International Journal of Recent Advances in Multidisciplinary Research
Vol. 01, Issue 03, pp.051-055, September, 2014

Full Length Research Article

PRODUCTIVITY ENHANCEMENT WITH LEAN CONCEPTS IN BELT DRIVEN COMPRESSOR INDUSTRY

***[1]P.V.Senthiiland [2]Aakash Shirrushti**

[1]Head Mech, Department of Mechanical, SPIHER, TN, India
[2] Final Mech, Mechanical EnggDept, SRM, TN, India

ARTICLE INFO

Article History:
Received 05th June, 2014
Received in revised form
01st July, 2014
Accepted 09th August, 2014
Published online 30th September, 2014

Keywords:
Productivity,
Lean, Layout design,
5S principle,Poka-yoke,
Assembly line balancing,
Simulation, Promodel. etc…

ABSTRACT

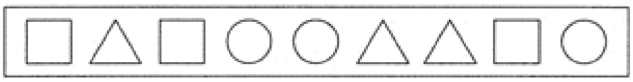
Productivity has been an important concern to all the manufacturing industry. Lean manufacturing emerged as production strategy capable of increasing productivity by identifying and eliminating non value added activities. This article deals with productivity improvement in a Compressor manufacturing industry with a case study using lean concepts with the use of Process flow chart and Time study. The data are collected and analyzed with the use of lean tools namely Value stream mapping, 5S principle, Poka-yoke, Assembly line balancing and Layout design. The new layout is validated by Simulation using promodel shop floor tool.

INTRODUCTION

Lean Manufacturing, also called Lean Production, is a set of tools and methodologies that aims for the continuous elimination of all waste in the production process. The main benefits of this are lower production costs; increased output and shorter production lead times.Another way of looking at Lean Manufacturing is that it aims to achieve the same output with less input – less time, less space, less human effort, less machinery, less material, less cost.Toyota Production System (TPS) which is known as Lean manufacturing by in their book "The Machine That Changed the World" has influenced the manufacturing practices around the world (Womack, *et al*., 1990). The fundamental of TPS is to eliminate wastes and produce only the items needed at the required time and in the required quantities. Principles of lean are universal as they are broadly accepted by many manufacturing operations andhave been applied successfully across many disciplines. It has become an integrated system composed of highly inter-related elements and a wide variety of management practices including Just-in-time, quality system, work teams, cellular manufacturing, etc (KartikRamchandran, *et al*., 2001). The main purpose of implementing lean manufacturing isto increase productivity, reduce lead time and cost and improve quality thus providing the up most value to customers. There are many descriptions regarding lean manufacturing. It is most frequently associated with the elimination of the seven important wastes to make the effects of variability in supply, processing time or demand. The seven wastes mentioned are: overproduction, waiting, unnecessary transport or conveyance, over processing or incorrect processing, excess inventory, unnecessary movement and defects.

****Corresponding author: PV Senthiil,*** *Head Mech, Department of Mechanical, SPIHER, TN, India*

According to J. P. Womack (1990), lean manufacturing uses less of everything compared to mass production - half the human effort in the factory, half the manufacturing space, half the investment in tools and half the engineering hours to develop a new product (Yon sheng Wang, *et al*.,1989). In addition, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products. In short, it is called lean because it uses less, or the minimum, of everything required to produce a product or perform a service.A mixed model line Figure 1 helps to produce different models of the same product in a single assembly line so that potential market opportunity is not lost. Mixed model assembly lines are used for the assembly of two or moremodels or products, so that the different products may be processed on the same line in a sequence (Lean Manufacturing– Spring, *et al*., 2001). The primary focus model-sequencing problem (MSP) is to find an optimal sequence of products to level workload on the line.



B. Mixed-model line

Figure 1. The mixed-model assembly line (Scholl, 1999)

Wastes in the Organisation

The key to lean manufacturing is to compress time by eliminating waste and this continually improving the process. TaichiOhno, *et al*., (1988) defines waste as all elements of production that only increase cost without adding value that customer is willing to produce. The wastes in the organisation are: (TaichiOhno, *et al.*, 1988)

1. Overproduction: Producing more than needed.
2. Waiting: Idle operator or machine time.
3. Motion: Movement of people or machine that does not add value.
4. Inventory: Any excess supply required to produce product.
5. Transportation: Any material movement that does not directly support value added operations.
6. Defects: Making defective parts.
7. Extra processing: Any process that does not add value to the product.
8. Underutilizing people: Not taking advantage of people's abilities.

Tools of Lean Manufacturing

Standardized work: Operations are organized in the safest, best known sequence using the most effective combination of resources. Jobs are broken down into elements and examined to determine best and safest method for each. The standard is then established, taught and sustained by repetition. Workplace Organization/5S: Various housekeeping activities are often used for continuous improvement. The workplace organization activities are:

1. Sort-out - what is required and not required;
2. Set in order - a place for everything and everything in its place;
3. Shine / cleanliness - cleaning all the work places with an eye of preventive maintenance;
4. Standardize - the system throughout the organization;
5. Sustain - the efforts with self-discipline.

Visual factory (VF): Information is made available and understandable for each operator to see and to use in achieving continuous improvement. Point of use storage: Locate all parts raw material, tools and fixtures as close as possible to where they are being used.

Kanban: A Kanban system is an information system that controls the required parts at the required time.

Kaizen: Kaizen is a Japanese word for continuous improvement. Kaizen is the process of identifying and eliminating wastes as quickly as possible at the lowest possible cost (Kazuhiro Yamashita, *et al*., 2002).One piece flow: To minimize work in process operator should focus on completing one part through the process before starting on the next part.TAKT time: TAKT time is the maximum time per unit allowed to produce a product in order to meet demand. Total productive maintenance (TPM): TPM consist of companywide equipment maintenance program that covers entire equipment life cycle and requires participation by every employee (Abduelmula, et al., 2003). Value stream mapping (VSM): VSM serves as a starting point to help management, engineers, suppliers and customers recognize waste and identify its waste. VSM is a method of visually mapping a product's production path including material and information flow. It takes a look at the activity required (both value added and non-value added) to move a product from raw material to customer.

Case Study

This is a practical case study of an assembly line set up which is done at ELGI Equipments, Coimbatore, done in the Belt Driven Compressor are whose production line target is to manufacture 144 compressors/ month on one shift basis. In the existing set up, the assembly line having a production capacity of 96 compressors/ month was conveyed on a U Shaped assembly line with total 5 stations having a tact time of 120 minutes for each station. The demand for the New Model (EN53) and Compact compressors wasincreasing so as per the market research carried out by the marketing department of the company, the customers demand (as per sales forecasting) is more than the required production rate i.e. 144 compressors/ month.The system under study is production line whose target is to manufacture 144 compressors/ month on one shift basis having a tact time of 96 minutes for each station. The Compressor production line consists of eight main stations, sub-assembly, assembly, testing, Trolleys for material feeding in each station, LCA (Least Cost Automation) for easy operation and Kits for material feeding.

Problem Identification

- Low productivity due to, Bottleneck in assembly process.
- High work in process.
- High inventories.
- Storage and space constraint.
- No proper material movement.
- No Lean manufacturing features.
- Unable to meet market demand.

Line Balancing

Table 1. Line Balancing time Final

Sl.No	Process	Model (time in min)		
		TMSAC	Comp Air	EN 53
1	Motor air end sub assembly	45	45	45
2	Air end SA	11	13	--
3	Cooler sub assembly	5	9	--
4	Manifold block sub assembly	18	--	--
5	Tank sub assembly	11	23	--
6	Main assembly	90	90	45
	Total time in min	180	180	90

EN53 Precedence Diagram (after Lean Implementation)

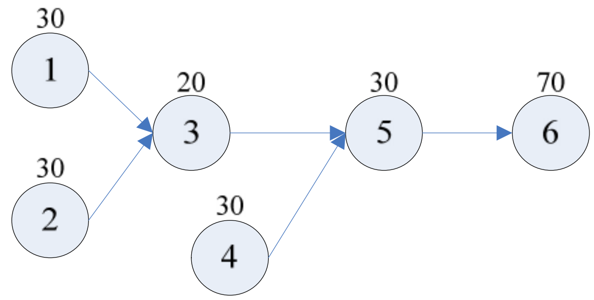


Figure 2.EN53 Precedence Diagram (after Lean Implementation)

1. Drive System Sub Assembly
2. Cooler, Fan and AVM Sub Assembly with Base
3. Drive System Assembly with Base & Hoses assembly
4. Controller & Control Panel Sub Assembly
5. Canopy Assembly
6. Testing & Final Panel Assembly & PDI & Packing Combined

No of Units per day= 6nos
Available time = 8 hours
= 480 minutes

COMSOL Algorithm After Lean (For EN53 Model)
C.T=Production time/Production volume
C.T=480/6=80 minutes

Table 2. Unassigned Cycle time (after Lean)

Station No	Preferred	Work Element Selected	UACT
1	--	1	80
			30
			50
		2	30
			20
		3	20
			0
2	4	4	80
			30
			50
	5	5	30
			20
3	6	6	80
			70
			10

Total Idle time in min (0+20+20+10) = 30 min

Efficiency= {1-{UACT/C.T x St.NO}}*100
Efficiency= {1-30/ (80 x 3)}*100
Efficiency = (1-0.167)*100
Efficiency=83.3%

Promodel Simulation

Advanced computer programs can simulate weather conditions, chemical reactions, atomic reactions, even biological processes. In theory, any phenomena that can be reduced to mathematical data and equations can be simulated on a computer. In practice, however, simulation is extremely difficult because most natural phenomena are subject to an almost infinite number of influences. One of the tricks to developing useful simulations, therefore, is to determine which the most important factors are (Kazuhiro Yamashita, *et al.*,2002)

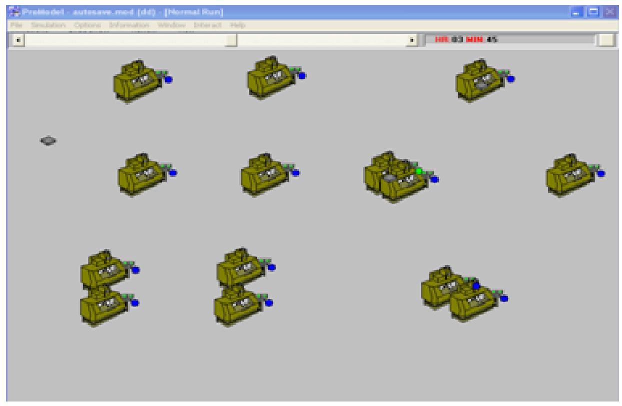


Figure 3.Promodel based simulation model

In addition to imitating processes to see how they behave under different conditions, simulations are also used to test new theories. After creating a theory of causal relationships, the theorist can codify the relationships in the form of a computer program. If the program then behaves in the same way as the real process, there is agood chance that the proposed relationships are correct.Simulation is done for mixed model with two operators to complete 3 models and the best utilization of the operators for every subassembly is derived(ArashShahin-NassibehJanatyan-InternationalBusiness Research, *et al.*, 2010)

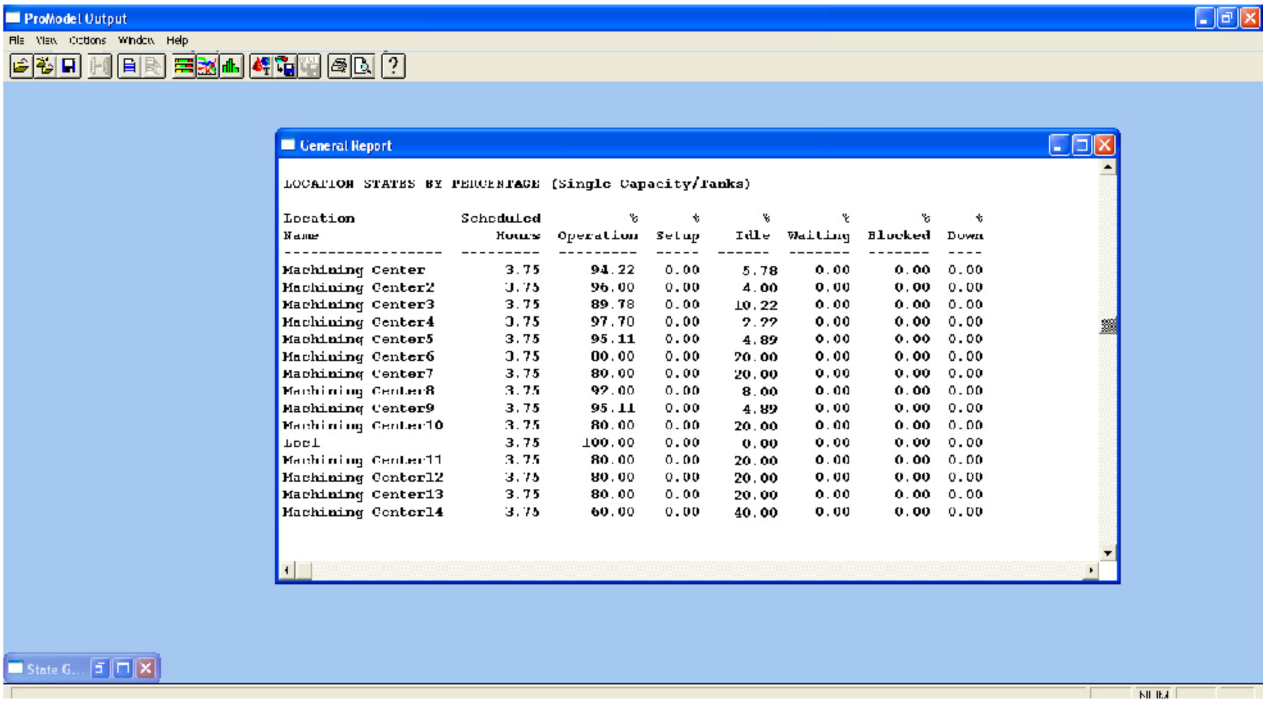
Table 3. Distribution Data Input

Process no	Distribution	Max	Min	Operator	Model – SA / MA
1	UNIF	13	11	1	TMSAC – Airend
2	UNIF	6	5	1	TMSAC – Cooler
3	UNIF	12	11	1	TMSAC – Tank
4	UNIF	20	18	1	TMSAC – Cone & Manifold
5	UNIF	46	45	2	EN53 - Motor
6	UNIF	46	45	1	EN53 - Main
7	UNIF	47	45	2	TMSAC - Motor
8	UNIF	14	13	1	Compair - Airend
9	UNIF	10	9	1	Compair - Cooler
10	UNIF	25	23	1	Compair - Tank
11	UNIF	47	45	2	Compair – Support plate
12	UNIF	47	45	1	TMSAC – Main I
13	UNIF	46	45	1	TMSAC – Main II
14	UNIF	93	90	2	Compair – Main

RESULTS OF DISCUSSION

1. During 90 minutes of operation EN53 Model is completed.
2. Operator's idle time is reduced.
3. Each operator have equal nos of process station = 7 nos
4. Queue for material for assembly is reduced.
5. Total time for completing 3 models (TMSAC, Compare, and EN53) is obtained as 225 minutes.
6. Takt time is derived from the simulation is 45 Minutes.

During the setting techniques and areas of lean manufacturing were being introduced for improving the productivity and removing the wastes during the installation and work in process. Different points were being discussed, out of this discussion study of the layout, material handling, equipment's, employees, suppliers, inventory, TAKT time, line balancing, kaizen, ergonomics, safety and employee's intake had a major role (ArashShahin-NassibehJanatyan-International Business Research, *et al.*, 2010)



LOCATION STATES BY PERCENTAGE (Single Capacity/Tanks)

Location Name	Scheduled Hours	% Operation	% Setup	% Idle	% Waiting	% Blocked	% Down
Machining Center	3.75	94.22	0.00	5.78	0.00	0.00	0.00
Machining Center2	3.75	96.00	0.00	4.00	0.00	0.00	0.00
Machining Center3	3.75	89.78	0.00	10.22	0.00	0.00	0.00
Machining Center4	3.75	97.70	0.00	2.22	0.00	0.00	0.00
Machining Center5	3.75	95.11	0.00	4.89	0.00	0.00	0.00
Machining Center6	3.75	00.00	0.00	20.00	0.00	0.00	0.00
Machining Center7	3.75	80.00	0.00	20.00	0.00	0.00	0.00
Machining Center8	3.75	92.00	0.00	8.00	0.00	0.00	0.00
Machining Center9	3.75	95.11	0.00	4.89	0.00	0.00	0.00
Machining Center10	3.75	80.00	0.00	20.00	0.00	0.00	0.00
Loc1	3.75	100.00	0.00	0.00	0.00	0.00	0.00
Machining Center11	3.75	80.00	0.00	20.00	0.00	0.00	0.00
Machining Center12	3.75	80.00	0.00	20.00	0.00	0.00	0.00
Machining Center13	3.75	80.00	0.00	20.00	0.00	0.00	0.00
Machining Center14	3.75	60.00	0.00	40.00	0.00	0.00	0.00

Figure 4. Results of simulation

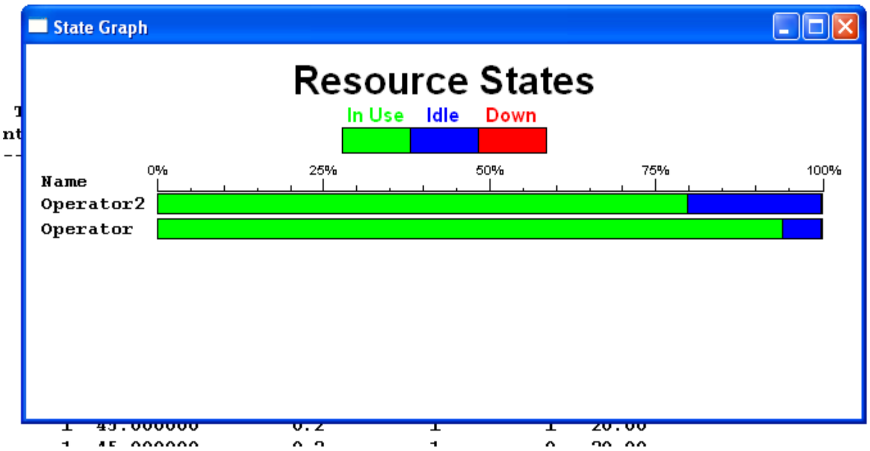


Figure 5. Operator Resource utilization

Table 4. Simulation Output

Sl.No	Parameter	Before	After	Savings	Remarks
1	space	274 sq.m	250.5 sq.m	10%	-
2	movement	268m	126 m	53%	Proposed 76%
3	waiting	23min	3min	0%	Trolly&mtls supplied
4	productivity	4 units	6 units	37%	-
5	manpower	24	16	8	-
6	rework	6%	2%	4%	Handling damages brought down

1. Based upon the area available 3 different layout were taken into consideration and from these three layout one layout was finalized, where it was possible to set up the assembly, testing, packaging without disturbing the initial set up of workstation.
2. For travelling of material from the initial stage to the final stage different material handling applications were being introduced; Trolley, Pallet, Hydraulic forklift And Electronic forklift was provided. the product from the raw component stage to the finished assembled stage having total 8 assembly stations, Forklift are used for lifting packed engines from pump set packaging area to finished goods area, stackers and trolleys for handling 2 – bin material, raw components from the storage towards the desired area(Mohammad Taleghani- Journal of American Science- Key factors for implementing the lean manufacturing system)
3. The takt time was reduced from 120 minutes to 45 minutes based upon the work distribution and increase in the work stations.

4. As the production capacity was increased from 96 compressors/ month to 144 compressors/ month, the intake of the Employees was also less.
5. Different new equipment's were introduced for improving the productivity; Laser alignment tools for pulley alignment motor and air end bracket assembly fixture to rotate 180^o. The main assembly work station can lift the unit for the level of operator's hands (1 meter height) so the operator need not bend and works for the particular operation.

Conclusion

Lean production method is an effective way to improve management, enhance the international competitiveness of manufacturing enterprises. The key areas proposed are more comprehensive to assess the current state of adoption and implementation of lean manufacturing. The proposed set of key areas will be validated and improved using a pilot study that involves experts from the academia and industry. From the case study it can be concluded that the production of Compressors (Belt Driven) has been increased from 4models per day to 6 models per day. And the number of operators utilized is reduced for 3 persons to 2 persons. This increase in productioncan yield significant financial benefits and savings to the company.

REFERENCE

Abduelmula and C. Wagner-DESIGN AND EVALUATION OF LEAN MANUFACTURING CELLS: A SIMULATION MODEL.(2003)

ArashShahin-NassibehJanatyan-InternationalBusiness Research Vol. 3, No. 4; October (2010)-GROUP TECHNOLOGY (GT) AND LEAN PRODUCTION: A CONCEPTUAL MODEL FOR ENHANCING PRODUCTIVITY.

J.P. Womack, D.T. Jones and D. Roos, The Machine That Changed the World, Rawson Associates, New York, NY, (1990).

KartikRamchandran, "A Complete Guide for Lean Manufacturing",- Spring (2001).

Kazuhiro Yamashita-A Research Paper-IMPLEMENTATION OF LEAN MANUFACTURING PROCESS TO XYZ COMPANY IN MINNEAPOLIS AREA.(2002)

Lean Manufacturing– Spring 2001.Duplaga, E. A., and D. J. Bragg, "Mixed model assembly line sequencing heuristics for smoothing component parts usage: a comparative analysis," *International Journal of Production Research*, Vol. 36, No. 8, (1998), pp. 2209-2224.

Mohammad Taleghani- Journal of American Science- Key factors for implementing the lean manufacturing system.

TaichiOhno, Toyota Production System, Productivity Press, June, pp. 6, 58, 126, (1988).

Yon sheng Wang, Ershi Qi, "Enterprise Planning of Total Life Cycle Lean Thinking",(1989)

****