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PRODUCTIVITY IMPROVEMENT by APPLICATION of LINE BALANCING

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Abstract: This paper reveals the application of line balancing to improve the productivity of component under consideration. The company was facing problem for delivering the flywheel housing after increase in demand from their customer. The past data of component manufacturing process, resources required, work in process inventory and raw material inventory data was collected. When analysed the past data, constraints were observed on two machines in the production line which were needed to be focused. Eliminating the bottlenecks on these resources was the solution to cope up with the increased demand and also to minimize the raw material inventory as well as work in process inventory. The concepts described in Line Balancingwere applied to overcome the bottlenecks. The results obtained were at satisfactory level. The actual performance against the targeted level was measured and observed that productivity improved with considerable reduction in work in process as well as raw material inventories.

Keywords:Line balancing, productivity, constraints, work in process inventory and raw material inventory

I. INTRODUCTION

Line balancing is a tool that can be used to optimize the workstation or production line throughput. This tool will assist in the reduction of the production time and maximizing the output or minimizing the cost. Assembly line is a flow oriented production system where the productive units performing the operation referred to the workstation and the work pieces move from one station to one station with some kind of transportation system.

Normally there will be a problematic area in the production line or technically known as the bottleneck workstation [3]. Bottleneck is based on the analogy of the shape of a bottle. When liquid is poured into a bottle, the liquid will flow slowly at the bottlenecks that have a smaller parameter compare to the wider body. That is the conceptused for the term bottleneck in production line. At an assembly line, bottleneck is will create a queue and a longer overall cycle time.

The cycle times of each process in the factory were gathered to give a better understanding of the bottlenecks that might exist and of the work content at each station [4]. Gathering detailed information on cycle times and work content for all workstation is important in order identify the bottleneck of the entire operation.

II.CASE STUDY

Company manufactures a variety of products for many customers spread across the country. Preliminary analysis of 'Engine Flywheel Housing' products manufacturingon housing production lines was carried out. The target was on a specific type of housing product, theEngine Flywheel Housing no. 39.468,manufacturing for oil Engine Company. The demand for these housing parts is around 1200 housings per month. Current output is in the range about 950-1000 housings per month. Thus, there is need to increase the productivity of housing product no. 39468 by improving performance of housing production line. This includes increasing capacity of machine resources, reducing work in process inventory and utilization of workforces. The company has offers this problem for productivity improvement of targeted housing product. It is proposed to apply line balancing approach to current problem by focusing on bottlenecks in the housing production line and improve the productivity of the housing product by taking care of capacity constraint resource.

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A. Problem Associated with Company Existing Technique

The company manufactures different types of housings on the housing production line according to customer demand. The production of housings carried out according to monthly demand from customers. Once the customers place order for any housing component, the production planning and control department prepare schedule for monthly production. They divide monthly production requirement into weekly production requirement and weekly into daily production requirement.

The company was facing problem for delivering the selected flywheel housing product after its increase in demand from their customer. After studying the past data of housing component such as, manufacturing process, resources required, work in process inventory and raw material inventory, we found problems regarding dispatch and inventory control for the component.

III. METHODOLOGY

A. Identification of Constraint Resources in the Production Line

Identification of constraint is most important step of the Line Balancing. The constraint identification process suggests that there are two most important steps determining the constraint.Analysis of capacity and analysis of WIP accumulated in front of resource.

B. Analysis of Total Available Capacity of Each Resource in the Production Line

According to time study data analysis, average of total available capacity of each resource in the production line has determined which is shown in table I. Analysis of available capacity of each resource by considering cycle time as well as loading and unloading time require for each job on each resource in production line.

TABLE I
TOTAL AVAILABLE CAPACITY OF EACH RESOURCE IN THE PRODUCTION LINE

Machine Name	Cycle Time (min.)	Loading and Unloading Time (min.)	Total time per unit (min.)
Turret Lathe 1	6.00 min	3.00 min	9.00 min
Turret Lathe 2	6.00min	3.00min	9.00 min
VMC 4	7.00 min	3.00min	10.00 min
VTL2	8.50 min	3.00min	11.50 min
HMC2	12.50 min	----	12.50 min
VMC1	5.00 min	3.00min	8.00 min
Deburing and Chamfering	4.50 min	----	4.50 in

C. Analysis of Available Machine Capacity per Day Each Resource of the Production line

All the machines in the production line can be operated in three shifts per day. For each shift the all machines are available eight hours. But the machines cannot run continuously throughout the shift due to number of reasons. Hence some allowances must be applied to this available machine capacity.There are three types of allowances that can be applied here. They are machine setup allowance, machine maintenance allowance and fatigue allowance of the operators. The machine setup allowance and machine maintenance allowance has considered on the basis of previous data and time study literature.

TABLE III
TOTAL AVAILABLE MACHINE CAPACITY PER DAY EACH RESOURCE IN THE PRODUCTION LINE

Type of Allowance	Percentage of Allowance
Setup allowance	4%
Maintenance allowance	3.6%
Fatigue allowance of operator	7.4%

The total allowance considered 15% for each shift which is shown in table II. Therefore, machines are utilizes 410 minutes per shift including allowances.Thus, the total available capacity per day for all the resources in line is 1230 minutes per day approximately.

D. Analysis of Demand Placed on the Resources

Demand placed on resources has analysed using total available capacity and demand per day. The demand per day of selected product is 120 housings. Analysis of demand Placed on the resources is given in table III.

TABLE III
ANALYSIS OF DEMAND PLACED ON THE RESOURCES

Sr. No	Machine Name.	Total Time Required per Unit (min.)	Demand perDay	Total timeper Day (min.)
1	Turret Lathe 1	9.00 min	120 housings	1080 min
2	Turret Lathe 2	9.00 min	120 housings	1080 min
3	VMC 4	10.00 min	120 housings	1200 min
4	VTL 2	11.50 min	120 housings	1380 min
5	HMC 2	12.50 min	120 housings	1500 min
6	VMC 1	8.00 min	120 housings	960 min
7	Deburing and Chamfering	4.50 min	120 housings	540 N

E. Comparison of Total Available Capacity of the Resources and Total Demand Placed on the Resources

Next step followed during implementation of Line Balancing is comparison between total available capacity of each resource and total required capacity (demand placed)on each resource in the production line. Identification of constraint resource by comparing available capacity and demand placed on each resource is shown in table IV.

.TABLE IV

COMPARISON BETWEEN AVAILABLE CAPACITY AND DEMAND PLACED ON EACH RESOURCE

Sr no.	Machine resource	Available Capacity (min.)	Demand per Day (Required Capacity) (min.)	Remark
1	Turret Lathe 1	1230 min	1080 min	Non Constraint Resource
2	Turret Lathe 2	1230 min	1080 min	Non Constraint Resource
3	VMC 4	1230 min	1200 min	Non Constraint Resource
4	VTL 2	1230 min	1380 min	Constraint Resource
5	HMC 2	1230 min	1500 min	Constraint Resource
6	VMC 1	1230 min	960 min	Non Constraint Resource
7	Deburing and Chamfering	1230 min	540 min	Non Constraint Resource

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From this information the available capacity of resources, Turret Lathe 1, Turret Lathe 2, VMC 4, VMC 1, Chamfering and Deburing resources is more than demand; hence these resources are identified as non-constraint resources (NCR). But available capacity of resources VTL 2 and HMC 2are less than required capacity (demand), hence VTL 2 and HMC 2 are identified as constraint resources (CR).

F. Analysis of the Number of WIP Inventory Accumulated in Front of Each Resource

The number of WIP inventory accumulated in front of each resource in the production line is important issue for identification of the constraint resource. This is because the fact that the constraint resource is associated with huge number of WIP inventory. Thus, the number of WIP inventory ahead of each resource may give an idea about the constraint resource. Analysis of WIP inventory of selected housing product manufacturing on production line has carried out; and observed that WIP inventory associated with HMC 2 machine and VTL 2 machine is huge amount. The average WIP inventory registered 207 housings before implementation of Line Balancing.

G. Exploitation of the Constraint Resources

Layout of housing production line before implementation of Line Balancing is shown in fig1.

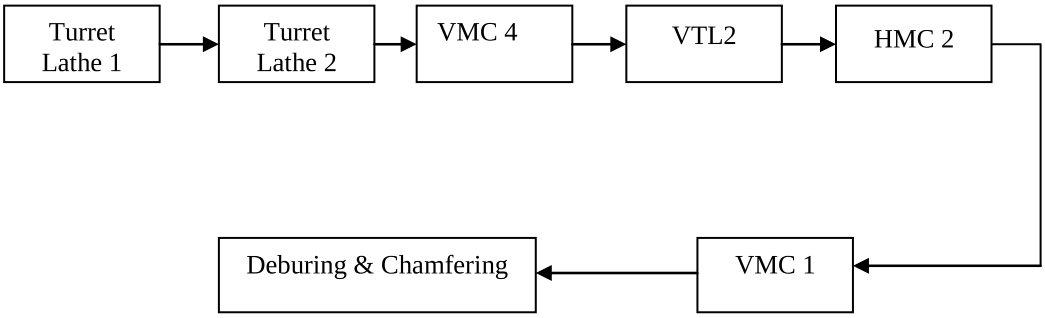

Fig.1 Layout of Housing Production Line before Implementation of Line Balancing

According to Line Balancing methodology, the resource whose capacity less than demand this resource identified as constraint resource and also the resource in front of maximum WIP inventory identified as constraint resource. Available capacity of the each resource in the housing production line is 1230 minutes per day. The demand placed on HMC 2 machine was 1500 minutes per day before Line Balancing. This means that capacity of HMC 2 machine was less than demand placed on it and maximum number of WIP inventory accumulated in front of HMC 2 machine. Hence HMC 2 machine has identified as constraint resource.

HMC 2 machine utilized for side milling, side drilling, tapping and countering operations on selected housing product. For these operations, cycle time required on HMC 2 machine was 12.5 minutes. To overcome this problem, we introduced Tap Fast 1 machine. The tapping and chamfering operations of HMC 2 machine shifted on Tap Fast 1 machine. Therefore HMC 2 machine now utilizes only for side milling and side drilling operations. The cycle time of HMC2 has reduced up to 10 minutes and same operator works on HMC2 and Tap Fast1 machine.

After performance of housing production line measured by introducing Tap Fast 1 machine, it is found that, VTL 2 machine has constraint resource because its capacity less than demand. Also in front of VTL 2 machine huge WIP inventory accumulated.

The capacity of the each resource in housing production line is 1230 minutes per day. The demand of VTL 2 machine is 1380 minutes per day. This means that, capacity of VTL 2 machine less than demand placed on it. In front of VTL 2 machine we observed 5 parts WIP inventory accumulated per shift; hence VTL 2 machine identified as constraint resource.

To overcome this problem, by introducing Turret Lathe 3 (TL 3) machine. Turret lathe 3 machine has maintained 5 housing parts (capacity buffer stock) in front of the VTL 2 machine and balance the production line. Total cycle time of (TL 3) machine has 16 minutes per job. After involving (TL 3) machine, it provided 5 parts per shift and line has balanced. Each shift TL3 utilize up to 80 to 90 minutes. Remaining 320 minutes TL3 utilized for machining of other

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housing products and development work.Layout of Housing Production Line after Implementation of Line Balancing shown in fig.2

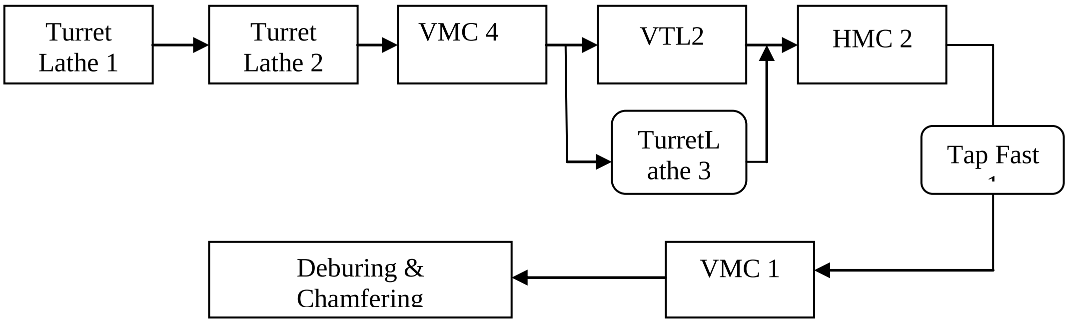

Fig. 2 Layout of Housing Production Line after Implementation of Line Balancing

IV. RESULTS AND DISCUSSION

To examine the impact of Line Balancing technique, performance measurement system has developed. After that, physical measurement of all performance measurement parameters carried out before and after implementation of TOC. The period from July 2012 to November 2012 represent pre-implementation period and post implementation period from December 2012 to April 2013.

A. Effect of line Balancing Methodology on Average WIP Inventory

The analysis of number of WIP inventory has carried out each week per month.

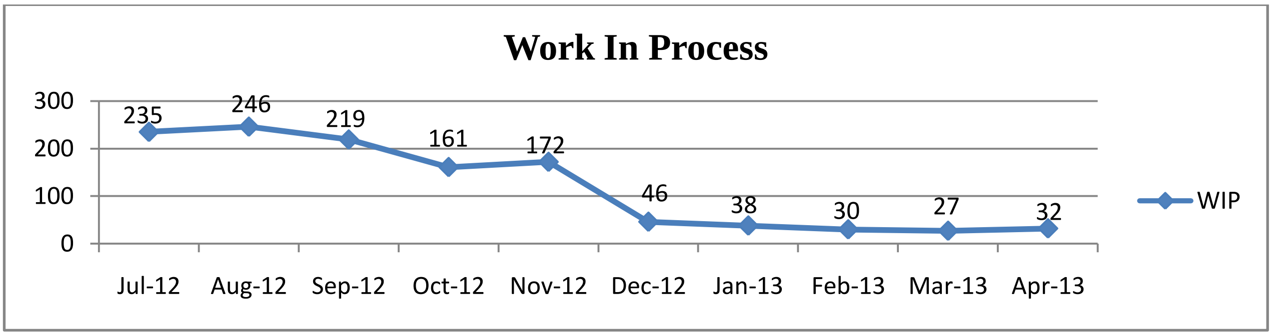

Fig.3 Number of WIP inventory before and after of Line Balancing

Fig.3 shows average number of WIP inventory before and after implementation of line balancing. From the above results, it is seen that there is considerable amount of reduction in number of WIP inventory of selected housing product due to implementation of line balancing technique. The average number of WIP inventory before implementation was 207 housings. This reduced to 35 housings per month after implementation of line balancing.

B. Average Percentage of On Time Deliveries before and after Line Balancing.

The average percentage of on time deliveries for selected housing product, before and after implementation of line balancing has measured. From fig. 4, it is seen that, the percentage of on time delivers almost good after implementation of Line Balancing i.e. December 2012 onwards. The on time delivers graphically represented by fig 4.

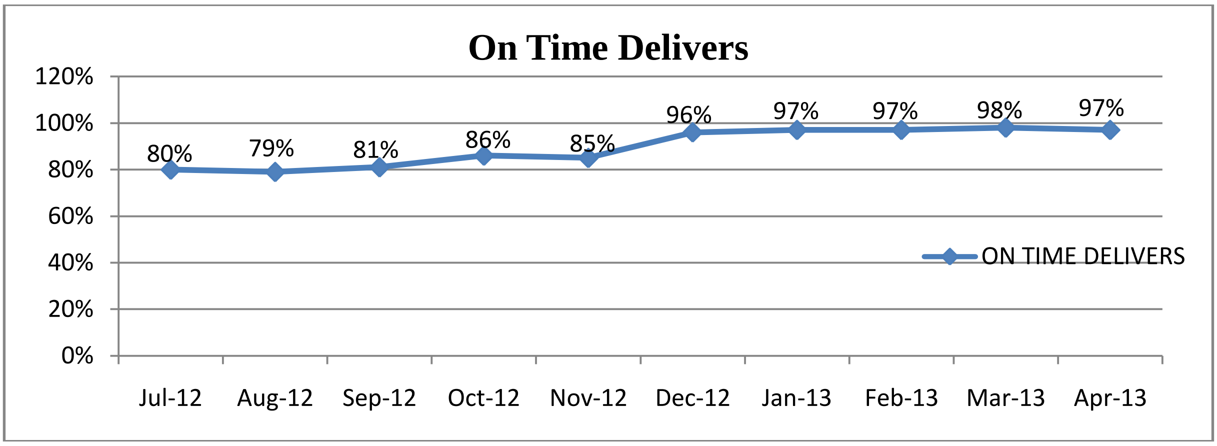

Fig. 4 Percentage of On Time Deliveries before and after Line Balancing

The average amount of on time delivers before implementation was 82%. This improves up to 97% after implementation i.e. 15% increment in on time deliveries after implementation of Line Balancing. This consequently resulted in improved throughput.

C. Effect of Line Balancing Implementation, on Raw Material Inventory (RMI)

The analysis of average number of raw material inventory before and after implementation of line balancing has carried out. Fig. 5 shows average number of WIP inventory before and after implementation of line balancing.

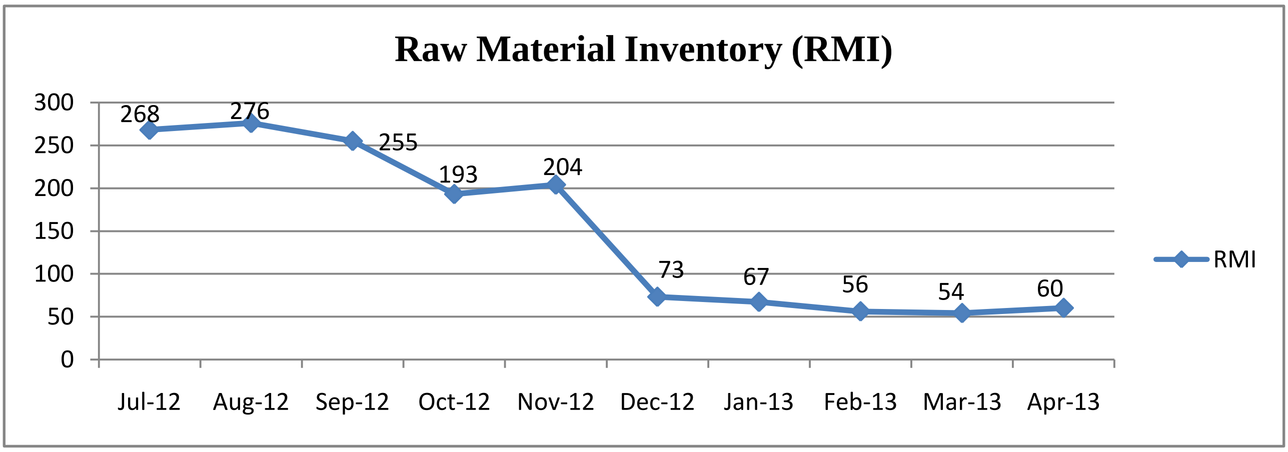

Fig. 5 Number of Raw Material Inventory before and after Line Balancing

From above results, it is seen that there is considerable number of reduction in raw material inventory for selected housing product due to the implementation of line balancing technique. Average number of reduction in raw material inventory due to the implementation of line balancing for selected housing product is graphically represented in fig.5.The average number of raw material inventory before implementation was 239 housings. This reduced to 62 after implementation.

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D. Effect of Line Balancing Implementation on Profit

After implementation of line balancing technique we observed that, there is little additional investment in the machining cost of the selected housing product.
The profit improvement due to the implementation of line balancing for selected housing product is graphically represented shown in fig.6.

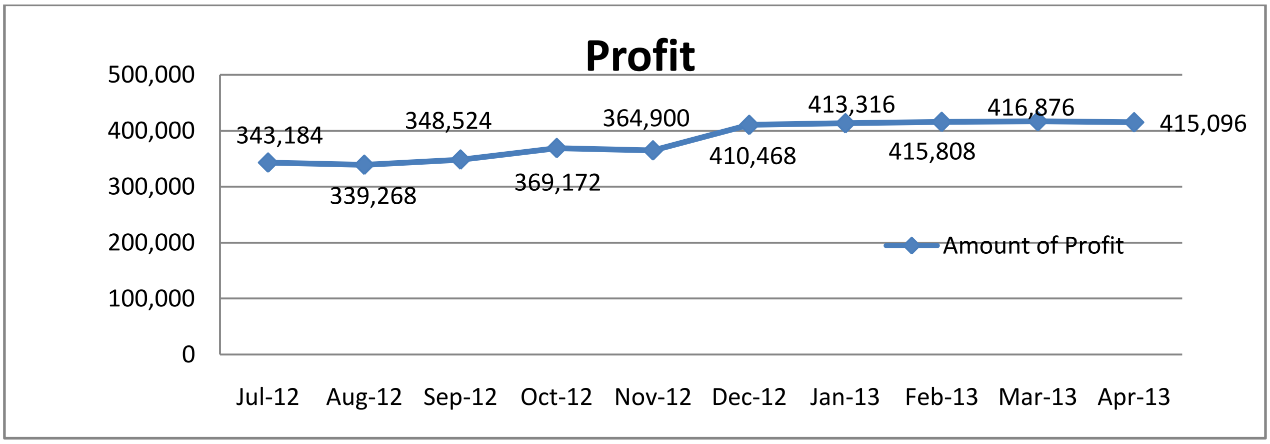

Fig. 6Profit before and after Line Balancing

The average profit before implementation was Rs.3,53,010/-. This improves Rs. 4,14,313/- after implementation i.e. 17% of profit improvement after implementation of line balancing.

V. PRODUCTIVITY MEASUREMENT

After the analysis of performance parameters such as on time deliveries, the productivity measurement has carried out for selected housing component. Productivity has measured in terms of labour, machine and material.
The table V indicates analysis of labour productivity, machine productivity and material productivity. After measurement of productivity it is observed that, labour productivity improved by 2.59%, machine productivity improved by 17.19% whereas the material productivity improved by 15.87%.

TABLE V
ANALYSIS OF PRODUCTIVITY

Type of Productivity	Before Line Balancing	After Line Balancing	Improved Values	Percentage of Improvement
Labour Productivity	17.71	18.17	0.46	2.59%
Machine Productivity	2.4195	2.8356	0.4161	17.19%
Material Productivity	0.3787	0.4388	0.060	15.87%

VI.CONCLUSION

Line Balancing brings a new dimension to management philosophy and provides an adopted within a wide variety of organizations and settings; it appears that organizations using line balancing has determined that it can help them achieve a number of management objectives, including continuous improvement. By application of line balancing it is possible to improve productivity by improving on time delivers, reducing inventory levels and better utilisation of resources.

After implementation of line balancing, the analysis gives following results.

1. After implementation of line balancingthe demand achieved for selected housing product is increased from 82% to 97%, which has resulted on time delivers improved by 15%.
2. Initially the average amount of production of housing product was 992. After involving machines (Turret Lathe Machine 3 and Tap Fast Machine 1) on the suggested place the production of selected housing product is increased up to 1163. This results, increased in production volume by 17%.
3. The profit of selected housing product was Rs. 3,53,010/- before implementation of line balancing. Whereas after implementation of line balancingprofit is Rs. 4,14,313/-. This results profit increased by 17%.
4. After implementation of line balancing the labour productivity increased by 2.59%, machine productivity increased by 16.94% and material productivity increased by 15.87%.
5. The average amount of work in process inventory for selected housing product is reduced. Before implementation of line balancingWIP was 207 housings and it is reduced up to 35 housings after implementation. This gives 83% reduction in work in process inventory.
6. The average amount of raw material inventory has considerably reduced; earlier it was 239 housings while it has come down to 62 housings. This gives 74% reduction in raw material inventory.

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BIOGRAPHY

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