ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

	
Description: Solenoid bracket taking from back side (Time reqd= 8 sec)	Description: Solenoid bracket taking from side of operator (Time reqd= 4 sec)

Table-4 shows that before kaizen improvement, the solenoid bracket has to be taken from the back side of the worker. After, the tray is provided by the side of the operator.

Table-5: Kaizen Improvements (4)

Kaizen Objective: To reduced time and fatigue	Idea: To provide arrangement for back plate & air shroud
Problem/Present status: More time & fatigue during BOM issue	Countermeasure: Hanger type trolley provided for back plate & air shroud
Before	After
 	

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

Description: Before BOM issue for back plate, it is in box (Time reqd= 09 sec)	Description: Trolley for Air shroud & back plate (Time reqd= 6 sec)

Table-5 shows before kaizen improvements, the back plate was provided in box on the assembly line which causes fatigue during BOM issue. The trolley is provided for air shroud And back plate, reduces fatigue and time during BOM issue.

5S IMPROVEMENTS

These are workplace related improvements. These cause the best utilization of the workplace.

Table-6: 5'S' Improvements (1)

5S Objective: To improved 5's' and increase working space	Idea: To provide location arrangement for s/a of EGR valve
Problem/Present status: 5's' not maintained and difficulty for working	Countermeasure: Hanger provided for s/a of EGR valve
Before	After
	

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

Description: S/a of EGR valve on working table	Description: S\a of EGR valve on hanger

Table-7: 5'S' Improvements (2)

5S Objective: To improved 5's'	Idea: To provide location arrangement for oil return pipe fitment gauge
Problem/Present status: 5's' not maintained	Countermeasure: location change and separate stand provided for gauge
Before	After
	
Description: Gauge location and material bin location is same not separate	Description: separate location provided for gauge location

As shown in Table-6 and Table-7, these are 5'S' improvements. The right location is set for all the materials. After usage, same is placed to its respective location. These are out of some of the 5'S' improvements.

Table-8 shows the time before (P) line balancing and the time required after (Q) line balancing at all workstations. Action taken to reduce the timing at each workstation is also included in the table. All the time study is done in seconds.

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

Table-8: Time Before and After the Improvements and the Actions Taken

WS No.	P	Q	Actions Taken
01	74.4	85	Activity rebalanced for 90 sec
02	94.2	88	Activity rebalanced for 90 sec
03	52	52	IPV-1 (End Float) Man-less
04	123.6	82	Layout changed & rebalancing done
05	126	81.4	Motion loss reduced
06	88.8	81.6	Motion loss reduced
07	121.2	69	Motion loss reduced
08	67.2	82	Activity rebalanced for 90 sec
09	79.2	67.8	Activity rebalanced for 90 sec
10	124.8	82.2	Activity rebalanced for 90 sec
11	85.2	81.6	Activity rebalanced for 90 sec
12	85.2	85.8	Activity rebalanced for 90 sec
13	62	62	IPV-2 Torque To Turn (Man-less station)
14	81.6	79.2	Motion loss reduced
15	81	84	Activity rebalanced for 90 sec
16	126	72	Motion loss reduced
17	81	66.6	Activity rebalanced for 90 sec & motion loss reduction

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

18	67.8	87	Activity rebalanced for 90 sec
19	85.2	75.6	Activity rebalanced for 90 sec
20	120.6	69	Motion loss reduced
21	78.6	90	Activity rebalanced for 90 sec & motion loss reduced
22	78.6	78	Activity rebalanced for 90 sec
23	73.2	82	Activity rebalanced for 90 sec
24	86.4	85	Activity rebalanced for 90 sec
25	0	82	Idle station used to utilize conveyor & Activity rebalanced for 90 sec
26	77.4	83.4	Activity rebalanced for 90 sec
27	121.2	73.2	Motion loss reduced
28	0	0	Idle station
29	0	0	Idle station
30	84	72.6	Motion loss reduced

Thus, the total task time required before line balancing is 2426.4 seconds and that required after line balancing is 2180 seconds. Fig-3 below shows the graph for above data for Online WS-01 to WS-30. WS-28 and WS-29 are idle stations. The activities at all workstations are balanced for 90 sec by using motion losses, changed layout and rebalancing of activities.

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

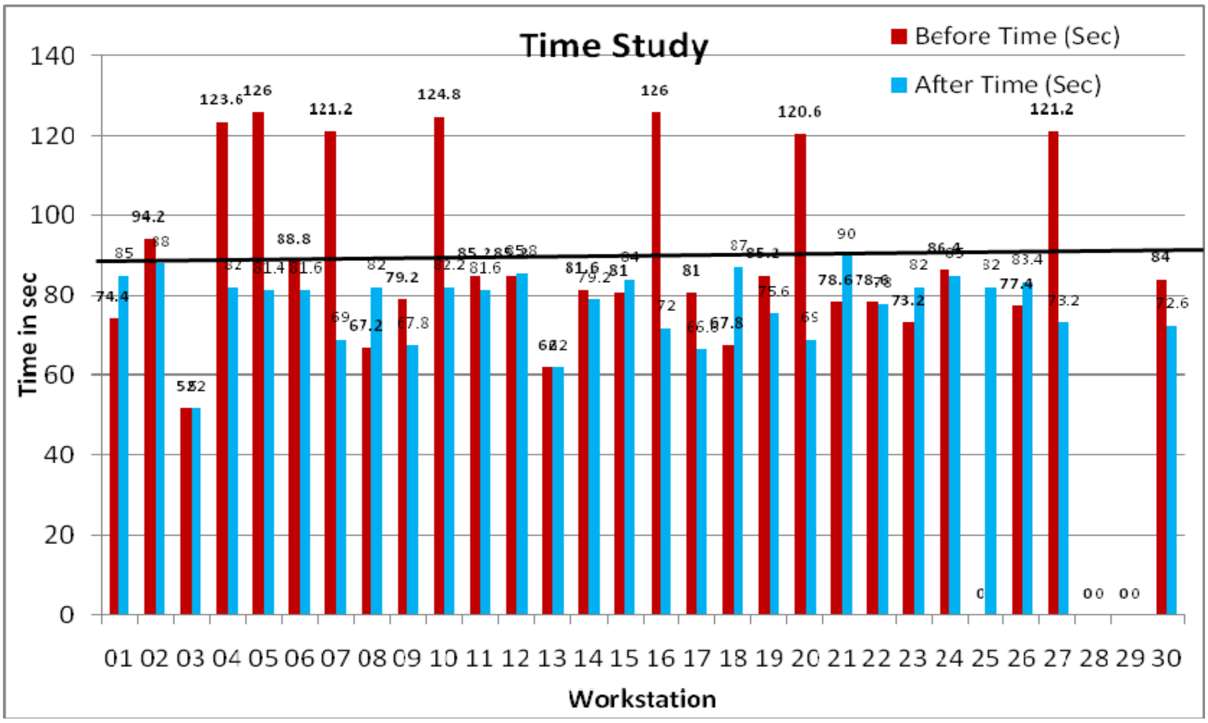

Figure 3: Time study and Takt Time

As shown in above Figure 3 , the cycle time is rebalanced for 90 seconds at all workstations, which is takt time.

c) DATA AFTER LEAN IMPLEMENTATION

i) Production capacity:

Before Improvement = 225 Engines/Shift

After Improvement = 262 Engines/Shift

Percentage Improvement = (262-225) / 225×100

= 16% improvement.

ii) Production lead time: Time from start of physical production of first sub-module/part to production finished (ready for delivery).

From Table-7, the production lead time before was 2426.4 seconds and that after line balancing is 2180 seconds. Thus production lead time is also found to be reduced.

iii) Product yield per employee or Output/Man = 262/34 = 7.71 engines, which was 6.67 engines before improvement.

iv) It determines optimize use of labor. It measures effectiveness of manufacturing process and productivity of employee. Thus, in this case study, it is found to be increased.

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

v) Additional 925 (= 37×25) engines can be made in one shift basis only.

vi) With 225 engines/shift we can ran single shift up to maximum 5625 engines/month but with 262 engines/shift, we can achieve 6550 engines per month with the same manpower.

d) Results Observed after Lean Implementation

i) Productivity Improvement

Increase in the number of engine assembly leads to increase in the productivity. Here, the number of engines assembly is increased from 225 to 262 engines per shift. Percentage improvement observed is 16% improvement. This shows that the lead time is also reduced since there is increase in the number of engine assemblies in the same amount of time.

ii) Line Efficiency

Eq. 3 below shows the formula for calculating the efficiency of the assembly line. From Table-7, adding the data for before line balancing, the equation gives the line efficiency before improvement [7].

$$Line\ Efficiency = \frac{\sum Task\ Time}{(Number\ of\ Workstations \times Largest\ Cycle\ Time)} \quad \text{................ (3)}$$

Line Efficiency = 2426.4 / (30 × 126) = 64.19%

Now, adding the data for after line balancing, Eq. 3 becomes,

Line Efficiency = 2180 / (30 × 90) = 80.74%

Thus, it can be seen that there is improvement in line efficiency from 64.19% to 80.74%.

I. G600WIII Engine Testing Department

In this department, every assembled engine is tested for its performance and the various settings are also done while testing of the engine. Some of these settings includes maximum RPM setting, low RPM, idle RPM settings, rico valve setting, etc. Testing of engine includes loading of engine on the testbed then running the engine and setting the different engine specifications and then again unloading of the engine. Testing department consists of total 11 testbeds on which engine is tested.

Following roadmap is prepared for the improvement in the testing department.

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

i) Video to be taken from Loading + Connection + Removal of connection to unloading.
ii) Conduct time study (Loading + Running + Unloading).
iii) Identify wastages/Improvement opportunities.
iv) Implement kaizen.
v) Check results.

a) Data Collection before and after Improvement

The data included the activities to be performed along with the time require for those activities before and after improvement. The improvement actions taken are also included in the Table-8. The improvements done are mainly kaizen improvements. The data collection is done for the three steps, loading of engine, running in cycle of engine and unloading of the engine.

Table-8: Engine Testing Department Summary

Terms	Before	After	Improvement
Loading(sec)	419	153	266
Running cycle(sec)	1166	982	184
Unloading (sec)	344	139	205
Total time (sec)	1929	1274	655
Cycle time (min)	32.14	21.23	10.55
Total hr working (min)	450	450	
Output per engineer(engine/engineer)	14	21.19	7
Testing capacity (engines/day)	447	670	223

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

b) Data Analysis for Observations Before and After the Improvements

Manpower required for 447 engines/day = 2.8 shifts/day.

Before required = 447/14= 32 TA (approx.)

After required = 447/21.19 =21 TA(approx.)

Benefit it can be seen that, after the improvements, required 11 Team associates (TA) less than previous.

Investment for test-bed improvement:

Per test cell investment (Rs. in lacs) = Rs. 0.5 lacs.

Total test bed (11nos.) investment = 11×0.5 = Rs. 5.5 lacs.

The required investment is regained back with the reduction in TA.

II. G600WIII PDI DEPARTMENT

This is the last department under study. This includes the per-dispatch inspection of engine. It also includes the addition of OK tags, markings, final tappet setting, and applying anti-rust. The data collection, data analysis, observations and data collection after the improvements are the major steps included in this study.

a) Data Collection and Improvements

There are 10 Workstations, Operation-10 to Operation-100. The following Table-9 shows time taken at various workstations before and after rebalancing and actions taken to rebalancing the PDI line.

Table-9: Engine PDI Department Summary

WS No.	Time Required (sec)		Actions taken
	Before	After	
OP-10	88	110	Line balanced for 110 sec
OP-20	85	0	Retorquing eliminated
OP-30	128	100	Motion eliminated
OP-40	112	105	Motion eliminated

OP-50	100	100	-
OP-60	135	101	Motion eliminated
OP-70	135	106	PTO retorquing eliminated
OP-80	132	103	Motion eliminated
OP-90	70	102	Line balanced for 110 sec
OP-100	105	109	Paint marking eliminated for one place

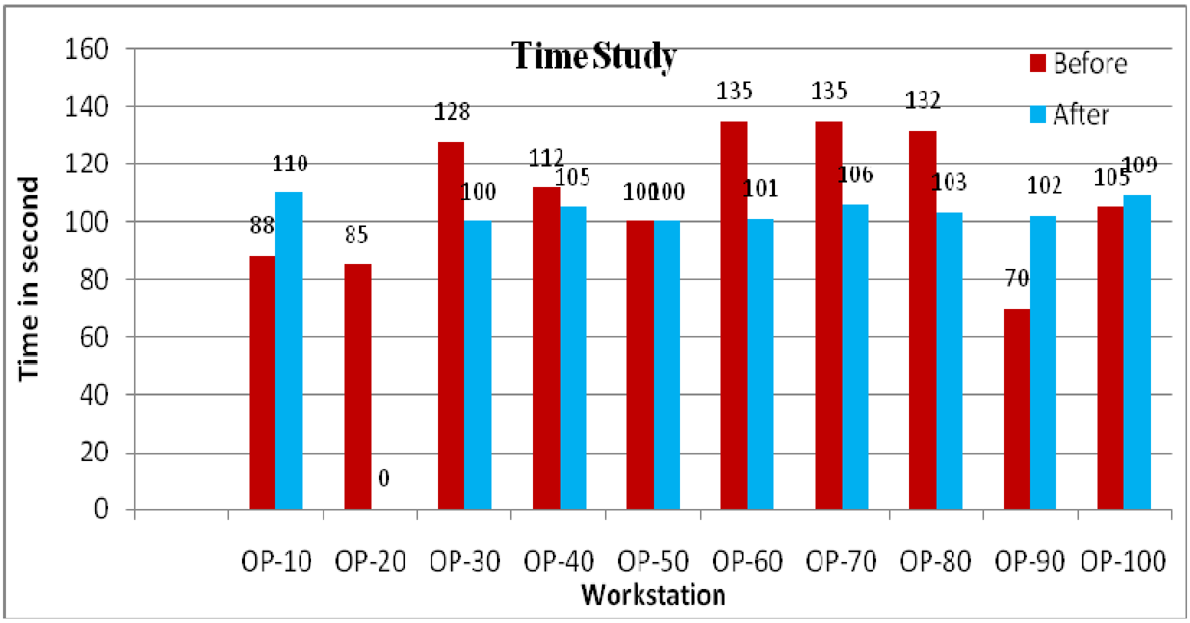

Figure 4: Time study and Takt Time

Fig-4 shows the graph for the time study for various workstations in PDI department. It can be seen that, all the workstations are balanced for the takt time of 110 seconds. The operation-20 is eliminated after the improvements [8].

b) Observations after the Improvements

i) Capacity improved to 270 engines/shift from 200 engines/shift.

Percentage improvement = (270-200)/200×100

= 35 % improvement.

ii) Output per man is improved from 20 nos. engines to 27 nos. engine.

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

iii) Additional 1750 nos. of engines per month can be made in one shift basis only.

iv) With 200 nos. engines/shift, we can run a single shift upto max. 5000 engines/month, but with 270 nos. of engines/shift, we can achieve 6750 nos. of engines/month with optimum manpower.

5. CONCLUSIONS

This is concluded that the assembly line balancing is one of the major step to be taken into consideration while increasing productivity of automotive industries. Line balancing is done with taking in account the takt time, cycle time and downtime and thus reduces the production lead time with increased number of output engines. Continuous improvement is the step to reduce unnecessary downtime losses. The productivity of engine assembly line is thus found to be increased. The testing department and PDI department also have some non-value-added activities. Those are also reduced or eliminated by the kaizen improvements and 5'S' changes and the operation are rebalanced taking in account the takt time. The productivity of both testing and PDI departments is also found to be increased. Thus lean manufacturing concept when deployed increases the productivity. The primary lean tools used are kaizen improvements and the 5S implementation. By using line balancing and Lean techniques, practitioners can better calculate the time and effort needed to complete their products or services, and also utilize their resources to the fullest to produce the output demanded by the customer.

6. REFERENCES

[1] Abhishek Dwivedi, "An analysis and development of software for assembly line balancing problem of manufacturing industry, " VSRD-MAP, vol. 2 (2), pp. 74-87, 2012.

[2] Duarte F. Gomes, Manuel Pereira Lopes and Carlos Vaz de Carvalho, " Serious Games for Lean Manufacturing: The 5S Game, " IEEE, vol. 8, no. 4, pp. 191-196, 2013.

[3] Daniel Kitaw, Amare Matebu and Solomon Tadesse , "Assembly line balancing using simulation technique in a garment manufacturing firm, " Journal of EEA, vol. 27, pp. 69-80, 2010.

[4] Jostein Pettersen, “Defining Lean Production: Some Conceptual and

ISSN: 2348-4098
VOLUME 02 ISSUE 05 JUNE 2014

Practical Issues," The TQM Journal, 2009, vol. 21, no. 2, pp. 127-142.

[5] R. B. Breginski, M. G. Cleto and J. L. Saas Junior, "Assembly Line Balancing using Eight Heuristics, " 22nd International Conference on Production Research.

[6] Hudli Mohd. Rameez and Dr. K. H. Inamdar, "Areas of Lean Manufacturing for Productivity Improvement in a Manufacturing Unit," World Academy of Science, Engineering and Technology, 2010, pp. 584- 587.

[7] P. M. Rojasra and M. N. Qureshi, " Performance Improvement through 5S in Small Scale Industry: A case study, " International Journal of Modern Engineering Research, vol. 3, issue 3, pp. 1654-1660, 2013.

[8] Scholl. A, Balancing and sequencing of assembly lines, 2nd ed., Physica, Heidelberg, pp. 62-63.