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Optimize Efficiency of Assembly Line by Time Study and Line Balancing

Mr. Dattu B. Ghane

Lecturer in Mechanical Engineering, Government Polytechnic Awasari (Khurd), Pune, Maharashtra, India

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Abstract- *Time study and line balancing methods are used frequently to maximize the production, improve the per day production, minimize the production cost and find out the time during a product making and to minimize the wasting time. These methods mainly utilized to increase the efficiency of assembly line with implementing the necessary findings from the study. We have carried out the time study and line balancing at ATLAS COPCO INDIA LIMITED, Chakan plant, pune. This plant is manufacturing of screw type Air compressors on assembly line named as LINE 2 (11-30 KW). The types of models manufactured on available line are GAE11-30, GA15-22, CPB etc. Analysis of available data is done and selected the Line No. 2 for time study and line balancing along with OGR-GAE 11-30 FF, O-GA15-22 TMFF and CPB TMD these three air compressor models assembled on this line. After the successful time study and line balancing assembly line efficiency increases by 33%, fatigue and movement of worker decreases, man-hours per machine for assembly is reduced by 11.5%, Available resources are utilized with design modifications resulting reduction in required main and subassembly workstations with same productivity. Also advance tooling used for critical and time consuming operations which has great positive impact on efficiency. These improvements results in reduction of manufacturing cost per compressor and increase in overall profit of organization.*

Key Words: Optimization, Efficiency, Assembly line, Time study, Line balancing etc.

1. INTRODUCTION

Time study and line balancing are the scientific methods designed by two different people for the same purpose, to increase productivity and reduce unit cost. Time study is the one element in scientific management beyond all others making possible the transfer of skill from management to men. Frederick W. Taylor 1881, he started to develop time study Taylor designed Time Study, it measures how long it takes a average worker to complete a task at a normal place. It helps management to determine how much product can be produced by workers in a specific period of time, therefore making it easier to predict work schedules and output. The study based on time and line balancing has been carried out at ATLAS COPCO INDIA LIMITED, Chakan plant, pune. This plant is manufacturing of screw type Air compressors. Atlas Copco having various assembly lines for various ranges of products. We have completed said study on assembly line named as LINE 2 (11-30 KW). The types of models manufactured on available line are GAE11-30, GA15-22, CPB etc. This line containing six main assembly and two subassembly work stations in existing layout before doing time study and line balancing work. Tools used for time study are Stop watch and Video recording camera. The main objectives of this studies are To reduce or eliminate nonproductive and non-value added time, Increase efficiency of assembly line, To fix standard time for doing the activity, To develop standard data for future reference, To improve process and product quality, Remove sub assembling out from line, Reduce manpower requirement per machine, Improve material handling activity and time required, Equal distribution of work contain in all stages, One piece material flow. Smart kitting and sequence material logistic concept, Tools distance and walking distance reduction, Correct and advance tooling selection for assembly operation and Reduce workspace if possible.

2. METHODOLOGY

Procedure adopted for study followed as given below:

1. Select – The job to be timed.
2. Define - The element, break the job into element convenient for timing.
3. Obtain and Record – Detail recording method, operator, job and working condition.
4. Extend – Observed time into normal time (basic).
5. Measure – Time duration for each element and assess the rating.
6. Compute – Standard time for the operation for defined job.
7. Determine – Relaxation and personal allowance.

3. STATEMENT OF THE PROBLEM

3.1 Time record before study start

Product	No. of Work Stations	Takt Time (Min.)	No. of Workmen Deployed	Total Time per Machine (Min.)	Standard Time (Min.)	Efficiency (%)
GAE 11-30 P	8	48	10	480	330	68.75
OGR-GAE 11-30 FF	8	48	10	480	390	81.25
GA15-22FMP	8	48	10	480	300	62.5
GA15-22FMFF	8	48	10	480	360	75
GA15-22 TMP	8	48	10	480	330	68.75
O-GA15-22 TMFF	8	48	10	480	390	81.25
CPB	8	48	10	480	300	62.5
CPB TMD	8	48	10	480	360	57
					Average Efficiency (%) =	69.69

Now average efficiency of this line no 2 is 69.69 % for including all 8 machines per shift. So we have to improve the efficiency of line by minimization or elimination of losses. So we have selected the three models for study having minimum and maximum efficiency out of these eight models. Hence models for study selected are 1) OGR-GAE 11-30 FF, 2) O-GA15-22 TMFF and 3) CPB TMD.

4. EXPERIMENTATION / MEASUREMENT

4.1 Input Data / Structure / Questionnaire

As per standard time study procedure, a skilled, well trained worker should be deployed to complete the work and activity will be video recorded. In addition stop watch required for macro level time recording. Actual clock reading for time is as given below.

Station Number	Details of Operation	Existing Timings (Min.)			Clock Reading (Min.)		
		OGR-GAE 11-30 FF	O-GA15-22 TMFF	CPB TMD	OGR-GAE 11-30 FF	O-GA15-22 TMFF	CPB TMD
ST1	Frame mounting	27	27	52	18	33	43
SA2	Element subassembly	96	96	48	87	90	37
ST2	Element mounting	21	21	52	10	10	10
SA3	Vessel subassembly	30	30	30	58	52	31
ST3	Vessel mounting and piping	48	48	48	58	72	34
ST5	Cooler and control panel assembly	136	136	136	57	122	63
ST7	Dryer and fan assembly	48	48	48	47	50	30
ST9	Canopy work and finishing	48	48	48	40	45	37

4.2 Material flow Data:

No of working stations: 8,
No of sequence material trolleys per machine: 7,
No of material handling labors: 2.
No of subassembly stations: 2,
No of kitting material trolleys per machine: 3,

4.3 Existing Layout of Assembly Line

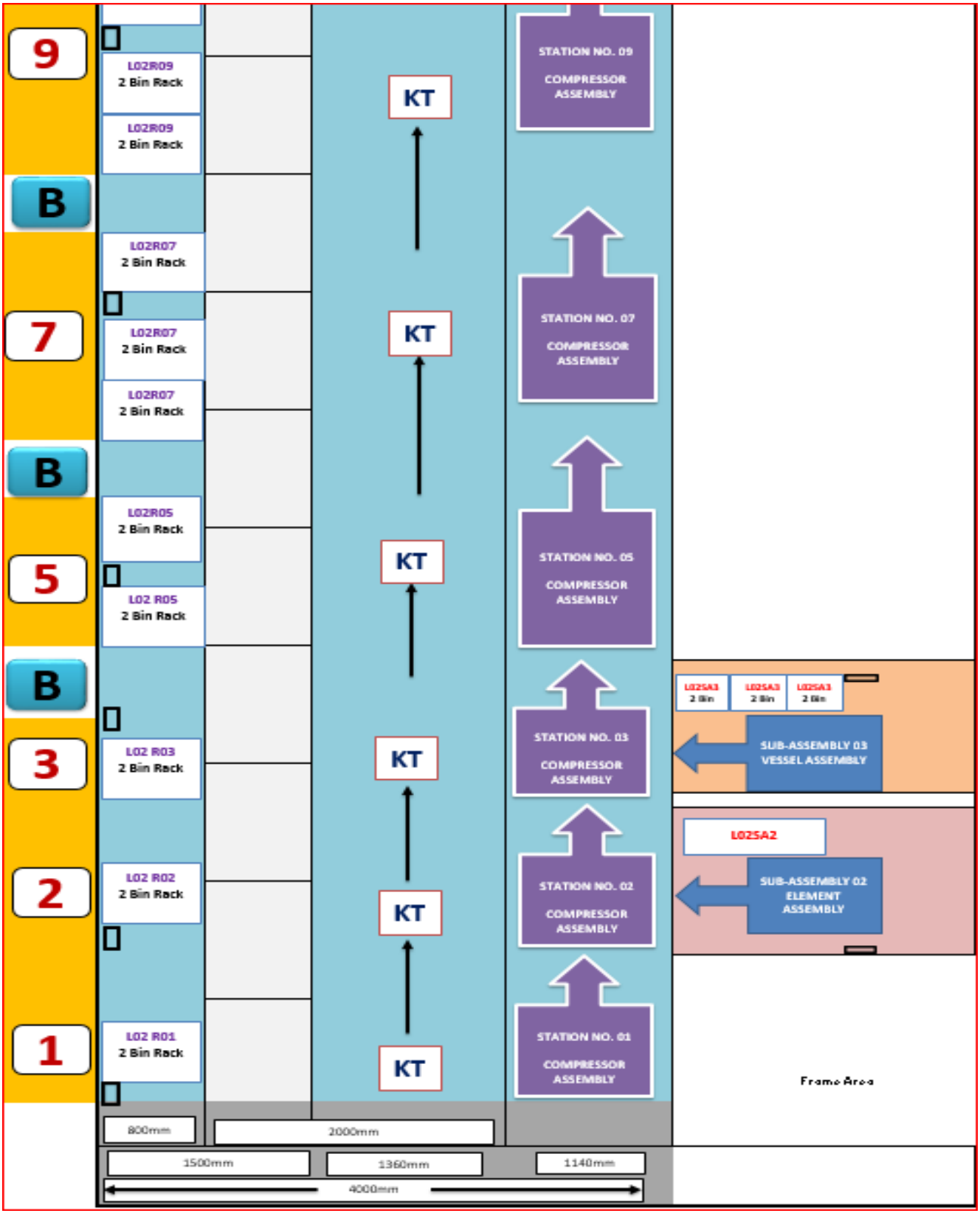

Figure: 4.3.1 – Exsisting Layout of Assembly Line

5. ANALYSIS/SOLUTION/DESCRIPTION

WORKLOAD BALANCE AND CORRECT NUMBER OF RESOURCES TO MAKE LINE EFFICIENT

Station No	Name of Element	Standard time	Total time in station	No of operators to be deployed	Availble time (minutes)	Customer Demand	TAKT time (minute)
ST-1	Motor and element coupling	48	66	1	435	6	72.5
	Frame Mounting	7					
	Motor Assembly Mounting	11					
ST-3	Vessel Assembly	21	62	1			
	Vessel Mounting	41					
ST-5	OP1 + OP2 (Activity from 1 to 5)	43	69	1			
	OP1 + OP2 (Activity from 6 to 29)	26					
ST-7	Fan Assembly, Dryer Assembly,	73	73	1			
	Fan Assembly, Dryer Assembly, (Activity 28 to 36) +AF Assembly, Hose piping, Canopy stage, Electrical, Number plates						

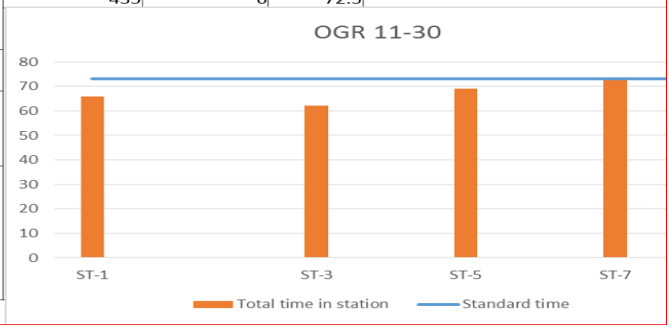

Figure: 5.1 – Analysis for OGR-GAE 11-30 FF product

WORKLOAD BALANCE AND CORRECT NUMBER OF RESOURCES TO MAKE LINE EFFICIENT

Station No	Name of Element	Standard Time required	Total time in station	No of operators to be deployed	Availble time (minutes)	Customer Demand	TAKT time (minute)
1	Element Subassembly	0:50:00	1:14:35	1	435	6	72.5
2	Motor and Element assembly mounting	0:13:49					
3	Tank Frame Mounting	0:10:46					
4	Vessel Assembly	0:29:20	1:10:29	1			
5	Vessel Mounting	0:41:09					
6	Control Panel Assembly Wiring	1:09:54	1:09:54	1			
7	Dryer Assembly, Hose Connection	1:13:19	1:13:19	1			
8	Canopy Stage						

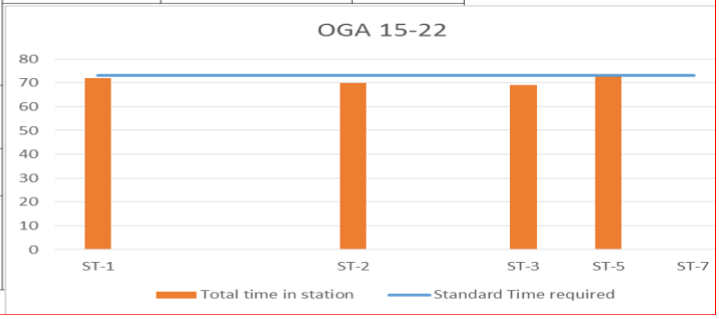

Figure: 5.1 – Analysis for O-GA15-22 TMFF product

WORKLOAD BALANCE AND CORRECT NUMBER OF RESOURCES TO MAKE LINE EFFICIENT

Station no	Name of Element	Standard Time	Total time in station	No of operators to be deployed	Availbale time (minutes)	Customer Demand	TAKT time (minute)
ST-1	Element SubAssembly	20	56	1	435	6	72.5
	Tank Mounting	26					
	Element Mounting	10					
ST-3	Vessel Sub Assembly	18	39	1			
	Vessel Mounting	21					
ST-5	Control Panel Assembly	45	44	1			
ST-7	Cabling (Activity 10 to 32)	38	65	1			
	Canopy	27					

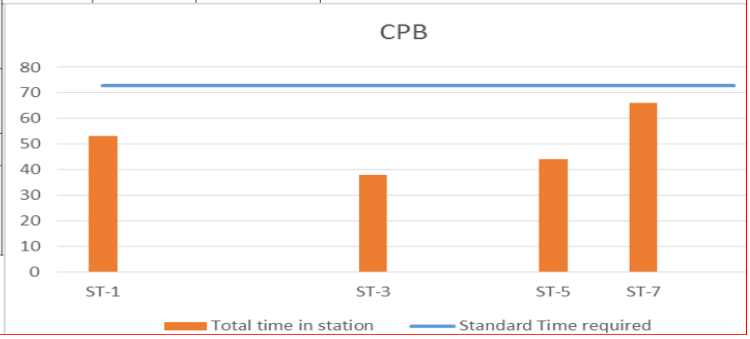

Figure: 5.3 – Analysis for CPB product

5.1 Proposed Timing to Meet Customer Demand

Available time per shift	480
Break Timings	25
Net available time per shift	435
Production Capacity	6
Takt Time (Min.)	73

Table: 5.1.1 – Summery Information

			Time Study							
Station	Model	Major Activities	Watch readings	Rating Factor	Basic Time	Allowance %	Standard Time (Min.)	Maximum Time (Min.)	Proposed Manpower	Required Production
SA2	OGR	Motor and element coupling	87	50	44	11	48	74	1	6
	CPB		37	50	19	11	21			
	OGA		90	50	45	11	50			
ST-1 + ST-2	OGR	Frame Mounting + Motor Assembly Mounting	28	50	14	11	16			
	CPB		53	50	27	11	29			
	OGA		43	50	22	11	24			
SA-3	OGR	Vessel Assembly	58	50	29	11	32	32	1	
	CPB		31	50	16	11	17			
	OGA		52	50	26	11	29			
ST-3	OGR	Vessel Mounting + Unloader mounting + Hoses	58	50	29	14	33	41		
	CPB		34	50	17	14	19			
	OGA		72	50	36	14	41			
ST-5	OGR	Control Panel Assembly Wiring + Cooler mounting	57	50	29	14	32	70	1	
	CPB		63	50	32	14	36			
	OGA		122	50	61	14	70			
ST-7	OGR	Fan Assembly, Dryer Assembly, Air Filter Assembly+ pulley alignment & belt tension+ Dry rail Canopy Stage	87	50	44	14	50	54	1	
	CPB		67	50	34	14	38			
	OGA		95	50	48	14	54			
									4	

Table: 5.1.2 – Proposed Timings

5.2 New Modified Layout of Assembly Line

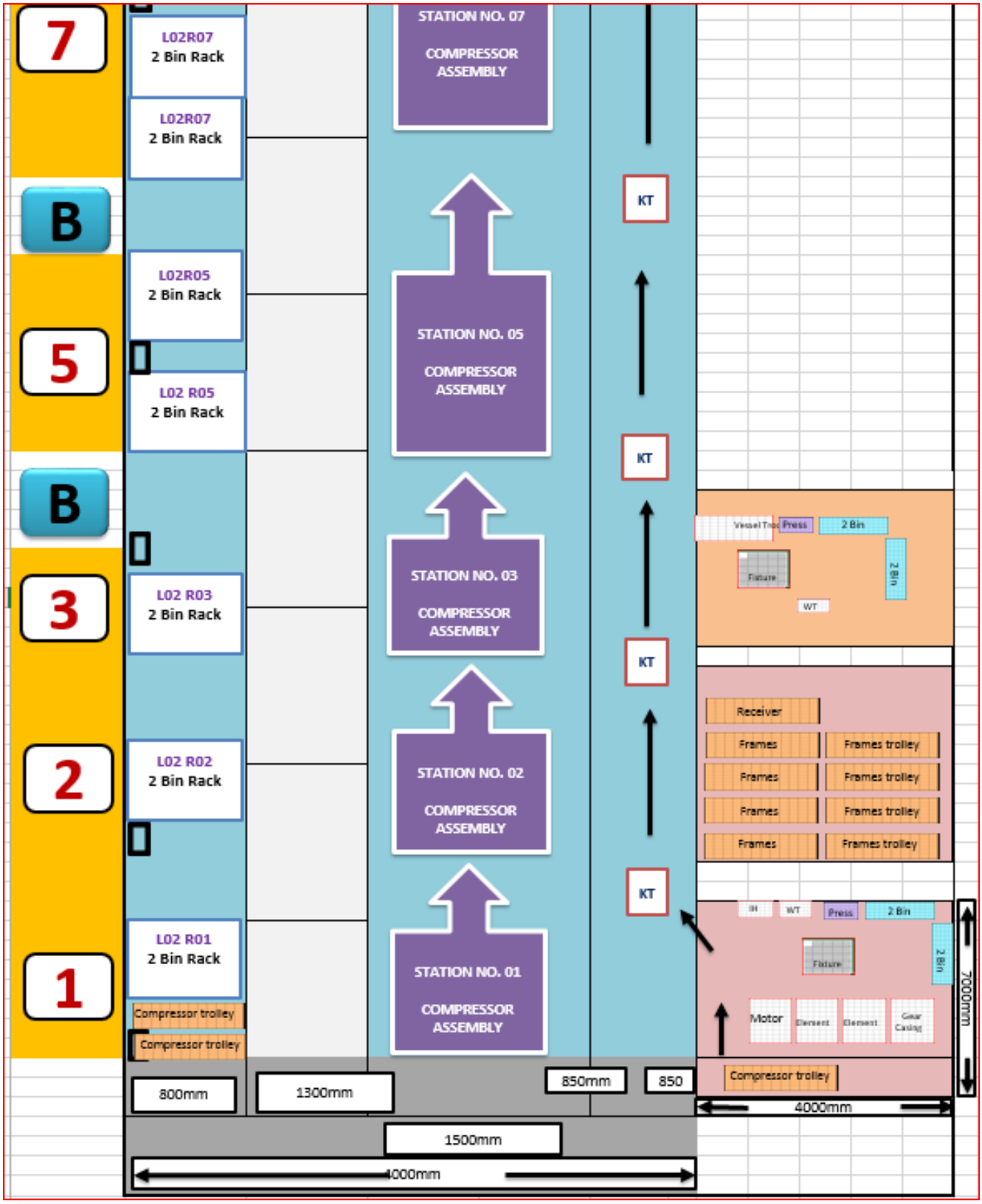

Figure: 5.2.1 – New Modified Layout of Assembly Line

6. BENEFITS DUE TO NEW MDIFIED ASSEMBLY LINE LAYOUT

6.1 Operator Walking Distance

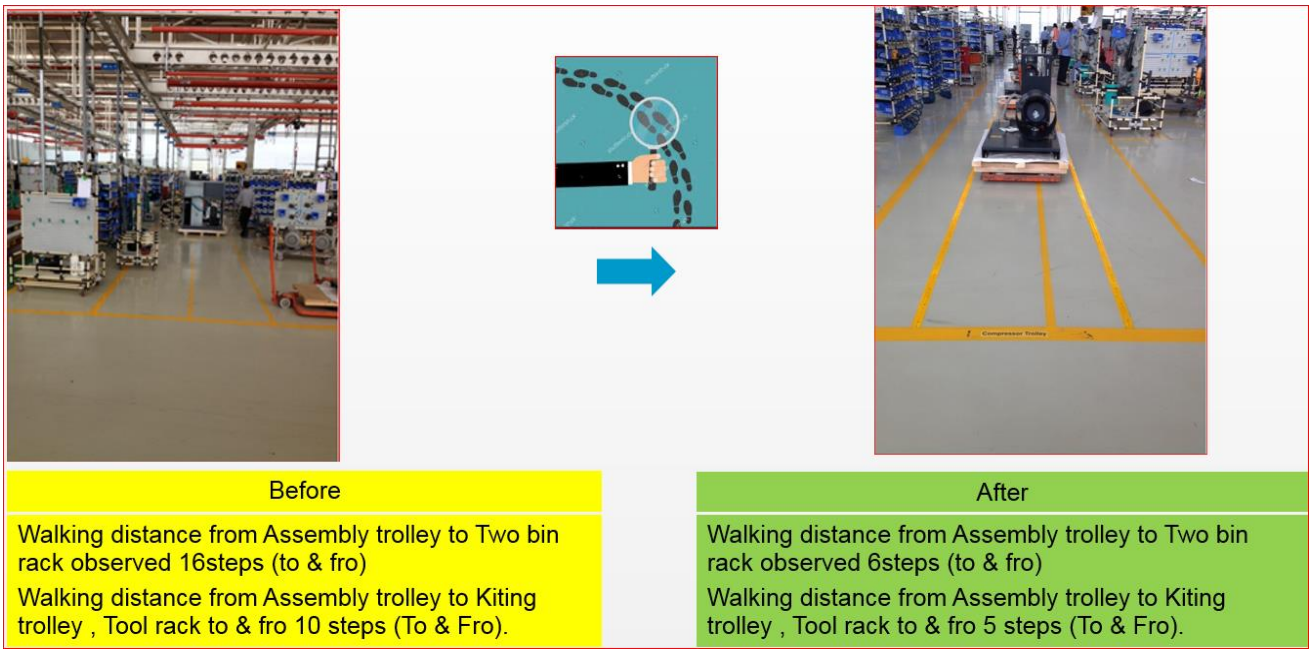

Figure: 6.1.1 – Operator Walking Distance

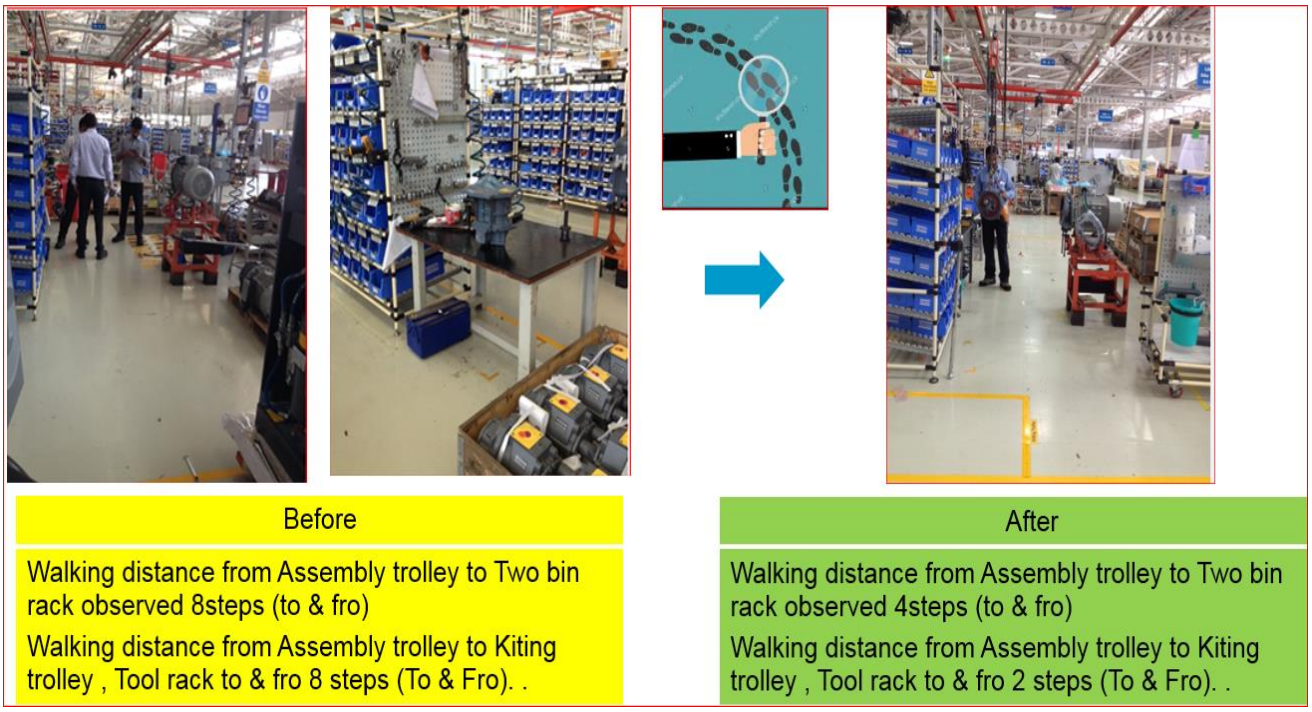

Figure: 6.1.2 – Operator Walking Distance

6.2 Implementation of Tool Board

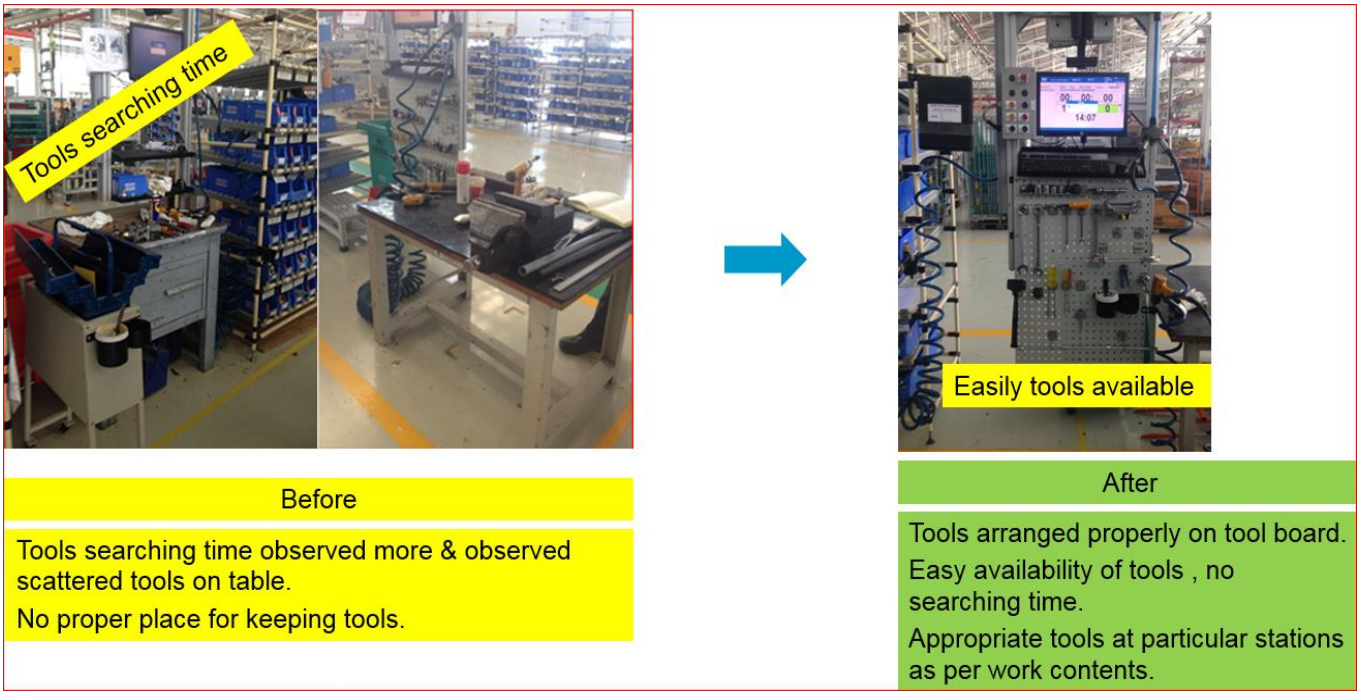

Figure: 6.2.1 – Implementation of Tool Board

6.3 Material Kitting trolley modification

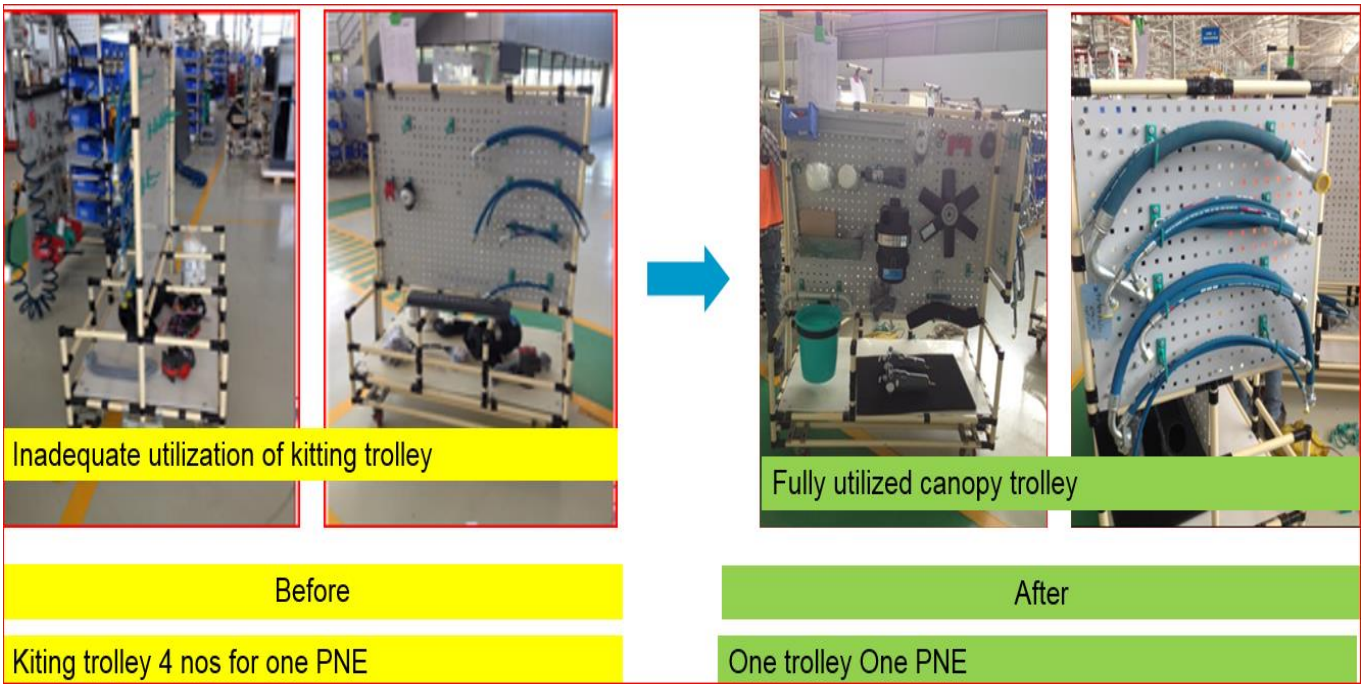

Figure: 6.3.1 – Material Kitting trolley modification

6.4 Advanced tooling implementation

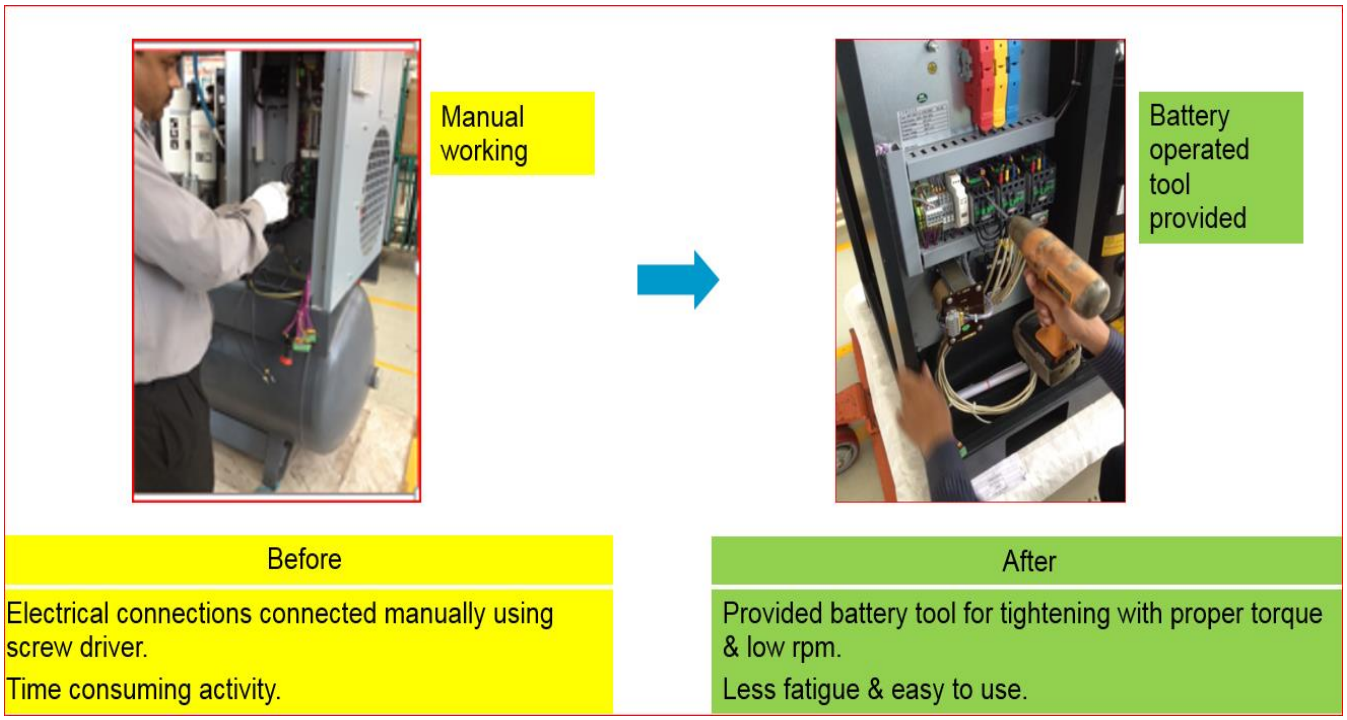

Figure: 6.4.1 – Advanced tooling implementation

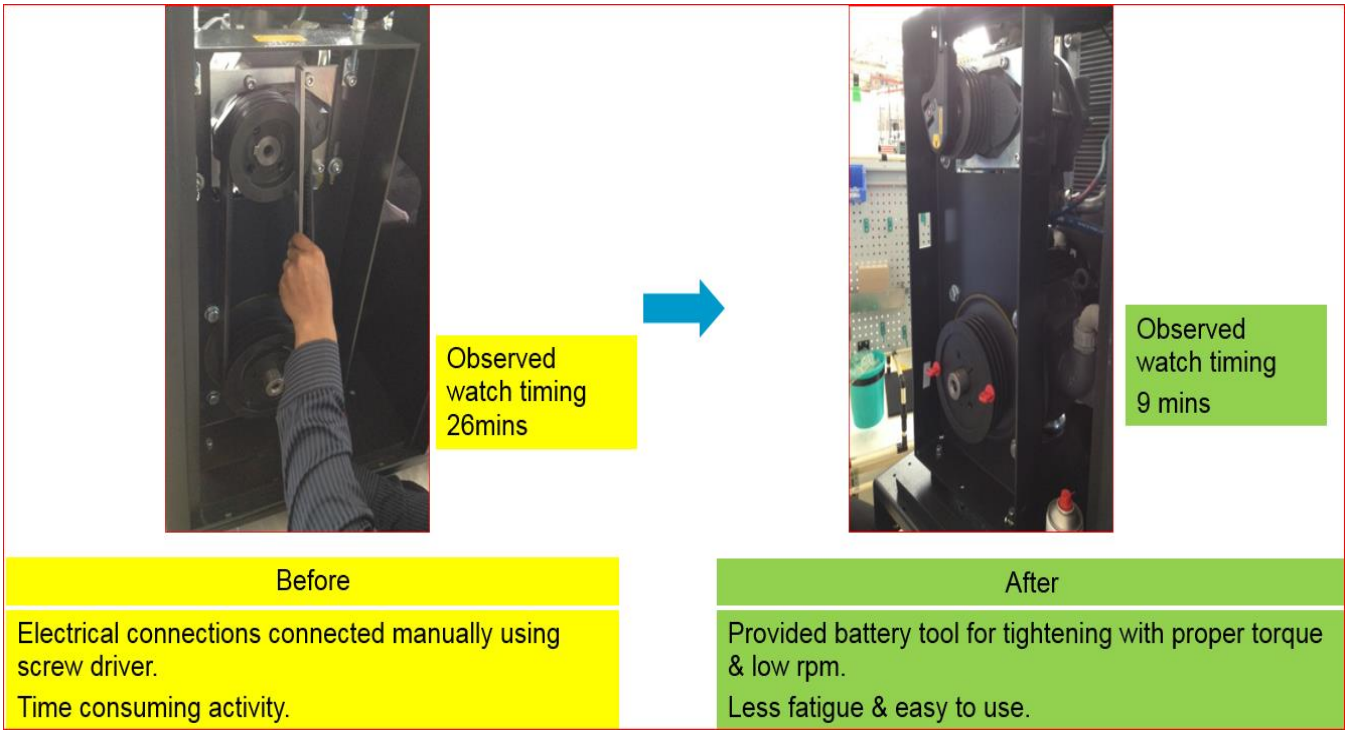

Figure: 6.4.2 – Advanced tooling implementation

7. RESULTS AND DISCUSSION

	Before Balancing			With Balancing		
No of machines/month	121			121		
Avg Hrs/Machine	6.7			6.7		
Hours/Man/Day	8			8		
Daily Production	4	6	8	4	6	8
Hours produced/day	26.8	40.2	53.6	26.8	40.2	53.6
No of stations	5	6	7	3	4	6
Manpower / day	6	-	10	4	5	7
Man hours / day	48	-	80	32	40	56
% Shop Eff	56%	-	67%	84%	101%	96%
% Production Eff	62%	-	74%	92%	111%	106%

Table: 7.1.1 – Results before and with line balancing

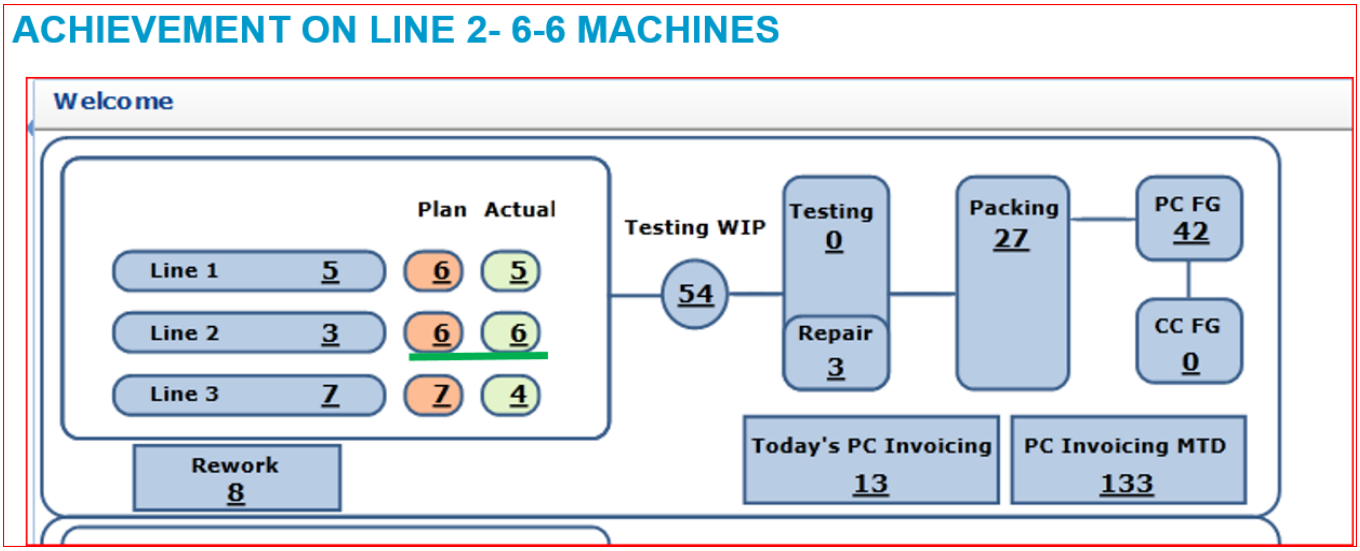

Figure: 7.1.2 – Achievement on line 2

1) After time study and line balancing assembly line efficiency increases by 33%.
2) The fatigue and movement of worker decreases which is result in to efficiency gain.
3) Advance tooling used for critical and time consuming operations which has great positive impact on efficiency.
4) After time study and line balancing man-hours per machine for assembly is reduced from 480 minutes to 365 minutes resulting reduction in manufacturing cost of compressor and increase in overall profit of organization.
5) Number of trolley per machine, kitter and handling labor is reduced from 3 to 1 due to kitting material trolley design modifications.
6) Number of subassembly workstations is reduced from 2 to 1 after time study and line balancing.
7) Number of main working stations is reduced from 6 to 4 for the completion of work after time study and line balancing.

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ABOUT THE AUTHORS

Mr. Dattu Balu Ghane is working as a Lecturer in the Department of Mechanical Engineering at Government Polytechnic, Awasari, Pune, Maharashtra, India. He is having wide industrial experience at world leading research center. He holds a Bachelor and Master degrees in Mechanical Engineering. He has published a large number of research articles in National and International Journals of high repute. His academic life includes serving as an AMIE Project Guide, Subject Expert and conducting a number of training programs. His areas of interest are Industrial Engineering, Automotive Technology Design, Pollution Control, Energy Conservation and Human Resource Development, Supply Chain Management, Simulation, Lean Manufacturing and Solar Energy. He has been awarded with various states, national and international awards.