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Research Article

Line Balancing through Cycle Time Reduction

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Abstract

Poor layout design is determined as a major problem in small and medium industry. These particular problems thus affect the productivity and the line efficiency as well. In automotive industries, assembly line is the major area to be taken into consideration for increasing productivity. The focus of this project is to identify the bottleneck workstations in the current layout and eliminate those activities that are taking time on those workstations. The time study is done manually by us. The current layout is redesigned by computing take time and processing times in each workstation. The case study shows how the takt time calculation is done and from this takt time, the processing time is decided for all workstations. The time consuming activities are reduced and thus the processing times at all workstations is made possibly equal. The time reduction increases productivity in the form of increased number of units of production in the same previous time. Line efficiency is also found to be improved which is described in terms Overall Line Efficiency (OLE).

Keywords: *Line Efficiency, Line Balancing, Bottleneck, Cycle time, Workstation, Idle time, Productivity.*

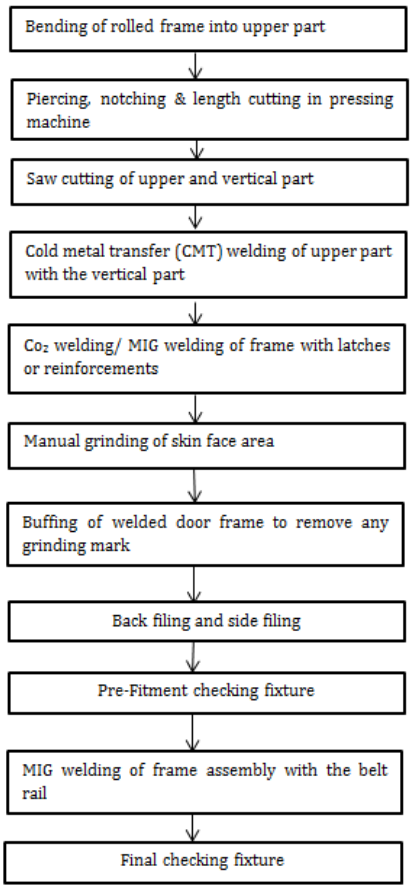
Introduction

The aim of this project is to increase the production. If the level of output is increased faster than that of input, productivity will increase. Conversely, productivity will be increased if the level of input is decreased faster than that of output. Also, an organization may realize a productivity increase from reducing more output with the same level of input. Finally, producing more output with a reduced level of input will result in increased productivity.

Productivity is the ratio between output and input. It is quantitative relationship between what we produce and what we have spent to produce. Productivity is nothing but reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people. Productivity denotes relationship between output and one or all associated inputs.

We use cycle time as the tool to measure each workstation's productivity. The workstation which takes the longest cycle time will be the critical process. This will decide the overall output in terms of units. So the productivity can be increased only if we debottleneck the critical process.

Process Flow



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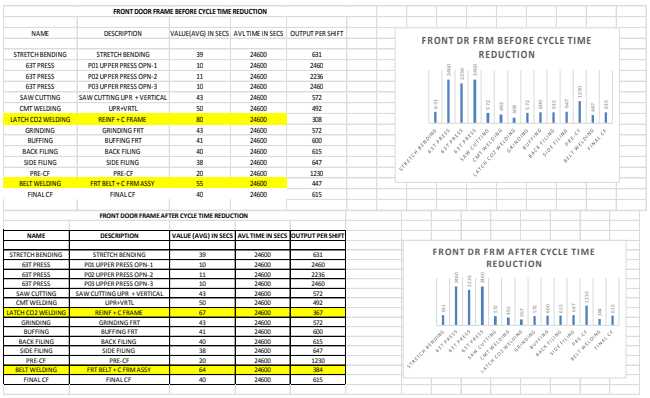
Observations

The cycle time for each process in door frame assembly line is calculated manually by us. The cycle time study report is made with the help of stop watch. Each process is studied in detail by taking ample number of recordings on various sessions. By taking into account of the available time for each shift, the number of output products is found out for each shift.

The process which takes the longest cycle time is regarded as the critical process and considered as the bottleneck for productivity. The longest cycle time also decides the minimum number of output products that can be produced per shift. So in order to increase the productivity, we have to increase the number of output products produced per shift. This can be achieved by reducing the cycle time for that critical process.

Further, it is found that the front door frame takes some more time to produce than rear door frame assembly. This is because of a provision to locate rear view mirrors in the front door panels, which is why latch Co2 welding process takes the longest cycle time in the assembly, leaving rest of the process to be same for both the frame assemblies. Also the assembly line is found to be balanced, leaving us to take only the cycle time reduction approach to improve the productivity.



FRONT DOOR FRAME BEFORE CYCLE TIME REDUCTION

NAME	DESCRIPTION	VALUE(AVG) IN SECS	AVL TIME IN SECS	OUTPUT PER SHIFT
STRETCH BENDING	STRETCH BENDING	39	24600	631
63T PRESS	P01 UPPER PRESS OPN-1	10	24600	2460
63T PRESS	P02 UPPER PRESS OPN-2	11	24600	2236
63T PRESS	P03 UPPER PRESS OPN-3	10	24600	2460
SAW CUTTING	SAW CUTTING UPR + VERTICAL	43	24600	572
CMT WELDING	UPR+VRTL	50	24600	492
LATCH CO2 WELDING	REINF + C FRAME	80	24600	308
GRINDING	GRINDING FRT	43	24600	572
BUFFING	BUFFING FRT	41	24600	600
BACK FILING	BACK FILING	40	24600	615
SIDE FILING	SIDE FILING	38	24600	647
PRE-CF	PRE-CF	20	24600	1230
BELT WELDING	FRT BELT + C FRM ASSY	55	24600	447
FINAL CF	FINAL CF	40	24600	615

FRONT DOOR FRAME AFTER CYCLE TIME REDUCTION

NAME	DESCRIPTION	VALUE (AVG) IN SECS	AVL TIME IN SECS	OUTPUT PER SHIFT
STRETCH BENDING	STRETCH BENDING	39	24600	631
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63T PRESS	P03 UPPER PRESS OPN-3	10	24600	2460
SAW CUTTING	SAW CUTTING UPR + VERTICAL	43	24600	572
CMT WELDING	UPR+VRTL	50	24600	492
LATCH CO2 WELDING	REINF + C FRAME	67	24600	367
GRINDING	GRINDING FRT	43	24600	572
BUFFING	BUFFING FRT	41	24600	600
BACK FILING	BACK FILING	40	24600	615
SIDE FILING	SIDE FILING	38	24600	647
PRE-CF	PRE-CF	20	24600	1230
BELT WELDING	FRT BELT + C FRM ASSY	64	24600	384
FINAL CF	FINAL CF	40	24600	615

Fig.1 Cycle Timings

CURRENT STATE CYCLE TIME				
PROCESS	DAY 1	DAY 2	DAY 3	OVERALL AVG IN SECS
STRETCH BENDING	39.1	39.4	37.7	39
63T PRESS OPN 1	10.2	10.8	10.7	10
63T PRESS OPN 2	11.4	10.7	11.35	11
63T PRESS OPN 3	10.65	10.4	10.85	10
SAW CUTTING 1 & 2	45.5	42.45	44.7	43
CMT WELDING	49.85	49	49.65	50
LATCH CO2 WELDING	80.65	80.25	80.25	80
GRINDING	42.95	41.45	43.4	43
BUFFING	40.5	40.65	40.25	41
BACK FILING	40.05	41.25	39.05	40
SIDE FILING	37.85	36.8	37.35	38
PRE-CF	19.7	21	21.5	20
BELT WELDING	54.7	54.75	54.55	55
FINAL CF	40.7	40.75	41.3	40

Fig.2 Current state cycle time

Methodology

Cycle Time improvement

World class companies that are finding a concentrated effort to reduce cycle time is one way to do the following:

- Enhance their competitive positions
- Increase profitability
- Achieve these results in a short period of time with minimal investment
- Major cycle-time improvement is not achieved by working faster, but through improved processes and the application of proven techniques and tools

Organizational culture transformation is usually set in motion by a high-level assessment to set a strategy for action. Although such an assessment has not been made part of the deployment process presented, it is important that all senior management have a clear understanding of the company's readiness to move into CTI activities. This includes understanding the following:

- How the financial success of the company is linked to cycle and lead times
- What the priority of CTI should be relative to other improvement activities
- Which cycle or cycles (business processes) need to be addressed
- How committed you are to improving competitiveness through CTI

Problem-solving tools applied to cycle time improvement (CTI)

These tools are used for developing a complete picture of all the possible causes of a problem and to reach agreement on the basic one(s). There are numerous tools in this category. For CTI, typical problem-solving tools include:

- Brainstorming
- Cause and Effect Diagrams
- Force Field Analysis
- Nominal Group Technique
- Pareto Chart
- Histogram
- Affinity Diagram
- Interrelationship Diagram
- Prioritization Matrices
- Analytical Matrices

Brainstorming Ideas

Table 1: Brainstorming ideas

S No	SOLUTIONS	REMARKS	CONCLUSION
1.	Addition of one more welding robot in Co_2 quadrant latch welding station	Costs approx. 20 lakhs, such an investment will not attract suitable rate of return The company has to bear such extra sum for each product they are producing, while its cost remains the same	Not ok
2.	Addition of man power or labour in the present layout to perform manual welding in the same Co_2 quadrant latch welding station	Manual welding is feasible but it will not produce the same quality as done by a robot Welding spots can be inconsistent if performed manually	Not ok
3.	The Co_2 spot belt welding station can be utilized for latch welding	Both the welding stations employ same kind of robot for producing Co_2 spot welds By doing this, cycle time for latch welding gets reduced hence productivity can be improved, there by line gets balanced	Ok

Improvements made

1. CO_2 Latch welding station

Fig.3 Co_2 Latch Welding Station

Current Scenario

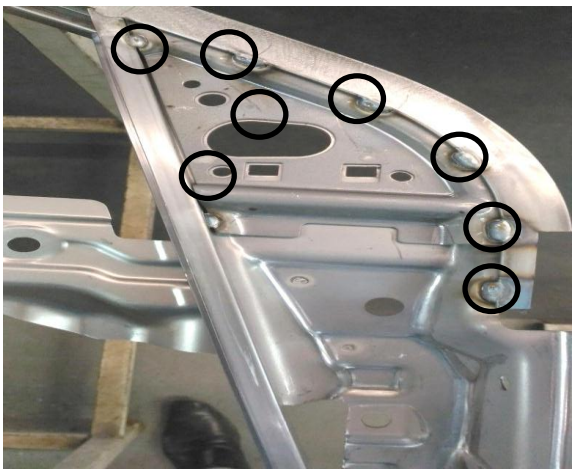

Fig.4 Current scenario

Cycle time for latch welding = 80 secs
No. of spot welds = 8 spots
Effective output = 270 units

Initially, the latch welding is done wholly by this welding robot. For that, the cycle time would be 80 seconds. This is the longest cycle time noted in the assembly line.

The number of product coming out from this station is going to decide the number of output for the whole line. Hence, cycle time reduction is done to increase output of this station. It is proposed to reduce the number of spot welds done by this robot and can be compensated by another robot in the same assembly line which performs belt spot welding. By doing so, the productivity can be increased and at the same time line also gets balanced.

Future Scenario

Fig.5 Future scenario

Cycle time for latch welding = 67 secs
No. of spot welds = 6 spots
Effective output = 330 units

The weld spots 1 and 2 will be removed from latch welding machine and going to weld by belt spot welding robot at its station. Therefore cycle time for 8 spots welding gets reduced. Hence, production rate is increased from 270 units to 330 units per shift, which is a 22% increase in the same assembly line.

2. Belt spot welding station

Fig.6 Belt Spot Welding Station

Current Scenario

Fig.7 Current scenario

Cycle time for spot welding = 64 Sec
No. of spot welds = 8 spots
Effective output = 380 units

In the belt welding station, the frame contains the latch welded on only 6 spots, done by earlier latch welding robot. The remaining two spots is going to be weld by belt welding robot

Future Scenario

Fig.8 Future scenario

Cycle time for spot welding = 55 secs
No. of spot welds = 6 spots
Effective output = 440 units

Initially, the belt welding station performs the welding of c-frame assembly with the belt reinforcement. For that, cycle time would be 55 seconds. Now, the belt welding station is proposed to perform some additional task to balance the assembly line. This can be done by performing additional spot welds carried out by Co2 welding station. Hence the number of output from the critical station gets increased.

Results

Line Balancing

Productivity of a manufacturing system can be defined as the amount of work that can be accomplished per unit time using the available resources.

Line balancing (LB) is usually undertaken to minimize imbalance between machines or personnel while meeting a required output from the line. Line balancing is a tool to improve the throughput of a work cell or line which at the same time reducing manpower and cost needed. It is often used to develop product based layout. Line Balancing job description is to assign tasks to a series of connected workstations where the number of workstations and the total amount of idle time are minimized for a given output level. The line is balanced if the amount of work assigned to each workstation is identical.

Line balancing is commonly used technique to solve problems occurred in assembly line. Line balancing is a technique to minimize imbalance between workers and workloads in order to achieve required run rate. This can be done by equalizing the amount of work in each station and assign the smallest number of workers in the particular work

Generally, Line Balancing technique is used by many companies to improve the productivity, decreases the man power, decreases idle time and buffer or even to produce more than two products at the same time. Line balancing technique is used to achieve the minimization of the number of workstations, the minimization of cycle time, the maximization of workload smoothness and the maximization of work relatedness.

Parameters in line balancing

1. Cycle Time = available time period / output units required per period
2. Production = no. of outputs made
3. Productivity = no. of outputs made / input (time)
4. Line efficiency = total station time / (cycle time * no. of workstations)

Overall Equipment Effectiveness (OEE) is a preeminent practice for monitoring and improving efficiency of the manufacturing processes such as machines, cells, assembly lines and etc. OEE when applied to assemblies is called as Overall Line Efficiency (OLE). OEE is simple and practical yet a powerful calculation tool. It takes the most common sources of manufacturing productivity losses and places them into three understandable categories which are Availability, Performance and Quality.

Reasons to have balanced production line

- Keeping inventory cost low results in higher net income.
- Keeping normal inventory levels lets the operator work all day long giving him/her the opportunity to earn more money by increasing his/her efficiency.
- Keeping the line balanced lets the supervisors improve other areas because they can use their time better.
- Balanced production keeps prices low which turns into repeat sales.
- Balanced assembly line reduces much of the idle time
- Balanced production means better production

Allowances

Table 2 Routine Time Table

Day plan	10
Morning tea break	10
Lunch break	30
Afternoon tea break	10
M/c cleaning time	10
Total time	70 mins

Productivity before cycle time reduction

Table 3 Productivity before Cycle Time

S.No	Contents	Duration
1	Total shift timing	8 hrs
2	Shift timing	480 mins
3	Exemptions	70 mins
4	Available timing	410 mins
		24600 secs
5	Cycle time	80 secs
6	Output	308 Units
7	OEE efficiency @90%	277 Units
8	Rounded off to	270 Units

Productivity after cycle time reduction

Table 4 Productivity after Cycle Time

S.No	Contents	Duration
1	Total shift timing	8 hrs
2	Shift timing	480 mins
3	Exemptions	70 mins
4	Available timing	410 mins
		24600 secs
5	Cycle time	67 secs
6	Output	367 Units
7	Oee efficiency@90%	330 Units
8	Rounded off to	330 Units

Productivity Improvement

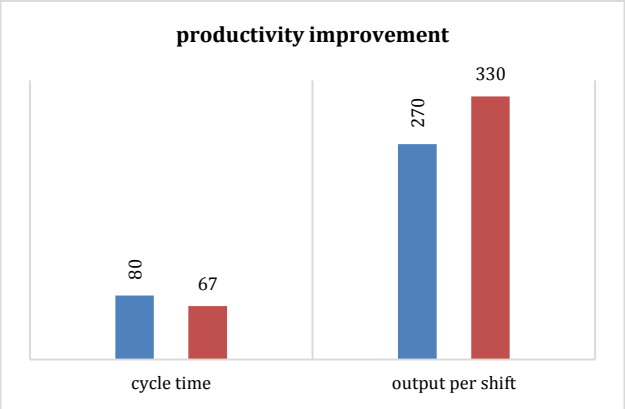

Fig.9 Productivity Improvement

Conclusion

This project describes assembly line balancing by cycle time reduction, 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 take time, cycle time and downtime and thus reduces the production lead time with increased number of output. Continuous improvement is the step to reduce unnecessary downtime losses. The productivity of assembly line is thus found to be increased.

The cycle time is noted for each workstation with the help of stopwatch. And successfully identified the bottleneck in the assembly line, which is Co2 latch welding station. Also, suitable countermeasures were proposed to eliminate the bottleneck to improve the productivity. At last, cycle time reductions in done in two steps to increase the present production rate. The results are:

Productivity Improvement

The number of parts produced in front door frame assembly before cycle time improvement is 270 units per shift. Now it can be increased to 330 units per shift by adapting cycle time reduction which is a 22% increase in productivity.

Overall Line Efficiency

The line efficiency before cycle time improvement and line balancing is 45%. Now it can be improved to 55% after employing line balancing by cycle time reduction.

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