RE-ENGINEERING THE ASSEMBLY LINE OF AIREND COMPRESSORS

A PROJECT REPORT

Submitted By

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**Re-engineering the assembly line of airend compressors**" is the bonafide work of

Ms.Mc-Lu-Ret - **Register No. 71206409006**

who carried out the project work under my supervision.

Signature of the HOD **Signature of the Supervisor**

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ELGI

COMPRESSOR DIVISION

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ABSTRACT

Manufacturing plays a pivot role in improving the economy of any country. The success of the manufacturing sector mostly depends on productivity because productivity is the watchword for any organization. This project work is done at ELGI EQUIPMENTS PRIVATE LIMITED, COIMBATORE, which manufactures compressors.

Due to globalization and because of hectic competition in this sector, ELGI Coimbatore is trying to introduce cost reduction strategies at shop floor level and productivity improvement and optimization techniques to compete in the market. Among various techniques available to improve productivity, assembly line balancing (ALB) is a dominant technique for mass production industries like automobile manufacturing industries and consumable manufacturing industries.

Assembly line balancing is a good example of product layout, which consists of number of work elements, each having its own processing unit. The time, which is, given, as the input for line balancing is the maximum station time, which is found by the work measurement techniques i.e. Stop Watch Time Study . The objective of work study is to investigate into all forms of work, with a view to increase productivity.

Work study investigates the work done in the organization and it aims at finding the best and most efficient way of using available resources, i.e., men, material, money and machinery. Method study aims at recording and critically examining the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective and less fatiguing procedure for doing the same job at lower costs.

The assembly layout designed is very user friendly, considering the movement of men and materials and with better utilization of existing plant and machinery through the elimination of unnecessary idle time, the more effective operation of processes and the better utilization of labour through the elimination of unnecessary and time consuming movement. Ultimately this project concentrates on the Re-engineering the assembly line .

ஆய்வு சுருக்கம்

ஒரு நாட்டின் பொருளாதார வளர்ச்சி அந்நாட்டின் உற்பத்தி திறனை பொறுத்தே அமைகிறது. உற்பத்தி திறனை பொறுத்தே உற்பத்தி திறனின் வெற்றியும் அமைகிறது. இந்த ஆய்வானது கம்ப்ரஷர் உற்பத்தியாளரான "எல். ஜி. எக்யூப்மெண்ட் பிரைவேட் லிமிடெட்", கோயம்புத்தூரில் செய்யப்பட்டுள்ளது.

உலகமயமாக்கலின் விளைவால் இன்றைய சூழ்நிலையில் ஏற்பட்டுள்ள கடினமான போட்டிகளை குறைக்க எல். ஜி. நிறுவனம் ஷாப் புளோர் லெவல், உற்பத்தி திறன் மேம்பாடு மற்றும் உகப்பாக்கம் முறைகளின் செலவுகளை குறைப்பதற்கான தந்திரங்களை அறிமுகப்படுத்தியுள்ளது. இதனை மேற்கொள்ள பல்வேறு வழிமுறைகள் கையாளப்படுகிறது.

ஒரு பொருளின் அமைவுக்கு "தொகுப்பு தடம் சமன் செய்தல்" முறை மிக சிறந்த உதாரணமாக கூறலாம். அது பல்வேறு வேலை பொருட்களை உள்ளடக்கியுள்ளது. அவை ஒவ்வொன்றிக்கும் தனித்தனி செயல்முறை பிரிவு உள்ளது. தொகுப்பு தடம் சமன் செய்தலுக்கு தரம் உள்ளீட்டு நேரமானது அதிகபட்ச நிலையை அடைய நேரமாகும். அதை வேலை அளவீட்டின் மூலம் அறியலாம். அதாவது கடிகார நிறுத்த நேர கற்கை முறை. இந்த பணியிட படிப்பின் நோக்கமானது அனைத்து வகை வேலைகளையும் ஆய்வு செய்து அதன் மூலம் உற்பத்திநிலை அதிகரித்தலாகும்.

மேற்கண்ட இந்த பணியிட படிப்பானது நிறுவனத்தில் உள்ள வளங்களை வைத்துக் கொண்டு எந்தெந்த வகைகளில் வேலையாட்கள், பொருட்கள், இயந்திரங்களின் செயல்பாடுகள் ஆகியவற்றை எவ்வாறு பயன்படுத்தலாம் என்பதனை பற்றிய விசாரனையை மேற்கொண்டுள்ளது. மற்றொரு நோக்கம் என்னவெனில் வேலை பொருளை எவ்வாறு எளிய முறையில் கையாளப்பத்தலாம் என்பதாகும்.

இந்த தொகுப்பு அமைவு வடிவமைப்பானது பயன்படுத்துவதற்கு எளிய ஒன்று. தற்போதுள்ள தொழிற்சாலைகளில் வேலையாட்கள் மற்றும் இயந்திரங்களை முழுமையாக பயன்படுத்துவதன் மூலம் தேவையற்ற நேரத்தை குறைக்க முடியும். சிறப்பான செயல்பாட்டின் மூலமும், வேலையாட்களை சிறப்பாக பயன்படுத்துவதன் மூலமும் தேவையற்ற நேரத்தையும் அதே சமயம் தேவையற்ற நேரத்தை உண்டாக்கும் இயக்கத்தையும் தவிர்க்கலாம்.

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All that have started well will end well and at this instant of time I would like to thank the people who were directly and indirectly instrumental in initiating me to do this work.

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Symbols / Abbreviations	Explanation
ALB	Assembly line balancing
PTS	Pre determined time standards
Std. time	Standard time
M/c	Machine
VA	Value added
NVA	Non value added

CHAPTER 1

INTRODUCTION

1.1 COMPANY PROFILE

ELGI equipments is located in Singanallur, Coimbatore-5. It is one of the leading manufacturer of air compressors and automotive devices. It has units in various parts of India. The ELGI product lines today, broadly comprise, rotary compressors, automotive compressors, reciprocating compressors, centrifugal compressors, automotive equipment and diesel engines. It has two manufacturing locations in Coimbatore, India, with 22 acres of land and 350,000 sq.ft of built up factory area.

ELGI was established in 1960 as service station equipment and reciprocating compressor manufacturing company. Over the years ELGI has become a multi product, multi market company manufacturing technically superior products in a highly competitive environment.

ELGI products are used in a wide range of applications in areas ranging from mining, defence, transport, pharmaceuticals, power oil, railways, chemicals, textiles, printing to ship building, paper, electronics, telecommunications, medical, food and beverages and plastics.

With its new axis air end compressors taking the market by storm, the company currently holds the no.1 position in the global market. ELGI is the first company to get E certification from Europe for its products, and also to get VDA6.1 and A6052

It has full fledged design, research and development department, test centre with CAD/CAM facilities. It established the metrology lab and it is equipped with the latest state of art, world class instruments & equipments.

1.2 WORK STUDY

Work study is the systematic examination of the methods of carrying on activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried out.

Work study aims at examining the way an activity is being carried out, simplifying or modifying the method of operation to reduce unnecessary or excess work, or the wasteful use of resources, and setting up a time standard for performing that activity. If work study results in cutting down the time of performing a certain activity by 20 percent, merely as a result of rearranging the sequence or simplifying the method of operation and without additional expenditure, then the productivity will go up by a corresponding value, that is by 20 percent.

Work study is a more valuable tool. It is a means of raising productivity of a plant or operating unit by the reorganization of work, a method that normally involves little or no capital expenditure on facilities and equipment. It is systematic. That ensures no factor affecting the efficiency of an operation is overlooked, whether in analyzing the original practices or in developing the new, and that all the facts about that operation are available. It is the most accurate means of setting standards of performance, on which the effective planning and control of production depends.

It can contribute to the improvement of safety and working conditions at work by exposing hazardous operations and developing safer methods of performing operations. It is relatively cheap and easy to apply.

1.2.1 Technique of Work Study

The term "work study" embraces several technique. but in particular method study and work measurement.

Method Study

Method study is the systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and more effective methods. Method study is concerned with the reduction of the work content of the operation or job.

Work Measurement

Work measurement is the application of techniques designed to establish the work content of a specified task by determining the time required for carrying it out at a defined standard of performance by a qualified worker. It is concerned with the investigation and reduction of the ineffective time and the subsequent establishment of time standards for the operation on the basis of the work content as established by method study.

1.3 ASSEMBLY LINE BALANCING (ALB)

Assembly line balancing consists of portioning the work necessary to assemble product(s) among different work stations of an assembly line. The objectives of assembly line balancing are to balance workload across work station so that no work station has an excessively high or low work load. This helps in minimizing the idle time and maximizing the throughput from the line.

Line balancing is an attempt to allocate equal amount of work to the various workstations along the line. The fundamental line-balancing problem is to assign a set of task to an ordered set of workstations, such that the precedence relations are satisfied and some performance measures are optimized.

When manufacturing activities are laid out as a line in a product layout it is important to ensure that the capacity of each facility on the line is approximately the same. Facilities should be planned to provide similar capacity. When designing an assembly line, which involves many manual assembly tasks, it is possible to organize where and when tasks are done to maximize efficiency. For example the assembly line of a product may require say twenty tasks, of differing standard tines. This does not mean that twenty operators are required, each doing

CHAPTER 2

LITERATURE REVIEW

LITERATURE REVIEW

Following are the overview of the relevant work done earlier related to the identified problem and the methodology to be adopted to solve the chosen problem for this work. This section describes the literature reviewed from various research papers published in journals, proceedings of various conferences and books.

M. Elnekave and I.Gilad, (2006), **Rapid video based analysis system for advanced work measurement,** International Journal of Production Research, 54, 134-167.

A digital video based approach is proposed to enhance work measurement and analysis by facilitating the generation of rapid time standards. A genuine description of the work situation is imported into the analytical system via digital video input, thereby enabling a free of work site attendance study for evaluating time and work performance.the proposed method serves as a computerized tool for remote work measurement with the ability to derive rapid generation of time standards.

Daniel F. Baldwin, Thomas E. Abell, Man-Cheung Max Lui,(1991), **An integrated computer aid for generating and evaluating assembly sequences for mechanical products,** International Journal of Robotics and Automation.

An integrated assembly line that is suitable for assembly line design and for concurrent design of mechanical products. Recognizing that early consideration of assembly sequence is important for productivity, quality control, flexibility and market responsiveness. The designer evaluates the set of sequences

according to criteria, leading to an informed sequence choice or to needed design refinement.

Jingxin Wang, Joe Mc Neel, John Baumgras(2001), **A computer- based time study system for timber harvesting operations,** Forest product journal, 53(3), 47-53.

A computer based time study system was developed for timber harvesting operations. The system consist of three major components a handheld device, data transfer interface and data storage. The data collection module resides in the handheld system and is used to collect time, motion, and other data of harvesting machines in the woods. This module allows the users to manipulate and export data collected in the field and provide accurate and reliable time study data.

Freivalds, A.,Konz, A.,Yurgec, A. and Goldberg, A.H., **Methods and work measurement and work design**, Int. J. Ind. Eng.,2000, 7, 108-114.

An effective design of an assembly line is characterized by two critical factors methods and work measurement and ergonomic optimization. Modeling & simulation is carried out for each line and analyses is made. The simulation results highlight problems concerning stress levels and ergonomic risks.

Arunachalam.V.P, Rajakumar.S, and Selladurai.V, (2004), **Work flow balancing strategies in parallel machines scheduling**, International Journal for Advanced Manufacturing Technology, 14, 215-234.

In many manufacturing environments, multiple processing stations are used in parallel to obtain adequate capacity. In parallel machine scheduling there are 'm' machines to which 'n' jobs are to be assigned based on different strategies. The procedure is based on workload balancing among the machines. A lowest workload of a machine is selected for assignment of a new job from the list of unfinished jobs. Different priority strategies are followed for the selection of jobs. Three different strategies are considered, namely random (RANDOM), shortest processing time (SPT), and longest processing time (LPT) for the selection of jobs for workflow balancing. The relative percentage imbalance (RPI)

is used to evaluate the performance of the three. The LPT provides the better results [1].

Arunachalam.V.P, Rajakumar.S, and Selladurai.V, (2005), **Simulation of work flow balancing in assembly shop floor operations**, Journal for Advanced Manufacturing Technology, 16, 265 – 281.

Providing a new model to solve the assembly planning of a textile machine in a shop floor, which can help researchers and practitioners. The assembly planning of a textile machine involves the allocation of operations to cross-trained operators. Workflow is defined as the workloads assigned to the operators. Operators with smaller workloads are selected to be assigned new operations from the list of unscheduled operations. Three different scheduling strategies – random (R), shortest processing time (S) and longest processing time (L) – are adopted for the selection of operations to be assigned to operators. Different combinations of these strategies are considered for the selection of both preceding and succeeding operations. The relative percentage of imbalance is adopted for evaluating the performance of these heuristics. The RL, SL, LL produced well-balanced workload schedules with lesser RPI values for all operators other than heuristics [2].

Arunachalam.V.P, Rajakumar.S, and Selladurai.V, (2006), **Work flow balancing in parallel machines through genetic algorithm**, International Journal for Advanced Manufacturing Technology, 18, 216-239.

A genetic algorithm (GA) is used to solve the parallel machine scheduling problem of the manufacturing system with the objective of workflow balancing.

The performance of GA is compared with three workflow strategies namely random (RANDOM), shortest processing time (SPT), and longest processing time (LPT).

The relative percentage of imbalance (RPI) is used to evaluate the performance of these heuristics. The GA provides the better performance for the combination of various job sizes and machines [3].

Asokan.P, Sachithanandam.M, and Saravanan.R, (2001), **Comparative analysis of conventional and non-conventional optimization techniques for CNC turning process,** International Journal for Advanced Manufacturing Technology, 17, 471 – 476.

This paper describes various optimization procedures for solving the CNC turning problem to find the optimum operating parameters such as cutting speed and feed rate. Total production time is considered as the objective function subject to constraints such as cutting force, power, tool-chip interface, temperature and surface roughness of the product. Conventional optimization techniques and non-conventional optimization techniques are employed in this work. Results are compared and their performances are analyzed [5].

Emin Aydin.M, and Terence C. Fogarty, **Modular simulated annealing algorithm for job shop scheduling running on distributed resource machine (DRM)**, White Paper.

In this paper a parallel implementation of a modular simulated annealing (MSA) algorithm a shortened simulated annealing (SA) algorithm, applied to classical job-shop scheduling (JSS) problems is presented. The implementation has been done as a multiple island system suitable to run on the Distributed Resource Machine (DRM) environment, which is a novel scalable, distributed virtual machine developed based on Java technology. The JSS problems tackled are very well known difficult benchmarks which are considered to measure the quality of such systems.

CHAPTER 3

PROBLEM DEFINITION

3.1 INTRODUCTION

The focused area of the project is the air end compressors of ELGI EQUIPMENTS PRIVATE LIMITED. The company produces different types of compressors for various sectors. ELGI does both the sub assembly and final assembly operations from the castings to the final assembled unit.

3.2 PROBLEM DEFINITION

The problem identified in ELGI is, there are no standard times, no standard operating procedures and the task are not equally distributed to workstations so they are facing the following problems:

a. No proper work load distribution

Due to improper allocation of tasks some station are heavily loaded and some station are less loaded. This makes the worker in the heavily loaded station get more tired than the other people.

b. Lot of idle time

The idle time of the person who is working on the less loaded station also gets the same amount of wages like the person who is in the heavily loaded station.

c. No time standards

The standard time is not determined in the production line. So it is not possible to calculate the time required for manufacturing the required quantity of product and the production planning and control becomes inefficient.

d. No standard operating procedure

The operating procedure is not predetermined, therefore non standard methods are performed by the operator according to his convenience.

e. High throughput time

Throughput time is defined as " the time taken for a job between the beginning of its operation and the time it comes out of the last operation". This is high for the existing system because of the improper line balance.

f. No professional line balancing

Due to the absence of professional assembly line balancing, it is not possible to distribute tasks evenly over the workstations, so that the idle time of men and machine is not minimized.

3.3 OBJECTIVES OF THE PROJECT

This project concentrates on the following objectives:

1) To Conduct Time study
2) To Conduct method study
3) To Increase the productivity
4) To Reduce the shop floor area
5) Graphical comparison of assembly line before and after balancing
6) To Provide better working atmosphere

CHAPTER 4

METHODOLOGY

4.1 WORK MEASUREMENT

Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a task at a defined rate of working. It is concerned with investigating, reducing and subsequently eliminating the in effective time, that is time during which on effective work is being performed, whatever the cause.

4.1.1 The use of work measurement

- To compare with time standards obtained by other methods.
- For timing repetitive operations employed in manufacturing different jobs.
- For determining schedules and planning work.
- Where it becomes necessary to breakdown an activity in detail and study.
- For determining standard cost and as an aid in preparing budgets.
- To determine in association with man-machine charts the number of machines an operative can run.
- For determining time standards to be used as a basis for the payment of wage incentive.

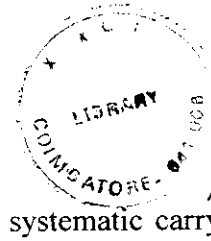
The time standards, once set, may then used:

- To provide information on which the planning and scheduling of

- To provide information that can enable estimates to be made for tenders, selling prices and delivery dates.

- To set standards of machine utilization and labour performance which can be used for any of the above purposes and as a basis for incentive schemes.

- To provide information for labour – cost control and to enable standard costs to be fixed and maintained.



4.2 THE BASIC PROCEDURE

The following steps, which are necessary for the systematic carrying out of, work measurement

- **Select** the work to be studied.
- **Record** all relevant data relating to the circumstances in which the work is being done the methods and the elements of activity.
- **Examine** the recorded data and the detailed work critically to ensure that the most effective method and motion are being used.
- **Develop** the most economic method taking into account all the circumstances.
- **Measure** the quantity of work involved in each element, in terms of time.
- **Compile** the standard time for the operation.
- **Define** precisely the series of activities and method of operation for which the time has been compiled and issue the time as standard for the activities and method specified.

- **Install** the ... method as agreed standard practice with the time allowed

- **Maintain** the new standard practice by proper control procedures.

4.3 THE TECHNIQUES OF WORK MEASUREMENT

The following are the principal techniques by which Work measurement is carried out as shown in figure 4.1.

The choice of techniques depends on the level of detail desired and the nature of the work itself. Highly detailed, repetitive work usually calls for time study and pre determined motion time data analysis. When work is done in conjunction with fixed processing equipment, elemental data are often used to reduce the need for direct observation.

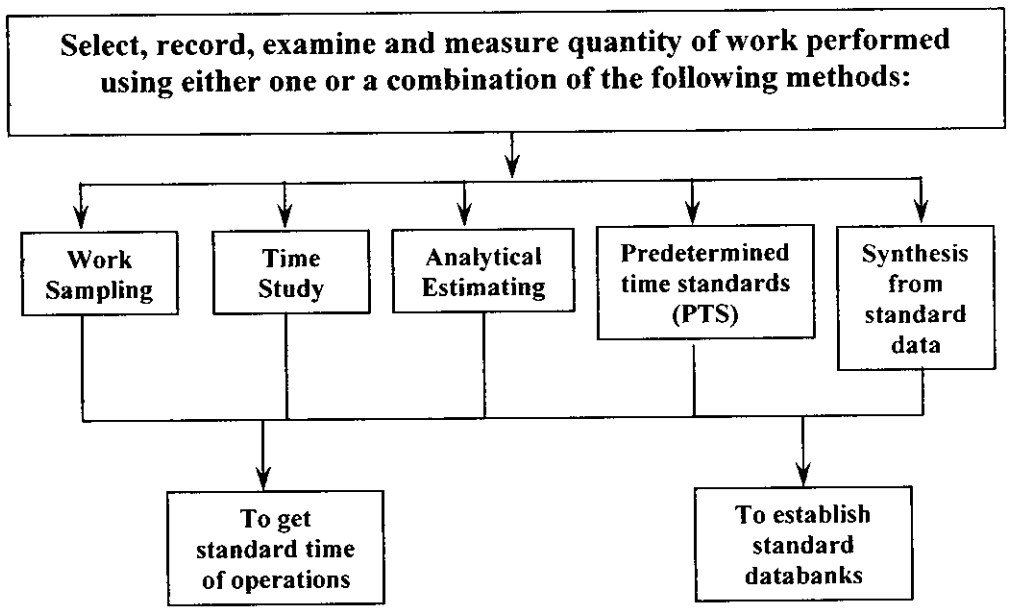


Figure 4.1 Methods of calculating standard time

4.4 Time study

Time study, originated by Taylor, was used mainly for determining time standards. It is a measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions and for analyzing the data so as to obtain the time necessary for an operator to carry it out at a defined rate of performance.

4.5 TIME STUDY EQUIPMENT

If time studies are to be made, certain items are essential. Basic time study equipment consists of:

- Stop watch
- Study board
- Time study forms

4.6 STEPS IN CONDUCTING TIME STUDY

When the work to be measured has been selected, the time study usually consists if the following steps:

1. Obtaining and recording all the information available about the job the operator and surrounding conditions likely to affect the carrying out of the work.

2. Recording a complete description of the method and breaking the operation into elements.

3. Examining with a time device (stop watch) and recording the time taken by the operator to perform each element of the operation.

4. Measuring with a timing device (usually stop watch) and recording the time taken by the operator to perform each element of the operation.

5. Assessing the effective speed of the working of the operator relative to a predetermined normal speed.

6. Converting observed time to normal time.

7. Determining the allowances to be made over and above the basic time for the operation .

8. Determining the standard time of the operation.

4.7 TERMINOLOGY USED IN TIME STUDY

- **Rating factor**

Rating (also known as performance rating) is the mental comparison by a work study man of the performance of the operator under observation with his own idea of a standard performance of a given method.

Normal performance is the working rate of the average worker under capable supervision but without the stimulus of an incentive wage payment plan. This pace can be easily maintained day after day without undue physical or mental fatigue and is characterized by the fairly steady exertion reasonable effort.

- **Observed time**

This is the actual time observed using a stop watch. The observed time of an operation is the total of the elemental times. The time study for the same job is conducted for a number of times. The average of the observed time is calculated.

- **Basic time**

This is the time for carrying out an element of work at standard rating

$$\textbf{Basic time} = \frac{observedtime * observedrating}{s\tan dardrating}$$

- **Allowances**

It is not possible for the worker to do a job continuously without any break. There are many interruptions (stoppage of work) taking place. Extra time is added to the basic time to compensate this interruption. This extra time given is known as allowances.

Various types of allowances are:

- Process allowances
- Rest allowances
- Fatigue allowances
- Contingency allowances

- Special allowances

- **The standard time**

Standard time is the total time in which the job should be completed at standard performance.

The standard time may be represented graphically as shown in figure 4.2.

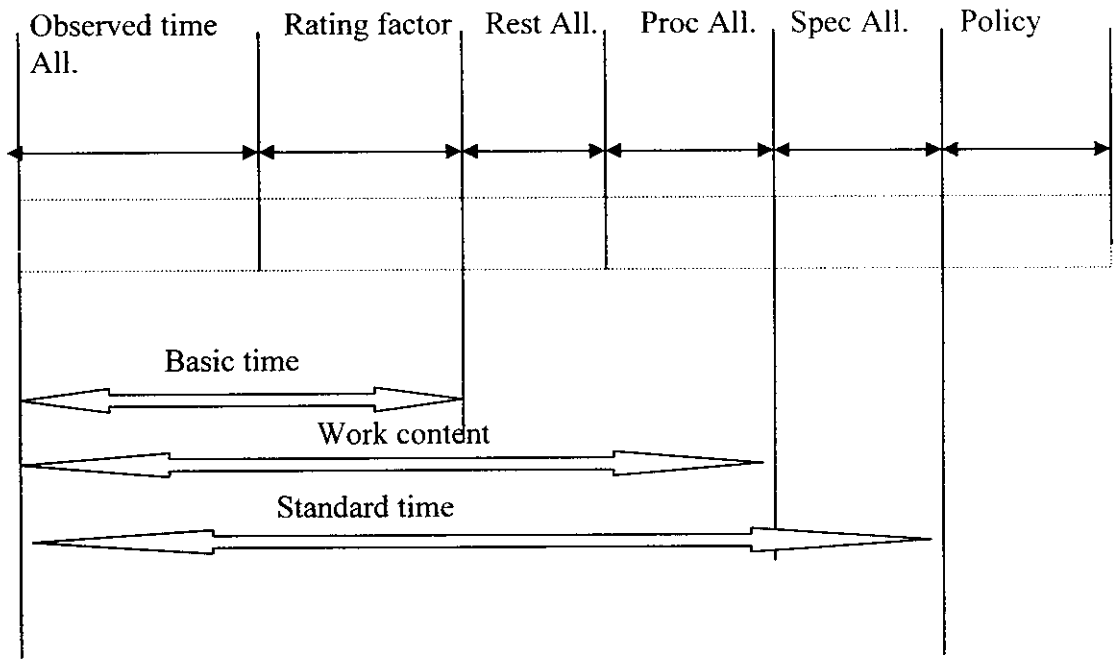


Figure 4.2 Representation of standard time

Standard time is derived by adding to basic time the allowances for personal needs, unavoidable worker delay and worker fatigue.

Standard time = basic time + (allowances*basic time)

CHAPTER 5

ASSEMBLY PROCESS IN ELGI

5.1 DESCRIPTION

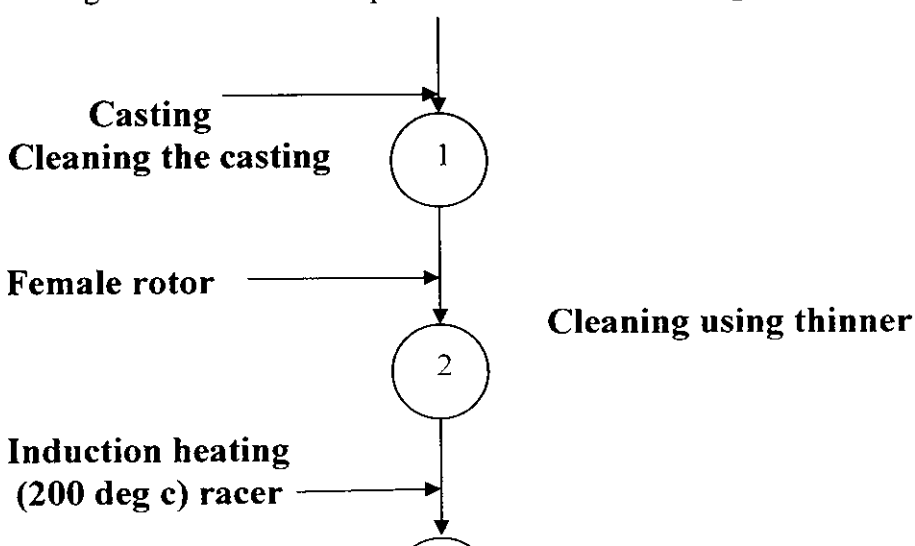
The assembly process of compressors is carried out in product type layout with dedicated assembly lines for different type of products. The study is conducted on assembly line of similar product. The existing assembly process consist of two separate process the main assembly and the outlet setting.

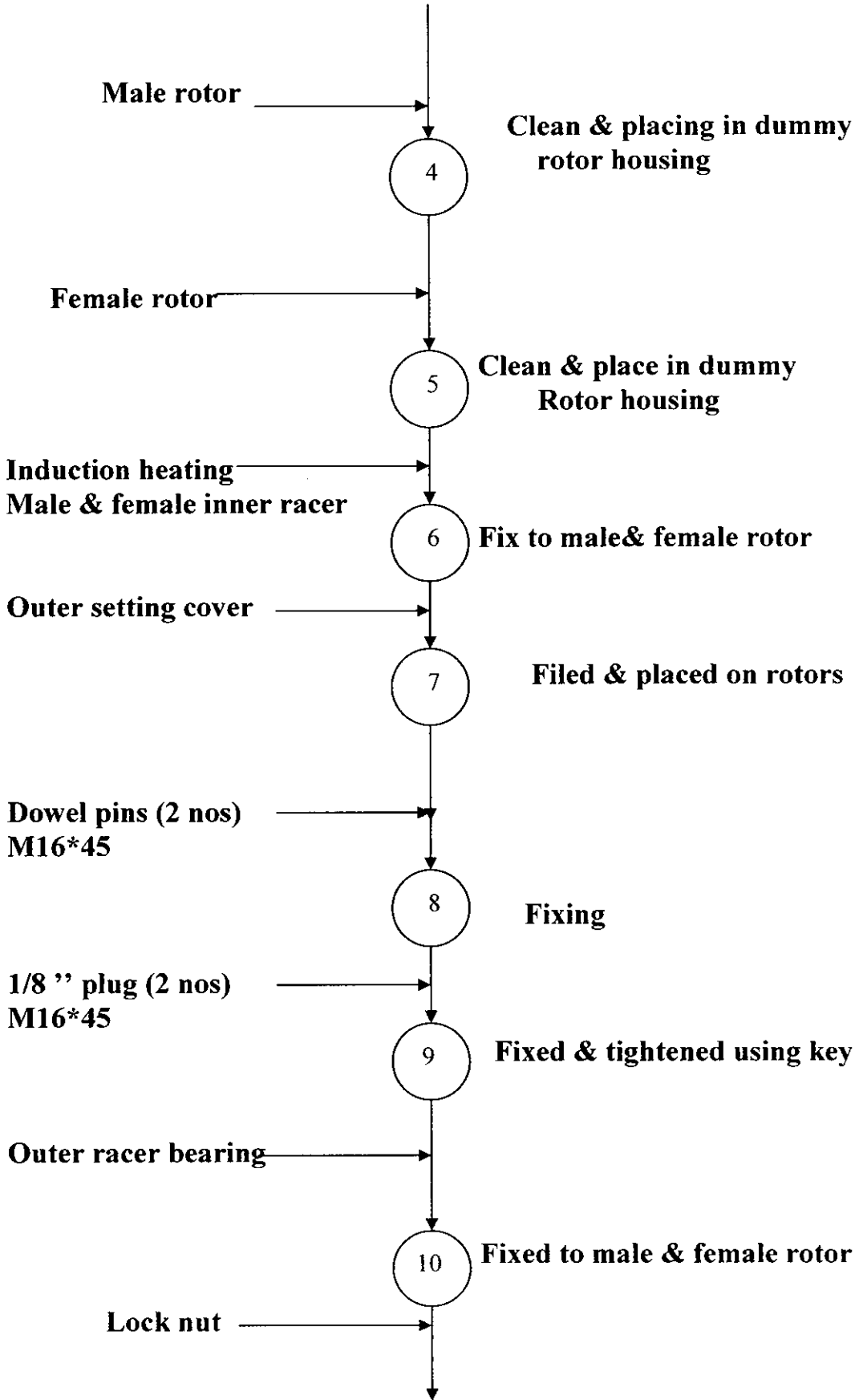
The outlet setting consist of setting the discharge clearance for the rotors, the male and the female rotor after a series of operation is fixed to the outlet setting also called as the dummy setup with the help of hoist. The discharge clearance is set with the help of the axial play setting. Now the rotor setup is lifted to the main assembly. The assembly of various components of the compressor is carried out in the main assembly fixture till the labeling process.

The assembly process is described below:

5.2 159 AIR END SUB ASSEMBLY (outlet setting)

The figure 5.1 describes the process chart of outlet setting




Male rotor
Clean & placing in dummy rotor housing
4
Female rotor
5
Clean & place in dummy Rotor housing
Induction heating
Male & female inner racer
6
Fix to male& female rotor
Outer setting cover
7
Filed & placed on rotors
Dowel pins (2 nos)
M16*45
8
Fixing
1/8 '' plug (2 nos)
M16*45
9
Fixed & tightened using key
Outer racer bearing
10
Fixed to male & female rotor
Lock nut

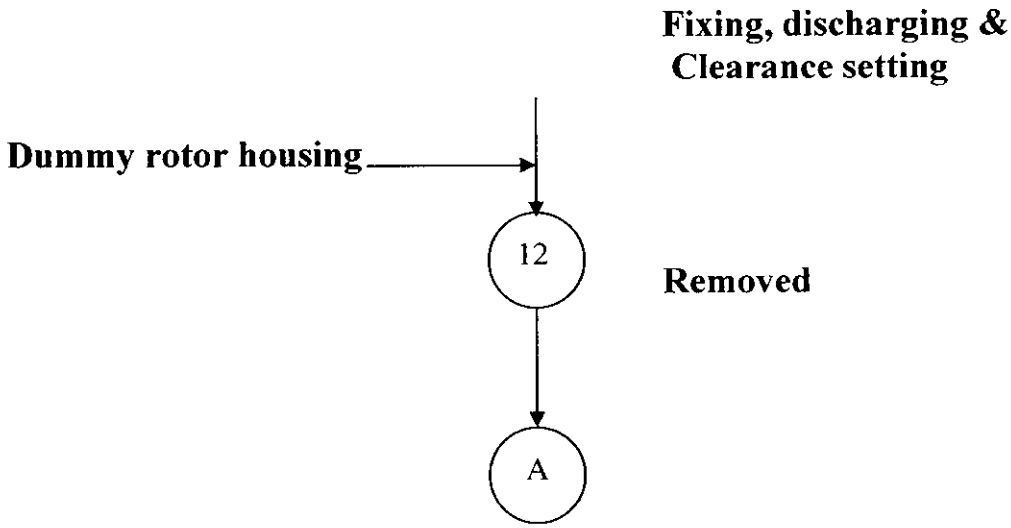
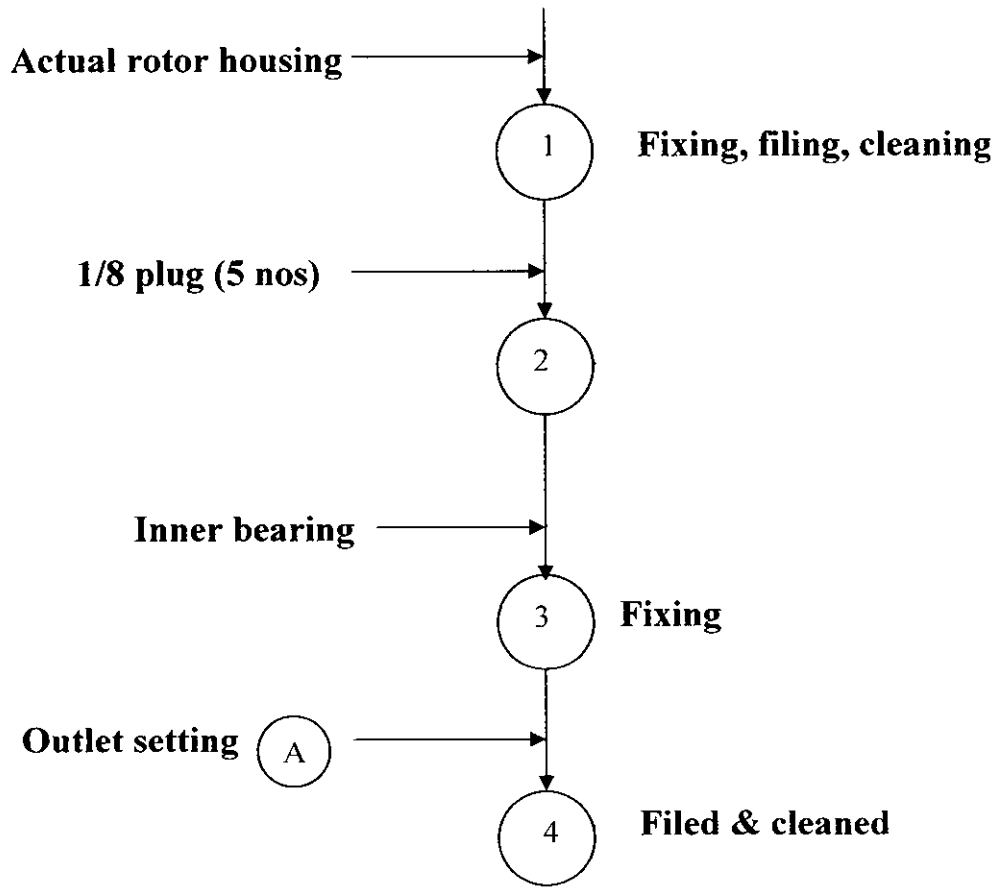
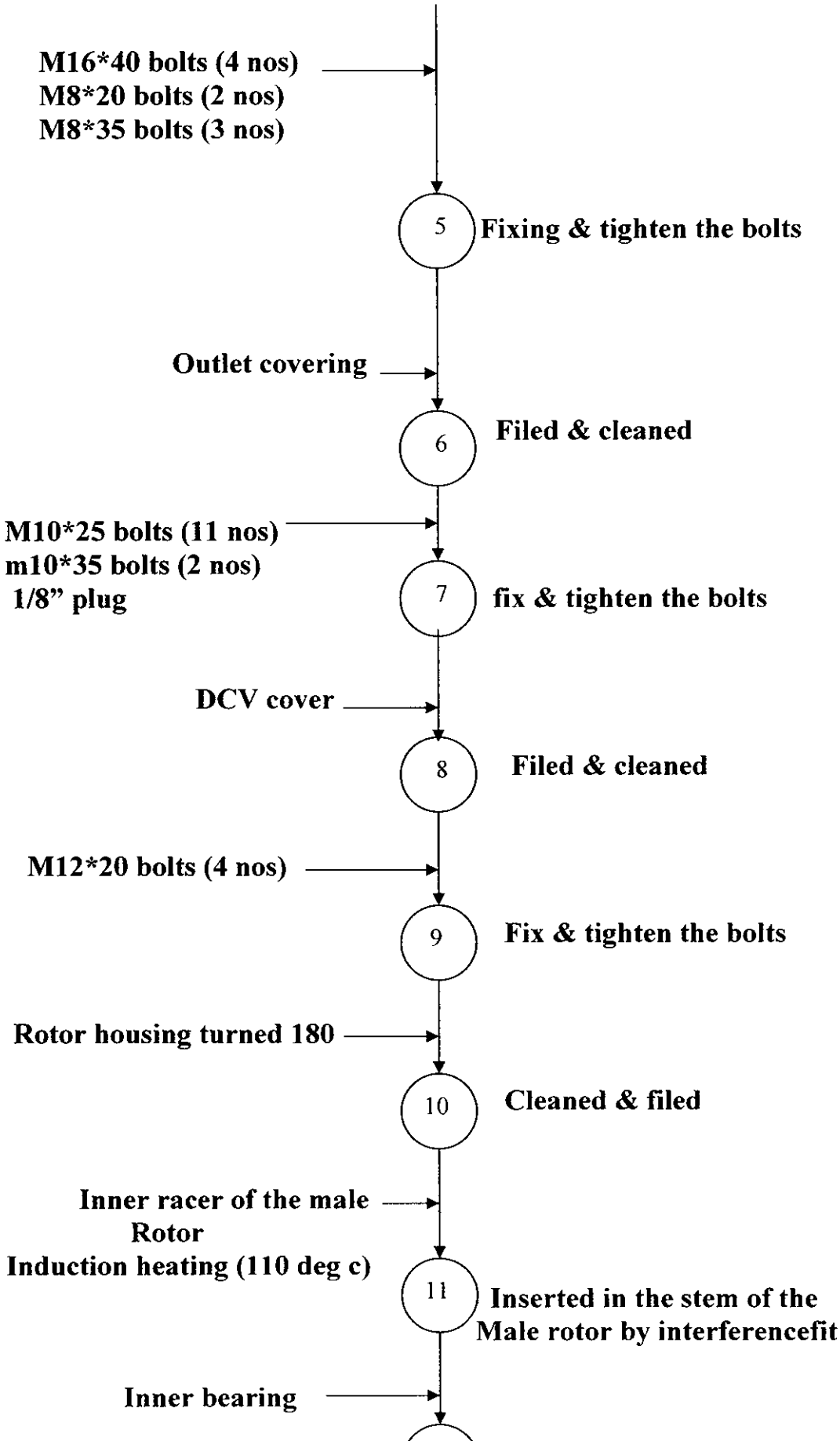


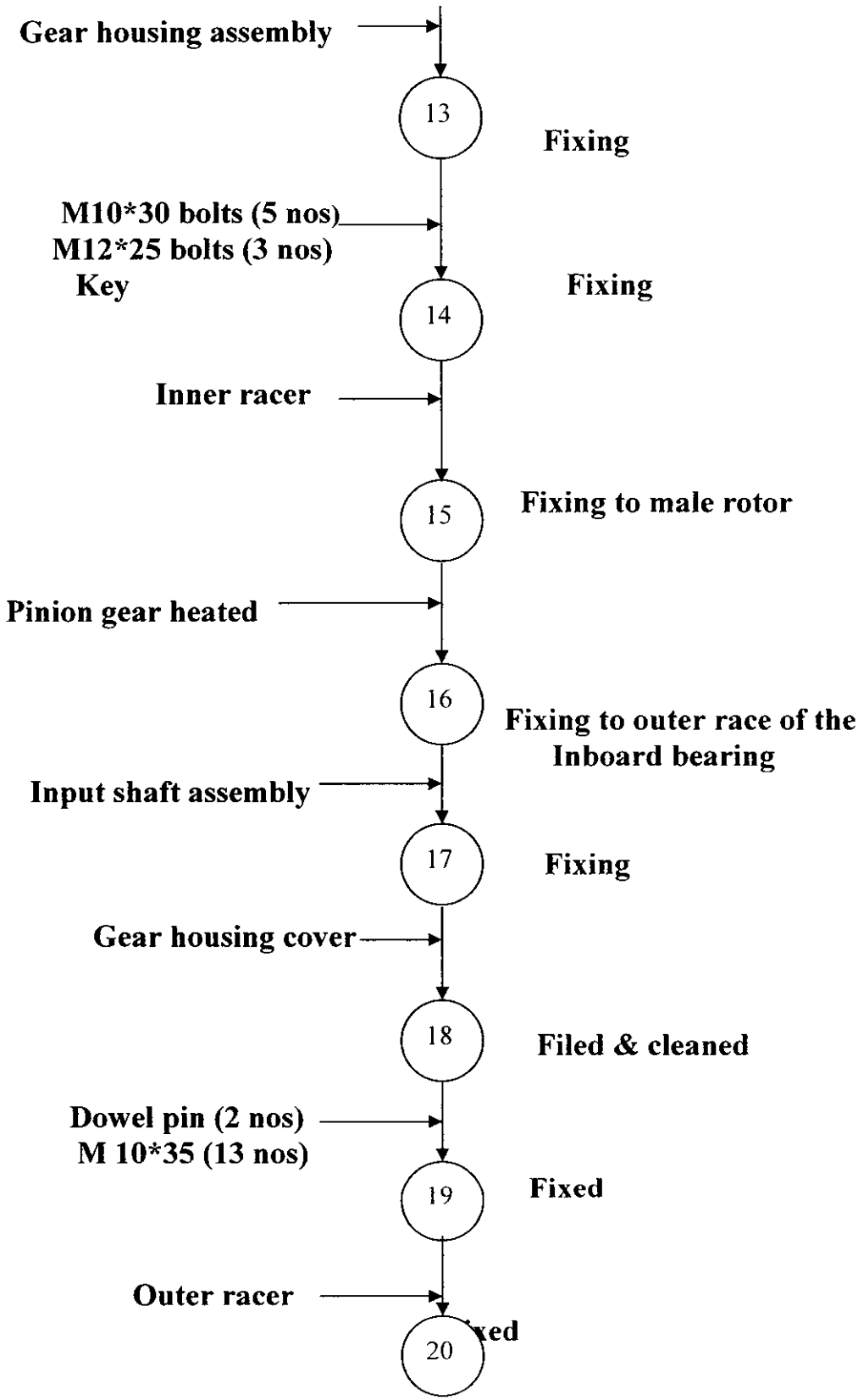
Figure 5.1 Process chart for outlet setting

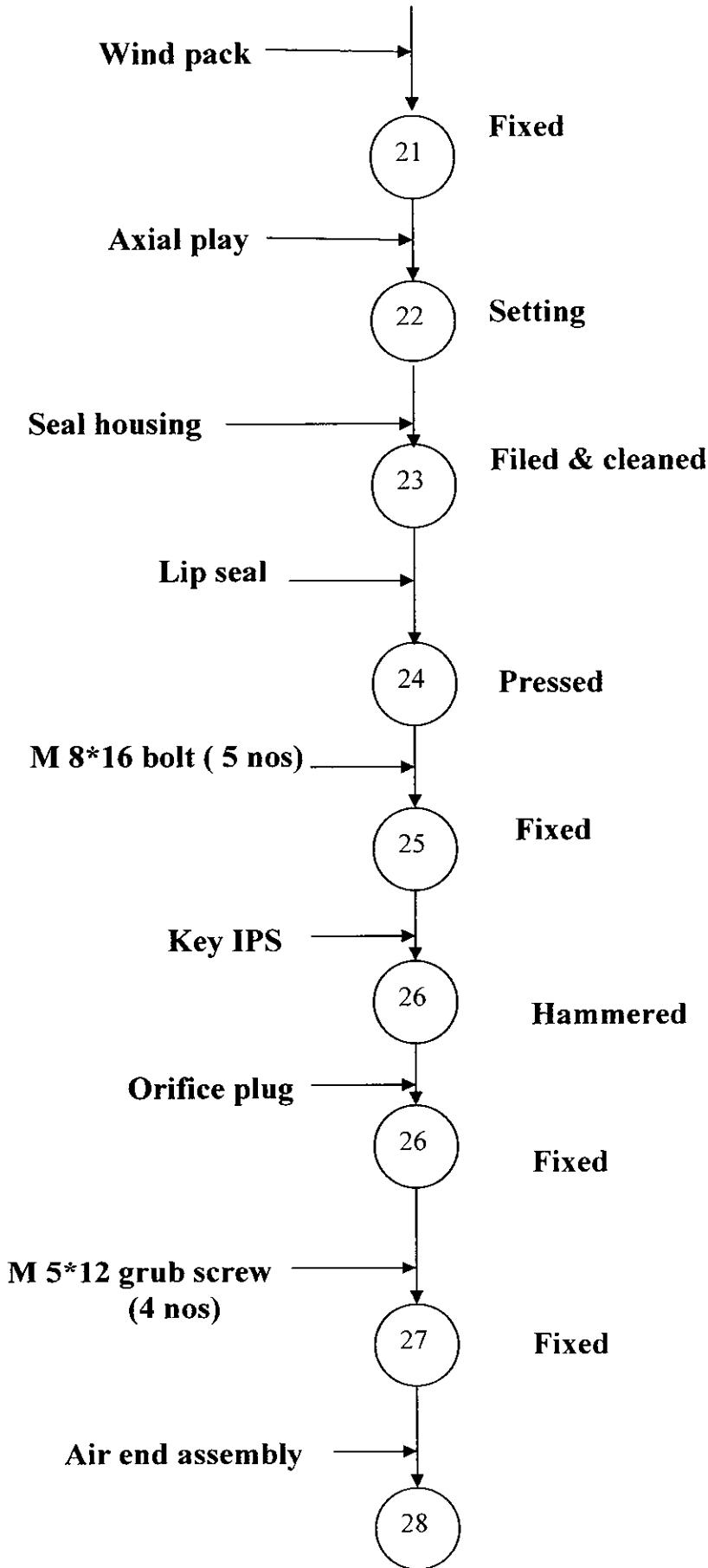
5.3 159 AIR END ASSEMBLY (MAIN ASSEMBLY)

The figure 5.2 describes the process chart of main assembly.




M16*40 bolts (4 nos)
M8*20 bolts (2 nos)
M8*35 bolts (3 nos)
5
Fixing & tighten the bolts
Outlet covering
6
Filed & cleaned
M10*25 bolts (11 nos)
m10*35 bolts (2 nos)
1/8" plug
7
fix & tighten the bolts
DCV cover
8
Filed & cleaned
M12*20 bolts (4 nos)
9
Fix & tighten the bolts
Rotor housing turned 180
10
Cleaned & filed
Inner racer of the male
Rotor
Induction heating (110 deg c)
11
Inserted in the stem of the
Male rotor by interferencefit
Inner bearing


Gear housing assembly
13
Fixing
M10*30 bolts (5 nos)
M12*25 bolts (3 nos)
Key
14
Fixing
Inner racer
15
Fixing to male rotor
Pinion gear heated
16
Fixing to outer race of the
Inboard bearing
Input shaft assembly
17
Fixing
Gear housing cover
18
Filed & cleaned
Dowel pin (2 nos)
M 10*35 (13 nos)
19
Fixed
Outer racer
20


Wind pack
21
Fixed
Axial play
22
Setting
Seal housing
23
Filed & cleaned
Lip seal
24
Pressed
M 8*16 bolt (5 nos)
25
Fixed
Key IPS
26
Hammered
Orifice plug
26
Fixed
M 5*12 grub screw
(4 nos)
27
Fixed
Air end assembly
28

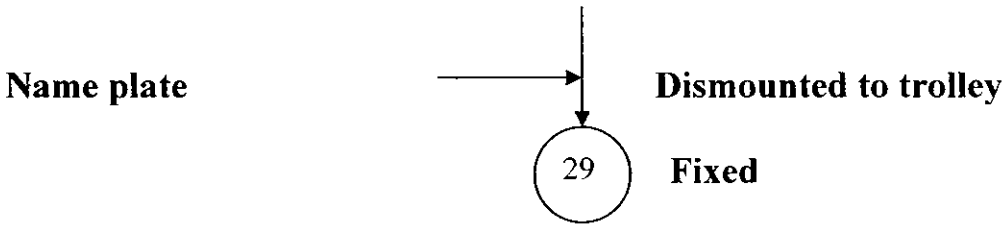


Figure 5.2 Process chart for main assembly

CHAPTER 6

TIME STUDY

6.1 INTRODUCTION

Time study is defined as the work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.

When the work to be measured has been selected, the time study usually consists if the following steps:

- Obtaining and recording all the information available about the job the operator and surrounding conditions likely to affect the carrying out of the work.
- Recording a complete description of the method and breaking the operation into elements.
- Examining with a time device (stop watch) and recording the time taken by the operator to perform each element of the operation.
- Measuring with a timing device (usually stop watch) and recording the time taken by the operator to perform each element of the operation.
- Assessing the effective speed of the working of the operator relative to a predetermined normal speed.
- Converting observed time to normal time.
- Determining the allowances to be made over and above the basic time for the operation.

Time study at ELGI was conducted for the 159 air end compressor for the two stages by the same operator and the standard time for the assembling is noted. The table 6.1 below gives the elemental time study.

6.2 ELEMENTAL TIME STUDY OF OUTLET SETTING

Table 6.1 Time study sheet for outlet setting

S.No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
1	Operator moving to trolley	Manual	15		15
2	Bringing trolley from position to setup	Manual	20		20
3	Fixing screws to male rotor	Manual	20	20	
4	Bringing hoist to dummy setup	Manual	29	29	
5	Lifting male rotor	Hoist	13	13	
6	Male rotor cleaned using thinner	Manual	29	29	
7	File taken from table	Manual	27	27	
8	Filing the male rotor	File	52	52	
9	Operator searching for emery paper	Manual	38		38
10	Filing using emery paper	Emery paper	18	18	
11	Cleaning using thinner & cloth	Manual	29	29	
12	Moving hoist to dummy set up	Manual	23	23	
13	removing the screws	Manual	16	16	
14	Cleaning the female rotor & filing	Manual	43	43	
15	Turning the rotor upside down & cleaning	Manual	29	29	
16	Picking file	Manual	19	19	
17	Filing process	File	42	42	
18	Operator searching for brush	Manual	23		23
19	Assembly paste applied to brush	Brush	18	18	

S.No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
20	Assembly paste placed back	Manual	12	12	
21	Inner racer taken from the rack	Manual	19	19	
22	Operator moving to induction heater	Manual	13	13	
23	Waiting for the heater	Manual	32		32
24	Heating process	Induction heater	70	70	
25	Operator moving to dummy setup	Manual	14	14	
26	Going for fixture	Manual	14		14
27	Placing on female rotar	Manual	8	8	
28	Placing heating rod back	Manual	24		24
29	Wiping hands	Manual	12		12
30	Female rotor inverted	Manual	11	11	
31	Hoist brought	Manual	29		29
32	Hook screwed	Manual	15	15	
33	Hoist lifted to dummy setup	Hoist	16	16	
34	Female rotor filed using thinner	Manual	120	120	
35	Rotor positioned	Hoist	35	35	
36	Screws removed and hoist back to position	Manual	21	21	
37	Operators discussion		53		53
38	Assembly paste applied to the stem of the rotors	Brush	17	17	
39	Brushed placed back	Manual	12	12	
40	Operator moving to rack for racers	Manual	24	24	
41	Opening the covers of male racers	Manual	14		14
42	Move to induction heater	Manual	15	15	
43	Heating process	Induction heater	54	54	

S.No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
45	Hammering	Hammer	18	18	
46	Tools back on table	Manual	21	21	
47	Opening the covers of female racers	Manual	17		17
48	Move to induction heater	Manual	14	14	
49	Heating process	Induction heater	54	54	
50	Placing racer on female rotor	Manual	11	11	
51	Hammering	Hammer	16	16	
52	Tools back on table	Manual	25	25	
53	Trolley moved	Manual	16		16
54	File taken from table	Manual	15	15	
55	Filling outer setting cover	File	120	120	
56	Thinner applied and wiped	Manual	23	23	
57	Filed & cleaned	File	30	30	
58	1/8 plug & key taken	Manual	29	29	
59	Loctite taken from hanger	Manual	13	13	
60	Loctite applied	Manual	30	30	
61	Tightened using key	Key	34	34	
62	Loctite applied	Manual	14	14	
63	Tightened using key	Key	25	25	
64	Cover lifted to dummy setup	Hoist	35	35	
65	Hands wiped	Manual	14		14
66	loctite back to hanger	Manual	9	9	
67	Oil applied to inner sides of rotor	Brush	35	35	
68	Dowel pins (2 nos) taken	Manual	22	22	

S.No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
69	Cleaned	Manual	19	19	
70	Hammering	Hammer	50	50	
71	Searching for screws (3 nos)	Manual	25		25
72	M8 bit taken	Manual	11	11	
73	Tightened using pneumatic gun	Pneumatic gun	37	37	
74	Bearings placed on rotors	Manual	36	36	
75	Operators discussion		25		25
76	Bearings fixtures taken	Manual	7	7	
77	Hammering	Hammer	37	37	
78	Tools back on table	Manual	12	12	
79	Locknut taken	Manual	21	21	
80	Cover removed	Manual	18		18
81	Wiping hands	Manual	22		22
82	Thinner applied and wiped	Manual	21	21	
83	Screwed on rotor	Manual	39		39
84	Removed	Manual	29		29
85	Male bearing taken	Manual	31	31	
86	Operator moving to induction heater	Manual	13	13	
87	Heating process	Induction heater	61	61	
88	Operator move to dummy setup	Manual	18	18	
89	Female bearing taken	Manual	17	17	
90	Cover removed	Manual	15		15
91	Operator move to induction heater	Manual	25	25	
92	Waiting for heater	Manual	93		93

S.No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
94	Operator move to dummy setup	Manual	16	16	
95	Back to heater to place the tool	Manual	13		13
96	Copper rings and plugs taken from cover	Manual	27	27	
97	Wiping hands	Manual	15	15	
98	Grease applied to locknuts	Manual	52	52	
99	Wiping hands	Manual	12	12	
100	Copper rings and plugs placed	Manual	14	14	
101	Screwed on rotor	Manual	36	36	
102	Wiping hands	Manual	15	15	
103	Discharge clearance set	Axial play	15	15	
104	Operator going for axial play setting	Manual	34		34
105	Operator going to notice board	Manual	73		73
106	Discharge clearance set	Axial play	578	578	
107	Operator going to notice board	Manual	18		18
108	Move to male rotor	Manual	522		522
109	Surface cleaning	Manual	24		24
110	Operator noting details on pad	Manual	160		160
111	placing tools back to position	Mánual	25	25	
	Total std. time in sec/unit		4194	2763	1431
	Total std. time in mins/unit		69.9	46.05	23.85

6.3 ELEMENTAL TIME STUDY OF MAIN ASSEMBLY

Table 6.2 Time study sheet for main assembly

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
1	Bring trolley from position to setup	Manual	15		15
2	Operator going in search of belt	Manual	106		106
3	Fixing belt screws to setup (2 nos)	Manual	35	35	
4	Operator waiting for crane	Manual	28		28
5	Bringing crane near trolley& fixing hook	Hoist	31	31	
6	Lifting to fixture	Manual	18	18	
7	Placing trolley back in position	Manual	16		16
8	Cleaning the housing at hoist and positioning	File	26	26	
9	Fixing the bolts	Manual	12	12	
10	Taking tool from hanger	Manual	13	13	
11	Tightening	Manual	69	69	
12	Positioning the hoist back	Manual	8	8	
13	Removing belt screws	Manual	34	34	
14	Searching tools	Manual	19		19
15	Searching the rack for 1/8 plug (5 nos)	Manual	12		12
16	Picking the plugs	Manual	16	16	
17	Applying loctite & fixing plugs	Brush	139	139	
18	Placing tools back to position	Manual	14	14	
19	Wiping excess loctite from outer surface	Brush	26		26
20	Taking tool from hanger	Manual	14	14	
21	Filing rotor housing	File	88	88	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
23	Filing using emery sheet	Manual	65		65
24	Placing sheet back on table	Manual	8		8
25	Tabing cloth & thinner from table	Manual	16	16	
26	Wipping th inner & outer surface of housing	Manual	31	31	
27	moving to air tube for dry cleaning	Manual	66	66	
28	Taking oil from table	Manual	13		13
29	Applying oil to inner sides of housing	Manual	20	20	
30	Placing oil back on table	Manual	8		8
31	Taking female inlet bearing from table	Manual	21	21	
32	Applying oil to bearing	Manual	12	12	
33	Placing inlet bearing in female bearing box	Manual	15	15	
34	Wiping hands	Manual	15		15
35	Taking female bearing fixture from table	Manual	9	9	
36	Fixing bearing	Manual	15	15	
37	Hammering	Hammer	10	10	
38	Tools placed in table	Manual	7	7	
39	Taking cloth & thinner from table	Manual	27	27	
40	Cleaning outer rim of housing	Manual	19	19	
41	Applying loctite	Manual	36	36	
42	Placing loctite on hanger	Manual	7	7	
43	Bringing roller from distance	Manual	13		13
44	Spreading loctite	Roller	35	35	
45	Placing roller back to position	Manual	12		12

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
46	Wiping excess loctite	Manual	24		24
47	Operator moving towards trolley	Manual	11		11
48	Bringing trolley near actual setup	Manual	25		25
49	Operator going for belt	Manual	11		11
50	Fixing belt screws to outlet housing	Manual	52	52	
51	Moving hoist to exact location	Manual	14		14
52	Fixing the belt to hoist hook	Manual	8	8	
53	Lifting the outlet seting	Manual	20	20	
54	Moving to setup	Manual	18	18	
55	Cleaning outlet setting using cloth and thinner	Manual	8	8	
56	Taking loctite from hanger	Manual	12	12	
57	applying loctite	Manual	22	22	
58	Hoist removed & rotor fixed	Manual	59	59	
59	Belt screws removed from hoist	Manual	9	9	
60	Hoist moved	Manual	14		14
61	Belt screws removed from o/s	Key	39	39	
62	Picking m16*40 bolts (4 nos) from rack	Manual	16	16	
63	Applying loctite and fixing plugs	key	24	24	
64	M8*35(3 nos) M8*20(2 nos) taken from rack	Manual	25	25	
65	Applying loctite	Manual	14	14	
66	Operator roaming for key	Manual	47		47
67	Fixing the screws	Manual	27	27	
68	Operator searching for tool	Manual	17		17
		Pneumatic			

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
70	Taking torque range	Manual	137		137
71	Setting torque	Torque range	49	49	
72	Replacing torque range	Manual	38		38
73	Wiping excess loctite	Manual	28		28
74	Wiping hands	Manual	14		14
75	Pouring oil to rotor housing	Manual	59	59	
76	Checking the movement of the rotor	Manual	105	105	
77	Wiping hands	Manual	14		14
78	Filing outer surface of actual housing	Manual	42	42	
79	Placing the file back	Manual	8	8	
80	Moving trolley near table for cover	Manual	17		17
81	Placing trolley back in position	Manual	21		21
82	Back to table	Manual	14		14
83	Filing the cover	File	27	27	
84	Taking cloth from thinner & table	Manual	21	21	
85	Wiping cover	Manual	19	19	
86	Move to actual rotor housing	Manual	14	14	
87	Removing burr	File	37	37	
88	Taking loctite from hanger	Manual	19	19	
89	Applying loctite on housing	Manual	29	29	
90	Placing loctite on hanger	Manual	9	9	
91	Bring roller	Manual	14		14
92	Spreading loctite	Manual	39	39	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
94	Wiping the excess loctite	Manual	16		16
95	Moving to table	Manual	37		37
96	Picking M12*20(2nos), M10*25(11nos), M10*35(2nos) from rack	Manual	22	22	
97	Cover fixed to actual housing	Manual	9	9	
98	Loctite applied & bolts placed	Manual	19	19	
99	Tightened using pneumatic gun	Pneumatic gun	81	81	
100	Operator going in search of torque range	Manual	61		61
101	Setting torque	Torque range	23	23	
102	Replacing torque range	Manual	51		51
103	Wiping the housing	Manual	13	13	
104	1/8 plug & key taken	Manual	25	25	
105	Loctite picked & applied	Manual	14	14	
106	Plug tightened	Key	37	37	
107	Key placed back on hanger	Manual	9	9	
108	Operator taking file	Manual	14		14
109	Outer surface filed	File	17		17
110	Taking cloth & thinner from table	Manual	14	14	
111	Wiping outer surface of housing	Manual	19	19	
112	Operator going to notice board	Manual	31		31
113	Loctite picked & applied	Manual	26	26	
114	Roller picked and used	Roller	22	22	
115	DCV cover taken	Manual	15	15	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
117	M12*20 (4 nos) taken from rack	Manual	30	30	
118	Loctite applied	Manual	9	9	
119	DCV fixed using bolts	Manual	27	27	
120	Key taken	Manual	2	2	
121	Bolts tightened	Allen key	59	59	
122	Key placed back on hanger	Manual	12	12	
123	Wiping the surface	Manual	14		14
124	Operator writing on pad	Manual	32		32
125	Operator discussion	Manual	381		381
126	Indexing the housing	Manual	25	25	
127	Placing bin below setup	Manual	9		9
128	Checking free movement of rotor	Manual	11	11	
129	Cleaning and wiping rotors	Manual	59		59
130	Assembly paste taken and applied to male rotor	Manual	16	16	
131	Paste placed on table	Manual	10	10	
132	Male bearing taken	Manual	23	23	
133	Cover removed	Manual	8	8	
134	Waiting for heater	Manual	112		112
135	Heating process	Manual	66	66	
136	Placing heated racer on male rotor	Manual	13	13	
137	Hammering	Manual	18	18	
138	Waiting for the racer to warm up	Manual	58		58
139	Taking uoter bearing from table	Manual	39	39	
140	Applying oil to sides	Manual	27	27	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
141	move to housing	Manual	11	11	
142	Fixing to rotor	Manual	16	16	
143	Hammering to fix	Hammer	40	40	
144	Wiping hands	Manual	22		22
145	Locting ring taken from rack	Manual	26	26	
146	Wiped with cloth	Manual	11	11	
147	Placed & pressed	Manual	17	17	
148	Searching for tool	Manual	18		18
149	Hammering	Hammer	14	14	
150	Key taken	Allen key	8	8	
151	Hammering	Hammer	26	26	
152	Placing hammer back on table	Manual	11	11	
153	Assembly paste taken	Manual	13	13	
154	Paste applied	Manual	14	14	
155	Going to trolley with file	Manual	13		13
156	Filing	File	56	56	
157	Wiped with cloth	Manual	33	33	
158	Operator going to notice board	Manual	19		19
159	Bring trolley from position to setup	Manual	19		19
160	Fixing belt screws to cover	Manual	52	52	
161	Bring hoist near trolley	Manual	16		16
162	Hoist lifted	Manual	21	21	
163	Placing trolley back in position	Manual	12		12
164	Taking cloth & thinner	Manual	36	36	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
166	Loctite applied	Manual	63	63	
167	Rolling	Roller	48	48	
168	Cover fixed to hoist	Manual	13	13	
169	M10*30(3nos), M12*25(5 nos)taken from rack	Manual	33	33	
170	Loctite applied	Manual	36	36	
171	Gear hosing placed	Manual	30	30	
172	Hoist lifted & moved	Manual	13	13	
173	Belt removed	Manual	44	44	
174	M10 bit taken	manual	30	30	
175	Fixing screws using pneumatic gun	Pneumatic gun	23	23	
176	Torque range taken from table	Manual	54		54
177	Torque setting	Torque range	33	33	
178	Torque range taken from distance	Brush	22		22
179	Torque setting	Torque range	24	24	
180	Placing torque range back	Manual	42		42
181	operator discussion	Hammer	24		24
182	Pinion gear cleaning	Manual	51	51	
183	Noting gear number	Manual	30		30
184	Moving to induction heater	Pneumatic gun	13	13	
185	Heating process	Manual	652	652	
186	Bringing gear to actual setup		14	14	
187	Hammering	Hammer	20	20	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
189	Oil applied to inner sides of rotor	Manual	38	38	
190	Hammering	Hammer	20	20	
191	Placing hammer back	Manual	18	18	
192	Drive gear fixed	Manual	22	22	
193	Checking process	Manual	15	15	
194	Filing done	File	48	48	
195	Trolley moved to actual setup	Manual	54		54
196	Fixing belt screw to cover (2 nos)	Manual	42	42	
197	Operator discussion		1054	1054	
198	Cover fixed using hoist to setup	Manual	27	27	
199	operator moving towards trolley	Manual	8		8
200	Screws removed & fixed	Manual	42	42	
201	Dowel pin taken from rack	Manual	11	11	
202	Hammering	Hammer	29	29	
203	Hoist lifted & brought to setup	Manual	40		40
204	Filing on cover done	File	42	42	
205	Cleaned using cloth & thinner	Manual	29	29	
206	Loctite applied	Manual	31	31	
207	Roller taken	Manual	18		18
208	Rolling	Roller	22	22	
209	Cover fixed using hoist	Manual	44	44	
210	Hoist moved to distance	Manual	15		15
211	Dowel pin hammered	Hammer	10	10	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
213	M10*35(13 nos) taken from rack	Manual	25	25	
214	Loctite applied	Manual	13	13	
215	Placing bolts	Manual	25	25	
216	Fixing screws using pneumatic gun	Pneumatic gun	49	49	
217	Torque setting	Torque range	55	55	
218	Wind pack taken from rack	Manual	12	12	
219	Cleaning wind pack	Manual	51	51	
220	Placing on rotor	Manual	72	72	
221	Operator searching for dial setting	Manual	61		61
222	Fixing & setting	Manual	154	154	
223	operator noting details	Manual	72		72
224	Cleaning outer surface	Manual	45	45	
225	Seal housing taken from trolley	Manual	22	22	
226	Filing	File	32	32	
227	Lip seal taken	Manual	22	22	
228	Loctite apllied	Manual	36		36
229	Seal fixed	Manual	51		51
230	Excess paste wiped	Manual	52	52	
231	Fixing	Manual	30	30	
232	Cleaning actual setup	Manual	18	18	
233	Loctite applied	Manual	41	41	
234	Rolled	Manual	25	25	
235	Loctite applied to seal	Manual	27	27	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
237	M8*16 (5 nos) taken from rack	Manual	22	22	
238	Loctite applied	Manual	18	18	
239	Fixing using key & lever	Key	110	110	
240	M5*12 grub screw (4 nos) taken	Manual	24	24	
241	Loctite applied	Manual	166	166	
242	Wiping excess loctite	Manual	45		45
243	I/p shaft taken from rack	Manual	20	20	
244	Hammering	Manual	25	25	
245	Hoist brought & screws fixed	Manual	26	26	
246	Orifice plug taken	Manual	23	23	
247	Loctite applied	Manual	24	24	
248	Fix using spanner	spanner	53	53	
249	Holding screws loosened	Manual	137	137	
250	Paper seal taken	Manual	27	27	
251	Outer surface wiped with thinner	Manual	14	14	
252	Paper seal stuck	Manual	13	13	
253	Operator bringing trolley	Manual	24		24
254	Hoist moved to trolley	Manual	104	104	
255	Screws removed	Manual	26	26	
256	placing housing	Manual	28	28	
257	Cleaning seal fixing area	Manual	56	56	
258	Name plate verified	Manual	40	40	
259	Seal placed	Manual	117	117	
260	Tools placed in position	Manual	65	65	

S. No.	Process description	M/c, equip, tools used	Std. time in sec.	VA in sec.	NVA in sec.
262	Trolley moved to position		15		15
	Total std. time in sec/unit		10169	7692	2477
	Total std. time in mins/unit		169.48	128	41.283

According to the time study conducted,

The time taken for outlet setting = 70 mins

The time taken for main assembly = 170 mins

Waiting time in both lines = 21 mins

Operator unnecessary movement = 17 mins

Operator searching for tools = 8 mins

CHAPTER 7

ANALYSIS

7.1 ANALYSIS

All the entries from the study sheet should be analyzed, and a summary sheet should be prepared. A basic time has been built up for the job or operation including all repetitive and occasional elements. The compilation has been done element by element, so that, if at any time in the future the job is changed slightly by deleting or by changing an element or by adding a fresh one, it will not be necessary to restudy the whole job. The entries on the analysis of studies sheet will still hold good for all the unchanged elements in the new job sequence, and therefore it will be possible to make a fresh compilation after studying the elements.

There are number of principles concerning the economy of movements which forms a good basis for the development of improved methods at the work place.

They may grouped under three headings—

- Use of human body
- Arrangement of work place
- Design of tools and equipments

They are useful in shop floors for improving the efficiency and reducing the fatigue of manual work

7.2 USE OF HUMAN BODY

When possible-

1. Two hands should begin and complete their movements at the same

2. Two hands should not be idle at the same time

3. Motions of hands should be symmetrical and in opposite direction and should be made simultaneous

4. Hand and body motions should be made at the lowest classification at which it is possible to do the work satisfactorily

5. Momentum should be employed to help the worker, but should be reduced to a minimum whenever it has to be overcome by muscular effort

6. Continuous curved movements are to be preferred to straight line motions involving sudden and sharp changes in direction.

7.3 ARRANGEMENT OF WORKPLACE

1. Definite and fixed stations should be provided for all tools and materials to permit habit formation.

2. Tools and materials should be pre-positioned to avoid searching

3. Gravity feed, bins and containers should be used to deliver the materials as close as possible

4. Tools, materials and controls should be located within the maximum working area and as near to the worker as possible

5. Materials and tools should be arranged to provide best sequence of motions

6. The colour of the workplace should contrast with that of the work and thus reduce eye fatigue.

7.4 DESIGN OF TOOLS AND EQUIPMENTS

1. Two or more tool should be combined wherever possible

2. The hands should be relieved of all work of holding the work piece where this can be done by jigs fixtures and foot operated devices.

3. Levers crossbars and hand wheels should be placed so that the operative can use them with least change in body position

Analyzing the time study the following points were noted

- To provide L slot mounting plate
- To provide new set of tools
- Redesign the trolley
- To provide dedicated fasteners rack
- To redesign fixture
- To provide better working atmosphere

7.5 ROOT CAUSES FOR THE HIGH INEFFECTIVE TIME INCLUDES

- Unbalanced work load
- No standard operating procedure
- Quality problems
- Ineffective layout specialization
- Unnecessary movement
- High waiting time

CHAPTER 8

CORRECTIVE ACTIONS

8. WORK DONE

8.1 EXISTING LAYOUT AT ELGI

The figure 8.1 shows the existing layout at ELGI.

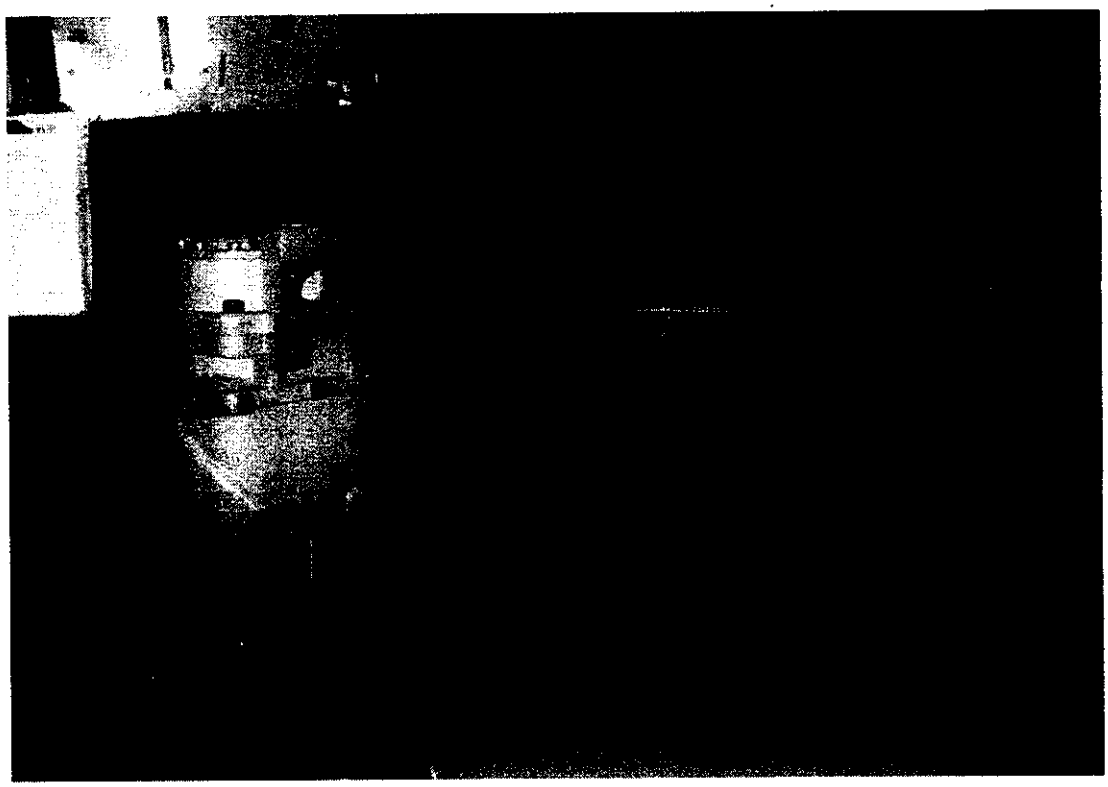


Figure 8.1 Existing layout

Demerits of the existing layout

1. Tools and materials are not pre positioned
2. Fasteners are not available at reach of hand by the operator
3. Two separate assembly lines are needed to assemble the compressor
4. No proper set of tools is available
5. Drop deliveries or ejectors are not available

6. Components to assemble are not located within the maximum working area

7. Movement of operator is more

8. Materials and tools are not arranged to permit the best sequence of motions

9. Labeling of fasteners for easy identification is not done

8.2 PROPOSED LAYOUT

Inadequate design of work places will inhibit the ability of the worker to perform his tasks and may result in injuries, strain or fatigue, a reduction in quality or output etc. The proposed layout has taken into consideration all the disadvantages of the existing system and it has been rectified in the proposed system. The figure 8.2 shows the proposed layout.

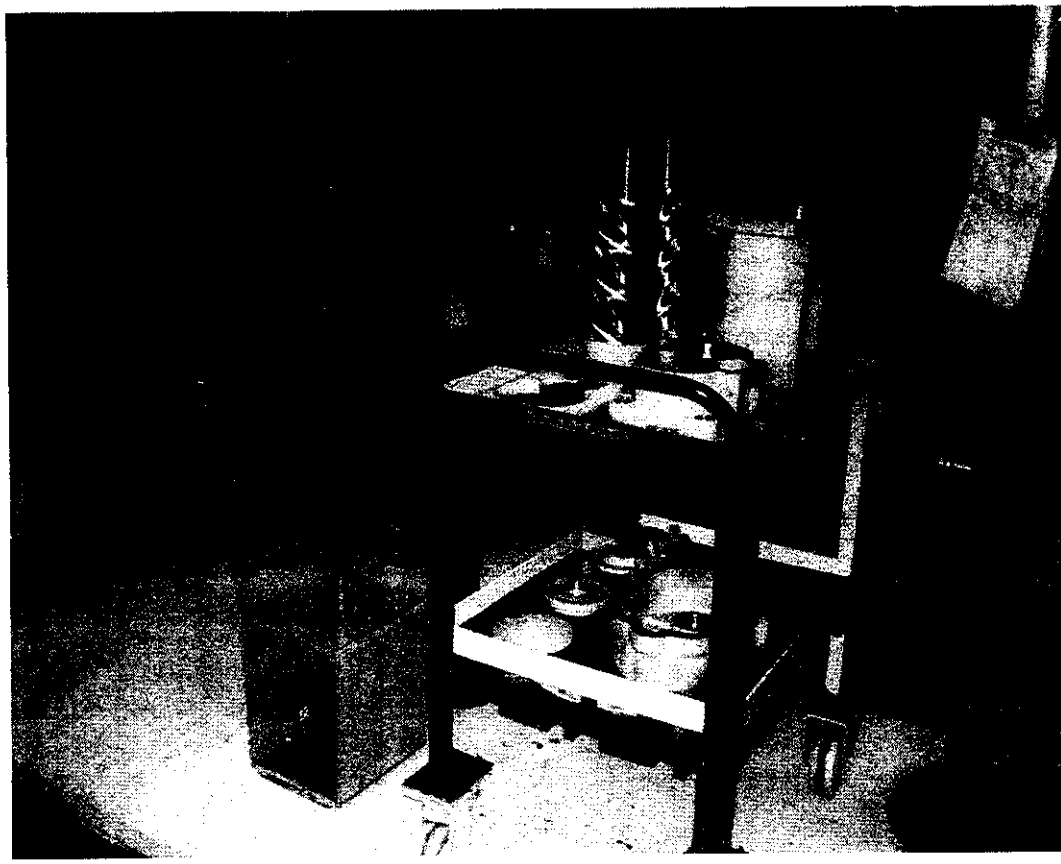


Figure 8.2 Proposed layout

Merits of the proposed layout

1. A typical work place with the principles of motion economy is designed

2. A fixture has been provided for holding the workpiece leaving both the operatives hands free for assembly work.

3. The tools box is suspended in front of the operative so that he has to make only very short and easy movement to grasp them and bring them to work the tools for use are within easy reach, so that the operator can pick them without searching.

4. All small parts are close to the operator, well within the maximum working area. Each fastener has a definite location, and the trays are designed with scoop fronts for easy withdrawal.

5. Movement of the operator is reduced considerably, since all the items are at reach of hand

6. Assembly components are placed near the working area.

8.3 EXISTING TROLLEY

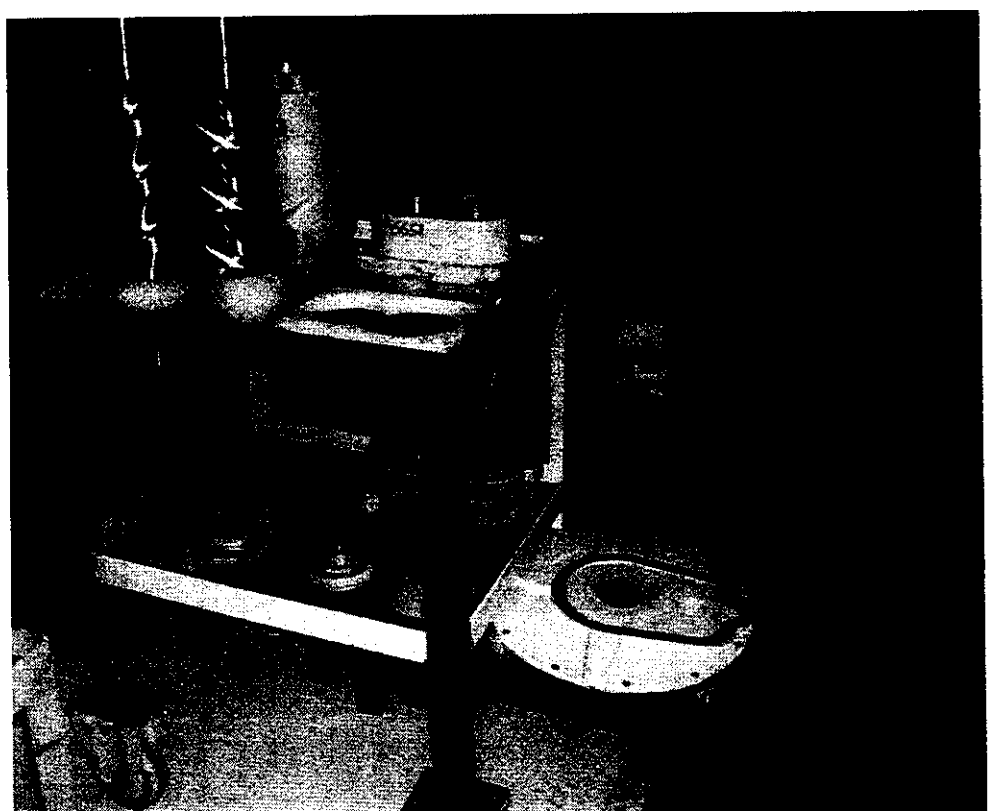
The figure 8.3 shows the existing trolley.

Demerits of existing trolley

1. Two trolleys were used for assembling one air end compressor.
2. The trolleys were positioned at a distance of about 3 meters after the aisle
3. The components were not sequenced
4. The operator has to move the trolley for every component and position the trolley back
5. The trolleys occupied of about 50 percent of the assembly area

8.4 PROPOSED TROLLEY

The trolley is designed to assist in plant layout so as far to eliminate the need for movement in production area and minimizing the distances moved. The figure 8.4 shows the proposed trolley.

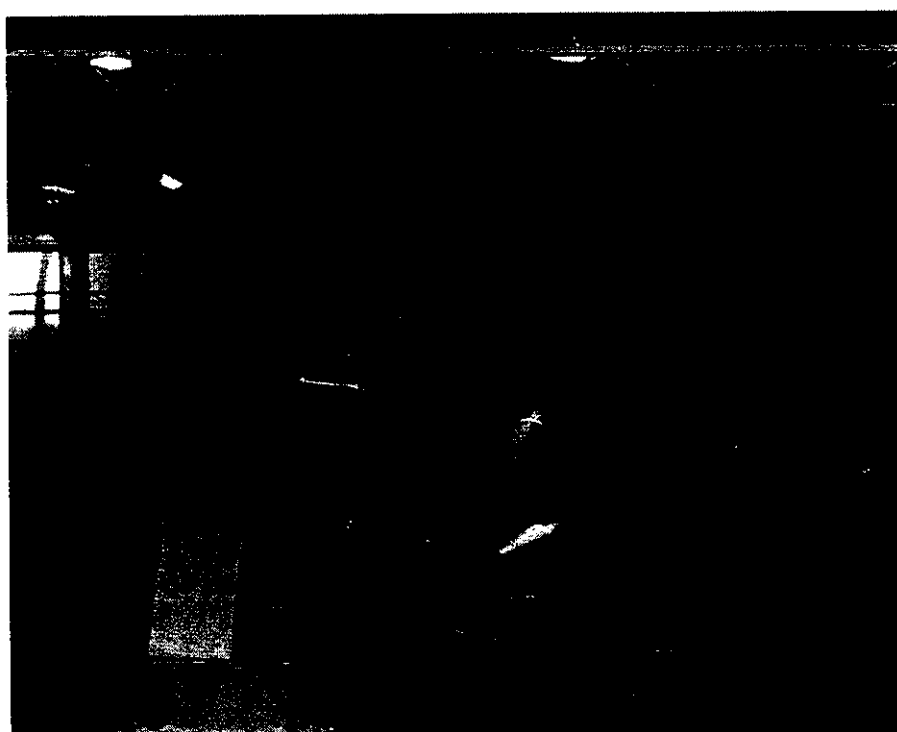


Merits of the proposed trolley

1. A flexible, safe, economical trolley is developed taking into consideration the conditions, fragility and size of the material involved
2. The usefulness and effectiveness of the trolley is evaluated from its performance of handling all the components
3. The cost of the trolley is economical
4. The components are placed in sequence of assembly
5. Trolley is designed ergonomically, with ease of lifting
6. The size of the trolley is comparatively less than the existing system
7. Trolley is positioned near the assembling area

8.5 EXISTING TOOLS STAND

The figure 8.5 shows the existing tools stand.



Demerits of the existing tools board

1. The tool board is of hanging time, so there is risk of tools missing
2. The is no provision for heavy tools in the board
3. Chances of dropping tools is high, which may lead to accidents

8.6 Proposed tools board

The figure 8.5 shows the proposed tools board.

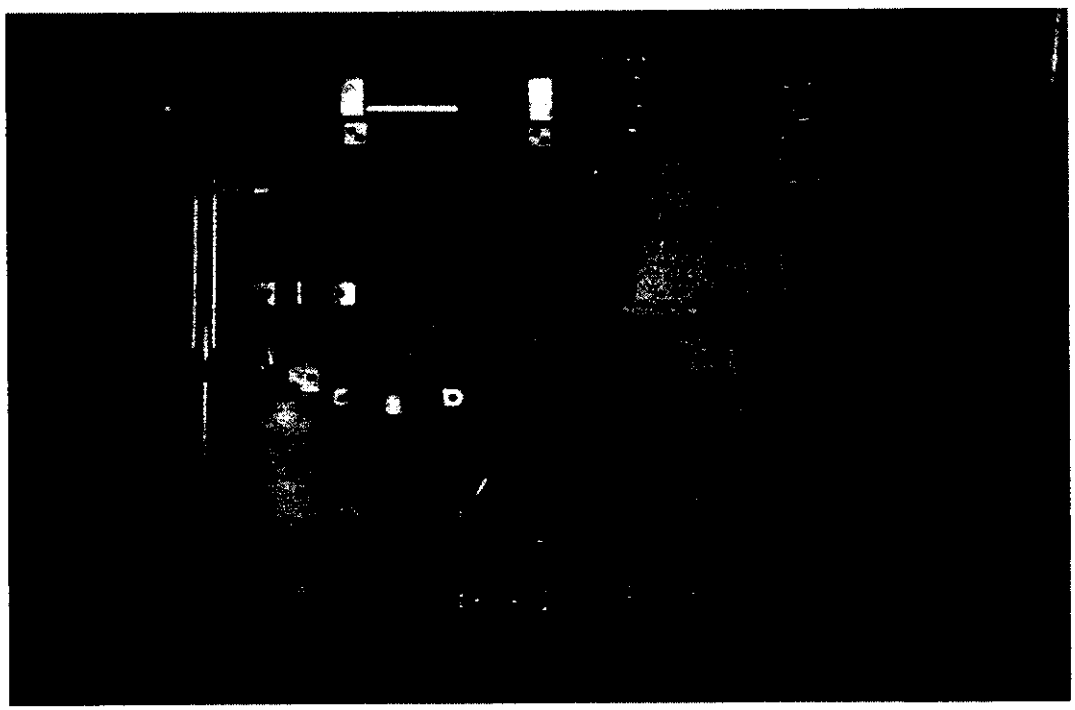


Figure 8.5 Proposed tools board

Merits of the proposed tools board

1. Tools are preplaced and located near work area
2. Tools which can perform more than one operation is used eg: torque wrench
3. The tools shadow board is made like a cupboard, so the tools can be kept safely

5. Maximum surface contact between the tool and the hand is provided. It helps proper application of hand force and minimizes fatigue.

6. It is the responsibility of the operator to replace all tools at the end of the shift.

8.7 EXISTING FASTENERS RACK

The figure 8.7 shows the existing fasteners rack.

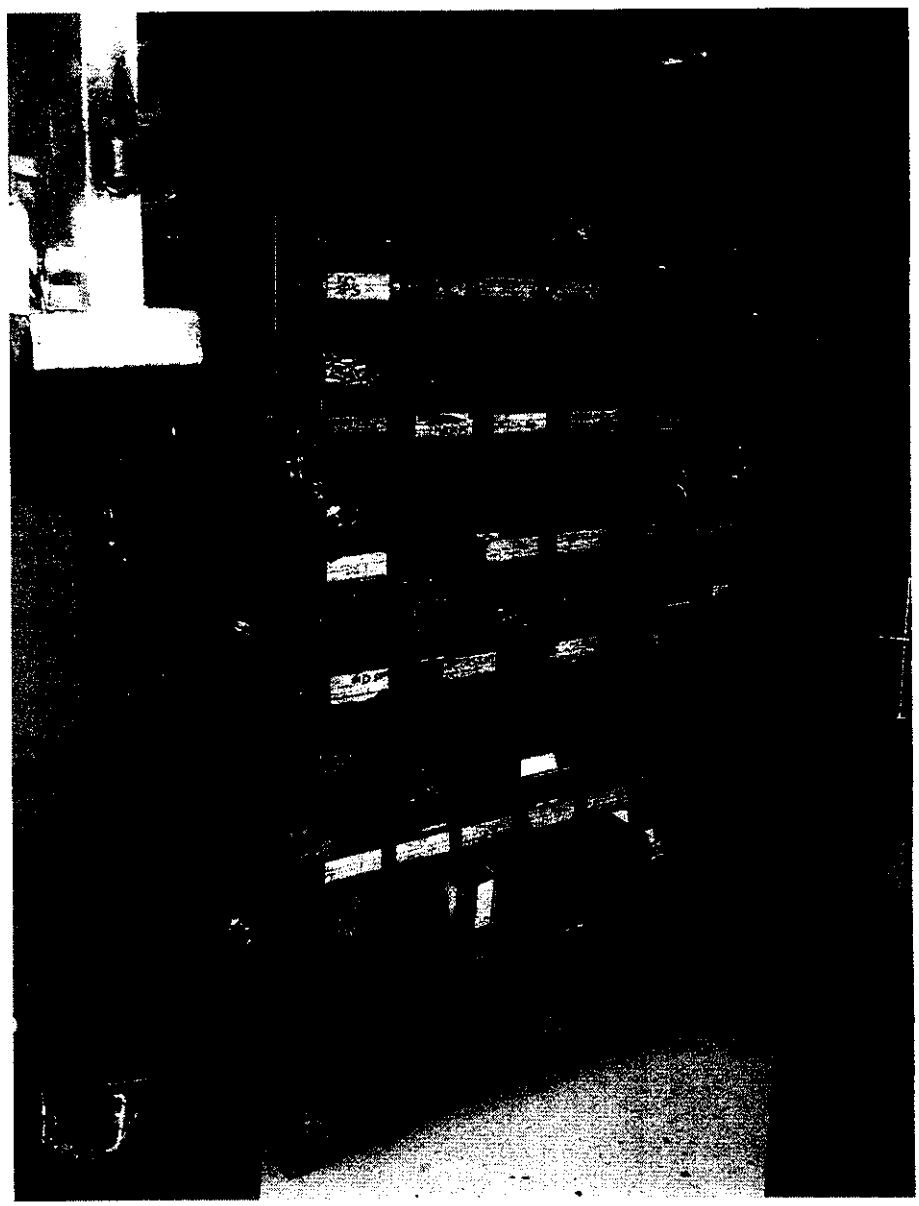


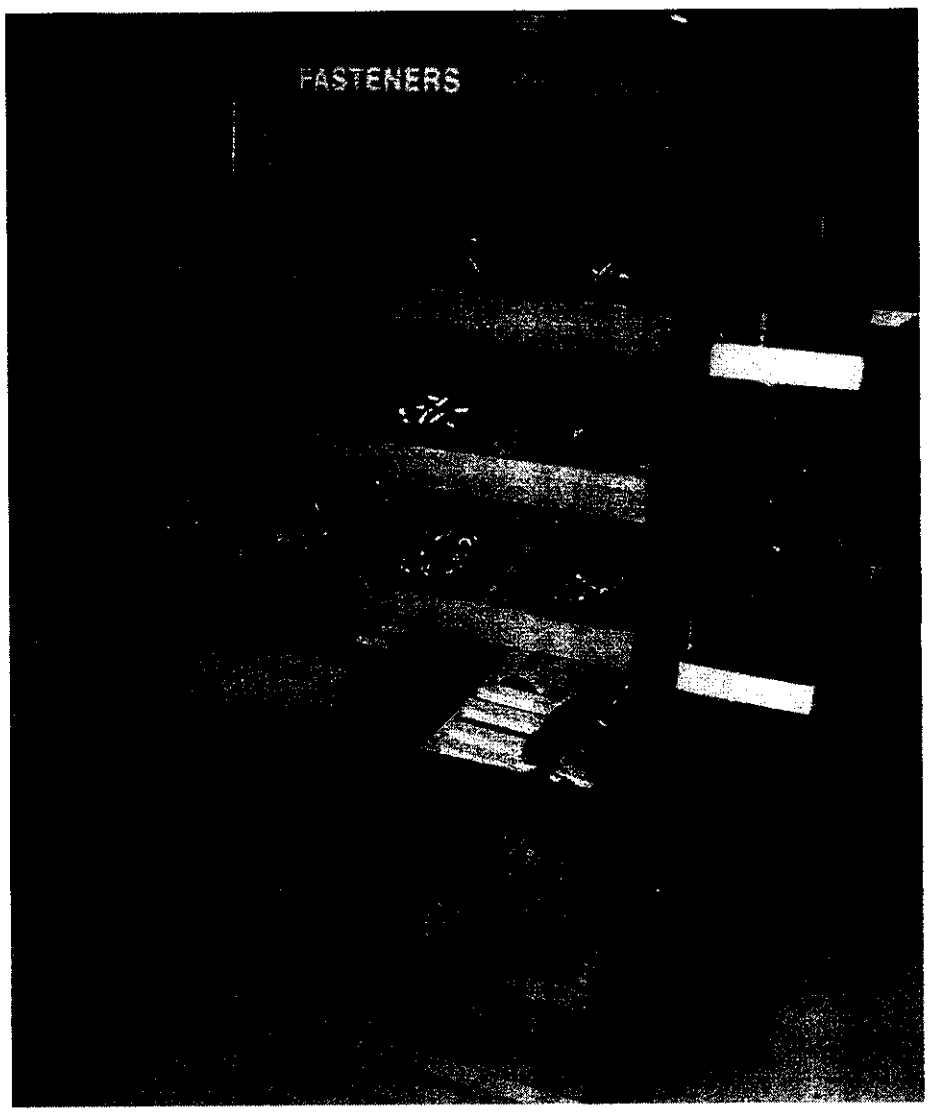
Figure 8.7 Existing Fasteners Rack

Demerits of existing fasteners rack

1. Separate allocation for kit materials is not provided
2. Fasteners not labeled accurately
3. Fasteners not placed in sequence, so identification is difficult
4. Excess bins are available which will lead to confusion
5. 5s not maintained
6. The size of the rack is too big

8.8 PROPOSED FASTENERS RACK

The figure 8.8 shows the proposed fasteners rack.

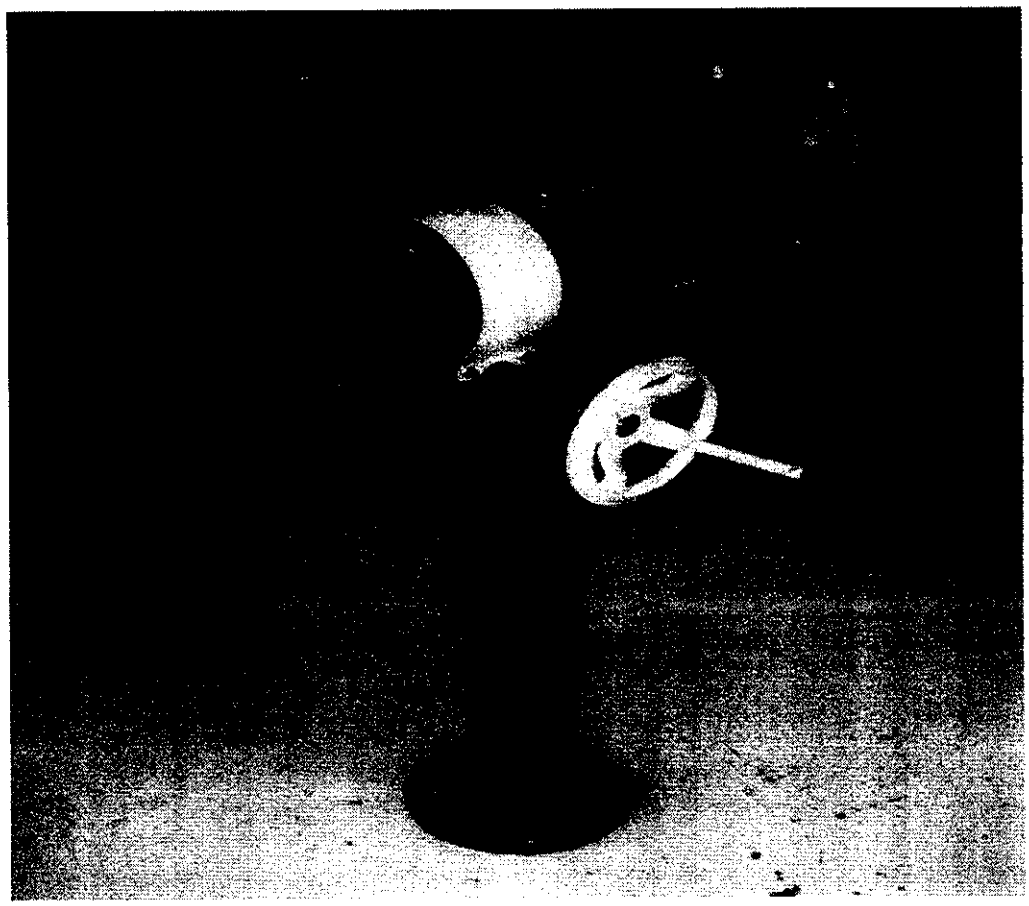


Merits of proposed fasteners rack

1. Compact fasteners rack designed ergonomically
2. Fasteners arranged in the sequence of picking
3. Two bin system is maintained
4. Space is allocated for placing the kit box
5. Empty bins can be placed below
6. clear identification is made
7. Rack is placed near the fixture, movement of the operator is reduced

8.9 PROPOSED FIXTURE

The two stages of the existing system is replaced by the new fixture in which both the stages are present. Indexing of the fixture is possible with the help of pinion gear system. The system is simple, effective, user friendly, cost effective and reliable. The figure 8.9 shows the proposed fixture.



Merits of proposed fixture

1. Stage is reduced
2. One operator can assemble both the air end
3. Unnecessary movement of the operator is reduced considerably
4. Easy indexing and rotation can be done
5. Use of hoist is reduced

8.10 EXISTING BEARING PRESSING TOOLS STAND

The actual system consisted of 11 bearing pressing tools. The tools are used to press the heated racers to the rotors with the help of hammers. The bearing pressing tools are used to accurately allocate the gears system, which helps in discharge clearance setting. The figure 8.10 shows the existing tools stand.

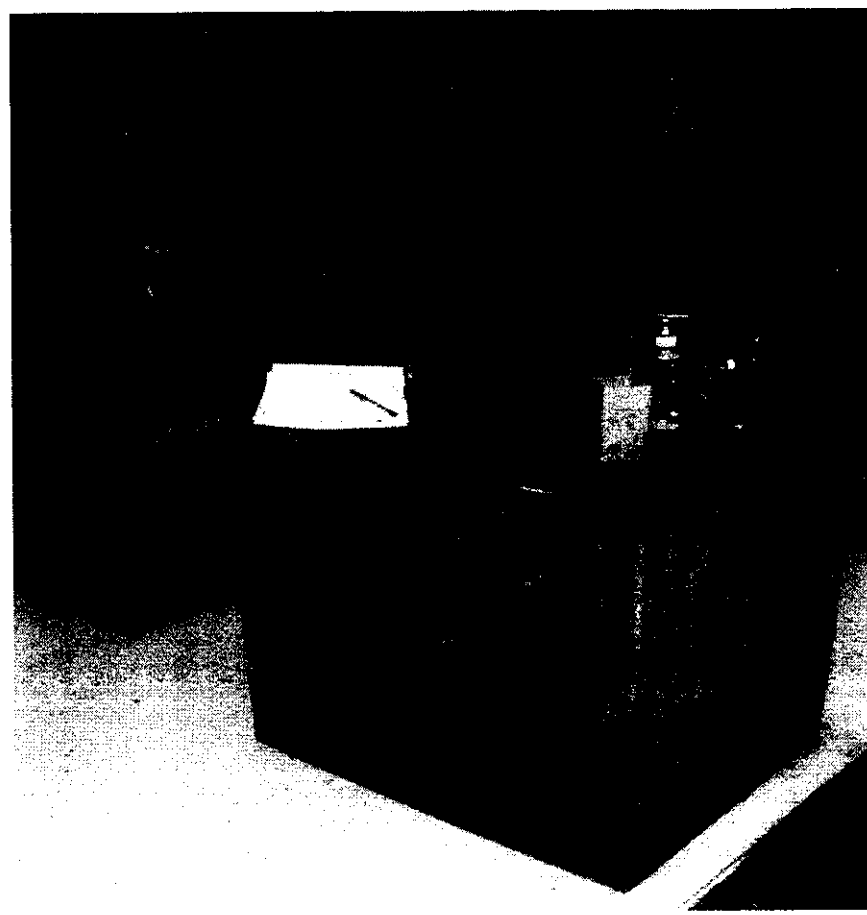


Figure 8.10 Existing tools stand

Demerits of bearing pressing tools stand

1. No proper location for the tools
2. Tools are lifted to stages
3. Tools are heavy and so cause fatigue to the operator

8.11 PROPOSED BEARING PRESSING TOOLS STAND

The figure 8.11 shows the proposed bearing pressing tools stand.

Figure 8.11 Proposed bearing pressing tools stand

1. Separate area allocated for placing the bearing pressing tools
2. Picking of the tools is handy
3. The rack is placed to the right hand side of the operator, so carrying of the tool is reduced

8.12 SPACE & CYCLE TIME DETAILS

TABLE 8.1 SPACE & CYCLE TIME DETAILS

	Space (in Sq.mtr.)	Cycle time/unit (in mins.)	OUTLET SETTING	MAIN ASSEMBLY
Existing	30	240	70	170
Target	15	80	23.33	56.66
Proposed	15	160	40	140
Achieved	14	180	45	135
Achieved%	53	25		

Graphical representation of the space & cycle time

The figure 8.12 below shows the graphical representation of space & cycle time.

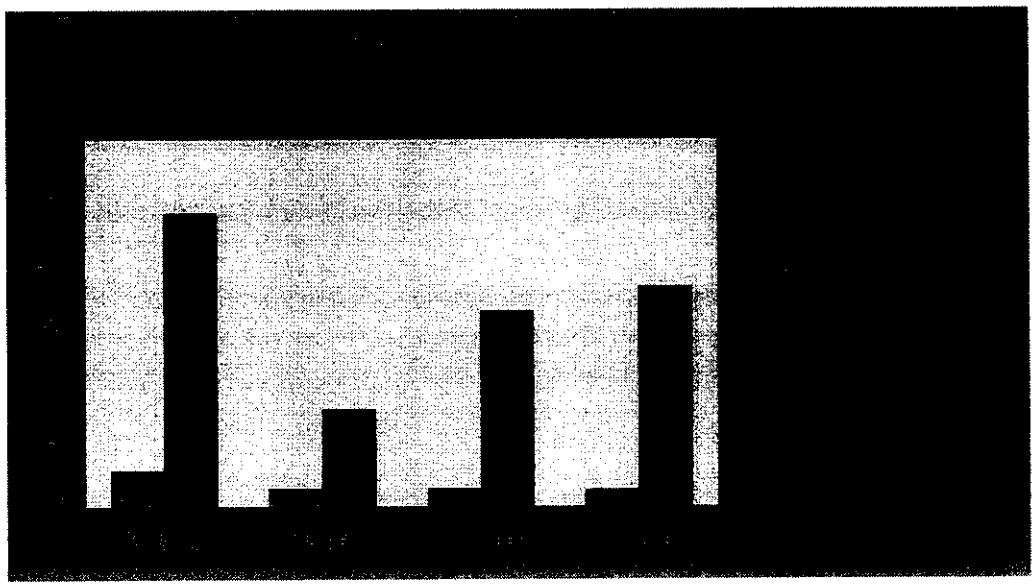


Figure 8.12 Graphical representation of space & cycle time

CHAPTER 9

CONCLUSIONS

9.1 CONCLUSIONS:

1. A thorough study of the product and assembly process has given an in depth knowledge of product and processes.

2. Standard time for each work station gives a clear idea to reduce the in effective time.

3. The number of work stations and the number of workers are reduced which will help in increasing the profit of ELGI.

4. There is an increase in the productivity by 25%.

5. The floor space utilization has been minimized by 53%.

6. Better working atmosphere is provided.

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