Application of Lean Techniques in Excavator Assembly Line

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***Abstract*-Volvo Construction Equipment, Bangalore is a worldwide known brand company that deals with the production of excavator and road machinery. The work was carried out in the excavator assembly line, where three models of excavator were assembled. The key objective of the work was to improve the productivity of the line by identifying and eliminating non value added activities. In order to enhance the line efficiency, line balancing and optimal allocation of workers to workstations was undertaken.**

Keywords*: *Productivity, Time study, line balancing, largest candidate rule method, Value stream map.

I. INTRODUCTION

Lean manufacturing techniques [1][2] implementation requires a system-level change for the factory-a change that will impact every segment of the company from accounting to shipping. Some of the following steps used in lean implementation are:-

1) Develop and simplify the flow of materials
2) Reduce and eliminate the setup in the cells
3) Integrate the quality control
4) Integrate Preventative Maintenance
5) Level and Balance and synchronize
6) Integrate Production Control
7) Integrate Inventory control
8) Automation
9) Restructure the Production system

At present, Volvo construction equipment has:

1) 8 main stations and 13 feeders in the line.
2) Fully automated with conveyors and cranes of various sizes around 8 tonne, 6 tonne etc.
3) Ergonomically designed with respect to the workers safety and comfort.
4) Testing drive inspection area (TDI), where the machines undergo enormous testing.
5) Painting section, where they strip the entire paint of the body and re-paint it again.
6) The assembly line is automated to assemble various models of excavators.

II.METHOD & ANALYSIS

The techniques [3][4][6] used in this work are:

Time study: Time study was used to understand the work procedures carried out at each station. it also helped to identify the non value added activities and value added activities and the total time taken to complete the operation in each station.

Line Balancing: line balancing was carried out to provide proper allocation of workers across the work station.

Value Stream Mapping: Value Stream Mapping was used ot identify and eliminate non value added activities. In this project the value stream map was used to map the current state and identify the unnecessary use of stations or feeders. And the future state was mapped.

Cost Benefit Analysis: A systematic approach was used to estimating the strengths and weaknesses of alternatives.

After data collections as shown Table 1, the following observations were made:

Table 1: Data collection

Activity	No.	Percent
VA	872	35%
NVA	1033	42%
SVA	583	23%
Total	2488	

- There were 1033 NVA which accounted to 42% of the activities. Hence, it was inferred that some of the activities can be eliminated in order to increase the VA activities.
- At present, the number of operators was around 29 as shown in Fig-1. It was noticed that by optimal allocation of man power the no. of operators could be reduced, which shall result in cost saving for the company.

Present Layout

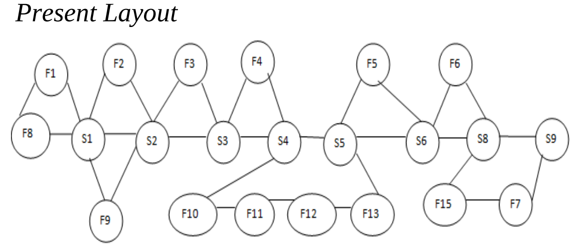

Fig-1: Present layout

Calculation of existing line & balance efficiency

T_{ws} = To assemble a product the total time taken is called the work content time = 2190 minutes

n = no of existing work station = 14

T_w=T_c=The maximum available workstation time = 205 minutes

Balancing efficiency of existing layout

$= T_{ws}/nT_w$

= 2190/ (14*205)

=76.30%

Line efficiency(η) of existing layout $=R_p/R_c$

Where R_p=average production rate(unit/hr) = D_a/52*S*H

D_a=annual demand for a single product (units/year),

S =number of shifts/week; H= number of hr/shift

=396/(52*5*8)

=0.190

R_c=cycle rate for the line (cycles/hr)

= 60 minutes/T_c

=60/205=0.29

η=0.190/0.29=64.9%

Proposed Layout

Largest Candidate Rule method [5] was used to balance the line using data in Table 2 and Fig-2.

Table -2: Precedence Table

Element	Element Time	Precedence
F-8	130	-
S-4	199	S-3 & F-4
F-2	176	S-1
F-10	167	S-4
F-9	143	S-1
F-15	142	S-8
S-2	113	F-2,S-1 & F-9
F-12	108	F-11
S-1	241	F-8
S-3	97	F-3 & S-2
S-9	94	S-8 & F-7
F-11	92	S-8 & F-7
S-8	78	S-6 & F-6
F-13	76	F-12
S-5	56	S-4 & F-13
F-7	54	F-15
F-4	54	S-3
F-3	39	S-2
S-6	39	S-5 & F-5
F-6	39	S-6
F-5	8	S-5

Table-3: Allocation of Workstation

Work Station	Element	Element time	∑ element time
I	F-8	130	130
II	S-1	241	241
III	F-2	176	176
IV	F-9	143	143
V	S-2 F-3	113 39	152
VI	S-3 F-4	97 54	151
VII	S-4	199	199
VIII	F-10	167	167
IX	F-11 F-12	92 108	200
X	F-13 S-5 F-5 F-6 S-6	76 56 8 39 47	226
XI	S-8 F-15	78 142	220
XII	F-7 S-9	56 94	150

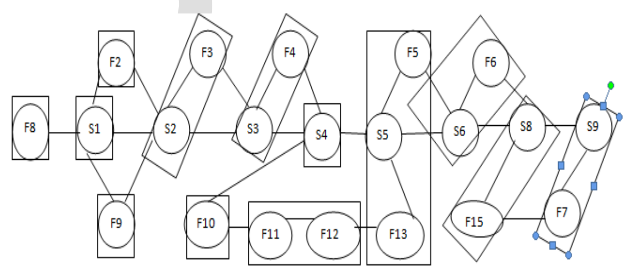

Fig 2: Proposed layout

- T_{ws} = 2155 minutes from Table 3.
- n = no of proposed work station = 12
- T_w=T_c=The maximum available workstation time = 241 minutes

Line efficiency of proposed layout (η) $=R_p/R_c$

Where Rp=0.190; R_c=60/241=0.248

η=76.61%

III. RESULTS & CONCLUSIONS

Eliminating Feeder-1 and Feeder-14,

It has helped the company to increase the line efficiency from 64.9% to 76.61%.

In detail:

1) By eliminating Feeder-1 as shown in Fig-3.

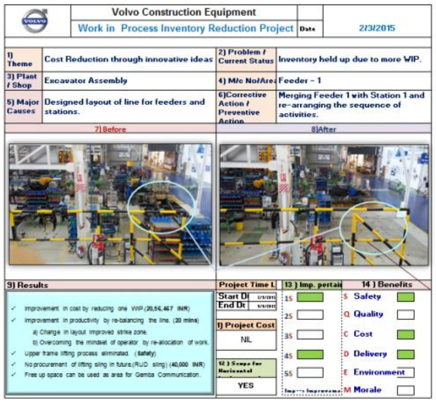

Fig-3: Feeder-1 elimination

2) By eliminating Feeder-14 as shown in Fig-4.

Fig-4: Before eliminating feeder-14

Fig-5: After eliminating feeder-14

- Lifting and placing on pallet is eliminated after doing the sub assembling as shown in Fig-5.
- Lifting and placing on fixture is eliminated, which can now be directly placed on the trolley and sub assembly can be done.
- Moving the Trolley from feeder to station is eliminated as it comes directly from the stores and placed on the trolley of station-1.
- A total of 38 minutes is eliminated.

3) By using the technique of line balancing, the number of work station is reduced from 14 to 12.

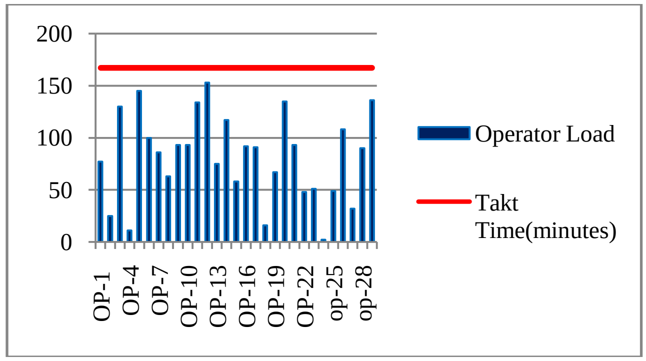

Fig-6: Before eliminating the stations

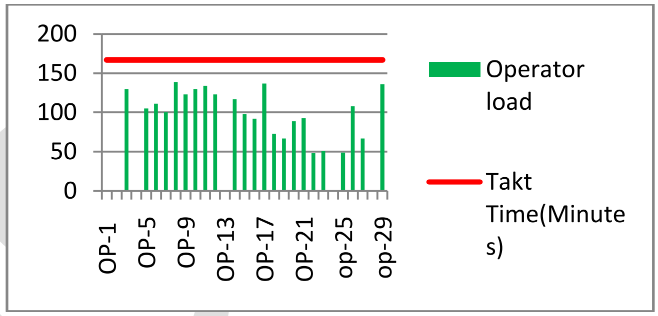

Fig-7: After eliminating the stations

The Distribution of load among workers as shown in Fig 6 & Fig 7:

- Since feeder-1 is eliminated, the load of Operator-1 & Operator -2 is given to Operator-17 & Operator-18 and a load of 46 minutes is added to operator-17.
- In feeder-10 & 11, Operator -4 is eliminated and the load of 11 minutes is given to Operator -6 to do the cleaning of track motor assembly.
- Operator-5 gives load of 40 minutes to Operator-15 to do the track motor assembly.
- In feeder-7 & station 9, Oprator-7 takes a load of 14 minutes from Operator-8 to fix the mirror stand and draining of oil from the lube pipe.
- In feeder-7 & station 9,Opeator-8 takes a load of 90 minutes to do Testing Drive inspection.
- In feeder-2 & station 2, Operator-12 gives a load of 30 minutes to Operator- 9 to do the seat sub assemble.
- Feeder 14 is eliminated and load of Operator-13 of 37 minutes is given to Operator-10 to do the hydraulic and fuel tank assembly.
- In engine sub assembly, Operator-27 is given a load of 35 minutes from Operator-20, i.e Operator 27 can help cowl RH & LH mounting along with OP-20.

- In station-1, Operator-18 takes a load of 11 minutes from Operator-20 who is working in cowl and frame. He can work on battery and tool box mounting along with Operator-19.

The costs benefit analysis:

1) Before eliminating the work station- each worker was paid=Rs 8000/-
   =29*8000
   =Rs 2,32,000/-

After eliminating the work station & doing line balancing it is proposed that the company can save:

- 6 workers are eliminated i.e 6*8000 =Rs 48000/-
- A savings of Rs 48,000/- per month.

2) The cost associated with eliminating the feeder-1 is:
   - Elimination of lifting the upper frame of the excavator using a sling which cost Rs 40,000/-.Hence there no requirement of sling, resulting in savings of Rs 40,000/-.
3) The cost associated with eliminating Feeder-14 is:
   - Use of fixture costing Rs 4,00,000/-used for placing the fuel and hydraulic tank is eliminated. Hence a saving of Rs 4, 00,000/- to the company.

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