	10.80		
			Walk back to start line	Walk	5.00	7.00	6.00	6.00	7.00	6.20			6.20
			STATION 5-II SUMMERY							349.20	305.00	0.00	44.20

VALVE COVER S/A										
Take 6 Valve cover from bin and place on sub assembly station	Manual	10.00	8.00	11.00	9.00	8.00	9.20	9.20		
Take valve cover Gasket from bin and assemble with valve cover	Manual	6.00	5.00	4.00	5.00	5.00	5.00	5.00		
Lift valve cover gasket S/A and put it in bin	Manual	2.00	3.00	2.00	3.00	3.00	2.60	2.60		
Repeat above stapes 5 times	Manual	40.00	40.00	30.00	40.00	40.00	38.00	38.00		
Transfer bin from sub assembly station to main line	Walk	7.00	6.00	6.00	6.00	7.00	6.40			6.40
Take Bolt and O ring bines from rack	Walk	7.00	0.00	0.00	0.00	0.00	1.40			1.40
Take Empty bin from rack	Walk	6.00	0.00	0.00	0.00	0.00	1.20			1.20
Take Bolt and O ring from respective bins and assemble with eac	Manual	4.00	4.00	4.00	4.00	4.00	4.00	4.00		
Put bolt assembly in empty bin	Manual	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Put every bin back to its initial position	Walk	16.00	0.00	0.00	0.00	0.00	3.20			3.20
Walk back to start line	Walk	2.00	3.00	2.00	3.00	4.00	2.80			2.80
							74.80	59.80	0.00	15.00

Station no	OP no	Process	Element	Categorized	RD 1	RD 2	RD 3	RD 4	RD 5	Avg.	Manual	Auto	Walk
				Up Fitment									
Up Fitment	5050	Assembly of HP nut bush, cable tie, polythene bag to coolent outlet	Walk to the pallet truck from starting point	Walk	5.00	7.00	4.00	5.00	6.00	5.40			5.40
			Move pallet truck from its position to test engine	Walk	19.00	18.00	22.00	31.00	21.00	22.20			22.20
			Bring engine near post test area	Walk	23.00	38.00	27.00	33.00	29.00	30.00			30.00
			Keep pallet truck back to its position	Walk	13.00	8.00	14.00	14.00	12.00	12.20			12.20
			Walk back to post test area	Walk	8.00	4.00	5.00	5.00	5.00	5.40			5.40
			Put hand gloves on	Manua	7.00	2.00	8.00	11.00	9.00	7.40	7.40		
			Take HP nut bush from rack	Manua	10.00	7.00	6.00	10.00	8.00	8.20	8.20		
			Mount bush on HP pipes	Manua	19.00	20.00	17.00	20.00	19.00	19.00	19.00		
			Take bush pressing tool from tool post	Manua	3.00	5.00	4.00	5.00	5.00	4.40	4.40		
			Press bush into HP pipes and keep tool back	Manua	13.00	17.00	12.00	16.00	14.00	14.40	14.40		
			Take cable ties and polythene bag from the rack	Manua	6.00	10.00	7.00	8.00	8.00	7.80	7.80		
			Attach cable ties and polythene on engine cooler	Manua	24.00	30.00	24.00	23.00	26.00	25.40	25.40		
			Take cutter from tool post and cut extra tie	Manua	17.00	30.00	14.00	11.00	18.00	18.00	18.00		
	5025	Assemble alternator bracket-auto	Take screwdriver from rack and correct the gap	Manua	17.00	18.00	20.00	14.00	18.00	17.40	17.40		
			Take alternator bracket bolt and fix it on block	Manua	15.00	19.00	11.00	23.00	17.00	17.00	17.00		
			Take alternator bracket and assemble on engine	Manua	41.00	35.00	39.00	45.00	40.00	40.00	40.00		
	5040	Pilot bearing fitment in flywheel	Take Pilot bearing, fixing tool and hammer from rack	Manua	11.00	11.00	13.00	15.00	13.00	12.60	12.60		
			Fix bearing into flywheel	Manua	15.00	20.00	8.00	11.00	14.00	13.60	13.60		
	5060	Assembly of protection cap	Take Protection caps from rack	Manua	24.00	26.00	20.00	24.00	24.00	23.60	23.60		
			Fix caps on the engine	Manua	78.00	84.00	64.00	76.00	26.00	65.60	65.60		
	5070	Checking of resistance of water temprature sensor	Check the front cover bolt with torque wrench	Manua	35.00	40.00	28.00	43.00	37.00	36.60	36.60		
			Checking of resistance of water temprature sensor	Manua	14.00	17.00	13.00	19.00	15.00	15.60	15.60		
			Put back the resistance measuring device back	Walk	17.00	13.00	9.00	11.00	13.00	12.60			12.60
	5090	Apply antirust	Apply antirust onto engine parts	Manua	124.00	100.00	130.00	130.00	121.00	121.00	121.00		
	5030	Sump & Front cover bolt re-torque	Bring hoist back to post test area	Walk	29.00	40.00	24.00	28.00	34.00	31.00			31.00
			Engage hooks to engines and lift engine up	Manua	22.00	14.00	11.00	8.00	14.00	13.80	13.80		
			Move engine to foot mounting area	Walk	16.00	31.00	36.00	42.00	34.00	31.80			31.80
			Tight all oil sump bolts	Manua	58.00	74.00	57.00	64.00	62.00	63.00	63.00		
	5010	Engine foot fitment	Bring engine at lower hight to moung engine legs	Manua	16.00	31.00	12.00	13.00	18.00	18.00	18.00		
			Legs fitting on engine	Manua	53.00	64.00	47.00	47.00	53.00	52.80	52.80		
		Engine Draining	Move engine to oil draing area	Walk	27.00	30.00	25.00	29.00	28.00	27.80			27.80
			Mounting engine on oil draining fixture	Manua	16.00	23.00	15.00	12.00	17.00	16.60	16.60		
			Change hand gloves	Manua	8.00	8.00	10.00	14.00	11.00	10.20	10.20		
			Take wrench and loosen oil drain bolt	Manua	10.00	17.00	14.00	21.00	16.00	15.60	15.60		
			Remove bolt by fingers spinning	Manua	23.00	28.00	21.00	16.00	23.00	22.20	22.20		
			Oil draining	Auto	120.00	120.00	120.00	120.00	120.00	120.00		120.00	
			Draing bolt fixing and tightning	Manua	47.00	56.00	61.00	37.00	51.00	50.40	50.40		
			Attaching oil filling pump to block and start filling	Manua	10.00	11.00	11.00	11.00	11.00	10.80	10.80		
			Oil filling	Auto	100.00	100.00	100.00	100.00	100.00	100.00		100.00	
			Check list filling and report writing	Manua	91.00	76.00	101.00	70.00	85.00	84.60	84.60		
			Walk to oil filling station and put gloves on	Walk	10.00	12.00	10.00	11.00	11.00	10.80			10.80
			Put filling pump back & Oil level checking using dip	Manua	16.00	16.00	19.00	21.00	19.00	18.20	18.20		
			Put Covering and dip stick back	Manua	11.00	7.00	9.00	10.00	10.00	9.40	9.40		
			Lift engine	Walk	20.00	18.00	24.00	18.00	21.00	20.20			20.20
			Clean and check oil drain bolt	Manua	32.00	20.00	15.00	22.00	23.00	22.40	22.40		
			Move to foot fitment area	Walk	12.00	20.00	11.00	14.00	14.00	14.20			14.20
			Removal of engine foots	Manua	41.00	34.00	33.00	31.00	33.00	34.40	34.40		
	5020	Compressor support bracket fitment	Take compressor support bracket and bolts from	Walk	10.00	9.00	15.00	12.00	12.00	11.60			11.60
			Fix compressor support bracket on block	Manua	12.00	8.00	12.00	11.00	11.00	10.80	10.80		
			Take nut runner and fix the bolts (Change socket	Manua	14.00	26.00	14.00	18.00	19.00	18.20	18.20		
			Put engine on pallet back again	Walk	53.00	47.00	42.00	36.00	45.00	44.60			44.60
			Put Hoist back to parking area	Walk	11.00	18.00	9.00	12.00	13.00	12.60			12.60
			Marking and inspection	Manua	59.00	73.00	36.00	72.00	45.00	57.00	57.00		
			Walk to pallet truck	Walk	30.00	28.00	60.00	19.00	35.00	34.40			34.40
			Bring Pallet truck to post test area	Walk	32.00	27.00	28.00	46.00	34.00	33.40			33.40
			Attach check list with route card	Manua	8.00	9.00	18.00	15.00	17.00	13.40	13.40		
			Keep engine after post test area	Walk	22.00	18.00	24.00	28.00	24.00	23.20			23.20
			Keep pallet truck back to its parking area	Walk	21.00	19.00	16.00	17.00	19.00	18.40			18.40
			Walk back to initial line	Walk	8.00	9.00	7.00	8.00	7.00	7.80			7.80
										1639.00	**1009.40**	**220.00**	**409.60**

St. no.	OP no	Process	Element	Categorized time	RD 1	RD 2	RD 3	RD 4	RD 5	Avg.	Manual	Auto	Walk
Rigging	NA	Mounings on engine	Remove all the protection Caps from the engine and put on the	Manual	19.00	14.00	15.00	13.00	20.00	16.20	16.20		
			Bring hoist near test engine	Walk	4.00	6.00	5.00	11.00	6.00	6.40			6.40
			Engage hooks with the engine	Manual	7.00	12.00	10.00	12.00	12.00	10.60	10.60		
			Lift the engine and bring it at near station for foot mountings	Walk	22.00	29.00	25.00	28.00	25.00	25.80			25.80
			Mounting four foots	Manual	40.00	38.00	39.00	50.00	42.00	41.80	41.80		
			Bring the engine near testing skid	Walk	16.00	13.00	15.00	15.00	15.00	14.80			14.80
			Rest the engine on engine testing skid	Manual	38.00	30.00	34.00	30.00	32.00	32.80	32.80		
			Remove the tackle hook & park hoist on its position	Walk	13.00	14.00	14.00	13.00	15.00	13.80			13.80
			Engage Fuel inlet, outlet, Water intake pressure QRC pipe, Air	Manual	40.00	39.00	40.00	43.00	45.00	41.40	41.40		
			Aline the flywheel adaptor with engine flywheel	Manual	10.00	11.00	11.00	11.00	10.00	10.60	10.60		
			Engage few adaptor bolts	Manual	6.00	7.00	7.00	7.00	8.00	7.00	7.00		
			Remove adaptor holding tool	Manual	16.00	5.00	11.00	4.00	7.00	8.60	8.60		
			Engage remaining adaptor bolts	Manual	20.00	21.00	21.00	25.00	20.00	21.40	21.40		
			Change the Socket of pneumatic gun	Walk	5.00	9.00	7.00	5.00	6.00	6.40			6.40
			Tighten Air intake & water intake Pipes	Manual	9.00	14.00	12.00	13.00	18.00	13.20	13.20		
			Walk to other side of engine	Walk	10.00	7.00	9.00	8.00	11.00	9.00			9.00
			Check engine oil level with dip stick	Manual	5.00	4.00	5.00	6.00	7.00	5.40	5.40		
			Pick the dip stick hole dummy cap from skid & engage with dip	Manual	8.00	8.00	8.00	6.00	8.00	7.60	7.60		
			Pick air compressor dummy plate from skid & engage with air	Manual	12.00	28.00	20.00	22.00	21.00	20.60	20.60		
			Tightening of dip stick hole dummy cap with wrench	Manual	6.00	3.00	5.00	5.00	4.00	4.60	4.60		
			Place water outlet on water manifold	Manual	5.00	6.00	6.00	5.00	6.00	5.60	5.60		
			Install intercooler intake hose on the engine	Manual	32.00	25.00	29.00	25.00	31.00	28.40	28.40		
			Mount engine exhaust connection	Manual	16.00	16.00	16.00	15.00	16.00	15.80	15.80		
			Take Screwdriver and fix bypass connection hose on water	Manual	19.00	16.00	18.00	20.00	13.00	17.20	17.20		
			Take nut runner and fix all the nut on exhaust side.	Manual	26.00	20.00	23.00	23.00	21.00	22.60	22.60		
			Take the socket from the table and torque all the flywheel adaptor	Manual	58.00	52.00	55.00	56.00	58.00	55.80	55.80		
			Walk back to start line	Walk	6.00	7.00	7.00	5.00	6.00	6.20			6.20
										475.20	**387.20**	**0.00**	**88.00**

Same method is repeated for all 25 stations, 13 sub assemblies, Testing and post test activities. Further analysis is done considering line balancing philosophy which starts with TAKT time as input and output as standerd work instruction with balanced line and equally distributed work. Steps followed are shown in next figure

Depending on the data collected from standard activities charts Standerd Work Combination Table is prepared. Using this SWCT analysis is done. Following are some of the examples of SWCT charts.

5. IMPROVEMENT AND RESULT

Type Of Waste	Improvement	Action Plan	Effect on WC in min	Time (Week)
Ready to use material	Filter	All the coverings, protection caps etc are removed by a person at super market area before being introduced into assembly line.	about 5 minutes	2
	Bearings			
	Piston			
	LDA Tube			
	Pulley			
	Turbo Charger			
	FIP			
	Block			
	Front Cover			
	Air Compressor			
	HP Pipes			
Excess Motion	From St. 1 to St. 18 for getting pallet bolts	Better layout and line balancing	about 4 minutes	3
	For loading block onto conveyor A			
	For Unloading to GTH S/A			
	From St. 7 to Front cover S/A			
	From Belt Tensor pulley S/A to St. 24			
	Between various S/A on conveyor C			
	From end of Conveyor C to End of Conveyor B with Legs Trolley			
	From end of Conveyor C to Unloading station for fixing protection Caps			
Transportation	Engine transfer from conveyor B to C	Layout modification and automation	about 4 minutes	3
	Engine transfer from assembly to testing			
	Cylinder head S/A to main line			
	GTH S/A to main line			
	PCR S/A to main line			
	Belt Tensioner pulley from press to St. 24			
	Engine Legs			
Material Handling	NA			
Inspection	Crank shaft	Inspection should be done by quality department before it assembled on assembly line	about 1 minute	2
	Cam Shaft			
	FIP setting TDC			
	Water and Oil Pump			
	Turbo Charger			
	Cylinder head S/A			
	Intake Manifold S/A			
	Water manifold S/A			
Line Balance	Station No.17	Line balancing according to TACT time, and feasibility	Reduction in cycle time	3
	Station No.12			
	Station No.20			
	Station No.22			
	Station No.26			
WIP Waiting	During Breather Housing S/A	Main line associate should work only on	About 10 min	2
	During Front Cover S/A			
	During Crankshaft damper S/A			

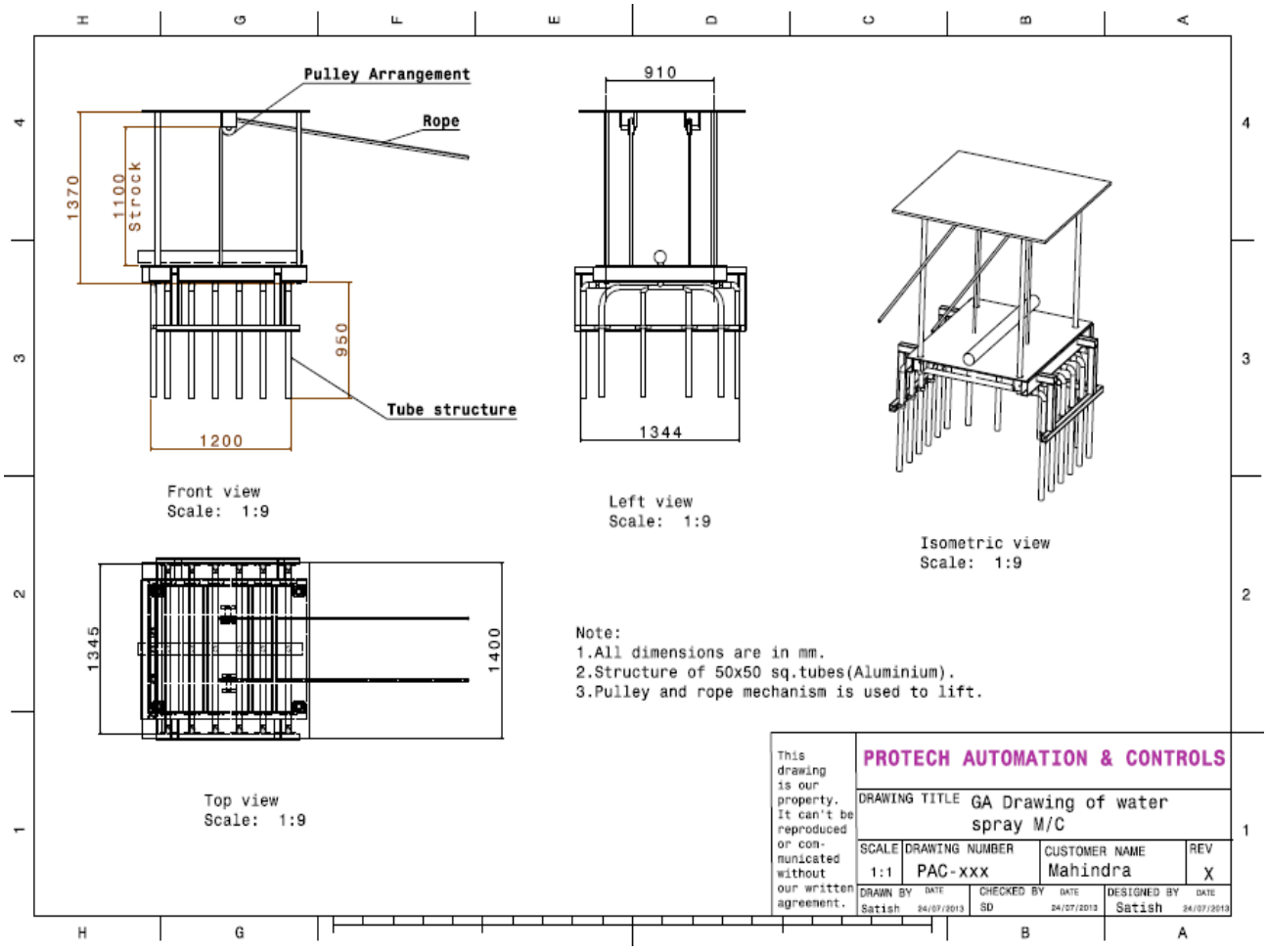
	During Crankshaft Gear Heating and pressing	main line not on sub assembly		
Standardization	Legs fitment at St. 18	Standard working procedure and instrument provision	About 2 min	6
	Turbo Charger fitment			
	Number Plate fixing			
	Unloading pallet change			
Automation	Sealant application on front cover	Special profile machines for sealant application and special machine for stud fitment same as cyl head bold fitment.	about 4 minutes	8
	Sealant application on block before oil sump fitment			
	Oil sump bolt fitting			
	Stud fitment			
Simultaneous Operation	Pretightning of MB cap bolts using medium torque	Change in SOP	about 5 minute	1
	Pretightning of Cyl head bolts using medium torque			
	During Leak testing			
	During name plate punching			
	Fitting of piston Con rod			

Improvement plans

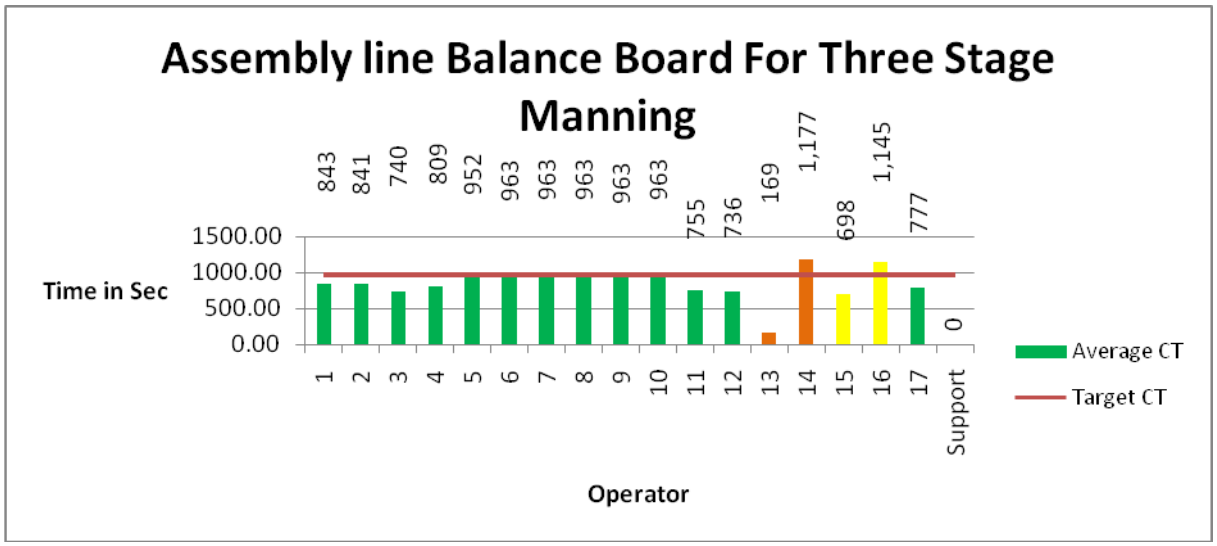
Sr. No.	St.	Observation	Action	Time Saving/ engine in sec.	Investment in Rs	Dept.
1	1	4 & 6 cyl. Set up change	Quick change plates	90	600,000	ME
2	5I	Conrod tigtening	Provide 2 piston cone & simultanious tightening	12	NA	ME/ Tooling
3	3-4	Gth to PCR sub assembly travel time	Relayout to reduce travelling time	10	NA	ME/ Maint/ Prod
4	All	Stage boundary confusion (pause pressed before stage over)	Provide yellow mark on movable track side to identify & stop conveyor	0	300	Utility
5	8	Press not avaible for pressing & travelling distance is 67 steps	Provide separate pressing unit at conv. C	8	150,000	ME
6	7	Compressor unpacking takes 13 sec.	Provide unpacked compressor Provide dedicated trolley	13	42,000	SCM
7	22	Valve cover O-ring inpacked condition	Provide without plastic bag.	1	NA	SCM
8	21	Valve drive lub. tube	Remove banjo caps & supply in bin	26	NA	SCM
9	17	Oil filter paking need to be removed	Provide as per genset packing - single pack for all filter	4	NA	Material
10	27	Exhaust elbow stover nut difficult to assemble	Provide flange nut as per 0301BAV00040N	18	NA	Engineering
11	24	Exhasut stud tigtening takes 9 sec per stud	Use of special stud driver of M10	36	75,000	ME
12	23	HPP tigtening takes more time	Provide tube crow foot type special nutrunner	24	380,000	ME
13	5	Conrod MSNR initial speed is very less	Increase initial speed of conrod tigtening	12	NA	ME/ Maint
14	12	Flywheel housing projection checking	Provide separate master to set dial	4	1,000	ME

		need zero setting on block				
15	12	Flywheel housing face & radial run out takes more time	Provide special gauge to check runout	4		ME
16	12	Front cover sealent dispencing requires more time	Provide dedicated dispencing machine	40	500,000	ME
17	12	Front cover sealent dispencing requires more time	Provide pneumatic manual dispensing gun	10	10,000	ME
18	17	Bolt pick up time is more	Provide dedicated tray to store bolt	3	800	ME
	TOTAL			**312**	**1,758,300**	

1. For Washing Mechanisum in testing



2. Using one extra associate



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5. *Fat to Lean Journey of Waste Elimination by Divyakuma*

