مجلة العلوم الاجتماعية

فصلية – أكاديمية – محكّمة

تصدر عن مجلس النشر العلمي – جامعة الكويت

تعنى بنشر الأبحاث والدراسات في تخصصات السياسة والاقتصاد والاجتماع والخدمة الاجتماعية وعلم النفس والأنثروبولوجيا الاجتماعية والجغرافيا وعلوم المكتبات والمعلومات

رئيس التحرير: هادي مختار أشكناني

تفتح أبوابها أمام

- **أوسع مشاركة للباحثين العرب في مجال العلوم الاجتماعية لنشر البحوث الأصيلة والاسهام في معالجة قضايا مجتمعاتهم**
- **التفاعل الحي مع القارئ المثقف والمهتم بالقضايا المطروحة.**
- **المقابلات والمناقشات الجادة ومراجعات الكتب والتقارير.**
- **تؤكد المجلة إلتزامها بالوفاء والانتظام بوصولها في مواعيدها المحددة إلى جميع قرائها ومشتركيها.**

توجه جميع المراسلات إلى:

رئيس تحرير مجلة العلوم الاجتماعية

جامعة الكويت

ص.ب 27780 الصفاة، 13055- الكويت

تليفون: 00965-4810436

فاكس 4836026

E-mail:JSS@kuc01.kuniv.edu.kw

الاشتراكات

الكويت والدول العربية		الدول الأجنبية	
أفراد	3 دنانير سنوياً ويضاف إليها دينار واحد في الدول العربية	أفراد	15 دولاراً
مؤسسات	15 ديناراً في السنة 25 ديناراً لمدة سنتين	مؤسسات	60 دولاراً في السنة 110 دولارات لسنتين

تدفع اشتراكات الأفراد مقدماً نقدا أو بشيك باسم المجلة مسحوباً على أحد المصارف الكويتية ويرسل على عنوان المجلة، أو بتحويل مصرفي لحساب مجلة العلوم الاجتماعية رقم 07101685 لدى بنك الخليج في الكويت (فرع العديلية).

Visit our web site: http://pubcouncil.kuniv.edu.kw/jss

Journal of Engg. Research **Vol. 2 - (1) March 2014** pp. 163-182

تحسين الإنتاجية في تصنيع مضخة مغمورة ناشر السكن الهزيل باستخدام نظام التصنيع الرقيق

[*]م. مورغان و [**]ف. سيلادوراي

[*]رئيس قسم الهندسة الميكانيكية، مبنى راثينام للتقنية، تاميلنادو 641021، الهند

[**] رئيس قسم الهندسة الميكانيكية، المعهد كومباتورللتكنولوجيا، تاميلندو 641014، الهند

خلاصة

في أي منظمة يتم إنتاج السلع والخدمات لإشباع الحاجات البشرية. المدخلات الأساسية لعملية الإنتاج هي البشر، والآلات، والمواد والخدمات والأساليب والمخرجات هي السلع والخدمات. قليل من المنظمات التي تقوم بعملية الإنتاج تهتم بعملية تحسين الإنتاج. وهذا إما لتقليل التكلفة التي ينطوي عليها ذلك و لزيادة ربحية المؤسسة. الاتجاه الحالي في معظم المنظمات هو خفض أسعارها لاكتساب ميزة تنافسية من خلال تقليل جودة المدخلات، ولكن هذه الممارسة لا تستمر جيدا على المدى الطويل، لذلك يجب دراسة تحسين الإنتاجية ورفع الانتاج مع زيادة هامشية أولا في المدخلات. ويمكن تحقيق ذلك عن طريق الاستفادة المثلى من الموارد وليس المساس بالجودة. الغرض الرئيسي من هذه الورقة هو ايجاد منهج لزيادة قدرة الموظف أو أية موارد أخرى في أداء هذه المهمة. ويمكن مقارنة الأداء الفعلي في تحقيق الأهداف والمعايير للحصول على نتائج محددة سلفا. تصنيع العجاف هي عملية التصنيع التي تضيف قيمة منتجة للمواد من خلال التقاط عمليات الإنتاج الحصرية في عملية التصنيع بتوفيرالمواد من قبل الباعة من مصدر وحيد. يتناول تصنيع العجاف المواد، والإدارة، وتكاليف اليد العاملة بما في ذلك تكاليف تخزين ومناولة المواد داخل المصنع. وبالتالي فإن الهدف الرئيسي من هذه الورقة هو الحد من اهدار الوقت، العمل في عملية مجردة، مساحة الطابق المفتوح المشترك مجانا وزيادة الإنتاج في صناعة الإسكان الناشر من خلال تنفيذ نظام التصنيع العجاف.

Productivity improvement in manufacturing submersible pump diffuser housing using lean manufacturing system

M. MURUGAN* AND V. SELLADURAI**

**Principal & Professor & Head, Department of Mechanical Engineering, Rathinam Technical Campus, Coimbatore-641021, Tamilnadu, India. E-Mail: murugan_srec@yahoo.co.in*

****Principal & Professor & Head, Department of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore-641014, Tamilnadu, India. E-Mail: profvsdcit@yahoo.com*

ABSTRACT

In any organization goods and services are produced for the satisfaction of human needs. Basic inputs of the production process are men, machines, material, plant, services and methods and the outputs are goods and services. All organizations are undergoing the process of production but only a few organizations are concentrating in productivity improvements. This will either reduce the cost involved in it as well as increase the profitability of the organization. In the present trend most of the organizations are reducing their prices to gain competitive advantage by reducing their quality inputs, but this practice will not hold good for long run, so in order to study on productivity improvements will raise the output with marginal or no increase in the input. This can be achieved by optimizing the resources and not on compromising the quality inputs. The major purpose of this analysis is to systematically find out the ability of an employee or any other resources in performing this task. Actual performance can be compared to pre-determined goals and standards for getting the results. Lean manufacturing is a manufacturing process that productively adds value to materials by capturing proprietary production processes in manufacturing cells supplied by sole-source vendors. Lean manufacturing addresses material, administration, and labor costs including the costs of storing and handling materials within the factory. Hence the main aim of this paper is to reduce lead-time, work in process inventory, free up floor space and to increase the production in the manufacturing of diffuser housing by implementing Lean Manufacturing System.

Keywords: Lean manufacturing system; productivity; diffuser housing; management of manufacturing systems; cellular systems and performance analysis.

INTRODUCTION

Mass production was the production system of the 20th century, lean manufacturing, which focuses on the elimination of waste in the production process has been heralded as the production system of the 21st century. Although the Japanese automaker Toyota pioneered the concept, the term lean manufacturing itself was coined in the early 1990s by three researchers, (Womack, *et al.*, 1990). Lean techniques are also worthy of investigation because they eliminate large capital outlays for dedicated machinery until automation becomes absolutely necessary. The concept of lean manufacturing represents a significant departure from the automated factory so popular in recent years. Products are manufactured one at a time in response to the customers requirements rather than batch manufactured for stock. The goal is to produce only the quantity required and no more. This requirement for maximum flexibility creates unique demands on the lean work cell and the components that make up the lean work cell. Lean manufacturing is a performance-based process used in manufacturing organizations to increase competitive advantage. The basics of lean manufacturing employ continuous improvement processes to focus on the elimination of waste or non-value added steps within an organization. The challenge to organizations utilizing lean manufacturing is to create a culture that will create and sustain long-term commitment from top management through the entire workforce. Lean manufacturing techniques are based on the application of five principles to guide managements actions toward implementation:

1 - Value: The foundation for the value stream that defines what the customer is willing to pay for.

2 - The Value Stream: The mapping and identifying of all the specific actions required to eliminate the non-value activities from design concept to customer usage.

3 - Flow: The elimination of all process stoppages to make the value stream flow without interruptions.

4 - Pull: The ability to streamline products and processes from concept through customer usage.

5 - Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.

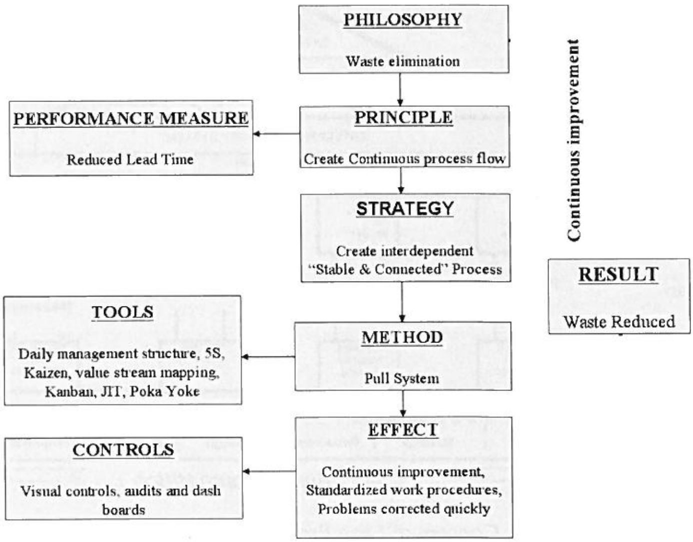


Fig. 1. Conceptual Model of Lean

Basic Objective of Lean Manufacturing System is to do more and more with less and less human effort, less equipment, less time and less space (Figure 1). At the same time coming closer and closer to providing customers what exactly they want. It aims to reduce the time line by reversing the sequence of activities and eliminating non value added operations. Excess production results in waste because it captures resources too early and retains the value that is added until the product can be used (sold). In todays highly changing society, many items are produced before they are sold to customers; they often go obsolete before demand is realized. This means that a perfectly good product is often scrapped because it is obsolete. Producing a product simply to keep a production resource busy (either machine, operator or both) is a practice that should be avoided.

Delays, such as waiting for raw material, also result in the poor use of capacity and increased delivery time. Raw materials and component parts should be completed at approximately the time that they will be required by downstream resources. Too early is not good, but late is even worse. Movement and transportation should always be kept to a minimum. Material handling is a non-value added process that can result in three outcomes: 1) the product ends up at the right place at the right time and in good condition, 2) the part ends up in the wrong place, and 3) the part is damaged in transit and requires rework or scrap. Two of the three outcomes are not desirable, which further leads to minimizing handling. Because material handling occurs between all operations, when possible, the handling should be integrated into the process, and the transport distances minimized.

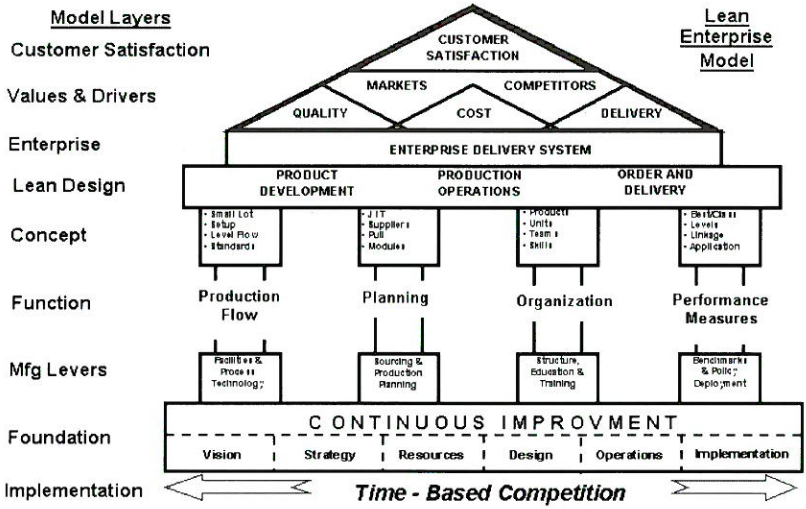


Fig. 2. Concept of Lean Production System

Continuous process improvement is a critical part of Lean Manufacturing as shown in Figure 2. Waste can indirectly serve as a good measure of productivity. Productivity of any system has been defined as the ratio of the desired output to input. Hence a new concept of Wastage had been propounded, which can serve as an adequate measure of performance of any system and is rather easy to measure and the 7 forms of wastes has been shown in Figure 3. The way to escape the pitfalls faced by manufacturing companies today requires a redefinition of inventory and a new production philosophy which eliminates the need to produce based on forecasts, or to fill stock levels, and to eliminate rework and acceptance of non-conformances. This paper presents the tools necessary to make this leap.

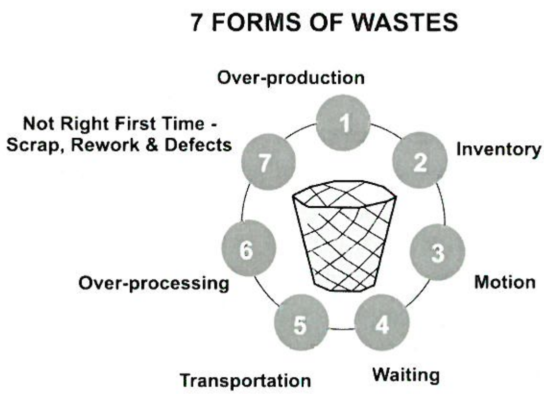


Fig.3. Seven Forms of waste.

SEVEN WASTES

The key to lean manufacturing is to compress time by eliminating waste and thus continually improving the process. Ohno defines waste as "all elements of production that only increases cost without adding value when the customer is willing to purchase. The seven wastes of manufacturing are:

- Overproduction - producing more product than needed;
- Inventory - any supply in excess of required product;
- Waiting - idle operator or machine time;
- Motion - movement of people or machines which does not add value;
- Transportation - any material movement that does not directly support value added operations;
- Defects - making defective parts; and
- Extra Processing - any process that does not add value to product.

LITERATURE SURVEY

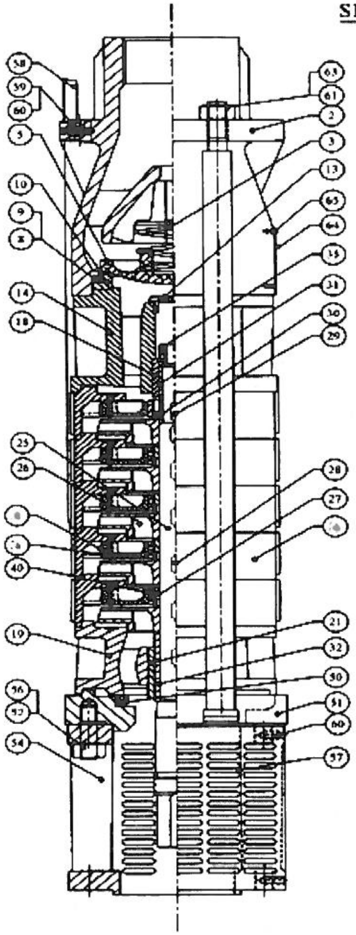
Achanga *et al.* (2004) presented the implementation of Lean Manufacturing within small and medium sized enterprises. Feld (2000) described Lean manufacturing tools, techniques, and how to use them. Karlsson and Par (1996) presented the difficult path to lean product development. Hines *et al.* (1998) conducted a case study on implementation of lean manufacturing and creating a lean supplying network. Isatto and Formoso (1998) proposed a design and production interface in Lean Production and performance improvement criteria. Howell and Ballard (1998) conducted a case study on implementing Lean Construction. James Moore and Gibbons (1997) investigated lean methodology. Karlsson and Ahlstrom (1996) proposed a change process towards Lean Production and discussed the role of the management accounting system. McDonald *et al.* (2002) presented utilizing simulation to enhance value stream mapping and applied in a manufacturing case. Andery *et al.* (1998) proposed an approach for lean thinking. Duray *et al.* (2000) primarily investigated mass customization from a manufacturing point of view and defined mass customization as "building products to customer specifications using modular components to achieve economies of scale". Shah and Ward (2003) showed that bundles of lean practices individually and as a group influenced operational performance. Rother and Shook (1999) described on value stream mapping to add value and elimination of wastes. Womack and Jones (1994) coined the term "lean production" in their book and described on forming lean production to the lean enterprise. Babson and Steve (1993) described on empowerment and exploitation in the global auto industry through Lean work. Dennis and Roger Daina (1993) defined production and inventory management systems for process industries. Detty and Yingling (2000) conducted a case study on quantifying benefits of conversion to lean manufacturing with discrete event simulation. David and Paul (1990) presented an historical perspective on the modern productivity paradox.

Suzaki and Kiyoshi (1987) proposed techniques for continuous improvement and elimination of wastes. Sweeny (2003) described on forms and facts from one companys 5S effort. Rasch and Steven (1998) presented Lean Manufacturing practices at small and medium-sized U.S. parts suppliers. Oke and Szwejczewski (2005) described the relationship between UK manufacturers, inventory levels and supply, internal and market factors. Martin and Formoso (1998) proposed the evaluation method of building systems based on production process management and lean construction concepts. Galbraith and Strandridge (1994) conducted a case study on analysis in manufacturing systems simulation. Creese (2000) presented cost management in Lean Manufacturing enterprises. Levy (1997) proposed Lean production in an international supply chain. Christiansen *et al.* (2003) presented mapping of competitive priorities, manufacturing practices, and operational performance in groups of Danish manufacturing companies. Panizzolo (1998) applied the lessons learned from 27 lean manufacturers to the relevance of relationships management. U.S. Environmental Protection Agency (2002) coined the list of solid waste of an office and elimination of hazardous wastes. Zayko *et al.* (1997) described Lean manufacturing that yields world class improvements for small manufacturer. Womack and Jones (1996) presented on banishing wastes and creating wealth in manufacturing industries through Lean Manufacturing. Taylor (1996) developed a linear programming model to manage the maintenance backlog. Taylor *et al.* (1981) described on different kinds of processing industries. Billesbach (1994) applied lean production principles to a process facility.

Adopting a lean manufacturing approach promises significant improvements in productivity, quality and delivery, resulting ultimately in substantial cost savings. However, many companies across a range of industrial sectors have introduced lean working practices; lean initiatives are often not under pinned by appropriate and rigorous cost management and waste elimination methods.

In this research paper, the lean manufacturing approach is implemented in a leading pump manufacturing industry to reduce lead-time, work in process inventory, reduction in floor space, increase variation in products and demands for perfect quality and reduce wastages. A case study has been conducted in a leading pump manufacturing industry to implement lean manufacturing approach. The remainder of this paper is organized as follows. Section 3 discusses the statement of the problem, Section 4 discusses about the component description of diffuser housing. Section 5 discusses about existing process layout of the company and drawbacks of existing layout. Section 6 introduces lean manufacturing approach and proposed changes in the layout. Section 7 presents the results and comparison of the proposed layout with the existing layout, etc. Finally, the conclusions are presented in Section 8.

SECTIONAL VIEW OF RS SUBMERSIBLE PUMP



PART NO	PART NAME	QTY
1	PUMP ASSY.	-
2	VALVE CASING	1 No.
3	SPRING	1 No
5	NON-RETURN VALVE	1 No.
8	VALVE SEAT (UPTO 5.0 HP)	1 No.
9	VALVE RUBBER SEAT	1 No.
10	VALVE METAL SEAT	1 No.
13	DUMMY	1 No.
14	PUMP BRG.HOUSING ASSY.	1 No.
18	BRG.BUSH	1 No.
19	PUMP BRG.HOUSING ASSY.(INT.)	N
21	BRG.BUSH (INT.)	N
25	PUMP SHAFT	1 No.
26	IMPELLER	S
27	DISTANCE PIECE	S-1
28	KEY(IMPELLER)	S
29	KEY (SLEEVE)	1 No.
30	COLLAR	1 No.
31	SLEEVE (TOP)	1 No.
32	SLEEVE (INT.)	N
35	LOCK NUT	2 Nos.
36	DIFFUSER HOUSING ASSY.	S
38	DIFFUSER	S
39	RIVET(DIFFUSER)	3*S
40	DIFFUSER BUSH	S
50	LIP RING	1 No.
51	INLET GUIDE RING	1 No.
52	STUD (IG RING)	4 Nos.
54	INLET BRACKET	1 No.
56	NUT (IG RING)	4 Nos.
57	STRAINER	1 No
58	CABLE GUARD	2 Nos.
59	CABLE GUARD CLIP	2 Nos.
60	SCREW	6 Nos.
61	TIE BOLT	4 Nos.
63	NUT (TIE BOLT)	4 Nos.
64	NAME PLATE	1 No.
65	RIVET (NAME PLATE)	4 Nos.

NOTE:-

S - NUMBER OF STAGES

N - NUMBER OF PUMP BRG.HOUSING ASSY.(INT.)

Fig. 4. Cross sectional view of submersible pump

PROBLEM DEFINITION

The main objectives of the organizations are, to increase the profit or to reduce the cost involved in the product and to improve the quality and quantity of the manufacturing. Price is the competitive weapon used in the marketplace; profitability is related to the difference between price and cost. Cost is the variable that can allow lower price that may be profitable. To compete on the basis of price, requires an operation function capable of producing at low cost. Therefore the effect of location, layout design, products design of equipments, labour productivity and so on all contributes to the resulting cost. The evidence concerning our global competitiveness indicated that in order to become competitive, management of productive systems need to be more effective.

COMPONENT DESCRIPTION

The Diffuser Housing is one of the main components of the radial flow submersible pump and its cross sectional view is shown in Figure 4 and the individual components of the diffuser housing have been shown in Figure 5 and 6 respectively.

COMPONENT OF DIFFUSER HOUSING

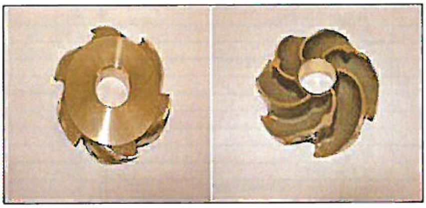


Fig. 5. Diffuser
(Material: Gun Metal; Outer dia: 114mm, Centre Hole Dia: 33mm; Hole Depth: 11mm)

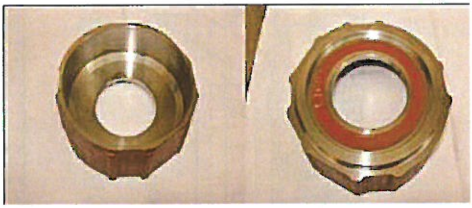


Fig. 6. Diffuser Housing
(Material: Cast Iron; Outer dia: 140mm Centre Hole Dia: 60mm)

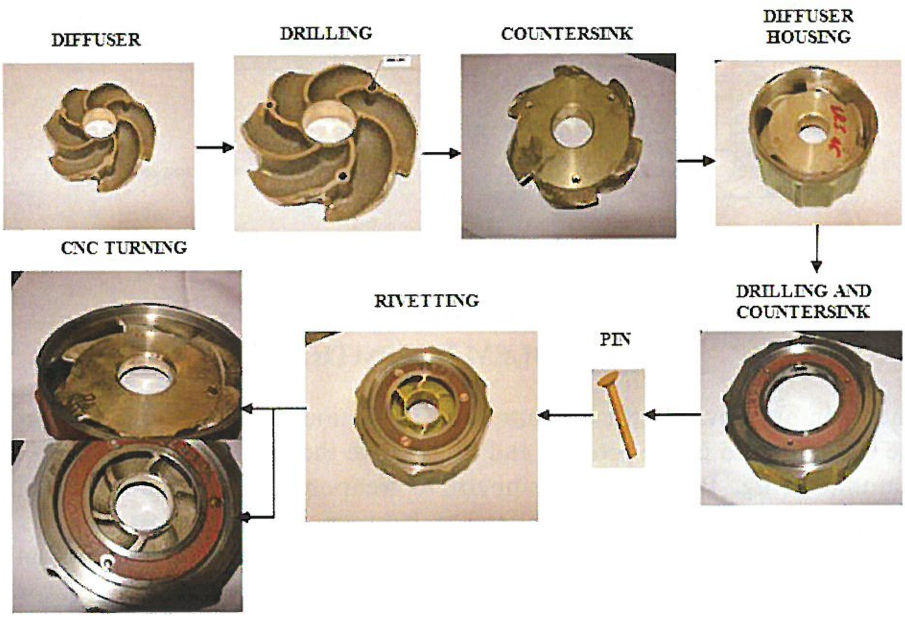


Fig.7. Process flow in diffuser housing

Process flow of diffuser housing has been shown in Figure 7 traced to study the effectiveness and efficiency of the system, and the sequence of operations carried out in manufacturing diffuser housing is as follows.

The sequence of operations carried out on a diffuser housing using the existing layout is shown in Figure 8. 1- Diffuser from pallet to Table 2 - Diffuser from table to drilling machine. 3 - Diffuser from drilling m/c 1 to drilling m/c 2. 4 - Diffuser from drilling m/c 2 to table. 5 - Housing from pallet to table. 6 - Diffuser and housing to pneumatic press. 7 - Diffuser housing from pneumatic press to table. 8 - Diffuser housing from table to drilling m/c 1. 9 - Diffuser housing from drilling m/c 1 to drilling m/c 2. 10 - Diffuser housing from drilling m/c 2 to table. 11 - Diffuser housing from table to riveting m/c. 12 - Diffuser housing from riveting m/c to pallet. 13 - Diffuser housing from pallet to CNC m/c. 14 - Diffuser housing from CNC m/c to pallet.

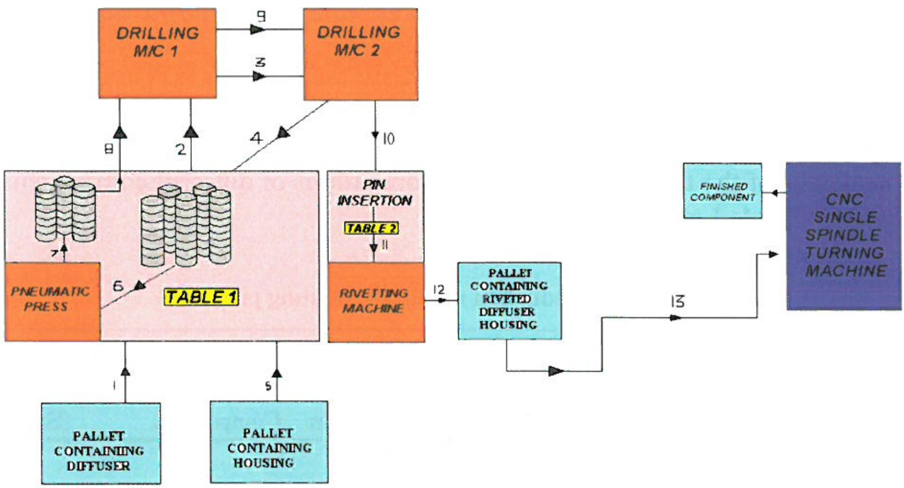


Fig. 8. Existing process layout

DRAWBACKS OF EXISTING PROCESS LAYOUT

Handling

Finished Diffuser Housing is handled up to 87 meters before reaching the CNC turning. There is high risk for the housing to get damaged during this transit. Any sort of rejection due to handling in the final stages of the production will increase the manufacturing cost of the final product.

Non-Value adding activities

Delays and Storage

There are lot of delays due to handling and storage during the processes like,

- Semi-finished diffuser housing waiting for subsequent process/ operation.
- Waiting for quantity verification
- Document preparation for each transaction.
- Waiting for Incoming Inspection, etc.,
- These delays due to handling and storage take about 2 days.

Excess Inventory

Excess raw material inventory, work in process inventory or finished goods inventory results in longer lead times. Also, excess inventory hides problems such as production imbalances, defects and equipments down time and long setup time.

RESULTS OF EXISTING PROCESS

The details of the time taken for various operations of different components are shown in Table 1 and 2.

Table 1. Production rate in the existing process

Operation	Timetaken (Hours)	No. Of Persons	No. Of Components	Timetaken Per Component (Sec)
Drilling To Riveting	8	1	180	160
Drilling To Riveting	8	4	720	40
Drilling To Riveting	8	5	900	32
CNC Turning	8	2	200	100

Table 2. Process details of existing process for diffuser housing

S. No	Operation	Time (Sec)	Distance (metre)	Cum. Distance (metre)
1	Diffuser to Table	300	1	1
2	Table to Drill 1	4	1.20	2.20
3	Drill 1	15	0	2.20
4	Drill 1 to Drill 2	10	1.58	3.78
5	Drill 2	15	0	3.78
6	Drill 2 to Table	5	3.20	6.98
7	Housing to Table	300	1	7.98
8	In process Inventory	600	0	7.98
9	Diffuser Housing	5	0	7.98
10	Pneumatic Press	10	0	7.98
11	Press to Table	5	0.80	8.78
12	In process Inventory	900	0	8.78
13	Table to Drill 1	4	1.20	9.98
14	Drill 1	20	0	9.98
15	Drill 1 to Drill 2	10	1.58	11.56
16	Drill 2	15	0	11.56
17	Drill 2 to Table	5	0.57	12.13
18	Pin Insertion	10	0	12.13
19	Table to Riveting M/C	200	0.57	12.70
20	Riveting Operation	20	0	12.70
21	Riveting M/C to Pallet	600	1	13.70
22	Inprocess Inventory	129600	0	13.70
23	Forklift to Turning M/C	500	87.50	101.20
24	Pallet to Table	300	1	102.20
25	CNC Turning Operation	98	0	102.20

IMPLEMENTATION OF LEAN MANUFACTURING APPROACH

1. CELLULAR LAYOUTS

A cellular layout should provide all of the equipment, tools, work instructions and materials to accomplish a single task or group of related tasks. It does not matter if the cell is a T, I, U or V. The best shape is the one that produces the most efficient production in a safe manner. If cells are U or V shaped they should first be setup to flow counter clockwise because most people are right handed, so this is the most ergonomically correct way to move parts or objects.

2. U - SHAPED CELLULAR LAYOUT

The above processes are arranged in a U shaped line in order to increase the production and to bring a one piece flow as shown in Figure 9. U-shaped production line can be described as a special type of cellular manufacturing used in just-in-time (JIT) production systems and Lean Manufacturing. The U-line arranges machines around a U-shaped line in the order in which production operations are performed. Operators work inside the U-line. One operator supervises both the entrance and the exit of the line. Standard operation charts specify exactly how all work is done. U-lines may be simple or complex, depending on the number of tasks to be performed, the production volume and setup times. U-lines are rebalanced periodically when production requirements change. The U-line satisfies the flow manufacturing principle. This requires operators to be multi-skilled to operate several different machines or processes. It also requires operators to work standing up and walking because they need to operate different machines. When setup times are negligible, U-lines can be operated as mixed-model lines where each station is able to produce any product in any cycle. When setup times are larger, multiple U-lines are formed and dedicated to different products.

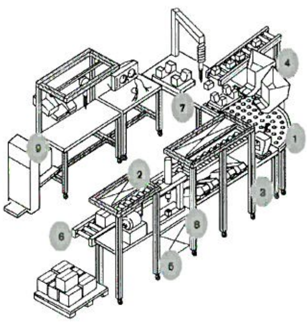


Fig.9. Typical U-Shaped cell for Lean Manufacturing

3. PROPOSED APPROACH

The new approach to solve the U-shaped LBP consists of taking into account: the variability of the task times from cycle to cycle, the physical location of the machines (layout), the performance of the operators with different workloads. All this can be modeled using a simulation software or language. For this research, Arena software has been used to model the U-shaped system. Then after the model is validated a multi-criteria optimization technique will be applied to find the set of non-dominated solutions. The criteria that can be taken into account are:

- Minimize the machine idle time.
- Maximize operators' usage.
- Maximize production.
- Minimize the average number of parts in the system.

4. GRAVITY CONVEYER

A gravity conveyer as shown in Figure 10 is also introduced to move the component from one machine to the next machine. Here the machines are positioned based on the operation sequence.

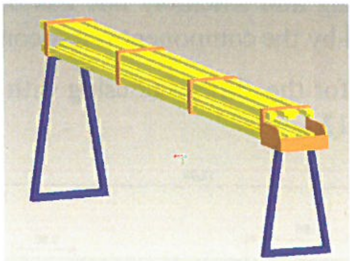


Fig.10. Schematic View of Gravity Conveyer

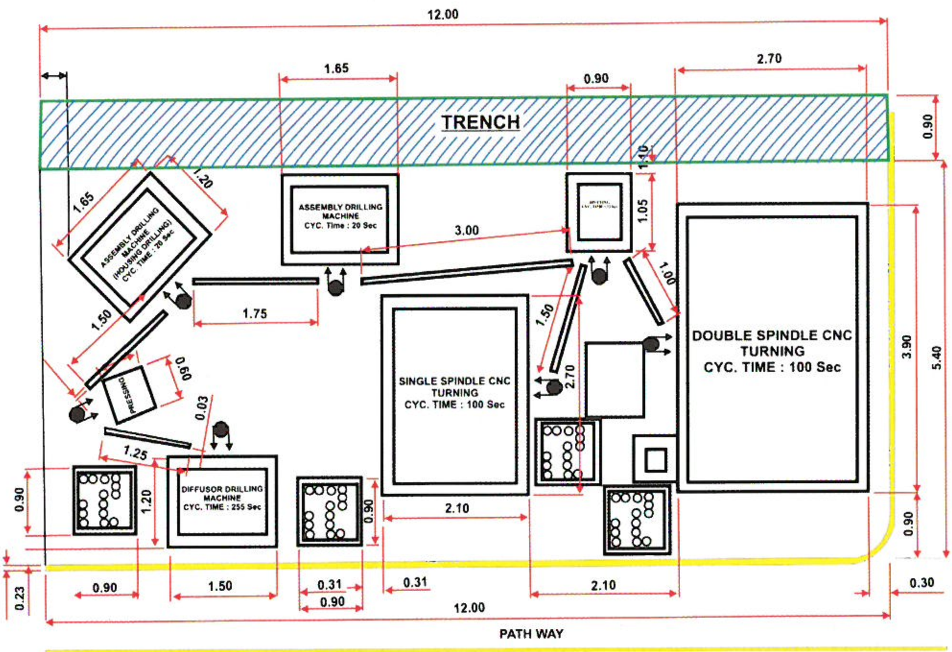
5. METHODLOGY

The system under study is a job setup, which was later modified and proposed to suit the customers requirements. Many of the activities were manually done, which was unsafe ergonomically. The demand for the diffuser housing was increasing day by day as per the market research carried out by the company. The customers demand is more than the required production rate.

The proposed manufacturing system under study is a lean manufacturing system manufacturing submersible pump diffuser housing, whose target is to manufacture 2000 Nos/day on two shift basis. This production system consists of seven main stations namely 1) Diffuser Drilling Station 2) Pressing Station, 3) Assembly Drilling Station (Housing), 4) Pin Inserting Station, 5) Riveting Station, 6) Single Spindle CNC and 7) Double Spindle CNC Station. During the setting of the production and assembly line with different tools, techniques and areas of lean manufacturing were being introduced for improving the productivity and removing the waste during the insulation and work-in process. Many points were being discussed namely study of the layout, material handling, equipments, employers, suppliers, inventory line balancing, Kaizon, ergonomics and safety had a major role. Based on the area available in the shop floor, different layouts were taken into consideration. One layout was finalized with conveyer system for material handling. It was possible to setup the manufacturing and assembling line of diffuser housing without any disturbance.

Travelling of materials from the initial stage to the final stage, gravity conveyers were introduced for material handling. Material handling section has seven work stations from the initial components stage to finished sub assembly stage. The lead time was reduced significantly based upon the work distribution of various work stations (Table 5). The production rate was increased from 1000 diffuser housing/day to 2000 diffuser housing/day. The number of employees is also reduced due to mechanization of material handling systems. The additional equipment was introduced for improving the productivity. The layout selected for the new manufacturing and assembly line has better free space utilization and the distance travelled by the component is less compared to the existing one.

The proposed layouts for the diffuser housing with and without conveyor are shown in Figures 11 and 12.



NOTE : ALL DIMENSIONS ARE IN METER

Fig.11. Proposed layout without conveyer

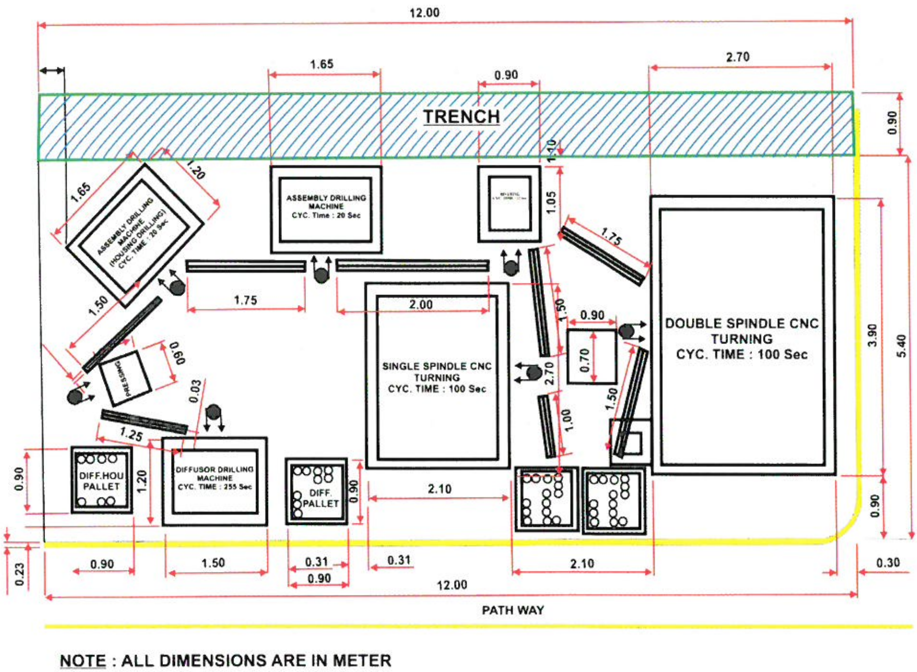


Fig.12. Proposed layout with conveyor

The process result of the proposed layout is presented in Table 3.

Table 3. Process results of proposed layout

S. No.	Operation	Time (Sec)	Distance (metre)	CUM. Distance (metre)
1	Drilling and Countersink in Diffuser	25	0	0
2	Drill M/C 1 to Diffuser	4	1.20	1.20
3	Diffuser Housing from Pallet to Press	4	1	2.20
4	Pneumatic Press	20	0	2.20
5	Press to Drill M/C 2	5	1.50	3.70
6	Drilling in Diffuser Housing	20	0	3.70
7	Drill M/C 2 to Drill M/C 3	5	1.75	5.45
8	Countersink in Diffuser Housing	20	0	5.45
9	Drill M/C 3 to Riveting M/C	5	2.00	7.45
10	Pin insertion and Riveting Operation	25	0	7.45
11	Riveting M/C to Single Spindle CNC Turning M/C	5	1.50	8.95
12	Riveting M/C to Double spindle CNC Turning M/C	5	1.75	10.7

Cont. Table 3. Process results of proposed layout

S. No.	Operation	Time (Sec)	Distance (metre)	CUM. Distance (metre)
13	Turning Operation in Single Spindle CNC Turning M/C	98	0	10.7
14	Turning Operation in Double Spindle CNC Turning M/C	98	0	10.7
15	Single Spindle CNC Turning M/C to Pallet	10	1.00	11.7
16	Double Spindle CNC Turning M/C to Pallet	10	1.50	13.2

From the process result of the proposed layout the following results are obtained. The Table 4 indicates the number of persons and the corresponding production rate per shift.

Table 4. Production rate for proposed layout

Operation	Time taken	No of persons	No of components	Time taken per component (seconds)
Drilling to CNC Turning	8 HOURS (28800 seconds)	7	900	30

The results of the existing and the proposed lean manufacturing approach have been compared and the improvements after implementing the LMS are shown in the Table 5.

Table 5. Comparison of the existing process with the implemented Lean Manufacturing System

S.No	Contents	Existing process	Implemented LMS
1.	Value Added Ratio	0.1595%	79.69%
2.	Distance Travelled	102.20 meters	13.20 meters
3.	Number of Processes	9	7
4.	Number of Operators	10	7
5.	Production rate/shift	200	900
6.	Total Lead Time	1,33,551Sec (1.55days)	261 Sec
7.	Method of Production	Push Type	Pull Type
8.	Non-Value Added Activities	Waiting, Transportation, Motion	Rectified
9.	Flow Line	Unbalanced	Balanced

CONCLUSION

Plant layout has been altered to decrease the wastes in many forms, thereby increasing the productivity of the organization. The proposed one-piece flow cell concept has been suitable for components of same part families. The production rate is doubled than the existing, as the production increase with the same input people in the cell can be positively motivated by incentives schemes, based on quantity produced. Recruiting, training and development have been made effective. So that the rejections out of unawareness has been reduced. Preventive maintenance has been enhanced and the maintenance crew size has been increased to avoid production loss because of non-availability of machines due to breakdown. Appropriate tests are conducted before accepting the lot from the various parties. The company has successfully implemented lean manufacturing approach to improve the existing setup and to increase the productivity. The reported benefits are impressive when a company changes from traditional production system to U-shaped flow lines. Productivity has been improved by an average of 40-80%, Work in process (WIP) has been dropped by 60-85%, Lead time has been reduced by 50-75% and Defective rates have been dropped by 40-80%. Therefore Lean production method is an effective way to improve management, enhance the international competitiveness of manufacturing enterprises. From the case study it can be concluded that the production of the pump set has increased from 3200 to 8000. This increase in production can yield significant financial benefits and savings to the company.

REFERENCES

Achanga, P., Taratoukhine, V., Roy R. & Nelder G. 2004. The Application of Lean Manufacturing within Small and Medium Sized Enterprises. Proceedings of ICMR conference, UK, Sheffield Hallam University.

Andery, P., Carvalho, A. N. & Helman H. 1998. Looking for what could be wrong: an approach to lean thinking, Proceeded in 6th Annual International Conference. Group Lean Constr, Guaruja, Brazil.

Babson & Steve 1993. Lean Work: Empowerment and exploitation in the global auto industry. Detroit: Wayne State University Press.

Billesbach, J.T. 1994. Applying lean production principles to a process facility. Production and Inventory Management Journal. 3: 40-44.

Christiansen, T., Berry, W.L., Bruun, P. & Ward, P.T. 2003. A mapping of competitive priorities, manufacturing practices, and operational performance in groups of Danish manufacturing companies, International Journal of Production and Management. 23(10): 1163 - 1183.

Creese, R.C. 2000. Cost Management in Lean Manufacturing Enterprises. AACE International Transactions, USA, West Virginia University.

David & Paul, A. (1990). The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox, American Economic Review, Vol. 80, No.2, pp. 355-361.

Dennis & Roger Daina 1993. Defining production and inventory management systems for process industries, Ph.D dissertation, University of Cincinnati.

Detty, R.B. & Yingling, J.C. 2000. Quantifying benefits of conversion to lean manufacturing with discrete event simulation: a case study, International Journal of Production Research, 38(2):429-445.

Duray, R., Ward, P.T., Milligan, G.W. & Berry, W.L. 2000. Approaches to mass customization: configurations and empirical validation. Journal of Operations Management, 18: 605-625.

Feld, M.W. 2000. Lean manufacturing tools, techniques, and how to use them, Boca Raton, London: The St.Lucie Press.

Galbraith, J. & Strandridge, C.R. 1994. Analysis in manufacturing systems simulation: A case study, Simulation, 63: 368-375.

Hines, P., Rich, N. & Esain, A. 1998. Creating a lean supplying network: A distribution case, European Journal of Purchasing & Supply Management, 4: 235-246.

Howell, G. & Ballard, G. 1998. Implementing Lean Construction: Understanding and Action, Proceeded in 6th Annual International Conference. Group Lean Constr, Guaruja, Brazil.

Isatto, E. L. & Formoso, C. T. 1998. Design and Production Interface in Lean Production: A Performance Improvement Criteria Proposition, Proceeded in 6th Annual International Conference. Group Lean Constr, Guaruja, Brazil.

James-Moore, S.M. & Gibbons, A. 1997. Is Lean Manufacture Universally Relevant? An Investigative Methodology, International Journal of Production and Management, Vol.17, No.9, pp.899-911.

Karlsson, C. & Ahlstrom, P. 1996. Change process towards Lean Production: the role of the management accounting system, International Journal of Production and Management, 16(11): 42-56.

Karlsson, C. & Par, A. 1996. Assessing change towards lean production, International Journal of Operation & Production Management, 19 (2): 24-41.

Levy, D.L. 1997. Lean production in an international supply chain, Sloan Management Review, Winter, 94-102.

Martin, A. P. S. & Formoso, C. T. 1998. Evaluating Building Systems Based on Production Process Management and Lean Construction Concepts, Proceeded in 6th Annual International Conference. Group Lean Constr, Guaruja, Brazil.

McDonald, T., Van Aken, E.M. & Rentes, A.F. 2002. Utilizing simulation to enhance value stream mapping: A manufacturing case application, International Journal of Logistics: Research and Applications, 5 (2): 213-232.

Oke, A. & Szwejczewski, M. 2005. The relationship between UK manufacturers inventory levels and supply, internal and market factors, International Journal of Production Economics, 93-94: 151-160.

Panizzolo, R. 1998. Applying the lessons learned from 27 lean manufacturers- The relevance of relationships management, International Journal of Production Economics, 55: 223-240.

Rasch & Steven, F. 1998. Lean Manufacturing Practices at Small and Medium-Sized U.S. Parts Suppliers - Does it work?, Becoming Lean: Inside Stories of U.S. Manufacturers, Portland, Oregon: Productivity Press, 103- 118.

Rother, M. & Shook, J. 1999. Learning to see: Value stream mapping to add value and eliminate muda Brookeline, MA: The Lean Enterprise institute, Inc., 1.2.

Shah, R. & Ward, P.T. 2003. Lean manufacturing: context, practice bundles, and performance, Journal of Operations Management, 21(2): 129 - 150.

Suzaki & Kiyoshi 1987. The New Manufacturing Challenge: Techniques for Continuous Improvement, The Free Press.

Sweeny, E.J. 2003. Forms and facts from one companys 5S effort, Lean Enterprise Institute.

Taylor, R.W. 1996. A linear programming model to manage the maintenance backlog, Omega, 24(2): 217-227.

Taylor, S.G., Seward, S.M. & Bolander, S.F. 1981. Why the process industries are different, Production and Inventory Management Journal, 22: 9-24.

U.S. Environmental Protection Agency 2002. Office of Solid Waste, RCRA Hazardous Waste Delisting: The First 20 Years, EPA/530-R-02-014 (Washington DC: US Government Printing Office).

Womack, J. P. & Jones, D.T. 1996. Lean Thinking: Banish waste and create wealth in your corporation, (New York: Simon & Schuster).

Womack, J. P., Jones, D.T. & Roos, D. 1990. The machine that changed the world: The story of lean production, New York: Harper Collins Publishers.

Womack, J.P. & Jones D.T. 1994. Form lean production to the lean enterprise, Harvard business review, 72(2): 93-103.

Zayko, M.D., Broughman & Hancock, W. 1997. Lean manufacturing yields world class improvements for small manufacturer, IIE Solutions, 29(4): 46-64.

Submitted : *18/08/2013*
Revised : *23/11/2013*
Accepted : *09/12/2013*

Journal of Engg. Research **Vol. 2 - (1) March 2014** pp. 183-200

تقييم لفيضانات المياه الساخنة والبخار في خزان فارس السفلي

م. الغريب، ع. العجمي و ر. غربي

جامعة الكويت، ص. ب. 5969 الصفاة 13060 الكويت

خلاصة

عمليات استرداد النفط الحرارية من تقنيات الاسترداد المعزز الناجحة للنفط في العالم. تعتبر هذه العمليات من أهم مصادر الإنتاج اليومي من النفط في العالم. مدخلات الطاقة الحرارية في خزانات النفط والغاز تقلل من لزوجة النفط وتحسن حركية الزيوت الثقيلة. يمكن إدخال الطاقة الحرارية في التكوينات تحت السطحية من خلال الحرارة التي تحمل عن طريق عوامل مثل الماء الساخن أو البخار. تعتبر هذه الآليات من تقنيات الاسترجاع الحراري الهامة التي يتم تنفيذها حاليا في العديد من حقول النفط لزيادة كفاءة استرداد النفط.

تقييم اداء ضخ الحرارة في تحسين أنتاج النفوط عالية اللزوجة قضية بالغة الاهمية لتحسين اقتصاديات مشاريع الحقن الحراري. ولذلك، ينبغي التحقيق من أداء عمليات الاسترجاع الحراري تحت مختلف الظروف قبل التطبيق الميداني.

في هذا البحث، تم التحقيق في آثار العديد من العوامل على أداء الماء الساخن والبخار في خزان فارس السفلي فارس بالوسائل الرقمية. والهدف من هذه الدراسة تسليط الضوء على العلاقات بين الحقن بالحرارة وعامل استرداد النفط تحت مختلف الظروف التشغيلية و الخاصة بالخزان. هذه الشروط تشمل الترتيب لآبار الحقن والإنتاج، أبعاد الخزان الجانبية، معدل الحقن، علاقة اللزوجة في درجة الحرارة والنفط، و سمك الخزان. يتم عرض النتائج من حيث عامل استرداد النفط مقابل وحدة الحرارة التراكمية. وتبين النتائج أن العوامل التي تم التحقيق منها تأثر بدرجات مختلفة على اداء المياه الساخنة والبخار.