A STUDY ON PRODUCTIVITY IMPROVEMENT, COST SAVING IN HORN ASSEMBLY LINE USING WORK MEASUREMENT

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BONAFIDE CERTIFICATE

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CHAPTER 1

INTRODUCTION

In a dynamic world that is driven by technology, a successful presence depends on the way you mould that technology to fit popular needs. Indigenous talent, a daring attitude, courage to accept and learn new things and the simple spark of an idea – That is the genesis of ROOTS.

Roots Industries India Ltd. is a leading manufacturer of HORNS in India and the 11th largest Horn Manufacturing Company in the world. Headquartered in Coimbatore - India, ROOTS has been a dominant player in the manufacture of Horns and other products like Castings and Industrial Cleaning Machines.

Since its establishment in 1970, ROOTS has had a vision and commitment to produce and deliver quality products adhering to International Standards. Roots Industries India Ltd is managed by an excellent team of path-breakers, chief among them being the Chairman, Mr. K. RAMASAMY, a Master's Degree Holder in Automobile Engineering from Lincoln Technical Institute, USA.

The company credo is echoed in his own words,

"At ROOTS, we believe that if something is worth doing, it is worth doing well. And this attitude is reflected in every realm of our activities. As a customer, you naturally expect the best. We are fully geared, in spirit and method, to meet your requirements."

He is supported by technical and administrative people, experts in their own field, who together strive to maintain the highest quality quotient in all of ROOTS' products.

With a strong innovative base and commitment to Quality, Roots Industries India Ltd has occupied a key position in both international and domestic market as suppliers to leading OEMs and after market. Similar to products, Roots has leading edge over competitors on strong quality system base. Now, RIL is the first Indian Company and first horn manufacturing company in the world to get ISO/TS 16949 certification based on effective implementation of QS 9000 and VDA 6.1 system requirement earlier. Roots' vision is to become a world class company manufacturing world class product, excelling in human relation.

Vision

We will stand technologically ahead of others to deliver world-class innovative products useful to our customers. We will rather lose our business than our customers' satisfaction. It is our aim that the customer should get the best value for his money.

Every member of our company will have decent living standards. We care deeply for our families, for our environment and our society. We promise to pay back in full measure to the society by way of selfless and unstinted service.

Quality - An All Pervasive Entity

Roots is committed to manufacture customer-centric and technology-driven products on par with international quality standards. For example, the horns manufactured undergo a rigorous life-cycle test and are subjected to an endurance of over 200,000 cycles of performance while the industry norm requires only 100,000.

What's more, Roots believes in a quality culture that goes beyond just products. Equal emphasis is given to quality in human relation and quality in service. Roots in its journey towards Total Quality Management has reached important milestones: ISO 9001, QS 9000, VDA 6.1, ISO/TS 16949 and ISO 14001 Certification, presently in the process of obtaining NABL accreditation for our Metrology lab. The Group's TQM policy has a well-integrated Quality Circle Movement with active employee participation at various levels.

Quality Policy:

We are committed to provide world-class products and services with due concern for the environment and safety of the society.

This will be achieved through total employee involvement, technology upgradation, cost reduction and continual improvement in

- Quality of the products and services
- Quality Management system
- Compliance to QMS requirements

Quality will reflect in everything we do and think

- Quality in behavior
- Quality in governance
- Quality in human relation

Environmental Policy

With due concern towards maintaining and improving the Quality of Life, Roots is committed for sustainable development by minimising pollution and conserving resources.

This will be achieved through continual improvement in Environmental Awareness of all employees & associates, Legal Compliance and Objective towards Environmental Protection.

People - A Valuable Asset

Roots has a strong people-oriented work culture that can be seen and felt across all its member concerns. Whether they work in group or in isolation, their effort is well appreciated and achievements well rewarded. They have a sense of belonging and they revel in an environment of openness and trust. Cross-functional teams function as one seamless whole and foster the true spirit of teamwork.

Roots as a learning organization systematically trains its employees at all levels. Conducted in-house, the training programmes equip them to meet new challenges head on. Employees are encouraged to voice their feelings, ideas and opinions. There is a successful suggestion scheme in operation and best suggestions are rewarded.

Lasting relationship will evolve only when people know that their work is valued and that they contribute meaningfully to the growth of the organization. At Roots, people across the group companies, through interactions at workshops and seminars, get to know each other individually, share their common experiences and learn something about life.

Personal Culture

The management has been encouraging and promoting a very informal culture, "Personal touch", sense of belonging, enabling employees to become involved and contribute to the success of the company. The top management also conscientiously inculcates values in the people.

Work Environment

Special and conscious efforts are directed towards house keeping of the highest order. Renovation and modernization of office premises and office support systems are carried out on an on going basis.

Training

Roots believe in systematic training for employees at all levels. As a part of the Organizational Development efforts, training programmes are being conducted in-house, for employees at all levels. In addition, staff are also sponsored for need based training programmes at leading Management Development Institutes.

Total Quality Management

Customer Focus is not merely a buzzword but it has become an important factor of every day work and has got internalized into the work environment. There is an equal emphasis on internal customer focus leading to greater team efforts and better cross-functional relationship.

Quality Circle Movement

To ensure worker participation and team work on the shop-floor, Roots Industries India Ltd has a very effective Quality Circle Movement in the organization. As on today Roots Industries India Ltd has 3 operating Quality Circles having 24 members and some of them have won awards at different conventions and competitions.

Through interaction with workmen in these sessions, a process of 2-way communication has been initiated and valuable feedback has been received on worker feelings, perception, problems and attitudes. Simultaneously management has communicated the problems faced by them and the plans to overcome these problems.

Products

Roots' single minded pursuit of enhancing the quality of life has led to many other diversifications. Roots, today, is a multifaceted corporate entity with interests in automobile accessories, cleaning equipment, castings, precision tools, hi-tech engineering services, healthcare and education.

- Electric Horns
- Air Horns, Switches & Controllers
- Cleaning Machines
- Aluminium & Zinc Pressure Die Cast
- Dies, Tools, Jigs & Fixtures
- Instrument Calibration, Quality System, Consultancy
- Plastic components
- Nature Cure Therapy, Yoga & Massages
- International School
- Yoga and Meditation
- Electric Horns

Horns:

Roots Industries specializes in the manufacture of a wide range and line-up of automobile horns. Roots is a leading supplier to all the major vehicle manufacturers like Ford, Daimler Chrysler, Mitsubishi Lancer, Mahindra & Mahindra, Toyota, Tata Motors, Fiat Uno and Siena, TELCO, TVS Motor Company, Kinetic Honda, etc.

Roots Industries India Ltd places a premium on original technology and innovation. Roots' indigenous talent has kicked off a spree of growth unmatched in the history of automobile OE manufacturers.

Windtone Horns are those which comprise the pairing of low tone and high tone horns.

Characteristics of low tone horns

The important characteristics of low tone horns are

- Frequency is low
- Air gap is high (1.2mm – 1.4mm)
- Sound spreads out in a broader manner
- Sound travels for a shorter distance

Characteristics of high tone horns

The important characteristics of high tone horns are

- Frequency is high
- Air gap is less (0.93mm – 0.98mm)
- Sound spreads out in a narrow manner
- Sound travels for a longer distance

U251 horn assembly

U251 horns are assembled in different work stations. The horns are assembled in 2 different working lines.

- Line E – High tone horns are assembled in this line
- Line F – Low tone horns are assembled in this line

The line E & F have same type of working stations from 10 to 100. The work stations after 100 till 140 are common to line E & F

1.1 NEED FOR THE STUDY

In Horn division of Roots India Limited, they are assembling many models of Horns. I focused my view on U251 model Horn. The Production per shift was even from workstation 10 to 100 of the assembly section. The production was relatively lower in station, 105. The area of a process in which the production is less and also before which the production is more and even, is called bottle neck area. The less production of the bottle neck area affects the overall production of the entire process. In my detailed study on U251 pair horn assembly, station 105 was identified as the bottle neck area as production was less in that station and also it affected the overall production of U251 horns. So I set my goal in improving the productivity of the 105 station.

1.2 PRIMARY OBJECTIVE

To identify the bottle neck areas in the assembly line of Production in the Horn Manufacturing unit and to eliminate the bottleneck through Work measurement.

1.3 SECONDARY OBJECTIVES

- To find the ways to implement the Work measurement,
- To identify the problem and benefits by implementing the Work measurement

CHAPTER 2

LITERATURE SURVEY

Title 1 - Application of constrained management and lean manufacturing in developing best practices for productivity improvement in an auto-assembly plant

The Purpose is to increase productivity in an automotive assembly plant to satisfy customer demand and also develop best practices for productivity improvement for robotic welding operation lines. Principles of lean manufacturing and constrained management have been applied to increase the plant's output in order. Constrained management was used to identify bottlenecks in the plant that limits the throughput and lean manufacturing helped to identify waste (muda) in the constrained production areas. Analytical tools such as matrices are used for mapping sequence of robotics movements to identify interference and desired path for welding line. Results of applying constrained management and lean manufacturing in tandem have revealed the plant's overall bottlenecks and means of increasing the throughput. The research findings are from an automotive assembly plant in a mass production industry, and the results may not be applicable to other types of industry. A very useful best practice for the productivity improvement that is easy to use by plants' management to help them identify and manage bottlenecks, and to eliminate waste from the production system. This paper offers practical and easy-to-use productivity improvement tools based on lean and constrained management principles to help manufacturing managers to make their operations more productive.

Title 2 - Productivity and quality improvements, revenue increment, and rejection cost reduction in the manual component insertion lines through the application of ergonomics

The study is aimed at improving productivity and quality, increasing revenue and reducing rejection cost of the manual component insertion (MCI) lines in a printed circuit assembly (PCA) factory. Subjective assessment (through questionnaire), direct observation method, and archival data were used. Live experiments were conducted on production lines. Eleven problems were identified, i.e., long search for materials from the stores, unproductive manual component counting, obstructions during insertions, component fall-off while the PCA board was traveling on a U-shaped conveyor, etc. Interventions were made to rectify the problems, i.e., to have only one central store to eliminate confusion of the materials' whereabouts, use weighing scale for component counting, modify the MCI sequence and the bin arrangements to avoid obstructions, and use straight conveyor to reduce handling. As a result, there was a tremendous increase in productivity and yearly revenue (US$4,223,736) and a huge reduction in defects and yearly rejection costs (US$956,136). The ergonomics methods and interventions in this study can be replicated to solve similar problems in the MCI lines of electronic industry. They can be used in other industries that perform MCI of small parts. The results have revealed the effectiveness of ergonomics applied to MCI process.

Title 3 - Productivity Measurement and Improvement: Organizational case studies

Improving organizational productivity is an issue that has been with us for some time and will continue to be important. All types of organizations needs to be as productive as possible to best utilize their precious resources, to meet their customer needs, and to stay competitive with similar organizations. Productivity improvement is also at a national level. As we continue to improve national productivity, inflation is moderated, our standard of living improves, and jobs are created or retained. There are 2 basic approaches to improve productivity within an organization. One can change technology and one can change how people work. The former is the realm of the engineer; the second is the realm of a behavioral scientist. Our approach is the latter. Although improving technology is, of course, important to long-range productivity growth, it is how people use this technology that makes it a worthwhile investment to the organization. Thus, our concern is how to structure work so that people can and will want to behave in a way that maximize their productivity. This book will use a specific approach to measure the productivity and then using the resulting measurement as a feedback or methods of improvement to personnel doing the work.

Title 4 - Implementation of productivity improvement strategies in a small company
Small and Medium Enterprises (SMEs) have always played a key role in the economies of all major industrial societies in both Gross Domestic Product (GDP) and employment levels. In the past, most of the new manufacturing concepts and technologies have been implemented in large scale manufacturing industries. However, SMEs have not received due attention for the implementation of such new manufacturing concepts and technologies with the objective to improve productivity and quality. An attempt has been made in this paper to present some of the experiences of implementing new productivity improvement strategies in a small company.

The project has taken place in Valeo, a French company located in the United Kingdom, producing wiper systems for the automotive industry in the UK. The wiper systems include containers, pumps, jets and hoses. This company produces a high variety of low volume parts for varied customers in a job shop environment. The objectives of the project are to improve productivity in two cells of the company, one assembling jets with hoses and the other assembling jets and hoses with other devices for head lamp cleaning systems. In this paper, experiences with the implementation of various productivity improvement strategies are presented. The implementation concerns three aspects: the improvement of the tool used on a station, namely, the wet-set station; the implementation of a Kanban system between a hose-cutting machine, and jet and hoses assembly stations; and the development of an autonomous cell. A performance analysis and some recommendations conclude the paper.

Title 5 - Poor layout design is determine as a major problem contribution in small and medium industry. These particular problems thus affect the productivity and the line efficiency as well. Throughout the study, the aim is to proposed new layout to the related company to increase their productivity. The major step is to identify a bottleneck workstation in current layout. After identify related problems, the current layout is redesign by computing the standard time and processing time in each workstations. In each workstation the processing time is different and the longest time consumption is workstation will be identified as a bottleneck workstation. This related line is studied by time study techniques. The time is taken by stopwatch. In this study, application of Computer Aided tools is introduced which in this study is WITNESS SOFTWARE. The ~~related~~ inputs are going to be simulated with this software. The manual calculation also included especially in line balancing algorithm. The goal of the thesis is to seek the best layout in terms of line efficiency and productivity rate hence proposed to the company. Through out the study, 3 layouts have been achieved. Among 3 layouts only one will be propose to the company. This layout has better line efficiency and rate of productivity.

Quality product and capable to cope with customers demands are important aspects that should be take an account especially for small and medium industry. Management systems are also contributes in order to planning, controlling and measuring parameters related to the performance of the sectors. Companies should realize that the performance is depending on how well the production line in term of output.

Process layout, product layout and fixed-position layout are 3 basics types of layout [M.Davis.M, Heineke J, 2005].This project are interested on product layout. Product layout is defined as flow-shop layout where number of machine and work processes are arranged so that the products will pass through several workstation. Due to high demand the resources was rearranged from process layout to product layout. This required a sequence steps to make product. Industries often called as a assembly lines. Assembly lines are general described as progressive assembly linked by some type of material handling. This can be found especially for industries that assembles product such as electronics part, food and etc. An example of product layout is cafeteria, where customer trays are moving through series of workstations. However bottlenecks are often occurred in assembly line. This will cause delay in term of time and decreasing in line efficiency.

The aims of the study are improving the productivity and compute efficiency of an assembly line in small and medium industry. The objective are redesign the layout for purposing to improve line performance. Computer aided simulation are implemented in this project in order to analyze and investigate the problems occurring in assembly line.

The model will select and using time study techniques it will be analyzed. The line balancing method is use to solve the problem. Comparison of the current layout and new layout are done. Simulation is done by WITNESS software to accomplish this study.

"Manual assembly lines technology has made a significant contribution to the development of American industry in twentieth century" [Groover, 2001]. This phrase emphasizes the importance of assembly line especially in several sectors such as automobiles, consumer appliances and those sectors that produced large quantities product. This indicates the success factors are depending on the efficiency of assembly line. Along assembly lines various operations can be done either manually, automatically or integrated. For manual operations, the workers will perform jobs like brazing, assemblers, welding and so on. Normally for manual process the station will equipped with aided stationary depends on type of tasks. Automation operations are done for high volume quantities with additional features on the workstation. However, assembly line suffered one major problem, bottleneck. This phenomenon is defined as stage where causes the entire process to slow down or stop [Taj,2006]. This can be due to improper scheduling, improper line balancing and machine breakdown or equipment repairing. Improper line balancing for example is defined on distribution of workloads and workers are not equal along the assembly line. The workers are not assigning equally in each workstation. Machine breakdown sometimes contribute to bottlenecks problem since the products are moving and suddenly had to stop and it start accumulate at certain workstation. Due to this problem, there will one station that has maximum time to perform a task. This station is called bottle neck station [Groover, 2001]. Analysis will be performing to identify the location of bottlenecks. Furthermore the product will start to accumulate hence slow down the process yet reduce the line efficiency The production rate is depending on how well the line is running. In order to fixed or overcoming bottle necks problems, manual calculation has a limitation. Fact that to analyze every stations are impossible due to time consumption. Simulation is often used to determine the root of bottlenecks. The results are valid for engineers to predict the causes and effectiveness of current layout. New layout is proposed to overcoming this problem. Simulation is tools for conducting experiments without damaging and interfering the real systems.

Bottle necking and excessive workers are common problems rose in assembly line. These are the major problems that encounter and yet need to be overcome as soon as possible. Assemblers are often encounters this problems and if this happen it will be decreased the line efficiency and the targeted run rate. In preventing these problems, engineers should come out with a solution in order to fix these problems. One way to do so is using line balancing method. This aim is to minimizing workloads and workers on the assembly line while meeting a required output.

"Small and medium industries are covered 90 percent of enterprises in the world".[Taj,2006]. Due to competitiveness, meeting a required demand and provide continuous product are become important matters. In order to achieve this objective, assembly line should be design to make sure the flow is smoothly. Workers on assembly line are specialized person in particular area. Most of them have been exposed to various tasks and skilled have been developed.

A new layout is proposed to make sure the assembly line achieved required run rate. The layout will include the number of workers, the workloads and the flow of the products. Normally any changes of the layout depend on type of product, environment and company policies. Layout will be design based on the regulation provided by company. Software application also involve in the design since any changes will affect the productivity. Simulation become necessary tool in designing layout based on it capability to evaluate and improving current layout. Analysis on assembly is important in order to achieve targeted productivity.

Assembly line should be design smoothly and simulation should be done to predict the line efficiency and productivity difference between new layout and current layout.

Reducing line efficiency

In flow line production the product moves to one workstation due to time restriction. Once its get stuck due to accumulation in certain workstation, it exceeds the cycle time in that station. Faster station is limited by slowest station. Thus, decreasing the rate of productivity .

Unbalance workloads

Due to starving, the workers need to wait the products to come.

Title 6 - A focused study of the results of productivity improvements in a hand assembly area using partial productivity (human productivity) as a measurement tool (Sumanth 1994).

This study describes the hand assembly area as it has evolved, and problems with material flow and productivity. It then describes the focused improvement efforts and resulting improvements. Due to limitations of available information (financial) and to the nature of the improvement effort, human productivity is the only measurement used. The company faces stiff competition from low priced foreign labor on hand assembly operations, but prefers the control gained by keeping these operations in the US, for proximity to other processes, and further development. Since this study covers only human productivity over a five month period, and there was no real change in wages or benefits during this period, no deflator was used.

This production area is a complex assembly area dedicated to a single product line. The process has nine (9) to sixteen (16) operations, several with multiple stations, and the product has three major variations. Some elements of the production line are automated, but most are hand assembly.

The improvement tool used is known as standard operations (Shingo, 1982 and Ohno and Mito, 1986). Its objectives are as follows:

- Regulate production to match customer demand.
- Establish standard WIP quantities

- Balance line
- Improve workflow
- Pace production
- Improve flexibility
- Employee involvement in the improvement process and control over adjustments.

The goal of standard operations is 100% labor productivity. Since the time required for different operations usually varies greatly, and we tend to give each worker one operation, the workload is usually greatly uneven. Labor productivity is improved by giving some workers multiple operations and balancing the workload (in terms of time).

CHAPTER 3

METHODOLOGY

3.1 DATA AND SOURCES OF DATA

The primary data was collected through Process chart and Time Study Form. The Process chart is used to study the flow of Men, Material and Machine in the section of study. It helps us to understand each activity of it. The Time study form collects data about the observed time for each process separately through which average Observed time and Standard time can be derived.

3.2 POPULATION AND SAMPLE SIZE

A sample is a part of the Population being taken for the study. The total number of Horns manufactured per shift is 800. The 200 Horns manufacture in a shift is considered for the study and hence the sample size is 200.

3.3 SAMPLING TECHNIQUE

Since the study was done by random nature, it was found to apply Simple random Sampling technique. The study was done in Root India Limited which manufactures Horn.

3.4 RESEARCH TOOLS

3.4.1 Process Charts

Process analysis implements process charts. These charts are based on standardized symbols under Japanese Industrial Standards JIS Z 8206. These symbols effectively describe the flow of processes and make it possible to quickly determine where the problem exists in the process. The symbols are divided into basic and supplementary symbols. The basic graphic consist of 5 symbols, including Operation, Transportation, Storage, Delay and Inspection

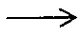
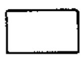
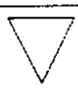
The Process chart records each step of an operation. Additionally, the chart records flow within a unit, a section, a department, or between departments. Flow may include the sequential steps of a production operator, or it may include the sequential steps that the worker, part, or material goes through.

A flow diagram supplements the flow process chart. It is used to study each step by drawing a layout of the area in which a process flows. The layout will be understood more easily by using the same symbols used on the worksheet.

Using the Process chart worksheet and the plan view flow diagram, problems in the process are defined. Changing the sequence of steps, eliminating or adding steps and changing the location of steps in the process are all possible methods for improving the process.

Table 3.1

Process chart symbols

Symbol	**Activity**	**Purpose for which it is used**
	Operation	Alters the shape or other characteristics of a material, semi-finished product, or product
	Transport	Changes the location of a material, semi-finished product, or product
	Inspection	Measurement of amounts of materials, parts, or products for comparison with the specified amounts to judge whether a discrepancy exists
	Delay	An unscheduled accumulation of materials, parts, or products
	Storage	A scheduled accumulation of materials, parts, or products under some form of authorization or an item is retained for references purposes

3.4.2 Objectives of good plant layout

In a good plant layout

- Material handling and transportation is minimized and efficiently controlled.
- Bottlenecks and points of congestions are eliminated (By line balancing) so that the raw material and semi finished goods move fast form one work station to another.
- Work stations are designed suitably and properly,
- The movements made by the workers are minimized
- Waiting time of the semi-finished products is minimized
- Working conditions are safer, better and improved
- There is increased flexibility for changes in product design and for future expansion
- There are improved work methods and reduced production cycle times
- Plant maintenance is simpler
- There is increased productivity and better product quality with reduced capital cost

3.4.3 Principles of plant layout

The following are some of the principles of plant layout.

a. **Integration**

It means the integration of production centers facilities like workers, machinery, raw material etc in a logical and balanced manner.

b. **Minimum movement and material handling**

The number of movements of workers and materials should be minimized. It is better to transport materials in optimum bulk rather than in small amounts.

c. Smooth and continuous flow

Bottlenecks, congestion points and tack tracking should be removed by proper line balancing techniques.

d. Cubic space utilization

Besides using the floor space of a room, if the ceiling height is also utilized, more materials can be accommodated in the same room. Boxes or bags containing raw material or goods can be stacked one above the other to store more items in the same room. Overhead materials handling equipments save a lot of valuable floor space.

e. Safe and improved environments

Working places –safe, well ventilated and free from dust, noise, flames, odours and other hazardous conditions decidedly increase the operating efficiency of the workers and improve their morale. All this leads to satisfaction amongst the workers and thus better employer employee relations.

f. Flexibility

In automotive and other industries where models of products change after some time, it is better to permit all possibility flexibility in the layout. The machinery is arranged in such a way that the changes of the production process can be achieved at the least cost or disturbance.

3.4.4 Work station design

The work station design affects the production rates, efficiency and the accuracy with which an operation can be performed. A work station not only needs space for the worker and the machine, there are plenty of others items which also need accommodation. Space requirements and a few more factors governing a good work station design, are described below:

Space requirements

- Space for the worker to stand or turn comfortably to operate the machine
- Space for the machine, taking into considerations the overhang, projection or the over travel of the machine parts like table of a milking machine or a planer.
- Space for the work if it is projecting out form the machine like a long rod fed to a turret lathe
- Space for bins storing incoming materials and processed goods.
- Space for additional attachment, accessories, or jigs and fixtures.
- Space for load large work on and off the machines

Other factors

- Considerations of the space required, for the movements of material handling equipments.
- Easy access to safety stops in case of emergency.
- Easy access to machine for inspection lubrication maintenance and repairs
- Convenience of making foundations and machine installation
- Aisle space between one machine and the next.

3.4.5 Line balancing

Line balancing means balancing a line. For example, it is balancing a production line or an assembly line. Suppose there are 3 machines A, B and C, which can process 5, 10 and 15 pieces per unit time respectively and pieces flow from A to B to C.

Since A has minimum capacity, (i.e.) of processing only 5 pieces per unit time naturally work station B will remain idle for 50% of its and machine for 66.66% of its time. It shows that the line is unbalanced. One way to partially balance the line is to have 3 machines of type A, 2 of type B with every machine of type C. Another approach to balance the line will be to give some other task to machines B and C so that they do not remain idle.

Line balancing aims at grouping the facilities and workers in an efficient pattern, in order to obtain an optimum or most promising balance of the capacities and flow of the production on assembly processes.

3.4.6 Ergonomics

Ergons means "work'" and Nomos means "Natural Laws". Ergonomics implies ` fitting the job to the worker'. Ergonomics combines the knowledge of psychologist, physiologist, anatomist, engineer, anthropologist and a bio-metrician.

(a) Applications

In Practice, ergonomics has been applied to a number of areas as discussed below.

i. Working environments
ii. The work place and
iii. Other areas

Normal working area is the space within which a seated or standing worker can reach and use tools, materials and equipment when his elbows fall naturally by the side of the body.

Maximum working area is the space over which a seated or standing worker has to make fall length aim movements in order to reach and use tools, materials and equipment.

3.4.7 Time Study

Time study is a direct and continuous observation of a task, using a timekeeping device like Stop watch to record the time taken to accomplish a task and it is often used when:

- There are repetitive work cycles of short to long duration,
- Wide variety of dissimilar work is performed, or
- Process control elements constitute a part of the cycle.

3.4.7.1 Time Study Equipments

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

(a) A stop watch

There are 2 main types of watch in general use for time study, the mechanical and the electronic

(b) A study board

The study board is simply a flat board, usually of plywood or of suitable plastic sheet, needed for placing time study forms. It should be rigid and larger than the largest form likely to be used.

(c) A time study form

Taking a time study requires the recording of substantial amounts of data. These data are in a regular form consisting of element codes or descriptions, ratings and element durations. Time study top sheet, Continuation sheet and Short cycle study form are some of the types of Time study forms. Below is a sample of a Short cycle study form.

Table 3.2

Time Study form

Time Study															
No	**Section Name**	**Observed Time**										**Total OT**	**Avg. OT**	**R**	**BT**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**				
	Note:														
	R - Rating				**Basic Time = (Observed Time * Rating) / (Standard Rating)**										
	OT - Observed Time														
	BT - Basic Time														

3.4.7.2 Allowances

Allowances are extra time added to the normal time to make the time standard practical and attainable. No manager or supervisor expects employees to work every minute of the hour.

(i) Personal

Personal allowances is that time an employee is allowed for personal things such as talking to friends about non-work subjects, going to the toilet, getting a drink, going to pray or any other operator – controlled reason for not working. An appropriate amount of time has been defined as about 5 percent of the work day, or 24 minutes per day.

(ii) Fatigue

Fatigue allowance is the time an employee is allowed for recuperation from fatigue. Fatigue allowance time is given to employees in the form of work breaks, more commonly known as coffee breaks. Breaks occur at varying intervals and are of varying duration, but all breaks are designed to allow employess to recuperate from on-the-job fatigue. Most employees today have very little physical drudgery involved with their jobs, but mental fatigue is just tiring. If an employee uses less than ten pounds of efforts during the operation of his job, then five percent fatigue allowance is normal. A five percent increase in fatigue allowance is given for every ten pound increase in exertion required of the employee. The breaks area calculated into the fatigue allowance because the reporting practice is to not report the time spent on breaks separately. Because lunch time is punched out and not reported, it does not enter into the allowance calculation. Allowance is for times when the employees is expected to perform but can't.

(iii)Delay

Delay allowance is called unavoidable because they are out of the operator's control. Something happens to prevent the operator from working. The reason must be known and the cost accounted for to develop the cost justification. The operator's performance must not be penalized for problems out of i\his control. Three methods are available to account for and to control unavoidable delays:

Add delay allowance to the standard

Time –study them and add them to the time standard

Charge the time to an indirect charge.

A three percent allowance will be added to the personal allowance of five percent plus a fatigue allowance of five percent to produce a 13 percent total allowance. An unavoidable delay is a foreign element that cannot be anticipated will require the operator to charge his or her time to indirect account. Supervisors will be required to approve all indirect charges and the time and the time should be more than six minutes to be statistically significant.

Anything that cannot be live with is not supposed to be in the time standard because it is difficult to get it out once it included.

3.4.7.3 Allowance Application

The fundamental purpose of all allowances is to add enough time to normal production to enable the average worker to meet the standard when performing at standard performance. There are two ways of applying allowances. The most common is to add a percentage of the productive time only. It is also customary to express the allowance as a multiplier, so that the normal time (NT) can be readily adjusted to the standard time (ST).

Allowances

$$ST = NT / (1 - \text{Allowance})$$

Where: ST = Standard time

NT = Normal time

3.4.8 Limitation of the study

Since the employees are aware that they are being observed, their work credibility varied from other situations.

While collecting the review the researcher faced difficulties in tracing out an appropriate source.

Finally due to time constraints, the time study is done only for the manufacturing of Mono Bloc Pump leaving the other products being manufactured in the organization.

3.5 DATA COLLECTED

3.5.1 Process Chart

The data was collected from the 105 section where the study is being conducted. The flow was recorded and a process chart was developed to understand the flow of assembly line of the Horn section.

Figure 3.1

Process Chart

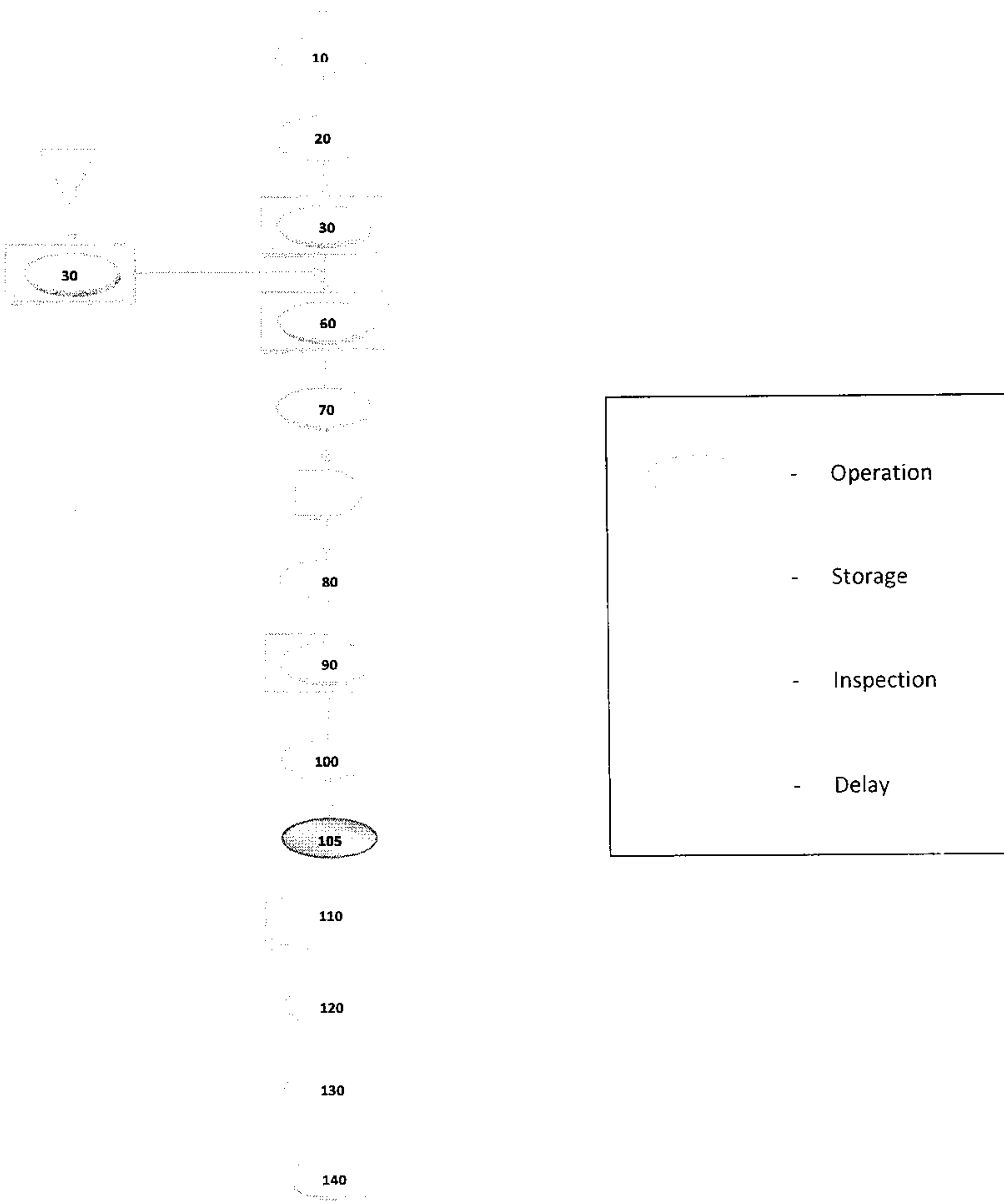


Table 3.3

Process Details

Station	Process
	Component storage in stores
10	Spool assembly locking-point holder and tuning screw assembly
20	Terminal base assembly, riveting & point plate positioning
30	Point plate tension checking & adjusting
40	Diaphragm assembly assembling, tightening, height measuring & adjusting
50	Pre horn assembling & crimping
60	Air gap measuring & adjusting
70	Silicon sealant dispensing and trumpet locking
12 hours delay for sealant curing (Vertical carousal system)	
80	Duco lacquer dispensing, mounting bracket assembling, terminal connector assembly insertion
90	Horn tuning & testing
100	Hot stamping, adhesive application, mounting bracket loosening
105	Terminal connector assembly insertion, mounting bracket assembling & adhesive application
110	QA 100% inspection
120	Palletizing, strapping & labeling
130	Pre - dispatch inspection
140	Dispatch/Document verification

3.5.2 Time Study

A time study was done and the data was collected using the Short cycle Study Form with the help of a stop watch and the entries were made in the form. The recorded data is given in the below Table:

Table 3.4

Time Study

Time Study															
No	**Section Name**	**Observed Time**										**Total OT**	**Avg. OT**	**R**	**BT**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**				
1	105-A	16.1	15.5	15.6	16.1	16.9	17.1	16.3	15	15.8	15.6	160	16	100	16
2	105-B	17	16.2	17	14.6	15.5	14.9	15.3	15.1	16.1	16.5	158.2	15.82	100	15.82
3	105-C	20.9	20.7	19.5	18.7	19.6	21.1	19.7	19.1	19.6	19.9	198.8	19.88	100	19.88
4	105-D	17.1	15.9	16.6	15.8	15.1	16.4	15.1	17	15.8	16.6	161.4	16.14	100	16.14
												Total Basic Time			67.84
							Basic Time			67.84					
							Allowance for this process			9%					
							Standard Time			73.9456					
	Details of Allowance														
	Fatigue Allowance	4%													
	Personal Allowance	5%													
		9%													
	Note:														
	R - Rating				**Basic Time = (Observed Time * Rating) / (Standard Rating)**										
	OT - Observed Time														
	BT - Basic Time														
	Standard Rating	100%													

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

A flow process chart was developed to understand the movement of material and to identify possible methods for improving the process.

4.1 Flow process chart

Location : RIL

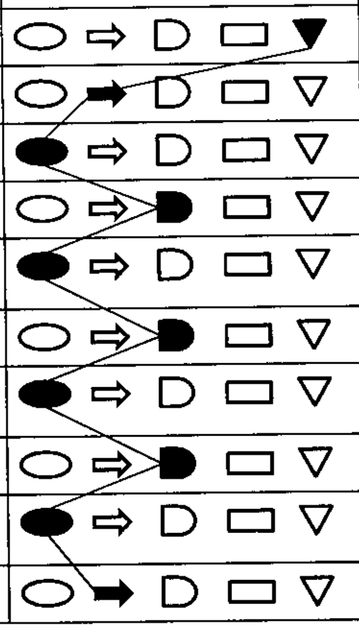
Activity : Pair Horn Assembly

Method : Present Proposed

Type : Worker Material Machine

Table 4.1

Flow Process Chart

Event description	Symbol	Method recommendation
Stock		
To terminal connecting assembly		
Connector lock, Oil application		
Stack		Conveyor can be used
Duco application on SCR, mounting bracket assembly, collar nut, Air gun tightening		Duco application on SCR can be carried out in Stage (1)
Stack		
Max tightening by torque wrench, Duco application on one collarnut, applying marker		Tightening using torque wrench can be done in Stage (2)
Stack		
Duco application on another nut and anobond application		
To QA inspection stage		

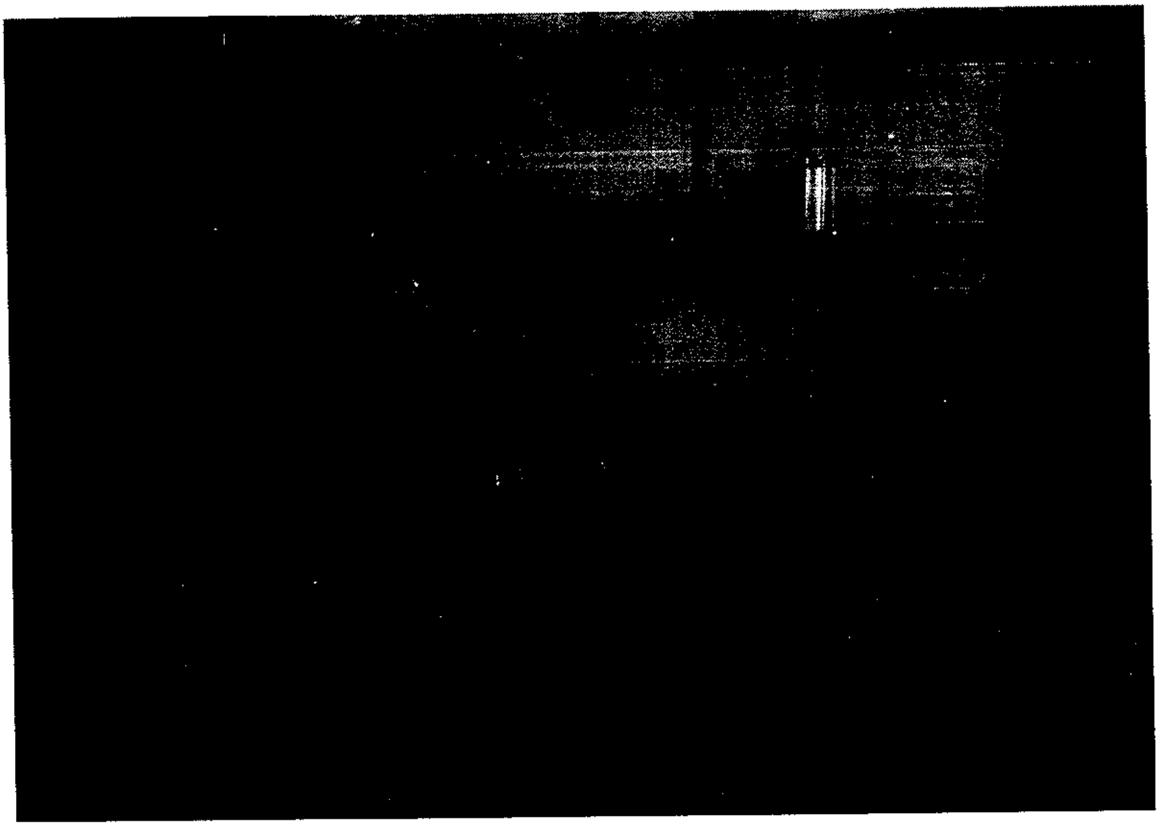
Inference:

Table 4.2

Summary			
Event	**Present**	**Proposed**	**Savings**
Operation	4		
Transport	2		
Delay	3		
Inspection	0		
Storage	1		

The above table shows the total number of major activities carried out during flow of material in the 105 section.

The below is the photograph of the 105 section.



4.2 Detailed Study

A detailed study was conducted on all activities of the 4 station of the 105 section and an initial analysis of those was carried out. Each activity was identified as follows.

E – Essential

W – Waste

NI – Need Improvement

Table 4.3

Detailed Study

105 – A

S. No	Description	E	W	NI	Remarks
1	Taking trays from Storage	-	√		Helper can bring trays to station
2	Keeping empty trays on ground	-	√		Some provision can be made so that the empty trays can be simply pushed down
3	Bending down to take horns from trays	-	√	√	Some provision can be made so that operator need not bend down to take horns
4	Leaning back to take horns from the trays	-	√	√	If trays are placed in inclined manner so that horns slope down the tray and the operator have no need to lean back
5	Picking the horns from the trays	√	-	-	-
6	Placing low tone horn in the fix	√	-	-	-
7	Holding high tone horn in the hand	√	-	√	High tone fix should be removed from working table
8	Placing terminal connector on low tone horn	√	-	-	-
9	Pressing Green button in the fix	√	-		-
10	Taking oil container in hand	√	-	√	The oil container can be big

11	Oil application on terminal connectors	√	-	√	-
12	Placing it again on table	-	√	√	The oil container can be hanged
13	Periodical adjustment of oil container nozzle	-	√	√	An effective nozzle can be placed to replace the present wool opening of container
14	Removing the LT horn from fix	√	-	-	-
15	Steps 10 to 13 to repeated for LT horn	-	√	√	As stated in steps 10 to 13
16	Keeping horns on table	√	-	√	Conveyor can be used
17	Finding place to keep the horns on table when horn gets dumped	-	√	√	More space can be allocated on working table
18	Keeping rejection parts in trays up	√	-	√	Trays can be placed below table

105 – B

S. No	Description	E	W	NI	Remarks
1	Taking horns from previous stage	√	-	√	Conveyor can be used
2	Placing HT & LT horns in jigs				-
3	Taking bracket trays	√	-	-	Helper can bring bracket trays
4	Taking bracket form tray	√	-	√	-

5	Bending town to take bracket	-	√	√	Possible solution suggested before should be adopted
6	Leaning back to take bracket	-	√	√	Possible solution suggested before should be adopted
7	Keeping empty tray on ground	-	√	√	Possible solution suggested before should be adopted
8	Applying Duco on SCR	√	-	-	-
9	Placing bracket on horn	√	-	-	-
10	Taking collar nuts from tray	√	-	-	-
11	Placing collar nuts from tray	√	-	-	-
12	Holding air gun &bringing it down	√	-	√	Height of suspension of air gun shall be lowered
13	Triggering the sir gun, tightening collar nuts on LT & HT horns	√	-	-	The collar nuts can be tightened here itself to preset torque
14	Removal of paired horns from the fixture	√	-	-	-
15	Placing it on table form next operation	√	-	√	Conveyor can be used
16	Time for finding space to keep horns on table	-	√	√	More space can be allocated on working table
17	Keeping rejected parts in trays up	√	-	√	Trays cab be placed below table

105 – C

S.No	Description	E	W	NI	Remarks
1	Taking horns from previous stage	√	-	√	Conveyor can be used
2	Placing HT & LT horns in FIX	√	-	-	-
3	Taking torque wrench	√	-	-	-
4	Tightening LT horn nut	√	-	√	Torque setting can be done in 105-B itself
5	Tightening HT horn nut	√	-	√	Torque setting can be done in 105-B itself
6	Placing torque wrench	√	-	-	-
7	Taking the marker	√	-	-	-
8	Marking on LT horn nut	√	-	√	Automating marking system can be used an in station 90
9	Marking on HT horn nut	√	-	√	Automating marking system can be used an in station 90
10	Placing marker back on table	√	-	-	-
11	Taking brush from duco container	√	-	-	-
12	Applying duco on LT horn	√	-	-	-
13	Inserting the brush inside duco container	√	-	√	The hole can be made somewhat bigger so that brush can be kept easily
14	Removing the horns from		-	-	-

	fixture	√			
15	Placing the horns from fixture	√	-	-	-
16	Time for finding space to keep horns on table	√	-	√	Space on table can be increased
17	Keeping rejected parts in trays up	√	-	√	Trays can be placed below table

105 – D

S.No	Description	E	W	NI	Remarks
1	Taking the paired horns	√	-	√	Conveyor can be used
2	Taking brush from duco container	√	-	-	-
3	Duco application on HT collar nut	√	-	√	This can be done by the C operator itself
4	Inserting the brush inside container	√	-	√	The hole of the container can be made big so that brush can be inserted easily
5	Taking anabond container	√	-	-	-
6	Holding horns & applying anabond on LT horn terminal connectors	√	-	-	-
7	Holding horns & applying anabond on HT horn terminal connectors	√	-	-	-
8	Sending horn pairs for station 100	√	-	-	-

Inference:

It was found that station 105 – A and 105 – B contributed to the maximum of activities classified as Waste. There were 8 activities in 105 – A and 4 activities in 105 – B identified as Waste. There is a lot of scope for development in these 2 stations which may result in the productivity improvement of the 105 section as a whole. There is a lot of scope of improvement in these 2 stations.

Also a lot of essential activities were carried at station 105 – C thus increasing the workload of that worker. All the 17 activities carried out at this station were identified as essential and at the same time there was a scope for improvement in this station

The last section has only 8 activities and there is no activity identified as waste and there were very few discrepancies in this station.

4.3 Time Study

Time study was conducted to identify the time taken by the worker to complete one cycle. The data was entered in the Short cycle Study Form. The recorded data is given below

Table 4.4

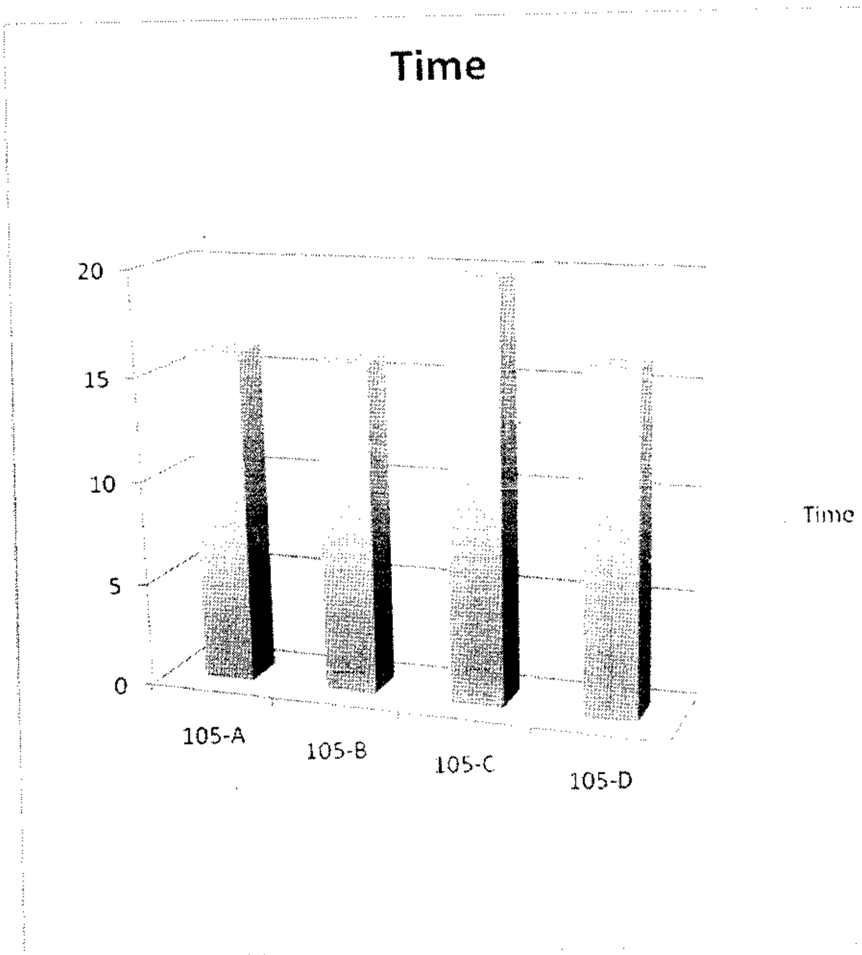
Analysis of Time Study

Time Study															
No	**Section Name**	**Observed Time**										**Total OT**	**Avg. OT**	**R**	**BT**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**				
1	105-A	16.1	15.5	15.6	16.1	16.9	17.1	16.3	15	15.8	15.6	160	16	100	16
2	105-B	17	16.2	17	14.6	15.5	14.9	15.3	15.1	16.1	16.5	158.2	15.82	100	15.82
3	105-C	20.9	20.7	19.5	18.7	19.6	21.1	19.7	19.1	19.6	19.9	198.8	19.88	100	19.88
4	105-D	17.1	15.9	16.6	15.8	15.1	16.4	15.1	17	15.8	16.6	161.4	16.14	100	16.14
												Total Basic Time			67.84
							Basic Time			67.84					
							Allowance for this process			9%					
							Standard CT			73.9456					
	Details of Allowance														
	Fatigue Allowance	4%													
	Personal Allowance	5%													
		9%													
	Note:														
	R - Rating				**Basic Time = (Observed Time * Rating) / (Standard Rating)**										
	OT - Observed Time														
	BT - Basic Time														
	Standard Rating	100%													

The below chart was prepared using the Basic time consumed by all the 4 stations.

Figure 4.1

Time Study

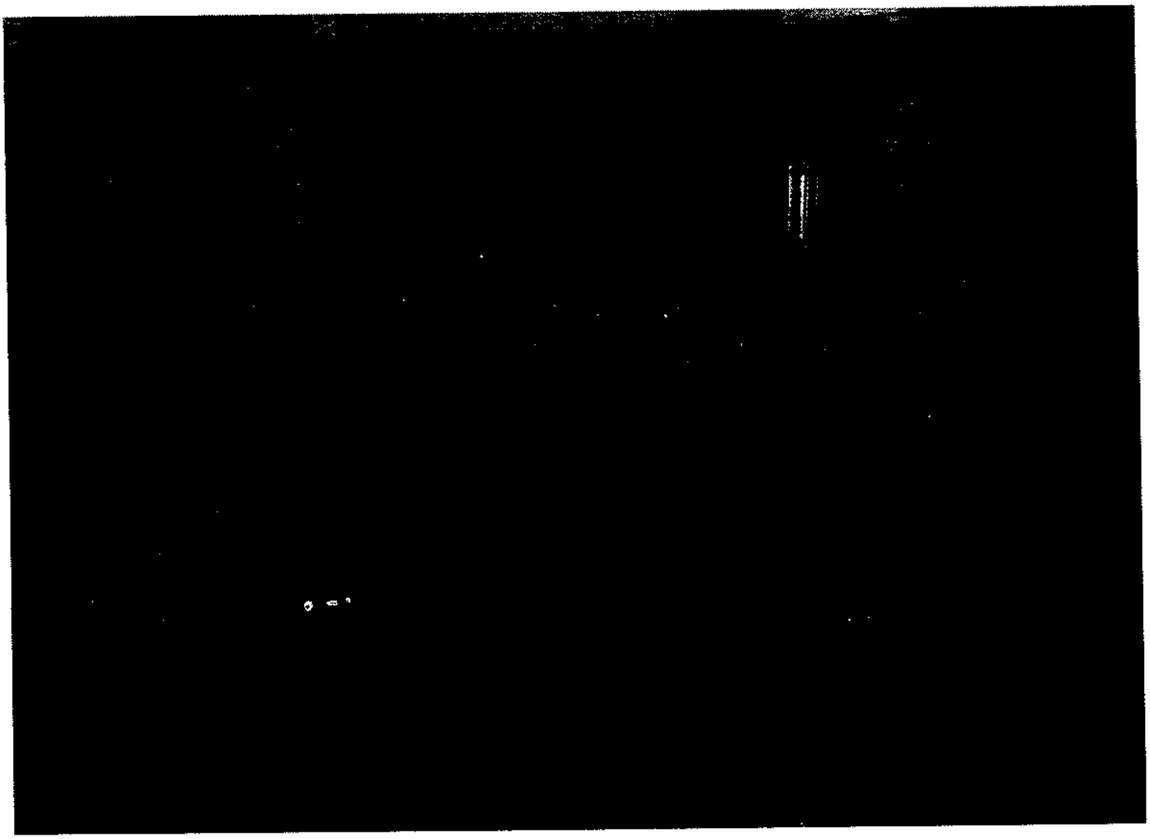


Inference:

The above chart infers that the time consumed at the station 105 – C is very high compared to all the other 4 stations. This is in line with the inferences of the Process flow chart that the 105 – C section is having more essential activities.

4.4 Proposed Change

Using Line balancing technique I tried to reduce the maximum cycle time. The last station 105 – D was removed from the layout and the activities were distributed within the 3 stations. Then a trial was conducted by arranging the proposed layout. The work was shared among the 3 stations. The below photograph shows the setup of the proposal.



4.4.1 Flow process chart:

The Flow process chart of the proposed change developed as below.

Location : RIL

Activity : Pair Horn Assembly

Method : Present Proposed

Type : Worker Material Machine

Table 4.5

Flow Process Chart of Proposed Layout

Event description	Symbol	Method recommendation
Stock	○ ⇨ D ▭ ▼	-
To terminal connecting assembly	○ ➡ D ▭ ▽	-
Connector lock, Oil application and Duco application on SCR	● ⇨ D ▭ ▽	-
Stack	○ ⇨ ◗ ▭ ▽	-
Mounting bracket assembly, collar nut, Air gun tightening and appling marker	● ⇨ D ▭ ▽	-
Stack	○ ⇨ ◗ ▭ ▽	-
Duco application on another nut and anobond application	● ⇨ D ▭ ▽	-
To QA inspection stage	○ ➡ D ▭ ▽	-

Inference:

Table 4.6

Summary of Proposed Flow Process Chart

Summary			
Event	**Present**	**Proposed**	**Savings**
Operation		3	1
Transport		2	
Delay		2	2
Inspection		0	
Storage		1	

4.4.2 Time Study

Time study was conducted to identify the time taken by the worker to complete one cycle in the proposed layout. The data was entered in the Short cycle Study Form. The recorded data is given in the below Table:

Table 4.7

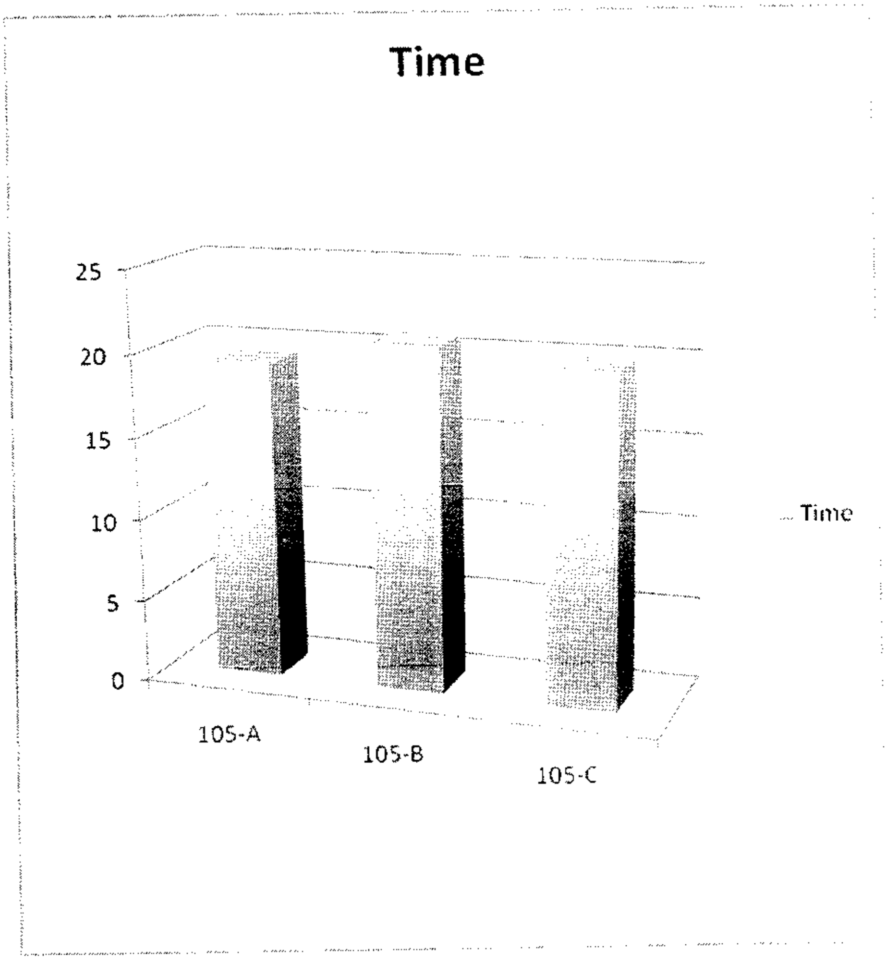
Analysis of Time Study of Proposed Layout

Time Study															
No	**Section Name**	**Observed Time**										**Total OT**	**Avg. OT**	**R**	**BT**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**				
1	105-A	18.6	19.5	19	19.4	17.5	19.2	19.5	19.9	20.2	19.6	192.4	19.24	100	19.24
2	105-B	21.2	20.7	20.6	19.4	21.1	20.1	21.2	20.9	21.8	21.2	208.2	20.82	100	20.82
3	105-C	19.9	20.4	20.5	19.9	20.6	20.1	19.9	19.1	18.6	19.9	198.9	19.9	100	19.9
												Total Basic Time			59.96
							Basic Time			59.96					
							Allowance for this process			9%					
							Standard CT			65.3564					
	Details of Allowance														
	Fatigue Allowance	4%													
	Personal Allowance	5%													
		9%													
	Note:														
	R - Rating				**Basic Time = (Observed Time * Rating) / (Standard Rating)**										
	OT - Observed Time														
	BT - Basic Time														
	Standard Rating	100%													

The below chart was prepared using the Basic time consumed by the 3 stations.

Figure 4.2

Time Study of Proposed Layout



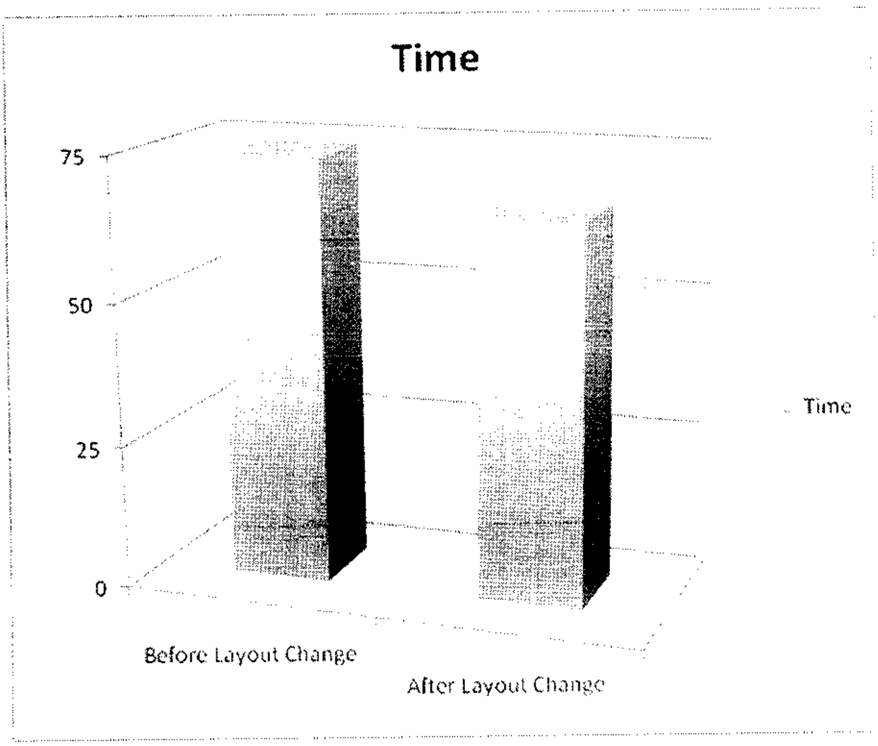
Inference:

From the chart we could see that the objective of line balancing was achieved. There is a balance and the not much difference in time consumption of the 3 stations. More importantly the Standard Cycle time of the 105 section has reduced which can facilitate the increase in productivity of this section.

The below chart was prepared using the Standard Cycle time of the 105 section before and after the proposed changes

Figure 4.3

Comparison of Time Study



Inference:

From the chart we the Standard Cycle time of the 105 section has reduced because of the new proposal which can facilitate the increase in productivity of this section.

CHAPTER 5

CONCLUSIONS

5.1 Findings

The productivity of 105-section was increased and the bottleneck was reduced. Previously the production was observed to be 400 pieces / shift. After our suggestion we found that the production was 500 pieces / shift. The number of labour was reduced from 4 members to 3. By line balancing the total cycle time was reduced. Previously the total cycle time was found to be 74 secs. After line balancing the total cycle time was reduced to 65 secs.

5.2 Suggestions

- Design of a spring trolley to facilitate the worker to avoid bending down to take the horns from the trays, thereby reducing time & fatigue caused to workers.
- A wire mesh between sections 100 & 105 to avoid visual disturbances.
- Use of conveyors to increase the efficiency of the workers.
- Use of vertical carousal system for the curing of duco lacquer and to avoid time waste in placing and bringing back trays to and from the storage between 100 and 105 sections.
- Possibility of mixing Anabond and oil and using it in a single station instead of using in two stations.
- Use of automatic marker system to avoid time waste in taking and placing the marker from the table by the worker

5.3 Conclusion

Based on the study and observations, the reasons for the bottleneck could be found. Those factors were analyzed and formulated some solutions to eliminate them.

By implementing those solutions, the bottle neck could be reduced to some extent. Thereby the task of achieving productivity improvement was successful.

In addition the manpower was reduced without increasing the workload on the other operators. This was achieved through line balancing and process layout principles. The suggestions put forth through this project were beneficiary to the company since it accounted for productivity improvement and cost savings.

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