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Productivity Improvement By Using Line Balancing And Automation Strategies in order To Improve overall Equipment Effectiveness

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Abstract: *Assembly line balancing is a technique or tool is to know how the tasks are to be assigned to work stations, so that the predetermined goals are achieved and also improve the throughput of assembly line while reducing non value added activities, cycle times. This work mainly focusses on improving productivity of assembly line by eliminating non productivity activities, implementing line balancing methods and automation strategies. The work adopted is to reach the requirements of future demand in battery division. The analysis includes calculations of cycle times of individual processes, reduce non value added activities and distribution of work load on each station by line balancing in order to improve overall equipment effectiveness of the line.*

Keywords*: Line Balancing, Overall Equipment Effectiveness, Availability, Performance, Quality.*

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I. Introduction

Line balancing is the tool used to optimize workstations or production line throughput. Effectiveness of equipment plays an important role in modern manufacturing industries. Line balancing is a methodology to increase the availability of the existing line. Line balancing results in maximum effectiveness of the equipment. However, for industry to produce products of right quality and quantity for the customers and be able to deliver the products at right time, so that the plant or equipment must operate effectively and accurately. For every manufacturing industry, the objective is to produce maximum number of products at minimum cost to get profit to industry and this is achieved by maximum availability of machine or equipment by reducing downtime due to unwanted stoppages. Without an effective and economically maintenance system, equipment reliability suffers, and plant pays the price with poor availability and increased downtime. All these mentioned poor key performance indicators could be a result of poor machine conditions and sometimes low employee morale. Low plant availability and overtime costs will negatively affect an industry operational efficiency. Plant engineers are better to design an effective maintenance system for the plant and equipment. The aim of the paper is to improve overall equipment effectiveness of existing line and implement some automation strategies in order to improve productivity of the assembly line.

II. Literature Review

Normally there will be a problematic area in every production line which decreases the productivity of the production line technically known as the bottle neck work station analysed by the authors shamuvel vpandit, sunil j kadam, avinash kharat, chetan u nayakawade where the work is carried out in an engine flywheel housing products manufacturing production lines et al. [1]. Md. Niaz Morshed & Kazi Saifujjaman Palash, studied on Assembly Line Balancing to Improve Productivity in an apparel using work sharing methods industry using work sharing method by eliminating non value added activities et al. [2]. In the studies of Binoy Boban and Jenson Joseph E [3] proposed a plan to implementation TPM through the various pillars of TPM. They had discussed the 5S and kaizen among the various pillars. After a small implementation of TPM in company, they found that the OEE is increased by some percent. Ashwin B. Virupakshar and Anil Badiger et al. [4] were studied the implementation of the total productive maintenance (TPM) for the overall productivity of the manufacturing industries and they implemented a few methods in which the work is carried out in India auto pins pvt. Ltd. India. M. Srinivasa Rao, M. Balaji, Venkatamuni .K et al. [5] studies includes Comparision of Overall Equipment Efficiency(OEE) with TPM stating that Frequent machine breakdowns, low plant availability, increased rejection are a great threat to increase operating cost and lower productivity in battery industry.

III. Assembly Line Setup:

This study is done on two wheeler battery manufacturing company. The study carried throughout five months in the company. There are 4 sections in this plant namely plate preparation section, assembly section, formation and finishing sections. Out of these assembly is the bottleneck, chosen by using past OEE data for 1 year collecting from production team. The company plant manufactures different types of two wheeler battery models like 2.5AH, 3AH, 5AH, 7AH, 8AH, 18AH. In this plant there are 9 assembly lines used for different models of batteries manufacturing. The method is used for the work is analysing the present OEE and compare it with world class OEE in manufacturing and thereby line balancing and introduce some automations in the line to improve OEE and efficiency of the line. The layout of assembly line is well established and as well as there is some non-value added activities and imbalanced cycle times of work stations. Assembly layout are as follow show in figure1.

This is semi-automated assembly line and it consists of 10 operators and the above layout consists of 13 work stations namely 1.Stacking machine 2.Semi insertion 3.Cast on strap 4.Half insertion 5.Full insertion 6.Short circuit test-1 7.ICW 8.SCT –2 9.Weld condition check 10.Heat sealing 11.Post trimming (manually) 12.TIG welding 13(a).Leak test, 13(b).Number Punch and 14.Lug Bending, Flux Wiping, Fluxing. the line set up of assembly show in below figure 2.

3.1 Analysis of Assembly Line

This analysis includes calculation of cycle times and how to reduce non value added activities to improve productivity. Cycle times of all the work stations are taken in all lines. By using cam and smart phone the video is taken and the video studied in timer pro software. Video length is about 5min in all work stations recorded up to 15 samples in each work station. Cycle times of each workstation and each linecan show in below table1.

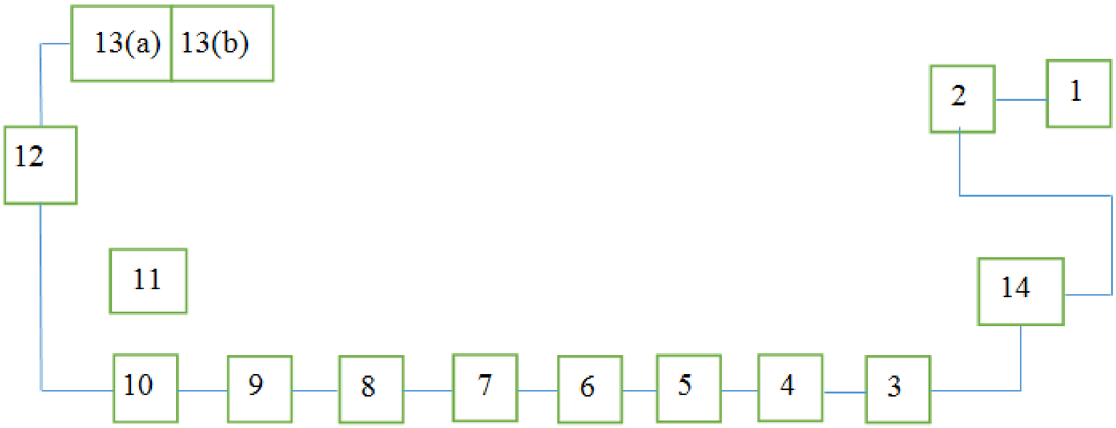
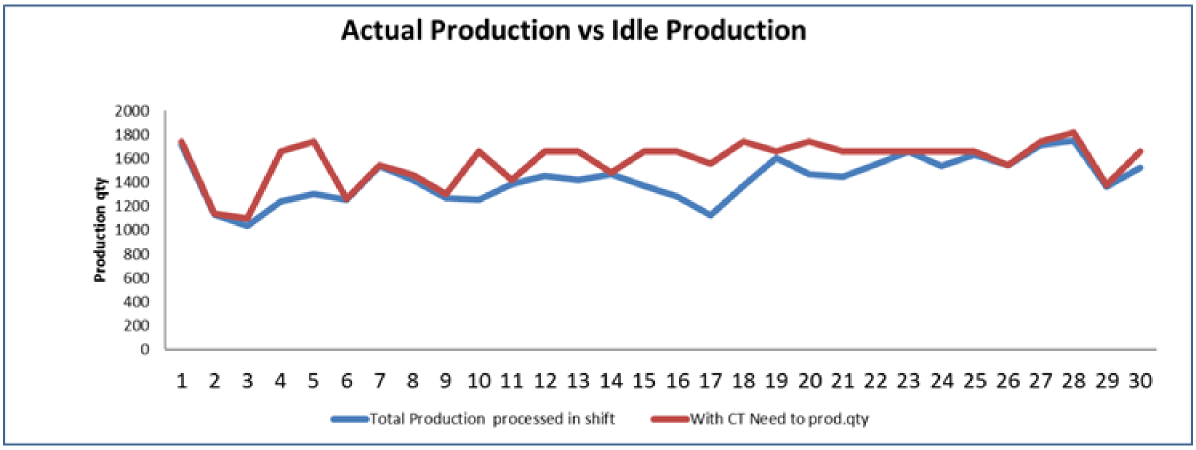


Figure1: Assembly Line Layout

Figure 2: Assembly Line set up

Table1: Assembly Cycle Times

Type (AH)	Line no	BM Stacking	Semi Insertion (for 2 batteries)	COS	Half insertion	Full insertion	Sct-1	ICW	SCT-2	WCC	Heat sealing (for 2 Batteries)	Post trimming	TIG welding	Leak test and number punch (for 2 Batteries)
2.5	1	13.56	23.14	14.45	13.12	10.36	13.02	14.77	15.2	8.02	25.25	9.12	11.44	24.48
	9	13.89	21.59	15.32	13.36	11.25	1303	14.45	13.32	9.12	25.23	9.12	11.44	22.25
	7	113.75	21.23	15.39	10.89	11.42	12.89	13.88	13.12	10.09	25.56	8.33	10.25	21.84
5.0	1	10.85	20.25	14.48	12.74	11.88	13.05	15.65	13.56	8.02	25.54	10.16	12.26	26.45
	5	12.97	20.29	15.42	12.78	12.03	13.12	14.15	13.54	8.03	25.21	8.06	11.11	22.45
	8	12.12	26.64	15.15	12.69	13.02	13.78	14.24	13.89	9.07	25.25	9.02	12.21	23.36
	6	12.36	28.65	16.52	13.12	12.87	13.58	14.22	13.45	8.72	24.52	9.66	11.14	28.15
6.0	7	11.58	25.87	16.87	12.23	13.05	12.01	13.23	13.49	9.18	24.48	8.65	11.14	22.11
7.0	5	15.20	28.23	18.69	13.56	11.87	13.41	13.35	15.56	10.31	25.54	10.08	11.14	23.25
7.2	1	15.18	31.69	15.54	14.87	11.41	13.33	15.52	16.05	10.26	25.58	10.12	No	25.65
8.0	7	17.89	28.25	15.52	11.56	15.02	15.69	13.04	13.02	10.32	26.77	9.06	11.44	23.34
9.0	2	18.12	25.17	19.09	14.12	14.41	14.05	15.51	15.56	10.21	26.78	7.94	12.21	25.74
18.0	2	18.14	41.24	30.56	14.05	13.96	14.09	18.06	17.02	10.12	31.12	10.08	No	29.87
MF-4	3	11.32	29.15	15.14	12.02	13.98	14.16	12.89	12.66	8.33	26.77	9.02	11.14	24.97
	4	12.16	22.56	15.14	12.74	14.03	14.02	13.65	13.22	836	26.77	8.65	12.44	22.41
MF-5	5	11.28	30.15	14.85	14.02	13.87	13.41	14.25	14.41	10.12	26.14	9.08	10.65	22.77



Graph 1: Total Production Vs Actual Production

Above table.1 shows the bottle neck workstation. Cast on strap is the bottle neck shows in below figure. In that work station cycle time is taken more. With that cycle time total production per shift be less.in order to improve productivity cycle time should be reduce. During analysis of assembly line some problems were find out for loss of production in assembly line. Those are shown in 3.2. Based on these cycle times of a assembly line no 6 a graph will plot between total production processed in shift vs actual production per shift variation shown in graph 1. (Based on past OEE data and it collected from production team). Total production processed in shift is less Based on these data bottlenecks are identified. This will discuss in below.

3.2 Bottle Necks Identification

Based on cycle times study in the assembly line shown in table: 1 we have to conclude that cast on strap is bottleneck, because it takes larger cycle times. Bottle neck work station shown in below figure 3.
Some more problems were identify during study in the assembly line. Those are listed below.

1. Loss due to unwanted activities of an operator at bottle neck process i.e. cast on strap. This is also main cause for loss of production. It results higher cycle times. And another one is break down losses. Because of these two availability rate is 83.9%. This results affect the OEE. Larger cycle's causes indicate performance loss.
2. More rejections are happening in the mode of plate count variations due to extra plates and dust particles present in the cassette. After rework it must go to the same operation it loses one cycle in production. This is also major cause for loss of production.
3. Another main problem is post trimming operation. This is done by present manually. In that work station the operator shows more variations in cycle times. Next work station is waiting for battery because of less cycle time.
4. Another main problem is reworks at lug bending station. This work is done by COS operator. When reworks are doing the cast on strap machine will idle this impact shows on loss of production. This is non-value added activity it should be remove.

Figure 3: Bottle Neck Work Station

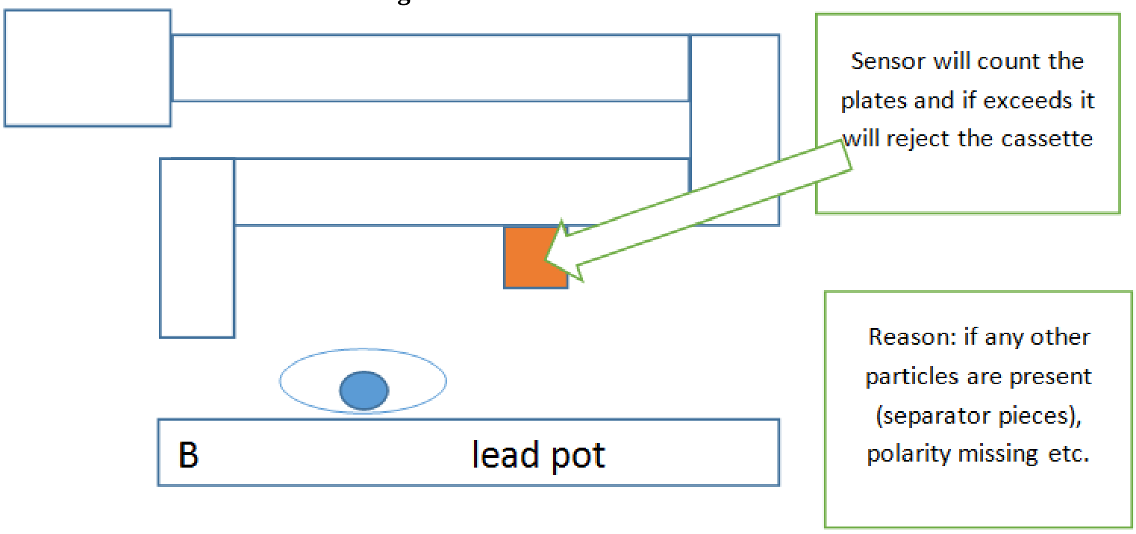


Figure 4: Identification of Rejections in the Mode of Plate Count Variation

IV. Results And Discussions

Based on collected data calculations are done on OEE

Table 2 .OEE Calculations Before Implementation

Number of shift per day	3 shifts
Duration of shift	8 hours
Planned break time	45 min/shift = 3915 min/month
Un planned down time or stop time	70min per shift =6090 min/month
Target production	133545 batteries/month
Number of batteries produced	112578 batteries/month
Number of rejected batteries	1740 batteries/month

Availability (A) = Run time / Plant operating time
= 365/435
= 83.9%
Run time = Operating time – Stop time
= 435-70
= 365
Performance = actual production per shift/Target production = 1273/1536 (Average monthly production/ shift)
= 0.8284 = 82.8%
Quality = Total good quantity / Total production
= (1273-20)/1273
= 0.9845
= 98.4%
OEE = Performance*Availability*Quality
= 0.83*0.82*0.98
= 66.6%

The result OEE is compare with some standard wold class OEE of the firm . this can show in below table 3.

Table 3: Comparison Between World Class and Obtained

OEE factor	World class	Obtained
Availability	90%	83.9%
Performance	95%	82.8%
Quality	99.9%	98.4%
OEE	85%	66.6%

Obtained OEE is less than world class OEE. So, Improvements Are Required. Some of them are implemented in the line those are

- Blowers are placed in order to avoid rejections at lug bending (for remove separator dust particles) sample figure shown in below figure 5.
- Automation proposed instead of manual post trimming to reduce cycle times and improve productivity and accurate and reduce rejections. Automation model shown in below figure 6.
- Distribution of work load of an operator is one solution at cos machine to nearest workstation operator.

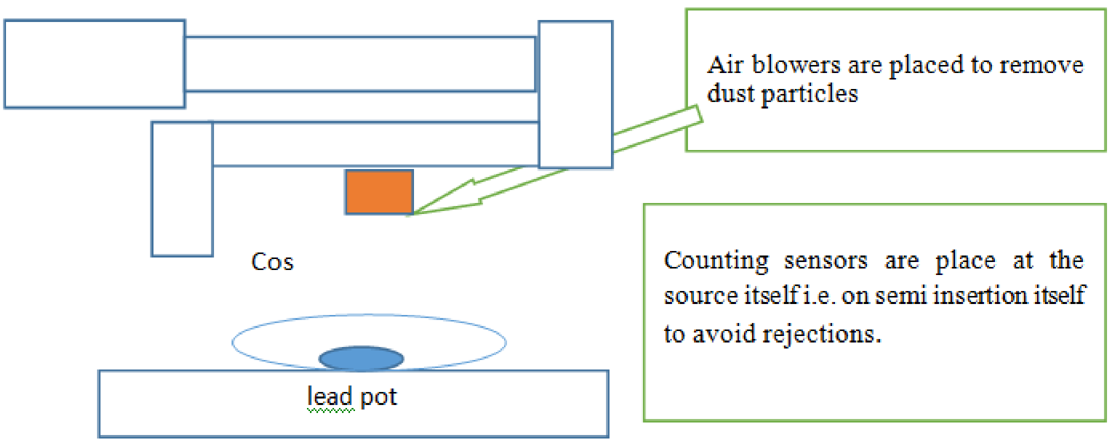


Figure 5: Solutions To Avoid Variation On Bottle Neck Process

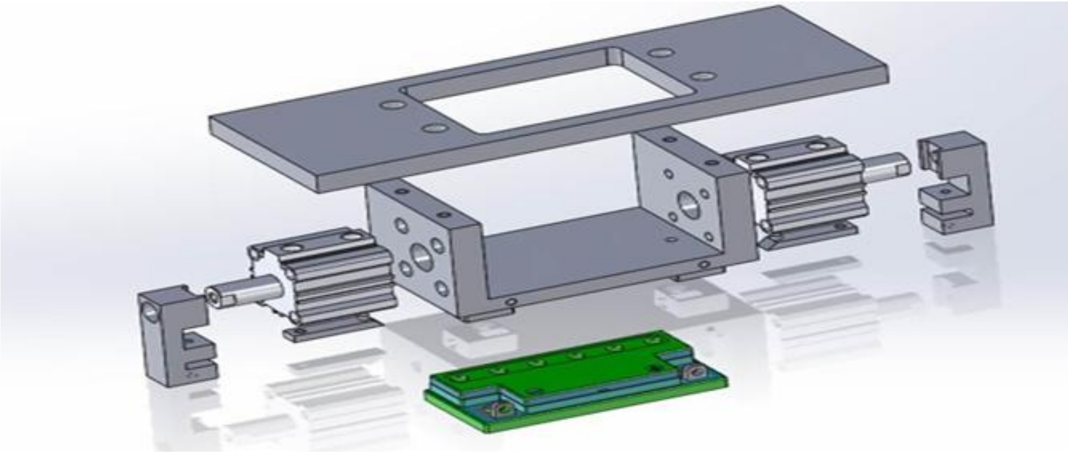
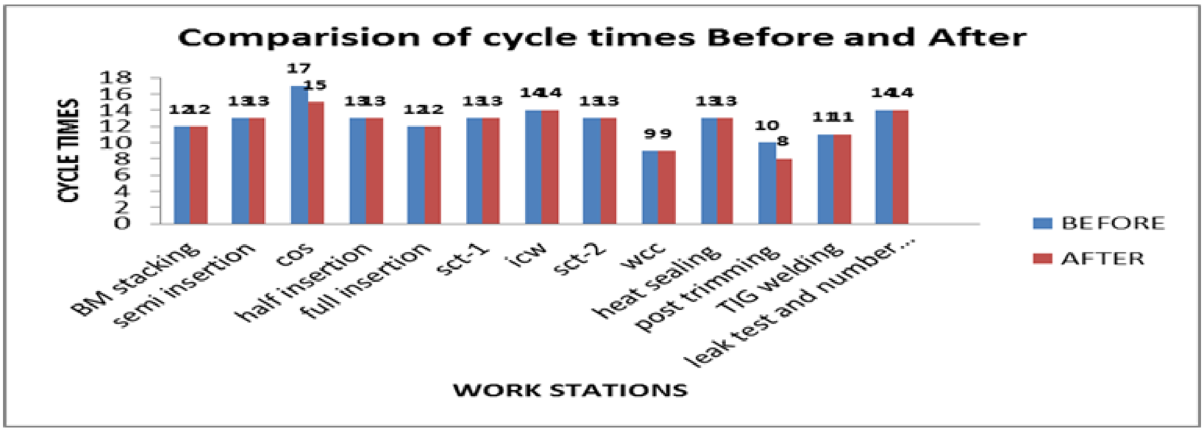


Figure 6: Post Trimming Automation

By implementing the above improvements the availability rate of machines increases and cycle times of the bottle neck work stations reduces. After line balancing and remove non value added activities of the line the cycle times are taken in line 6 and compare it with previous cycle times. The comparison will show in graph 3.



Graph 3: Cycle Times Before And After Line Balancing

Table 3. OEE calculations after implementation

Number of shift per day	3 shifts
Duration of shift	8 hours
Planned break time	45 min/shift = 3915 min/month
Un planned down time or stop time	40 min/shift = 3480 min/month
Target production	133545 batteries/month
Number of batteries produced	121290 batteries/month
Number of rejected batteries	1305 batteries/month

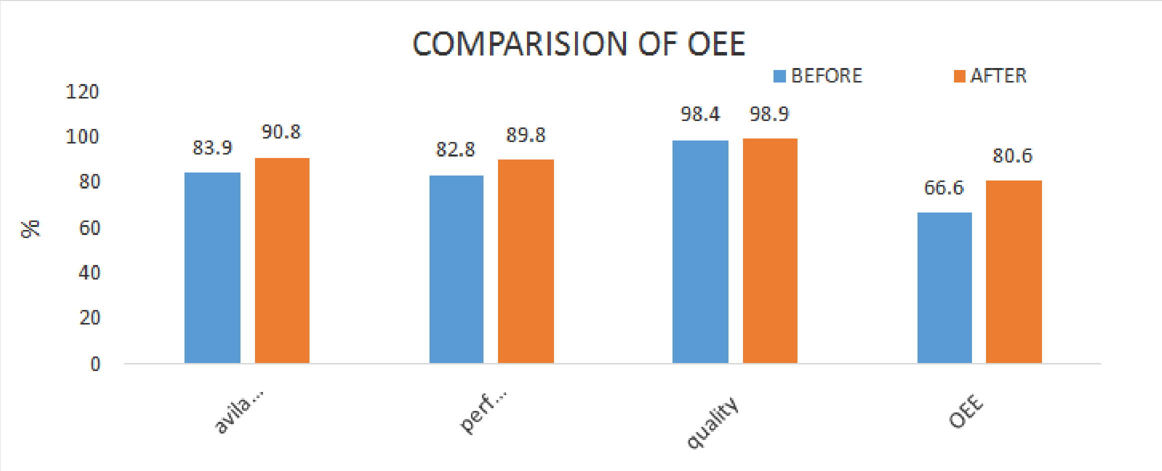
Availability (A) = run time / plant operating time
= 395/435
= 0.9080 = 90.8%
Run time = operating time – stop time
= 435-40 = 395

Performance = actual production per shift/target production =1380/1536(avg monthly production/shift)
= 0.8984 = 89.8%
Quality = total good quantity / total production

= (1380-15)/1380
= 0.9855 = 98.9%
OEE = performance*availability*quality

= 0.908*0.898*0.989
= 0.806 = 80.6%

Comparison of OEE before and after implementation Shown in below graph 4.



Graph 4: Comparison of oee

V. Conclusion

By implementation of line balancing in an assembly line the overall equipment effectiveness of the line will have increased by 14%.

- Non-value added activities are eliminated. I.e.
- Reworks are eliminated at cast on strap.
- By implement post trimming automation strategy in the line will reduce man power and also reduces rejection at leak test due to accurate cutting at post trimming.
- Productivity improved in line i.e. Shift production increases from 112578 to 121290 batteries per month from one line(line 6).
- It should be noted that some changes in the assembly line in company increase the availability, performance and quality and it improves the overall productivity in a line.

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