FEASIBILITY STUDY OF LEAN PRODUCTION SYSTEM IN RECIPROCATING COMPRESSOR DIVISION (MACHINE SHOP)

Thesis submitted in partial fulfillment of the requirements

for the award of the degree of

MASTER OF ENGINEERING IN MECHANICAL ENGINEERING

(INDUSTRIAL ENGINEERING)

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By

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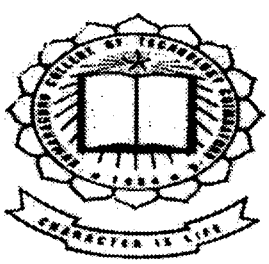

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DEPARTMENT OF MECHANICAL ENGINEERING

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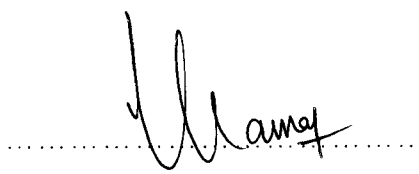
This is to certify that this thesis work entitled "**FEASIBILITY STUDY OF LEAN PRODUCTION SYSTEM IN RECIPROCATING COMPRESSOR DIVISION (MACHINE SHOP)**" being submitted by V.BALAN (REG. No. 0137H0005) for the award of degree of MASTER OF ENGINEERING IN MECHANICAL ENGINEERING (INDUSTRIAL ENGINEERING) is a bonafide work carried under my guidance. The results embodied in this thesis have not been submitted to any other university or institute for the award of any Degree or Diploma.



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This is to certify that **Mr. V. BALAN (0137H0005), M.E (Industrial Engineering)** student of **KUMARAGURU COLLEGE OF TECHNOLOGY, Coimbatore**, has carried out a Project in our Organisation titled **"FEASIBILITY STUDY OF LEAN PRODUCTION SYSTEM IN RECIPROCATING COMPRESSOR DIVISION (Machine Shop)"** for a period of six months.

During the project period his Conduct and Character was Good.

We wish him success in all his future endeavours.

for **ELGI EQUIPMENTS LIMITED**

C. VENKATARAMANAN
SENIOR OFFICER – HRD

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SYNOPSIS

SYNOPSIS

Lean Production system refers to a system of practices that increases material and information velocity, streamline flow, and increases space density based on the principle of elimination of waste and reducing variability. Its objectives are to reduce Work In Process, to reduce through put time, and to enhance the planning activity.

Lean manufacturing which emerges from Toyota Production System aims at fast, improved and cheap manufacturing, new product introduction and information flow. Lean manufacturing stresses in balanced use of people, equipment, space and material, which gives us the lowest manufacturing cost. It lowers manufacturing cost by increasing throughput time, reducing WIP, reducing the rejection rate, eliminating/minimizing Non-Value-Added's and proper planning and scheduling.

In this project, the various steps, which were carried out in implementation of lean production system in a real time environment, is discussed in detail. Each and every step such as preparation and system investigation with respect to the existing systems and processes, formation of cells and flow lines using group technology concepts, reduction of lead time through reduction of setup time and leveling the production. The various effects of lean implementations on the functioning of the manufacturing system as observed are highlighted. The feasibility of applying Lean Production System in Elgi Equipments Ltd. Coimbatore is studied.

CONTENTS

INTRODUCTION

1. INTRODUCTION

1.1 Introduction About The Organisation

ELGI Equipment Limited was established in the year 1960 to manufacture air compressors and service station equipments in technical collaboration with two reputed West German firms: PUMPEN FABRIK URACH and LANDIVEHR & Co. The ELGI products make their presence felt in areas as diverse as spray painting, dairy, plastic mining, food processing, pharmaceutical, electronic, automobile, oil drilling, borewells and practically everywhere.

ELGI's wide product range consists of reciprocating air compressors, vacuum pumps, exhausters, rotary screw compressors, drip irrigation systems, pasteurizer plants, bottle washing machines, air craft refueller, mobile workshops, mobile service units and auto accessories like air horns, wind screen, wipers and power brakes.

Many of ELGI's products have been innovated and manufactured for the first time in India and exported to USA, GERMANY, RUSSIA, AUSTRALIA, THAILAND, and THE MIDDLE SRILANKA.

The company has two factories and 14 branches. One factory at Singanallur and the other at Kurichi in Coimbatore with a total manpower of 1229Nos.

1.2 About the Products of the Company

a) SCREW AIR COMPRESSOR

Screw Air Compressor is the one of the core product in the organisation.

Screw Air Compressor is further divided into four types.

1. Electric Power Screw Air Compressor [EPSAC]
2. Diesel Power Screw Air Compressor [DPSAC]
3. Oil Free Screw Air Compressor [OFSAC]
4. Centrifugal Screw Air Compressor [CENTFUG]

1.EPSAC:

It is electrically powered and has a horse power (hp) of 10-16. It is of medium size.

2.DPSAC:

It is diesel powered and ranges between 300-750hp. It is used in riggs, dam projects and where high-pressure air is required. It is usually mounted in a lorry or a trolley.

3.OFSAC:

It is also known as oil free screw air compressor. It is an advanced version of EPSAC. It has a higher hp (i.e.) 200hp. The compressed air given out is 100% oil free. ELGI has a tie up with HITACHI – JAPAN for the technology used in OFSAC.

4.CENTFUG:

It is otherwise known as centrifugal screw air compressor. ELGI has a tie up with SAMSUNG-JAPAN for the technology used in CENTFUG.

b) RECIPROCATING AIR COMPRESSOR:

It has two divisions, they are

1. Railway reciprocating compressor.
2. Industrial reciprocating compressor.

1. Railways Reciprocating Compressor:

25% of the turnover of the company is from the railways department. 80% of the Indian railway necessities are supplied by Elgi Equipments Ltd.

2. Industrial Reciprocating Compressor:

It is smaller than the railways reciprocating compressor. It can be got in varied ranges of power. It is used more for factory purposes.

c) AUTOMOTIVE EQUIPMENTS:

Two and four wheeler manufactures and service stations use automotive equipments. Examples Tyre inflator, wheel changer, wheel aligner, spark plug tester, spark plug cleaner, two post lift, four post lift etc.

d) DIESEL ENGINES:

They are also manufactured at Kurichi. They are used in autos, bullet motorcycles, catamarans and agricultural applications. Elgi has a tie up with Farryman Diesel Engines, Germany for the technology used in these engines.

Turnover:

The turnover for the year of 2001-2002 was 242 cores. This year the company aims of achieving a target of Rs.250 cores.

Competitors:

1. AtlasCapco
2. Ingersol
3. Chicago Pneumatics
4. Breaves

Market share:

In the manufactures of screw air compressor, EPSAC and DPSAC are the number one in India, Ofsac and Centfug capture the 2nd position. In Automatic engines, ELGI is number one and in Diesel engine ELGI is number two in India.

Salient features of the Company:

ERP-BAAN Package:

ELGI began to use this package in 1997. Baan is a computer software firm in the Netherlands. ELGI was the first manufacturing company to adopt ERP. ERP was an integration package, which helped to knit the company together.

1.3 Introduction about Lean Production System

Lean production is defined as a system of practices that increases material and information velocity, streamlines flow, and increases space density based on the principles of eliminating waste and reducing variability [5].

An organization that practices Lean manufacturing will have these characteristics [3].

1. Systematic manufacturing practices.
2. Fast, efficient process of material.
3. Focus on improving material and information flow.

4. Reliance on workforce for process performance and continuous improvement.
5. Unrelenting pressure to reduce the total cost of producing product by eliminating waste.

Lean Manufacturing: History and Origins

The concept of lean production was originally introduced into the business world's vocabulary in a report, which was the final result of a five-year, five million dollar International Motor Vehicle Program (I.M.V.P) study released in 1990 by Womack, Jones and Roos [7]. In their study, which was circulated as a shortened book entitled "The Machine that Changed the World," they define lean production as: "Lean" because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer products, and produces a greater and ever growing variety of products.

A properly organized lean-production system does indeed remove all slack that's why it's lean. But it also provides workers with the skills they need to control their work environment and the continuing challenge of making the work go more smoothly...lean production offers a creative tension in which workers have many ways to address challenges [2]. This creative tension involved in solving complex problems is precisely what has separated manual factory work from professional "think" work in the age of mass production.

Advocates of lean production claim that this form of organizing the workplace makes jobs more challenging, permits workers to inspect their own work as well as the work of others, grants workers the 'freedom' to perform minor maintenance chores and allows workers to move between jobs easily and frequently. This last claim is lean production's key assertion with respect to

health and safety: workers are not tied to a single repetitive job which will strain the same muscles, ligaments and body parts until a workplace injury results [1].

The value of the lean production system is justified on four main grounds: Firstly, as it is more flexible it can be more responsive to consumer demands and hence offer more variety for the consumer. Second it will be more productive than conventional methods...we are told that lean production uses half of everything compared with conventional production methods... Third, lean production is justified on the basis that it provides satisfying work. Wood, Stephen (1993), "The Lean Production Model," paper presented at The Lean Workplace Conference, Port Elgin Ontario, September-October, 1993, 2.

It is on this point of worker satisfaction that management restructuring attempts to address itself [4]. Anticipating the inevitable backlash, Womack et al write that Lean production is a superior way for humans to make things. It provides better products in wider variety at lower cost. Equally important, it provides more challenging and fulfilling work for employees at every level, from the factory to the headquarters.

Lean Manufacturing: A fragile balancing act

Simply put lean production is fragile. Mass production is designed with buffers everywhere—extra ordinary, extra space, extra workers—in order to make it function. Even when parts don't arrive on time or many workers call in sick or other workers fail to detect a problem before the product is mass-produced, the system still runs [6]. However, to make lean production with no slack –no safety net –work at all, it is essential that every worker try very hard. Womack, James.P., Jones, Daniel.T., Roos, Daniel, The Machine that Changed the World (Toronto: Collier Macmillan, 1990), 102-3.

The objectives of lean production are to strip away these buffers, to reduce costs and to involve more systematically in production. This accomplished by a series of connected practices...Just in time (JIT) or

synchronous production minimizes buffers by making only what is needed at the amount needed at the necessary time.

This means that lean production relies on an industrial workforce which doesn't get sick, doesn't get tired, doesn't suffer from industrial accidents or injury and has an unremitting capacity for working at full intensity well over forty hours per week (overtime is a key feature of lean production plants)

PROBLEM DEFINITION

2. Problem Description

2.1 Introduction

Elgi Equipment Ltd. (Reciprocating compressor division) where this work is carried out manufactures cylinder, cylinder head, crankcase, connecting rod, web etc.

It consists of several machines such as fine boring, multidrilling, milling, honing, column drilling etc arranged as per product layout concept.

2.2 Study of existing system

The existing system in ELGI Equipments Ltd is push production system that is components are produced in batches. It is tedious process with very high "Work In Process"(WIP). This ultimately leads to high inventory levels and thereby resulting in high Inventory cost.

In the compressor division (Machine shop) four main components are manufactured, namely,

1. Cylinder and Cylinder head
2. Crankcase
3. Connecting Rod
4. Web

The "WIP" is found to be high in cylinder and cylinder head line. Therefore this line has been choosen to study the feasibility of implementing Lean Production System.

The various operations carried out in this section are as follows,

For Cylinder

1. Fine Boring
2. Multi Drilling
3. Valve Plate Milling
4. Honing (Rough)
5. Honing (Finish)

6. Chamfering and Tapping
7. Lapping

For Cylinder Head

1. Multi Drilling
2. Valve Plate Milling
3. Honing (Rough)
4. Honing (Finish)
5. Drilling and Tapping
6. Lapping

In Machine shop the following types of Cylinders and Cylinder heads are manufactured,

1. 50 mm diameter cylinder and cylinder head
    - Finger Valve Type
2. 60 mm diameter cylinder and cylinder head
    - Disc Valve type
    - Finger Valve type
3. 70 mm diameter cylinder and cylinder head
    - Standard [No 1] type
    - SC 30 [No 2] type
4. 78 mm diameter cylinder and cylinder head
    - Finger Valve type
5. 90 mm diameter cylinder and cylinder head
    - Disc Valve type
    - Finger Valve type
6. 100 mm diameter cylinder and cylinder head
    - Disc Valve type
    - Finger Valve type

The draw backs in the existing system are as listed below,

1. Large amount of Work-In-Process (WIP).
2. High Inventory.
3. Material Backtracking.
4. Long Lead-time.
5. High Inventory Cost.
6. Delay on parts arrival.

2.3. Problem Definition

The existing system in Elgi is batch production. In batch production the following drawbacks occur,

1. Large amount of work in process.
2. Long lead-time.
3. High Inventory.
4. Parts do not arrive on time.
5. Material backtracking.

Due to batch production above mentioned drawbacks occur. So aim of project work is to identify means to reduce the WIP, lead time and inventory by conducting the feasibility study of lean production system.

Previous studies indicate that reciprocating machine shop has high WIP. So, reciprocating machine shop is chosen for this study.

2.4 Aim of the Project

Aim of the project is to conduct the feasibility study of lean production system in reciprocating compressor division (machine shop) by,

- Applying the JIT concept
- Systemizing the Manufacturing practices
- Improving material and information flow

METHODOLOGY

3. METHODOLOGY

Lean Production System is otherwise termed as Toyota Production System.

3.1 Introduction To Just In Time (JIT)

In recent years, the competitiveness of Japanese manufacturing in the world market has lead to increased efforts by other parts of world to understand and implement the techniques used by Japanese. The Just in Time production philosophy developed by Toyota Motors Industries has been the main centre of attention. Many time that JIT is a system for reducing inventories, pushing responsibilities onto suppliers. In actual practice, JIT represents a complete philosophy centered around elimination of wastes in the total process of purchasing to distribution.

In JIT system, each process produces exactly what is needed, when needed and only how much needed by the subsequent process. That means material reaching inside the company will not wait anywhere inside till it leaves as a final product.

As a part of JIT philosophy there are three basic and important components for eliminating waste and thus, improving productivity. First, Waste elimination aims at establishing balance, synchronization and smooth flow between manufacturing processes. The second component is the company's attitude towards quality, the idea of "doing things right the first time". The third component of JIT philosophy is the employee involvement. It is a prerequisite for waste elimination that every member from shop floor to senior management has a part to play in the elimination of wastes and solving the manufacturing problems that causes the waste.

CASE STUDY

1. Cycle time

The main aim of the project is to obtain the smooth flow of materials between manufacturing processes. For this purpose the unbalanced operations are balanced with the help of Industrial Engineering Department Engineers in the company. As a result of reducing the cycle time, the lead-time also decreases. (This is given Table 1.1 to 1.6)

2. Work-In-Process (WIP)

As said already there is too many WIP in cylinder and cylinder head line. This is confirmed through the long lead times in that section. Long manufacturing lead times is an indication of the amount of WIP. (This is given Table 2.1 to 2.10)

3. Raw Material Inventory details

Raw material inventory is found to be high in cylinder and cylinder head section. This is evident from the data given below. This data indicates the number of days the raw material remains in the store. High inventory levels ultimately leads to increased holding costs. (This is given Table 3.1 to 3.3)

4. Break down details

The rates of break downs in high in cylinder and cylinder head section. Main reason for this is frequent problems arising in tapping machine. Data relating to frequent problems arising in Tapping machine is as shown below (This is given Table 4)

SUMMARY OF STANDARD TIMINGS PART NAME: CYLINDER						
Sl No.	**OPERATION**	**WORK CENTRE**	**MACHINE**	**STANDARD TIME (MINS)**		
				MODEL		
				DIA 50	**DIA 60**	**DIA 65**
10	BORING	3MO	292103	7.50	7.50	7.50
20	MULTI DRILLING	3MK	291802	3	3	----
30	MILLING	3MQ	292302	6	6	6
40	HONING (ROUGHING)	3MT	292801	4	4	4
50	HONING (FINISHING)	3MT	202801	2	2	2
60	CHAMFERING AND TAPPING	3M1	203502	2	2	2
70	LAPPING	3MZ	293404	6.85	6.85	6.85

Table 1.1(Summary of standard time)

SUMMARY OF STANDARD TIMINGS PART NAME: CYLINDER						
Sl No.	OPERATION	WORK CENTRE	MACHINE	STANDARD TIME (MINS)		
				MODEL		
				DIA 70	DIA 78	DIA 90
10	BORING	3MO	292103	7.50	7.50	7.50
20	MULTI DRILLING	3MK	291802	3	3	4
30	MILLING	3MQ	292302	6	6	12
40	HONING (ROUGHING)	3MT	292801	4	4	9
50	HONING (FINISHING)	3MT	202801	2	2	3
60	CHAMFERING ANDTAPPING	3M1	203502	2	2	2
70	LAPPING	3MZ	293404	6.85	NA	6.85

Table 1.2(Summary of standard time)

SUMMARY OF STANDARD TIMINGS PART NAME: CYLINDER					
Sl No.	**OPERATION**	**WORK CENTRE**	**MACHINE**	**STANDARD TIME (MINS)**	
				MODEL	
				DIA 100	**------**
10	BORING	3MO	292103	7.50	
20	MULTI DRILLING	3MK	291802	4	
30	MILLING	3MQ	292302	12	
40	HONING (ROUGHING)	3MT	292801	9	
50	HONING (FINISHING)	3MT	202801	3	
60	CHAMFERING ANDTAPPING	3M1	203502	2	
70	LAPPING	3MZ	293404	6.85	

Table 1.3(Summary of standard time)

SUMMARY OF STANDARD TIMINGS PART NAME: CYLINDER HEAD						
Sl No.	**OPERATION**	**WORK CENTRE**	**MACHINE**	**STANDARD TIME (MINS)**		
				MODEL		
				DIA 50	**DIA 60**	**DIA 65**
10	MULTI DRILLING	3MK	291802	2.56	2.56	2.56
20	MILLING	3MQ	292201	2.5	2.5	2.5
30	DRILLING & TAPPING	3MI	291706	6.85	6.85	6.85
50	LAPPING	3MZ	293402	6.85	6.85	6.85

Table 1.4(Summary of standard time)

SUMMARY OF STANDARD TIMINGS PART NAME: CYLINDER HEAD						
Sl No.	**OPERATION**	**WORK CENTRE**	**MACHINE**	**STANDARD TIME (MINS)**		
				MODEL		
				DIA 70	**DIA 78**	**DIA 90**
10	MULTI DRILLING	3MK	291802	2.56	3.5	3.84
20	MILLING	3MQ	292201	2.5	2.5	4
30	DRILLING & TAPPING	3MI	291706	6.85	10	10
50	LAPPING	3MZ	293402	6.85	NA	6.85

Table 1.5(Summary of standard time)

SUMMARY OF STANDAR TIMINGS

PART NAME : CYLINDER HEAD

SI. NO.	OPERATION	WORK CENTER	MACHINE	STANDARD TIME IN MINS
				MODEL
				DIA 100
10	MULTI DRILLING	3MK	291802	3.84
20	MILLING	3MQ	292201	4.00
30	DRILLING & TAPPING	3MI	291706	10.00
50	LAPPING	3MZ	293402	6.85

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
247963	50	Boring Multidrill Milling Honing Tapping Lapping	13/09/02 14/09/02 14/09/02 14/09/02 14/09/02 17/09/02	13/09/02 14/09/02 14/09/02 14/09/02 14/09/02 17/09/02	5
248342	10	Boring Multidrill Milling Honing Tapping	17/09/02 15/09/02 15/09/02 15/09/02 15/09/02	17/09/02 15/09/02 15/09/02 15/09/02 15/09/02	3
247575	75	Boring Multidrill Milling Honing Tapping	07/09/02 09/09/02 09/09/02 09/09/02 11/09/02	09/09/02 09/09/02 09/09/02 10/09/02 12/09/02	6
247037	50	Boring Multidrill Milling Honing Tapping Lapping	24/08/02 24/08/02 26/08/02 05/09/02 06/09/02 07/09/02	24/08/02 24/08/02 26/08/02 05/09/02 06/09/02 09/09/02	17
247062	50	Multidrill Milling Honing Tapping Chamfering	17/08/02 17/0802 19/08/02 03/09/02 26/08/02	17/08/02 17/0802 19/08/02 03/09/02 26/08/02	10
247555	50	Boring Multidrill Milling Honing Tapping Lapping	02/09/02 02/09/02 03/09/02 06/09/02 07/09/02 07/09/02	03/09/02 03/09/02 05/09/02 07/09/02 07/09/02 09/09/02	8
245280	25	Boring Multidrill Milling Honing Tapping Lapping	16/08/02 16/08/02 16/08/02 16/08/02 17/08/02 04/09/02	16/08/02 16/08/02 16/08/02 16/08/02 04/09/02 04/09/02	20

Table 2.2(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
247106	50	Boring Multidrill Milling Honing Tapping	23/08/02 28/08/02 28/08/02 30/08/02 31/08/02	23/08/02 28/08/02 28/08/02 19/09/02 20/09/02	29
247687	50	Boring Multidrill Milling Honing Lapping	22/08/02 22/08/02 24/08/02 11/09/02 28/08/02	22/08/02 23/08/02 24/08/02 11/09/02 15/09/02	25
248118	50	Boring Multidrill Milling Honing Tapping	06/09/02 10/09/02 10/09/02 10/09/02 11/09/02	07/09/02 10/09/02 10/09/02 10/09/02 11/09/02	6
247639	50	Boring Multidrill Milling Honing Tapping	05/09/02 05/09/02 05/09/02 06/09/02 07/09/02	05/09/02 05/09/02 06/09/02 11/09/02 07/09/02	7
247850	45	Boring Multidrill Milling Honing Tapping Lapping	28/08/02 28/08/02 28/08/02 29/08/02 30/08/02 29/08/02	29/08/02 29/08/02 29/08/02 31/08/02 30/08/02 29/08/02	4
247001	25	Boring Multidrill Milling Honing Tapping	25/07/02 01/08/02 01/08/02 02/08/02 02/08/02	25/07/02 01/08/02 01/08/02 02/08/02 02/08/02	8

Table 2.3(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
246472	50	Boring Multidrill Milling Honing Tapping	11/06/02 13/06/02 13/06/02 13/06/02 13/06/02	11/06/02 13/06/02 13/06/02 13/06/02 14/06/02	4
245224	35	Boring Multidrill Milling Honing Tapping	03/06/02 06/06/02 06/06/02 06/06/02 06/06/02	04/06/02 06/06/02 06/06/02 06/06/02 06/06/02	4
245615	25	Boring Multidrill Milling Honing Tapping	04/06/02 06/06/02 06/06/02 06/06/02 10/06/02	04/06/02 06/06/02 07/06/02 07/06/02 28/06/02	25
245489	38	Boring Multidrill Milling Honing Tapping	24/05/02 01/06/02 04/06/02 04/06/02 07/06/02	24/05/02 01/06/02 04/06/02 04/06/02 08/06/02	16
246448	25	Boring Multidrill Milling Honing Tapping Lapping	03/06/02 07/06/02 07/06/02 07/06/02 12/06/02 21/06/02	03/06/02 07/06/02 07/06/02 07/06/02 12/06/02 21/06/02	19
245464	25	Boring Multidrill Milling Honing Tapping	30/05/02 13/06/02 13/06/02 13/06/02 13/06/02	30/05/02 13/06/02 13/06/02 13/06/02 13/06/02	15
246221	40	Boring Multidrill Milling Honing Tapping Lapping	25/05/02 08/06/02 08/06/02 08/06/02 10/06/02 11/06/02	25/05/02 08/06/02 08/06/02 08/06/02 10/06/02 12/06/02	19

Table 2.4(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
246186	50	Boring Multidrill Honing Tapping	25/06/02 25/06/02 26/06/02 27/06/02	25/06/02 25/06/02 26/06/02 27/06/02	3
246301	50	Boring Multidrill Milling Honing Lapping	19/06/02 19/06/02 20/06/02 20/06/02 20/06/02	19/06/02 20/06/02 20/06/02 20/06/02 20/06/02	2
245664	30	Boring Multidrill Milling Honing Tapping	18/06/02 19/06/02 22/06/02 25/06/02 27/06/02	18/06/02 19/06/02 22/06/02 2606/02 27/06/02	10
246194	50	Boring Multidrill Milling Honing Tapping Lapping	27/0502 29/05/02 29/05/02 30/05/02 31/05/02 03/06/02	28/05/02 29/05/02 30/05/02 30/05/02 31/05/02 04/06/02	9
246026	50	Boring Multidrill Milling Honing Tapping Lapping	07/06/02 07/06/02 07/06/02 08/06/02 10/06/02 10/06/02	07/06/02 07/06/02 08/06/02 08/06/02 10/06/02 12/06/02	6
245476	25	Boring Multidrill Milling Honing Tapping	21/06/02 21/06/02 21/06/02 21/06/02 21/06/02	21/06/02 21/06/02 21/06/02 21/06/02 21/06/02	1
245689	25	Boring Multidrill Milling Honing Tapping	23/05/02 04/06/02 04/06/02 05/06/02 05/06/02	23/05/02 04/06/02 04/06/02 05/06/02 05/06/02	14

Table 2.5(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
246458	50	Boring Multidrill Milling Honing Tapping Lapping	06/06/02 10/06/02 11/06/02 14/06/02 18/06/02 21/06/02	07/06/02 10/06/02 14/06/02 14/06/02 18/06/02 21/06/02	16
246025	20	Boring Multidrill Milling Honing	01/06/02 06/06/02 06/06/02 06/06/02	03/06/02 06/06/02 06/06/02 06/06/02	7
246495	50	Boring Multidrill Milling Honing Tapping	12/06/02 12/06/02 12/06/02 12/06/02 13/06/02	12/06/02 12/06/02 13/06/02 13/06/02 13/06/02	2
244925	65	Boring Multidrill Milling Honing Tapping Lapping	14/06/02 17/06/02 18/06/02 18/06/02 18/06/02 18/06/02	15/06/02 18/06/02 18/06/02 18/06/02 19/06/02 24/06/02	10
246034	50	Boring Multidrill Milling Honing Tapping	12/06/02 24/06/02 24/06/02 24/06/02 24/06/02	24/06/02 24/06/02 24/06/02 26/06/02 25/06/02	14
246465	50	Boring Multidrill Milling Honing Tapping	12/06/02 17/06/02 17/06/02 18/06/02 18/06/02	15/06/02 17/06/02 18/06/02 26/06/02 18/06/02	15
246231	50	Boring Multidrill Milling Honing Tapping Lapping	20/06/02 24/06/02 24/06/02 24/06/02 24/06/02 24/06/02	25/06/02 25/06/02 26/06/02 26/06/02 28/06/02 28/06/02	9

Table 2.6(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
246221	45	Boring Multidrill Milling Honing Tapping	06/07/02 08/07/02 08/07/02 08/07/02 27/07/02	06/07/02 08/07/02 08/07/02 08/07/02 27/07/02	22
245223	25	Multidrill Milling Honing Tapping	11/07/02 11/07/02 11/07/02 11/07/02	11/07/02 11/07/02 11/07/02 11/07/02	1
246974	25	Boring Multidrill Milling Tapping Lapping	19/07/02 19/07/02 20/07/02 24/07/02 24/07/02	19/07/02 19/07/02 20/07/02 24/07/02 24/07/02	5
246115	10	Boring Multidrill Milling Honing Tapping	24/06/02 24/06/02 25/06/02 29/06/02 03/07/02	24/06/02 24/06/02 25/06/02 29/06/02 03/07/02	10
246566	50	Boring Multidrill Milling Honing Tapping Lapping	05/07/02 06/07/02 06/07/02 06/07/02 06/07/02 11/07/02	06/07/02 06/07/02 06/07/02 06/07/02 11/07/02 17/07/02	13
245658	88	Boring Multidrill Milling Honing Tapping	06/07/02 10/07/02 11/07/02 11/07/02 13/07/02	08/07/02 11/07/02 12/07/02 12/07/02 13/07/02	8
245618	55	Boring Multidrill Honing Tapping	29/06/02 29/06/02 29/06/02 04/07/02	04/07/02 04/07/02 06/07/02 06/07/02	8

Table 2.7(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
246530	30	Boring Multidrill Milling Honing Tapping Lapping	02/07/02 03/07/07 03/07/02 04/07/02 06/07/02 06/07/02	02/07/02 03/07/07 03/07/02 04/07/02 06/07/02 11/07/02	10
246298	50	Boring Multidrill Milling Honing Tapping	23/07/02 23/07/02 23/07/02 23/07/02 25/07/02	24/07/02 24/07/02 25/07/02 25/07/02 25/07/02	3
247228	50	Boring Multidrill Milling Tapping	24/07/02 24/07/02 24/07/02 24/07/02	24/07/02 24/07/02 24/07/02 24/07/02	1
245646	50	Boring Multidrill Milling Honing Tapping	02/07/02 03/07/02 03/07/02 04/07/02 27/07/02	03/07/02 04/07/02 04/07/02 05/07/02 27/07/02	26
246852	15	Boring Multidrill Milling Honing Tapping	20/07/02 20/07/02 20/07/02 20/07/02 20/07/02	20/07/02 20/07/02 20/07/02 20/07/02 20/07/02	1
246873	50	Boring Multidrill Milling Honing Tapping Lapping	22/07/02 22/07/02 23/07/02 23/07/02 25/07/02 25/07/02	22/07/02 22/07/02 23/07/02 23/07/02 25/07/02 26/07/02	4
245282	50	Boring Multidrill Milling Honing Tapping Lapping	05/07/02 20/07/02 20/07/02 20/07/02 20/07/02 20/07/02	20/07/02 20/07/02 20/07/02 20/07/02 20/07/02 27/07/02	23

Table 2.8(WIP details)

P.O no	Quantity	Operation	Stating date	Closing date	WIP days
247002	50	Boring Multidrill Milling Honing Tapping Lapping	25/07/02 25/07/02 25/07/02 25/07/02 25/07/02 26/07/02	25/07/02 25/07/02 25/07/02 25/07/02 27/07/02 27/07/02	3
245222	25	Multidrill Milling Honing Tapping	24/06/02 02/07/02 08/07/02 11/07/02	24/06/02 02/07/02 08/07/02 11/07/02	18
246554	54	Boring Multidrill Milling Honing Tapping Lapping	16/07/02 16/07/02 17/07/02 17/07/02 17/07/02 17/07/02	16/07/02 16/07/02 17/07/02 17/07/02 17/07/02 17/07/02	2
246958	50	Boring Multidrill Milling Honing Tapping	16/07/02 16/07/02 16/07/02 16/07/02 16/07/02	16/07/02 16/07/02 17/07/02 17/07/02 25/07/02	10
246083	50	Boring Multidrill Milling Honing Tapping Lapping	23/07/02 23/07/02 24/07/02 24/07/02 24/07/02 24/07/02	24/07/02 24/07/02 24/07/02 24/07/02 24/07/02 24/07/02	2
246131	50	Boring Multidrill Milling Honing Tapping	13/07/02 13/07/02 13/07/02 15/07/02 15/07/02	13/07/02 15/07/02 13/07/02 19/07/02 24/07/02	12
246871	50	Boring Multidrill Milling Honing Tapping Lapping	17/07/02 23/07/02 24/07/02 24/07/02 24/07/02 27/07/02	23/07/02 23/07/02 24/07/02 26/07/02 29/07/02 29/07/02	13

Table 2.9(WIP details)

STATUS OF WIP - FOR JUNE 2002								
	NUMBER OF PRODUCTION ORDERS							
Cylinder Dia meter	**50**	**60**	**70**	**78**	**90**	**100**	**Total**	**%**
WIP Days								
Up to 2	0	0	0	0	0	2	**2**	**10**
2 - 4	2	0	1	0	0	0	**3**	**14**
4 - 7	0	0	2	1	1	0	**4**	**19**
Above 7	3	2	2	0	2	3	**12**	**57**
Total	**5**	**2**	**5**	**1**	**3**	**5**	**21**	**100**

STATUS OF WIP – FOR JULY 2002								
	NUMBER OF PRODUCTION ORDERS							
Cylinder Dia meter	**50**	**60**	**70**	**78**	**90**	**100**	**Total**	**%**
WIP Days								
Up to 2	0	0	2	0	1	1	**4**	**18**
2 - 4	0	0	2	0	0	0	**2**	**9**
4 - 7	0	1	1	0	0	0	**2**	**9**
Above 7	5	2	2	1	0	4	**14**	**64**
Total	**5**	**3**	**7**	**1**	**1**	**5**	**22**	**100**

Table 2.10(Status of WIP)

Prod.Or.No.	Qty	Issue Dt.	Start Dt.	Month	Raw material inventory days
244925	65	14/06/02	14/06/02	June	0
245224	35	1/6/02	3/6/02	June	2
245464	25	15/05/02	30/05/02	June	15
245476	25	1/6/02	21/06/02	June	20
245489	38	16/05/02	24/05/02	June	8
245615	25	4/6/02	4/6/02	June	0
245644	30	14/06/02	18/06/02	June	4
246025	25	4/6/02	4/6/02	June	0
246026	50	7/6/02	7/6/02	June	0
246034	50	11/6/02	12/6/02	June	1
246194	50	20/05/02	27/05/02	June	7
246211	40	20/05/02	25/05/02	June	5
246231	50	18/06/02	20/06/02	June	2
246301	50	19/06/02	19/06/02	June	0
246448	25	3/6/02	3/6/02	June	0
246458	50	5/6/02	6/6/02	June	1
246465	50	12/6/02	12/6/02	June	0
246475	50	01/06/02	11/6/02	June	10
246495	50	12/6/02	12/6/02	June	0

Table 3.1(Inventory details)

Prod.Or.No.	Qty	Issue Dt.	Start Dt.	Month	Raw material inventory days
245222	25	1/6/02	24/06/02	July	23
245223	25	11/7/02	11/7/02	July	0
245282	50	6/7/02	6/7/02	July	0
245618	55	24/07/02	29/07/02	July	5
245646	50	24/06/02	2/7/02	July	8
245658	88	18/06/02	6/7/02	July	17
246083	50	13/07/02	23/07/02	July	10
246131	50	11/7/02	13/07/02	July	2
246155	10	19/07/02	24/07/02	July	5
246227	45	26/06/02	6/7/02	July	9
246298	50	23/07/02	23/07/02	July	0
246491	50	14/06/02	28/06/02	July	14
246536	30	26/06/02	2/7/02	July	5
246554	54	12/7/02	16/07/02	July	4
246566	50	5/7/02	05/07/02	July	0
246852	50	26/06/02	20/07/02	July	26
246871	50	11/7/02	17/07/02	July	6
246873	50	20/07/02	22/07/02	July	2
246958	50	15/07/02	16/07/02	July	1
246974	25	19/07/02	19/07/02	July	0
247002	50	23/07/02	25/07/02	July	2
247228	50	23/07/02	24/07/02	July	1

Table 3.2(Inventory details)

Prod.Or.No.	Qty	Starting Dt.	Closing Dt.	Month	Raw Mat. Inventory Days
247529	25	20/08/02	23/08/02	AUG&SEP	3
247226	50	13/09/02	14/09/02	AUG&SEP	1
247016	50	23/08/02	23/08/02	AUG&SEP	0
247687	50	20/08/02	22/08/02	AUG&SEP	2
247963	50	13/09/02	13/09/02	AUG&SEP	0
248342	10	17/09/02	17/09/02	AUG&SEP	0
247575	75	6/9/02	7/9/02	AUG&SEP	1
247531	20	29/08/02	4/9/02	AUG&SEP	6
248118	50	5/9/02	6/9/02	AUG&SEP	1
247639	50	4/9/02	5/9/02	AUG&SEP	1
247112	50	23/08/02	31/08/02	AUG&SEP	8
247009	25	23/08/02	2/9/02	AUG&SEP	10
247037	50	23/08/02	24/08/02	AUG&SEP	1
247555	50	27/08/02	2/9/02	AUG&SEP	6
247062	50	14/08/02	17/08/02	AUG&SEP	3
247850	45	28/08/02	29/08/02	AUG&SEP	1
245280	25	16/08/02	16/08/02	AUG&SEP	0
247001	25	20/07/02	25/07/02	AUG&SEP	5

Table 3.3(Inventory details)

Break down Hours Details From Apr'02						
	DATE	M/C NO	M/C DESCRIPTION	B/D Hrs.	NATURE OF COMPLAINT	
1	06/08/02	292104	BORING	4.00	Hydraulic motor problem	
2	08/08/02	292104	BORING	2.00	Leakage problem	
			Sub total	**6.00**		**8.66**
1	10/04/02	291802	MULTIDRILLING	3.00	Right side spindle problem	
2	11/4/2002	291802	MULTIDRILLING	2.00	Left side spindle key has broken	
3	24/07/02	291802	MULTIDRILLING	2.00	joint broken	
4	27/07/02	291802	MULTIDRILLING	5.00	m/c spindle problem	
			Sub total	**12.00**		**17.33**
1	03/04/02	292801	HONING	1.25	pump for coolant not functioning properly	
			Sub total	**1.25**		**1.81**
1	22/08/02	291706	COLUMNDRILLING	1.25	m/c switch problem	
2	30/04/02	291706	COLUMNDRILLING	2.50	m/c self problem	
3	05/05/02	291706	COLUMNDRILLING	2.00	m/c self problem	
4	25/06/02	291706	COLUMNDRILLING	3.00	do not engage self problem	
5	27/06/02	291706	COLUMNDRILLING	2.50	feed engagement problem	
			Sub total	**11.25**		**16.25**
1	15/04/02	293502	TAPPING	1.50	Up&down movement problem	
2	07/05/02	293502	TAPPING	3.00	Up&down movement problem	
3	24/05/02	293502	TAPPING	2.00	clutch unit tension spring problem	
4	27/05/02	293502	TAPPING	7.00	spindle revolution problem	
5	29/05/02	293502	TAPPING	1.00	tension spring cut	
6	11/06/02	293502	TAPPING	1.00	spring problem	
7	06/08/02	293502	TAPPING	6.75	spindle Up&down problem	
8	08/08/02	293502	TAPPING	1.50	tightening spring problem	
9	13/08/02	293502	TAPPING	4.00	spring broken	
10	19/08/02	293502	TAPPING	2.50	frame broken	
			Sub total	**30.25**		**43.68**
1	22/08/02	293402	LAPPING	2.00	m/c stator problem	
2	30/04/02	293402	LAPPING	6.50	m/c guide ring pillar problem	
			Sub total	**8.50**		**12.27**
			Total	**69.25**	In 5 months	

Table 4(Breakdown details)

4.1.2 Formation of Cells and Flow lines

a) Existing Cell Design

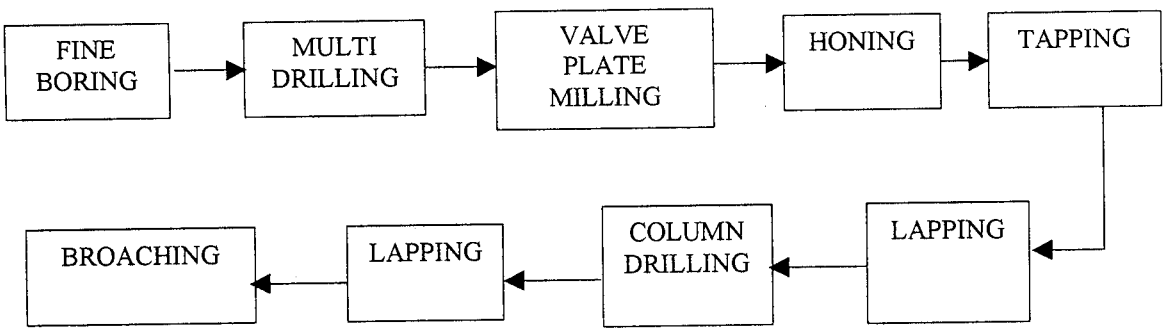


Fig. a

Draw Backs:

1.Material Backtracking

As per sequence of operations, only after completing Chamfering and Tapping Operation in column drilling machine, lapping has to be performed. But due to the presence of column drilling machine next to lapping machine, backtracking takes place. Therefore machines have to be properly arranged to avoid material backtracking.

2.Distance

Distance between column drilling machine and lapping machine is very long around 35 meters. This may be reduced by around 31 meters.

3.Unwanted machine

Machine belonging to another flow line, namely broaching machine is present in the existing cell.

4.High space density

Due to batch production in existing cell design at each and every stage requiring high space density.

b) Proposed Cell Design

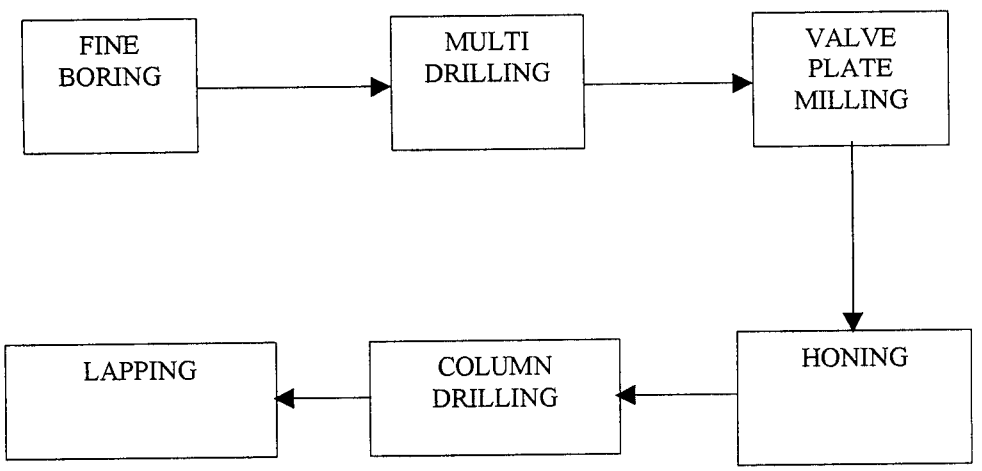
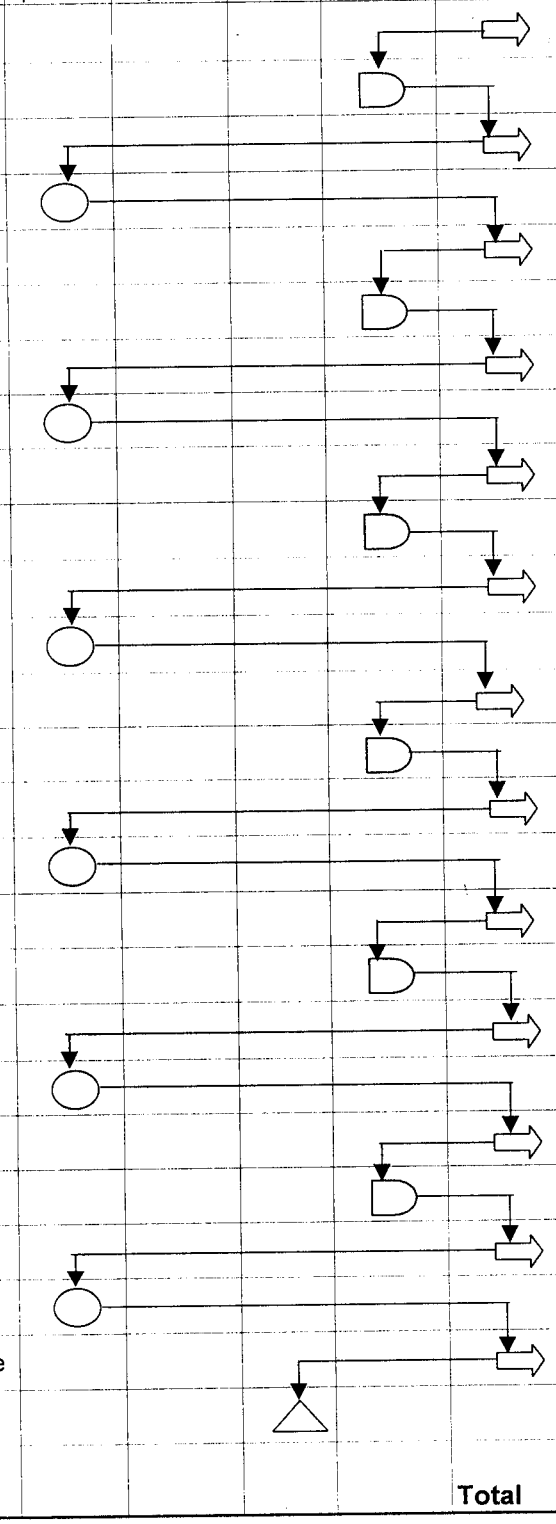


Fig. b

Advantages:

1. The drawbacks in existing cell design can be eliminated by the above proposed design.
2. Material back tracking can be eliminated by changing position of column drilling machine and lapping machine.
3. Distance between column drilling machine and lapping machine can be reduced to 4 meters.
4. Broaching machine has been moved to the respective flow line.

EXISTING FLOW LINE



Description of activities	operation	Inspection	Storage	Delay	Transpotation	Time	Days	Distance in mtrs
Transpotation of material from stores								
Waiting for loading							0-10	
To boring m/c								9
Fine Boring						+60+(7.5* 25)=247.5		
To storage area								9
Waiting for multi drill							0-2	
To Multi drill m/c								9
MultiDrilling						+60+(3.0* 50)=210.0		
To storage area								9
Waiting for Milling							0-2	
To Milling m/c								9
Milling						+60+(6.0* 50)=360.0		
To storage area								9
Waiting for Honing							0-2	
To Honing m/c								9
Honing						+60+(6.0* 50)=360.0		
To storage area								9
Waiting for tapping							0-2	
To tapping m/c								9
Tapping						+60+(3.0* 50)=210.0		
To storage area								9
Waiting for lapping							0-2	
To lapping m/c								35.9
Lapping						+60+(7.0* 50)=410.0		
To finished parts store								
Storage								
					Total	**30 Hrs**	**20 days**	**125.9**

Drawbacks in existing flow line:

- Time to complete 50 pieces is 30 hours.
- Delay between the stages is 20 days.
- Total distance moved by the material is 125.9 meters.

PROPOSED FLOW LINE

)escription of ctivities	operation	Inspection	Storage	Delay	Transport	Time	Distance in mtrs
ranspotation of aterials from stores							
Vaiting for loading							
o boring m/c							9
ine Boring						7.5min	
o Multi drill							3
ultiDrilling						3min	
o Milling							3.5
lilling						6min	
o Honing							2.9
oning						6min	
o Tapping							2.9
apping						2min	
o Lapping							35.9
apping						6.85min	
o Finished stores							
orage						60+32+(49*4)=288	
				Total		**ie 4.8 hrs**	**57.2**

Advantages in proposed flow line:

- Time taken to complete 50 pieces is 4.8 hours.
- Total distance moved by the material is 57.2 meters.
- Delay between stages has been eliminated.

4.1.3 Reduction of Lead time through reduction of setup time and leveling the production.

Production lead time is defined as the summation of machining/operation, setup, waiting and conveyance times. Setup time reduction activities start by identifying the processes with high setup times and then determining the setup elements by work sampling, or observation. Nest, the high setup time elements must be reduced by converting as many internal setup operations (performed without stopping the machine), using the principles of method design, work place arrangement, eliminating adjustment and proper tool design. Waiting times can be reduced furthermore by synchronizing the production of all the line by implementing standard operations routines based on cycle times requirements.

Recommendations:

i) Increasing The Number of Heads In Milling Machine

Milling machine is used for taking value plate groove in cylinder and cylinder head. Currently there is only one head. But two grooves had to be taken in each job. So after taking one groove the job is reset and the second groove is taken. Instead of that the number of heads in the machine is increased to two and simultaneous grooving on both sides is recommended.

ii) Automatic Indexing

Indexing is done manually in the milling machine presently. Automatic indexing reduces the set-up time. Thus the overall lead time comes down. So automatic indexing is recommended.

Iii) New Honing and Tapping Machine

Honing operation consumes a lot of time. To reduce the cycle time and balance the line a new honing machine is a must. Thus, a new honing machine is recommended to reduce the lead-time and hence balance the line.

Existing Tapping machine undergoes frequent breakdowns. Inspection of the machine shows that it needs replacement. Thus, a new tapping machine is recommended.

iv) Combined drill jig

Combined drill jig for all types of cylinder and cylinder head is recommended instead of individual drill jig, which are presently being used for side drill operation.

ANALYSIS

5. ANALYSIS

5.1 ANNUAL SAVINGS

Effects of setup time reduction:

Combined drill jig for all types of cylinder and cylinder head is recommended instead of individual drill jig, which are presently being used for side drill operation. The estimated swings in cost is as given below,

Models covered (diameter)	Budgeted annual quantity
50	4006 Nos
60	11254 Nos
70	18807 Nos
78	330 Nos
90	1800 Nos
100	10108 Nos
Total	**46305 Nos**

Approximate annul quantity take = 40,000 Nos

Batch quantity =75 Nos

Average number of setting =533

We will take 500 setting/year (for calculating purpose)

Present setting time =60 min/setup

New setting time =20 min/setup

Saving setting time =40 min/setup

Total saving hours/yr = (Avg no of setting *Saving setting time)/Present setting time

=(500X 40)/60

= 333 hours/year

Total savings = 333 X 100 (100-machine hour rate)

= **33,300 rupees/year**

Effect of Cycle Time reductions:

Diameter 70 Cylinder Head

Existing time/piece	=7.38 min
New time/piece	=6.85 min
Savings/piece	=0.52 min
Total savings in hrs/yr	=(Budgeted Annual Qty * savings)/60
	=(18807 * 0.52)/60 hrs
	=163 hrs.
Total savings in rupees/yr	=163 * 100
	=16300 rupees/year.

Diameter 100 Cylinder Head

Existing time/piece	=480/40
	=12 min
New time/piece	=480/45
	=10.6 min
Savings/piece	=1.4 min
Total Savings in hours/year	=(10108 * 1.4)/60
	=236 hours/year
Total savings in rupees/year	**=23,585 rupees/year**

5.2 Benefits of Lean Production System

It lowers manufacturing cost by,

- Increasing throughput time.
- Reducing WIP.
- Reducing the rejection rate.
- Eliminating and minimizing NVA's.
- Proper planning and scheduling.

5.3 Limitations of Lean Production System

When breakdown occur, smooth flow of material is distributed affecting Lean production Systems. Similarly labour absenteeism affect smooth material flow.

Lean Production Systems is affected by disturbance is smooth material flow. The reasons for the above may be,

1. Break down of machines.
2. Labour absenteeism.
3. Rejections.

CONCLUSION

6. CONCLUSION

The feasibility study of implementing Lean Production System has been conducted and the following are inferred,

1. Work in process reduces due to continuous flow it has been estimated that WIP reduces by 20 days.
2. Lead-time has come down dramatically by 25.2 hours.
3. The flow of material has been improved.
4. The distance travel during flow has come down by 68.7 meters
5. The cycle time has been lowered.
6. The estimated cost saved by all the above activities is rupees 73,185 rupees/year.

Thus, by implementing Lean Production System the company can experience the above-mentioned benefits and remain the highly competitive environment.

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