ANALYSIS AND DEVELOPMENT OF A FRAMEWORK FOR SELECTED FUNCTIONS OF QUALITY AND PRODUCTIVITY IN AN APPAREL COMPANY.

by

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March, 2008

MD. NURUR RAHMAN

This dissertation is dedicated to my parents,

Sayeeda Begum

and

Late Md. Shafiqur Rahman

TABLE OF CONTENT

TITLE PAGE

LIST OF FIGURES	viii
LIST OF TABLES	x
ABBREVIATION	xiii
ACKNOWLEDGEMENT	xiv
ABSTRACT	xv
CHAPTER-I: INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	1
1.3 Objectives	3
1.4 Methodology	4
CHAPTER-II: LITERATURE REVIEW	
2.1 Quality Productivity Strategy	5
2.2 Quality Management	6
2.3 Different Aspects of Quality	8
2.4 Implications of Quality	11
2.5 Evaluations of Modern Concepts	19

2.6 Quality Control 21

2.7 Conclusion 22

2.8 Production Management 23

2.9 Conclusion 33

CHAPTER-III: COMPANY PROFILE AND PRODUCT DESCRIPTION

3.1 Location 36

3.2 Description of the Company 36

3.3 Company Profile 37

3.4 Factory Specification 38

3.5 Products Description 38

CHAPTER-IV: TIME STUDY AND WORKER RATING

4.1 Time Study 39

4.2 Purpose of Time Study 39

4.3 Time Study: Situation I 41

4.4 Time Study: Situation II 46

4.5 Time Study: Situation III 51

4.6 Time Study: Situation IV 56

4.7 Time Study: Situation V 61

CHAPTER-V: METHOD STUDY

5.1 Method Study 67

CHAPTER-VI: LINE BALANCING

6.1 Line of Balance 76

6.2 Existing Line Balance 77

6.3 Proposed Line Balance: Situation I 79

6.4 Proposed Line Balance: Situation II 83

6.5 Proposed Line Balance: Situation III 86

6.6 Proposed Line Balance: Situation IV 90

CHAPTER-VII: RESULTS AND DISCUSSION

7.1 Results and Discussion 94

CHAPTER-VIII: CONCLUSSIONS AND RECOMMENDATION

8.1 Conclusion 97

8.2 Recommendation 97

References 99

LIST OF FIGURES

FIGURE	DESCRIPTION	PAGE
Figure 5.1	Control chart of existing observed time before splitting	69
Figure 5.2	Control chart of developed observed time before splitting	69
Figure 5.3	Control chart of existing and developed observed time before splitting	70
Figure 5.4	Control chart of existing per hour production before splitting	70
Figure 5.5	Control chart of developed per hour production before splitting	71
Figure 5.6	Control chart of existing and developed per hour production before splitting	71
Figure 5.7	Control chart of existing observed time after splitting	73
Figure 5.8	Control chart of developed observed time after splitting	73
Figure 5.9	Control chart of existing and developed observed time after splitting	74
Figure 5.10	Control chart of existing per hour production after splitting	74
Figure 5.11	Control chart of developed per hour production after splitting	75
Figure 5.12	Control chart of existing and developed per hour production after splitting	75

Figure 6.1	Pitch diagram of existing line balance of a T-Shirt of a sewing section	79
Figure 6.2	Schematic of existing assembly line of a T-Shirt of a sewing section	79
Figure 6.3	Pitch diagram of proposed line balance of a T-Shirt of a sewing section	82
Figure 6.4	Schematic of proposed assembly line of a T-Shirt of a sewing section	82
Figure 6.5	Pitch diagram of proposed line balance of a T-Shirt of a sewing section	85
Figure 6.6	Schematic of proposed assembly line of a T-Shirt of a sewing section	85
Figure 6.7	Pitch diagram of proposed line balance of a T-Shirt of a sewing section	88
Figure 6.8	Schematic of proposed assembly line of a T-Shirt of a sewing section	89
Figure 6.9	Pitch diagram of proposed line balance of a T-Shirt of a sewing section	92
Figure 6.10	Schematic of proposed assembly line of a T-Shirt of a sewing section	93

LIST OF TABLES

TITLE	DESCRIPTION	PAGE
Table 4.1	Pitch time of a T-Shirt of a sewing section	42
Table 4.2	Observed units of per hour operation of a T-Shirt of a sewing section	43
Table 4.3	Observed worker rating of a T-Shirt of a sewing section	44
Table 4.4	Basic pitch time and standard processing time of a t-shirt of a sewing section	45
Table 4.5	Pitch time of a T-Shirt of a sewing section	47
Table 4.6	Observed units of per hour operation of a T-Shirt of a sewing section	48
Table 4.7	Observed worker rating of a T-Shirt of a sewing section	49
Table 4.8	Basic pitch time and standard processing time of a T-Shirt of a sewing section	50
Table 4.9	Pitch time of a T-Shirt of a sewing section	52
Table 4.10	Observed units of per hour operation of a T-Shirt of a sewing section	53
Table 4.11	Observed worker rating of a T-Shirt of a sewing section	54
Table 4.12	Basic pitch time and standard processing time of a T-Shirt of a sewing section	55
Table 4.13	Pitch time of a T-Shirt of a sewing section	57

Table 4.14	Observed units of per hour operation of a T-Shirt of a sewing section	58
Table 4.15	Observed worker rating of a T-Shirt of a sewing section	59
Table 4.16	Basic pitch time and standard processing time of a T-Shirt of a sewing section	60
Table 4.17	Pitch time of a T-Shirt of a sewing section	62
Table 4.18	Observed units of per hour operation of a T-Shirt of a sewing section	63
Table 4.19	Observed worker rating of a T-Shirt of a sewing section	64
Table 4.20	Basic pitch time and standard processing time of a T-Shirt of a sewing section	65
Table 5.1	Result of method study of a T-Shirt of a sewing section before splitting	68
Table 5.2	Result of method study of a T-Shirt of a sewing section after splitting	72
Table 6.1	Existing line balance of a T-Shirt of a sewing section	77
Table 6.2	Calculation of labor utilization efficiency for 41.58 second cycle time	78
Table 6.3	The job times and precedence relationship of a T-Shirt of a sewing section	80
Table 6.4	Line balance and labor utilization efficiency of a T-Shirt of a sewing section	81
Table 6.5	The job times and precedence relationship of a T-Shirt of a sewing section	83
Table 6.6	Line balance and labor utilization efficiency of a T-Shirt of a sewing section	84
Table 6.7	The job times and precedence relationship of a T-Shirt of a sewing section	86

Table 6.8	Line balance and labor utilization efficiency of a T-Shirt of a sewing section	87
Table 6.9	The job times and precedence relationship of a T-Shirt of a sewing section	90
Table 6.10	Line balance and labor utilization efficiency of T-Shirt of a sewing section	91

ABBREVIATION

BPT = Basic Pitch Time

CL = Centre line

CWQC = Company wide quality control

LCL = Lower control limit

OR = Observed Rating

OT = Observed time

PT = Pitch time

PWP = plant-with-a-plant

PDCA = Plan-Do-Check-Act

QA = Quality assurance

SPC = Statistical Process Control

SPT = Standard Pitch Time

SQC = Statistical Quality Control

TQC = Total quality control

TQM = Total Quality Management

UCL = Upper control limit

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ABSTRACT

To increase the productivity of quality products is the main target of an apparel company. There are many problems in apparel company which hinder the higher productivity. Unskilled workers, absence of regular training of workers, absence of engineering knowledge and engineering management, which are directly related to production and the disinclination of higher authority to implement the engineering management and engineering tools to increase productivity, are the main obstacles in production sector of apparel company. Irrelevant persons, who are placed in relevant place to control production, think that daily production rate can be easily increased by their stubbornness, whimsicality and exercising of power over workers.

In this thesis, an experimental investigation has been carried out to find out the factors which directly control the productivity. During the investigation attention is concentrated on how Time Study, Worker Rating, Method Study and Line Balance influence the daily production rate. It has been found that if regularly Time Study, Worker Rating, Method Study and Line Balance is continued and these results are properly implemented then daily production rate increases up to a satisfactory level with the same efficient workers, same machineries and same technical facilities. It is also found that implementations of these engineering tools not only increase productivity but also decrease defects rate of products, fatigue of workers and opportunity loss.

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

To be successful in today's business environment, organization must pay attention to quality and productivity. Every business today wants to have quality products and services and by that they mean products and services that are better than average, perform to the level needed, and are affordable. Quality is one of the most important ways by which industry can add value to product and services to set them apart from those of a competitor. At one time managers believed that there was an inevitable trade-off between productivity and quality. They thought that the two were diametrically opposed-that increasing one meat decreasing the other. But today, organizations consider that productivity and quality as the two sides of the same coin-one that can increase profits and builds customer loyalty. [1]

There is a clear relationship between quality and productivity. Generally, when quality increases, so will productivity, because waste is eliminated. The amount of inputs required to produce outputs is reduced. So productivity increases. This can happen as long as the individual or group of individuals is willing to exert effort and has the capability to achieve the quality productivity levels desired. It is the operation manager's task to provide the facilities, tools and desire or motivation to do so. [2]

1.2 PROBLEM STATEMENT

Quality is a customer determination, not an engineer's determination, not marketing determination or a general management determination. It is based upon the customer's actual experience with the product or service, measured against his or her requirements-stated or unstated. conscious or merely sensed, technically operational or entirely subjective and always representing a moving target in a competitive market. Product and service quality can be defined as, "The total composite product and service characteristics of marketing, engineering, manufacture and maintenance through which the product and service in use will meet the expectations of the customer". Some other terms as reliability, serviceability and maintainability have sometimes been used as definitions of product quality. [3] The product must perform its intended function repeatedly over its stipulated life cycle under intended environments and conditions of use. So it must have good reliability. It is also of overriding importance that the product must be safe. The product must have appearance suitable to customer requirements. So it must have attract ability. Quality is the total customer-satisfaction-oriented concept. [4]

The Bangladesh economy, which is highly dependent on readymade garments sector, is now providing opportunities to the talented Bangladeshi entrepreneurs to compete in export market with quality goods. The apparel exported to other countries from Bangladesh are showing ever increasing trends. But the readymade garments sector is now facing new challenges at the advent of WTO, seems to have partially succeeded in sustaining its progressive performance by increasing the level of quality. But garments companies of India, China, Sri-Lanka and Pakistan have dramatically improved the level of quality of readymade garments sector in order to maintain the international standards of quality. In comparison with these countries, Bangladesh is lagging behind in quality and productivity sector. Quality, Competitiveness, and Efficiency are largely ignored by the manufacturers of apparel in Bangladesh. The output of the apparel industry in Bangladesh is typified as low cost, low value added and poor quality.

During the last decade, there have been several changes in the international trade agreements for apparel products, which are generating new challenges and opportunities for the export-oriented apparel industry of Bangladesh. Bangladesh economy in association with low labor productivity, a low efficiency of the workers, lack of efficient infrastructure , low level of investment; lack of opportunities on the job training, lack of knowledge and awareness of the management about productivity and quality are intensifying the internationally originated challenges. So it is necessary for the readymade garments industry of Bangladesh to develop a standard framework for some functions of quality and productivity to maintain the international level of standards of quality to meet the changing needs of all the customers.

Application of industrial engineering tools and techniques, such as motion and time study job shop scheduling, etc are totally absent, though these tools can help in increasing productivity. Although there are several reasons behind these, all can be attributed to lack of knowledge and awareness of the management about productivity and quality improvement tools and techniques. Additionally, quality and productivity are closely inter-linked. Improvement in quality automatically increases productivity, because poor quality not only means wastage of productive time, but also wastage of material. The main issue is to analyze the case-specific situation of productivity and quality issues and parameters that are affecting a particular case. [3]

The company under consideration, located at Fatullah, Narayangonj, is a big composite garments organization, having partial vertical integration. This project aims at analyzing and subsequently suggesting appropriate tools and techniques, and providing guidelines as to how to approach implementation.

1.3 OBJECTIVES:

The main objectives of this study are

1. Analysis of current productivity and quality scenario, worker skill rating.

2. Time study of selected group of products and development of facility layout.

3. Line balancing.

4. Analysis of rejection/ defect rate and reasons.

5. Suggestions for interventions required.

The main outcomes of this study are; 1) Skills inventory, 2) A model for quality improvement, 3) Set of guidelines for improvement

1.4 METHODOLOGY

The steps of the methodology for the study are:

1. Analysis of overall value chain.

2. Data collection from the sewing floor and human resource department.

3. Worker rating and time study.

4. Development of skill inventory.

5. Application of suitable technique for facility layout and line balancing.

6. Analysis of situations for quality control, identification of quality characteristics.

7. Development of a model for quality improvement.

8. Suggestions for implementation.

CHAPTER TWO
LITERATURE REVIEW

2.1 QUALITY PRODUCTIVITY STRATEGY

Improving quality is one important way to maintain a competitive position in today's markets. Quality can be promoted to customers and employees. Consumers want quality products and services and employees at all levels in the organization like to be associated with a winner. Most peoples associate high quality with a winning competitive position. Although employees may balk when they are encouraged to work more productively, very few, if any, will argue with quality as a goal. [2]

From an economic prospective, when quality is emphasized and subsequently improved, waste is decreased or eliminated. Hours are not wasted by reworking products. Material is not thrown away. Operation cost is reduced. As a result productivity increases. At the same time, the customers receive products and services that are "fit" for use. Moreover, prices can be lowered to share this productivity gain with customers, thereby stimulating an increase in the firm's market share. Alternatively, the higher quality product can command a premium price and temporarily secure a market niche. Market niche is often temporary since high price invites competitor. To employees these results mean increased job security because of sound competitive position. Organization can benefit higher overall profits and improve asset utilization. In short, high quality can make every one a winner- a message some firms and managers seem to understand better than others. [2]

The business world has witnessed a changed in the trend and fashion of business in the 21st century. Quality has become a common norm for success in business .The quality revolution began in Japan after World War II and has now spread to North America and other parts of the world. But the level of success in Japan and other countries differ significantly. It is partly because of difference in organizational culture and organizational behavior. [5]

Quality emerged as a major factor in business success after World War II. when Japanese
Quality emerged as a major factor in business success after World War II, when Japanese
opted for fighting in two fronts- quality and price. Prior to this, the US business organizations tended to focus on only price, quality being a distant second factor. The success of Japanese changed the whole complexion of business in the world. People started realizing the utmost necessity of quality as the primary success factor. In fact, the Japanese injected a revolutionary idea that increased quality means decreased cost, a completely opposite idea commonly prevailing those days, even partly now-a-days. The Japanese got an upper-hand, by taking a significant lead in the world business and capturing a significant share of U.S market. The perceptions about quality among Japannse and the counterpart US manufacturers vary widely, in fact, it is a basic difference For example, while many U.S. companies measure poor quality in terms of defectives per hundred, many Japanese firms have achieved such a high level of quality that they measure poor quality in terms of defectives per million units produced. There may be conflict of interest in two parameters - cost and quality. The main theme is whether the customers 'value' the service (performance) obtained from the product against the price they pay. A balance between the price and performance of the product is the focal point of 'quality'. [5]

2.2 QUALITY MANAGEMENT

Quality management should be in every manager's vocabulary. All managers should be thinking about how every organizational process can be conducted to provide products and services that are responsible tougher and tougher customer and competitive standards. To be successful in today's business environment, organization must pay attention to quality. A quality revolution is truly afoot in business today. [1]

There are hosts of opinion as to how to define quality. Traditionally producers think about quality as a determinant of producers, more specifically determinant of engineers and marketing professionals. But the new concept of quality differs here. It defines quality as a determinant of customer, more specifically level of customer's satisfaction determines level of quality. Broadly speaking, customers want see a result from the product or service what they pay for. [5]

Quality is defined by many persons in many ways. Quality is the totality of features and Characteristics of a product or services that bear on its ability to satisfy stated or implied needs. [8] In general quality refers to the characteristics of a product or service that defines its ability to consistency meet or exceeds customer expectations. The characteristics are added to the product or service though out its value chain, right form materials procurement, up to customer use. As such, all the departments of an organization have some rules to play in determining quality of the product or service. [5]

Some others have defined quality as "Fitness for use" which typically means its performance, conformance, safety, durability and reliability. [5]

Quality of a product is determined by the following factors:

1. Well-known name.
2. Word of mouth.
3. Past experience.
4. Performance.
5. Durability.
6. Workmanship
7. Price.
8. Manufacturer's reputation.

Customer is influenced by the following factors of a product:

1. Price.

2. Quality itself.

3. Performance.

4. Well-known name.

5. Appearance.

6. Design and style.

7. Easy to use. [8]

2.3 DIFFERENT ASPECTS OF QUALITY

Customers are interested in various aspects of quality depending upon requirements, which may vary widely from case to case. It is hard to identify any specific aspect as being the sole characteristic of quality. In many cases. customers may not have clear idea about what aspect to look in to. Nevertheless, a customer generally has perceived ideas about quality, depending upon some commonly considered views.

However, whatever is done, one must always keep in mind that commitment to quality is actually ensured at design stage, which involves decisions regarding specific characteristics or aspects of a product or service such as shape, size, aesthetics, and so on. The designer has to decide about target quality against cost through an efficient quality plan. The `Quality of Design' refers to level of quality that can be achieved without increasing committed cost. An efficient design means better `Quality of Design'. This is done by the designer by including or excluding certain features in a product or service. Design decisions must take into account customer wants, production or service capabilities, safety and liability (both during production and after delivery), costs, and other similar considerations. Customer wants may be determined by collecting information through customer survey, a marketing research tool.

`Manufacturability' is another important thing to think about while preparing design. A good design may be such that it becomes difficult to manufacture, thereby increasing the chance failure and cost as well. Designers must work closely with representatives of operations to ascertain that designs are manufacturability; that is, production or service has the equipment, capacity, and skills necessary to produce or provide a particular design. The commonly considered aspects of quality that the customer may value include:

1. Performance: This refers to appropriate functionality of the product, or whether the Product performs satisfactorily as desired or expected by the customer. This refers not only the target output, but also up-to the-mark level of output, as planed by the producer.

2. Conformance: Each product should have a specification, either stated by the customer or designed by the producer. Conformance refers to how well or accurately a product or service corresponds to designed specifications. Out of specification situation is termed `defective' to mean non-conformance.

This adherence is important from customer point of view. Any deviation from specification creates customer dissatisfaction. Conformance is affected by process capability, operator skills, training, and motivation; manufacturability; monitoring process to assess conformance, corrective and preventive action, etc.

3. Reliability: This refers to the ability of an item to perform a required function under stated conditions for a period of time. It is measured in terms of probability of performsance. This may also mean consistency of performance over a period of time.

4. Durability: This refers to useful technical life or longevity of performance of the product or service. However, technical life may be shorter than economic life of the product.

5. Innovative features: Extensive research on product has led towards frequent introduction of innovative features in product line. This has in turn made product life cycle shorter. Innovative feature refers to extra useful characteristics of the product, more than the desired primary ones.

Service after sale - For many years, service after sales had been considered as an extra business, or an optional aspect. But, now-a-days, because of increased focus on customer satisfaction, service after sales is considered as part of the product. Handling of customer complaints, or checking on customer satisfaction, warranty, etc. are considered as aftersales-service.Truly speaking, increased competition brings better after-sales service as a follow-up activity to sales.

6. Maintainability / Serviceability - Maintenance and servicing of engineering products are of importance now-a-days to a large cross-section of customers. Products should be designed in such a way that it gives easy options for maintenance and servicing.

7. Ease of use - One of the recent trends of customer's quality requirements is ease of use of product. Customers never like a product which is complex to use. Thus, ease of has become one of the major aspects of quality.

It must be noted that quality does not mean technical complexity. From technology point of view, a product may be technologically excellent, but may not be a 'good quality product' if it is difficult to use for the customers because of technological complexity. While in use, 'Ease of use' and clear-cut user instructions are important. Customers, patients, clients, or other users must be clearly informed on what they should or should not do.

8. Aesthetics - Aesthetics of product, especially in case of consumer goods, is of utmost importance to customers. Thus, aesthetics is also an important aspect of quality.

9. Others - Now-a-days, many other aspects, such as safety, health issues, etc. are considered as part and parcel of quality. For instance, customers are increasingly becoming interested to know whether a product contains more than a safe range of chemical, which is detrimental to health. In addition to above aspects of quality, there are many other product/service specific aspects as well. [5]

So to achieve customer satisfaction quality of products and services must be an organization's number one priority." Quality assurance'' and "quality control'' address the means and technique of producing quality products. Quality assurance means to assure quality in a product so that a customer can buy it with confidence and use it for a large period of time with confidence and satisfaction. Quality control is a system of means whereby the quality of products or service is produced economically to meet the requirements of the purchaser. [8]

24 IMPLICATIONS OF QUALITY

There are several things which have direct implications with quality. Either they want it and use it, or they are responsible for delivering it. In other words, these are the key elements that have direct relation with quality. The basic elements those have implications with quality are of four categories:

1. Customers: They are the ultimate users or beneficiaries of quality. As such, any quality Management drive should focus on this element while preparing a quality plan.

2. Processes - This element is responsible for transforming the inputs to quality outputs. Traditionally, people used to think that the process is the only factor which needs to be controlled for ensuring quality. This is a blatant wrong idea. Modern quality management views that employees and materials (thus, suppliers too) should also be held responsible for quality.

3. Employees - Now-a-days, role of employee in delivering quality product is valued highly. Employees are considered as internal customers, who need to be kept satisfied in order to deliver quality product. Thus. they should be trained regularly, with high degree of motivation and skill.

4. Materials - Role of suppliers in delivering quality goods is now well recognized. A good manufacturing process does not have much to contribute to quality if supplied materials are not of good quality. That's why the Japanese producers now extend their quality activities up to the suppliers' premises. [5]

In recent year, operations management has experienced a revolution in manufacturing techniques and philosophies which includes as total quality control(TQC) and total quality management(TQM).Total quality control(TQC) is an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of various groups in an organization so as to enable marketing, engineering, production, and service at the most economical levels which allow for full customer satisfaction. [8]

Total quality management (TQM) is both a philosophy and asset of guiding principles that represent the foundation of a continuously improving organization. It is the application of quantitative methods and human resources to improve the materials and services supplied to an organization, all the process within an organization, and the degree to which the needs of customers are met, now and in future. Quality management integrates fundamental management techniques, existing improvement efforts and technical tools under a disciplined approach focused on continuous improvement. A customer is any one who receives or is affected by the product or process. There are two classes of customers: 1) External customers and 2) Internal customers.

External customers are people who are affected by the product, for example, The purchaser and ultimate users of good or service. In a broad sense, external customers include the general public or society. The term internal customer refers ton the people within the production organization. They are the people "up or down the line" in the departments and stakeholders (owners, investors, and contributors). The classical definitions of quality are insufficient to approach quality as a science. There are two fundamental elements of the science of quality.1) The experience of quality; 2) The creation of quality. Experience of quality: Experience of quality results from a product for an external customer or production process for an internal customer. The experience of quality results in customer satisfaction or dissatisfaction and is developed through the customer benefits created by and burdens resulting from organization's product process. In other words, the experience of quality is a function of fulfillment of human needs and expectations. The quality experience for external customers is developed in four fundamental dimensions: 1) product performance regarding function, form, and fit. 2) product cost(initial , operating, maintenance, and disposal cost). 3) product and service timeliness(delivery, product service, repair time, and so on) and 4)customer service Customers "buy" benefits to make their lives more productive and pleasant. Benefits must result from product in order to establish customer satisfaction. Customer must believe that they can obtain benefits in order to make a purchase and, furthermore, they must experience significant benefits to become satisfied customers. The experience of quality for internal customers is broadly centered in the production process. The basis for internal customers satisfaction is the same as for external customers – customer needs and expectation; however, the dimension are more abstract. These dimensions include job challenge, work place environment, reward and recognition. All in all, the experience of quality is a complicated phenomenon which is the true determinant of quality. If organization fail to recognize the experience of quality as the driving force for individual, organizational, and societal success then organization will be unable to focus it's effort to create quality. Creation of quality means to create quality through processes that organization develop and maintain. The creation of quality is accomplished through the following fundamental processes: 1) definition, 2) design, 3) development, 4) production, 5) delivery, 6) sales and customer service, 7) use, and 8) disposal, which includes recycle. Each of these general processes has distinctive quality characteristics. These fundamental processes form a sequence of activities that organization must approach in a systemic fashion to provide its external and internal customers with a positive quality experience. Figure 2.1 depicts the creation and experience of quality as an interactive sequence or system. This sequence has a profound influence on the internal customer in the early processes. The impact on the external customer develops in the later processes.

Creation of quality	Experience of quality
Qualities of definition Qualities of design Qualities of development Qualities of production	Benefits and burdens most apparent to internal customers (job challenge, empowerment, expect for workers, recognition for work, pay, hours, safety and so on).
Qualities of delivery Qualities of sales and service Qualities of use Qualities of disposal/recycle	Benefits and burdens most apparent to external customers (product function, form, and fit, long life, Cost, delivery time, and so on)

Figure 2.1 The experience and the creation of quality.

So to achieve customer satisfaction quality of products and services must be an organization's number one priority. [8]

The important characteristics of a product are specified when it is designed, prior to it's manufacture. The characteristics are called design specifications. After the product has been produced, it can be observed that the extent to which it conforms to or deviates from the design specifications. Quality or product quality is the degree to which the design specifications for a product are appropriate to it's function and use and the degree to which the product conforms to it's design specification. Service quality is similarly defined.

Among popular alternative concept of quality are the following:

1. Quality is fitness for use.

2. Quality is doing it right the first time and every time.

3. Quality is the customer's perception.

4. Quality provides a product or service at a price the customer can afford.

5. Customer pay for what he gets (Quality is the most expensive product or service)

The first key to managing for quality is being aware of the need to improve. Second is selecting improvement techniques with the best chance for success. An understanding of product characteristics, product design, and process capability will help an organization to be aware of quality issues in operations.

Product characteristics: All characteristics of a product are not equally important to all customers. The important product characteristics are determined by the specific market goals of the organization and by the technical requirements of the important stages of the conversion process.

Design: Price of same product of different firms always differs. The difference is often a result of the emphasis placed on quality in the design phases of product development, prior to full scale production. The old adage, "quality is design into the product," holds true. The number of stages on the conversion process, the types of input resources needed, and the types of technical processes required to produce the output are all largely determined in the product design phase.

Process capability: It is the ability of a conversion process to produce a product that conforms to design specification. Since the performance of machines and people used in conversion process varies from day to day, process capability is described by a range of variation from the design specification- the variation expected under normal working conditions. A statement about process capability is thus a statement about product uniformity. Instead of various parameters of the process – parameters of machines, workers, and so on-process capability relates to various parameters of the process.

The manager must first determine how quality fits into the overall organizational strategy. Then more specifically, manager must determine the role that quality will play in the manufacturing strategy, the approach used in production or operations should complement the overall strategy of the organization. Next the quality theme must be clarified. It is essential that individuals at all levels within the organization will comprehend the quality goals.

For any organization there are key elements that effect quality. Effective managers must be able to identify these elements – typically peoples, facilities, and materials and seek to understand how they affect the quality in the organization.

Organization can developed company wide quality control (CWQC) which has evolved from inspection oriented quality control through a statistical quality control growth phase and total quality control growth phase. The goal of CWQC is to mobilize the entire work force in a pursuit of specific company goals aimed at satisfying customer requirements for quality, price and delivery.

The CWQC organization improves the effectiveness and efficiency of every element in the business through statistical thinking, managing with facts, and preventive defects and error and stresses these six elements:

1. Consider quality first in all business thinking and action.

2. Ensure the quality of new product development.

3. Make quality customer oriented, not product oriented.

4. Consider the next step in any process as the customer.

5. Use a continuing "plan, do, check" action cycle in all business element.

6. Respect humanity.

A key to achieving and marinating high quality is first to set a strategy, and then effectively communicate this strategy as a theme to employees and customers. Reflecting definition of quality both product design and conformance to the design specifications must be clarified for engineering and operations. To establish and achieve the desired quality, there are several significant steps in effectively managing for quality. Figure 2.2 summarizes the activities operations managers must perform to establish an overall quality framework, as well as to carry out the details to achieve or improve quality.

The manager must first determine how quality fits into the overall organizational strategy. Then more specifically manager must determine the role that quality will play in the production or operation strategy; the approach used in production or operations should complement the overall strategy of the organization. Next the quality theme must be clarified. It is essential that individuals at all levels within the organization must comprehend quality goals. [2]

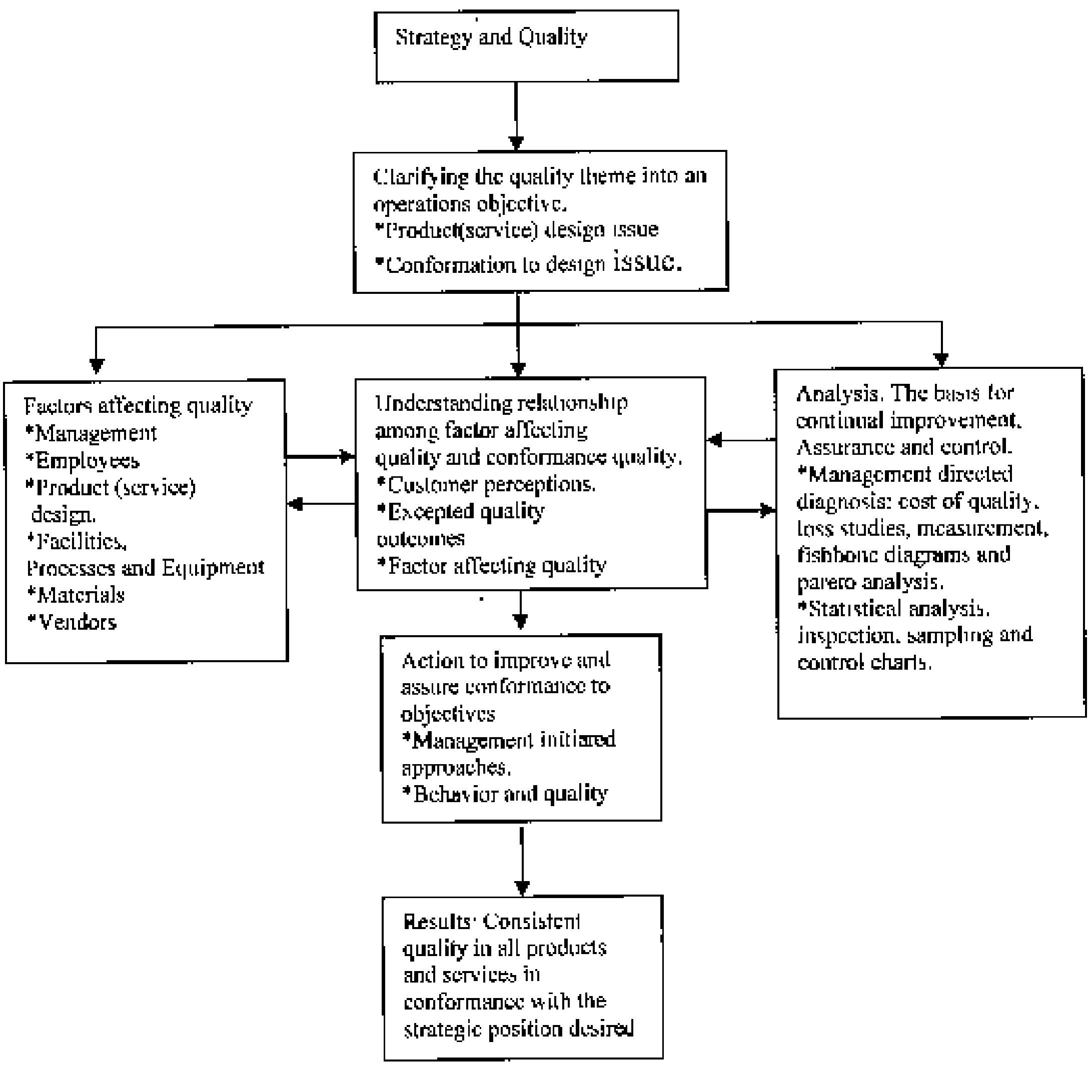

Figure 2.2 Managing for quality products and services.

To ensure quality an organization must emphasize that people skills, materials, and processes are blended together to provide product and services for customers. These products and services are of certain quality, evaluated by how well they conform to expectations. Expectation must be customer based rather than internally based, that is, manufacturing or engineering based. In reality, manufacturing and operations attempt to conform to internally based expectations. Thus, the design must ensure that these internally set specifications are consistent with customer expectations. Furthermore, design must also ensure that specifications are accurately translated into the language of manufacturing and operations – bills of materials, drawings, route sheets, procedures manuals, job description and so forth. In manufacturing, this is the work of manufacturing engineering. There must be a customer product or customer service link, a well managed interface with clear instructions and feedback to operations, where the work is actually performed. This link is equally important for services and manufacturing organizations. [2]

To be more specific about the blending of people skills, materials, and processes, manager must know about the key variables in operations that affect product or service quality. Though it depends on manufacturing or service situation, it is needed to clarify. The way resources are blended (technology), the relative emphasis of one resources over another (cost structure), and the skills and abilities of people are all crucial. Competition, pride, knowledge – they list can go on and on as to what contributes to quality performance. At this point attempts to definitively model these interrelationships are speculative at best. Advances in product or service design, statistical thinking, planned change, and selected behavioral interventions hold the most promise for contemporary operations managers attempting to improve quality. A systems Viewpoint helps manager to understand the key elements, both external and internal affecting quality. The organization as a system interacts externally with customer and vendors- two key elements that specify and effect quality at the boundaries of the firm. Internally, an organization's managers, employees, materials, facilities, and equipment all affect quality. [2]

2.5 EVALUTIONS OF MODERN CONCEPTS

The recent view of quality management has arrived at this stage through a long history of evolution. Several experts contributed in revolutionary manners, which completely reshaped the ideas of quality management what people used to think for a long time. In many cases, the new ideas are just the opposite side of the coin. For a long time, people used think that quality is an issue to be dealt by quality control and production departments. This vital function was really confined within the functional boundary of these two departments. The quality control was heavily inspection-based before its final delivery to customers. In this kind of mass inspection system, emphasis was on finding and correcting problems, known as rework. Two major problems, related to this kind of system are : firstly, time required for heavy inspection, and manpower required incur considerable costs; secondly, in many cases, hidden problems could not be found before the end of the line. In the 1950s, the philosophies of quality management went through a revolutionary change. Before that, people used to think suppliers as adversaries, who need to be dealt with strong hand through tough negotiation. The raw material suppliers' stake and interest in product quality was not of interest to the suppliers themselves. On the other hand, suppliers' contribution to quality and role was not recognized by the producers too. [5]

But from late 1950s and early 1960s, the philosophies went through a breakthrough change. The philosophy of `mutual benefits' of suppliers and producer got footage. Many companies, especially those Japanese, shifted their concentration from detecting defects in the production process, to prevention, company-wide. Price tag based supplier selection was shifted to long-term relation-based supplier selection. Moreover, quality is no longer the exclusive domain of the quality control department. Instead, it is the responsibility of everybody in the organization. Suppliers are being treated as partners in the quality venture. In this more enlightened approach; price is only one of several considerations that are taken into account when dealing with suppliers.

The complete evolution of quality may be divided in to four domains:

1. Early stage: Inspection-based quality

As outlined earlier, quality was totally inspection-based. Inspection aimed at sorting and grading the output. In this stage, the corrective action took place at the end of the production line, when wastes were already created, and corrective action was impossible.

2. The next stage: Statistical Quality Control

People started realizing that heavy inspection-based systems are often time consuming and expensive. The new idea was sampling-based, where random samples used to be taken for further statistical analysis to evaluate the ability of the processes. This is known as Statistical Process Control and Statistical Quality Control (SPC/SQC). Necessary actions used to be taken when the system goes out of the limits. But still then, involvement of all in the organization was not though of. The idea was still limited to quality and production departments.

3. The third stage: Quality Assurance

A new idea evolved which says - one can give early assurance if a process is diagnosed as being capable. Quality assurance (QA) phase, in which stress was on providing some advance assurance of quality of the service/products that it would fulfill the requirements of customers. received acceptance.

4. Last and current stage: Total Quality Management (TQM)

The most modern idea of quality says - quality is not the responsibility of two departments only, rather a responsibility of all in the organization. When the philosophy of 'Customer satisfaction' became the definition of quality, the organization-wide quality management got establishment. This is Total Quality Management (TQM), which advocates for end-less continuous improvement

Table 2.3: Summary of evolution.

Criterion	Stage I Inspection	Stage 2 SQC	Stage 3 QA	Stage 4 TQM
Objective	Measurement of specifications for conformance	Statistical Process Control for analyzing process capability	Developing a capable process for advance assurance, documentation and audit	Responsibility for all, and continuous improvement, Internal and external customer satisfaction
Responsibility for quality	Quality control and production departments	Quality control and production departments	All departments	Top management leadership with involvement of all, including external stakeholders (e.g. suppliers, etc.)

The above table (Table 2.3) summarizes the views of these stages of evolution. [5]

2.6 QUALITY CONTROL

In management, control is the next step of planning. Once the plan is implemented for execution, it needs to be monitored to ensure stipulated outcome. This is where certain degree of control is required. The activities required for meeting the planned or desired quality target. for conformance, is termed quality "control". It is quite similar to production control in the shop floor, or budget control in the financial year, or cost control in project management. [5]

There are normally four steps in such control:

I. Setting benchmarks - Determine the required quality target in terms of a tradeoff between cost and quality characteristics/aspects (such as performance, reliability, etc.). While setting benchmarks, or standards, manufacturability of machineries and equipment, and skill of manpower need to be taken into account.

2. Appraising conformance. Regular monitoring and evaluation are essential for measuring key characteristics of quality, preferably in quantitative terms, which should be followed by appraisal for ensuring conformance as per specifications.

3. Acting when necessary. If conformance appraisal shows deviation from the benchmarks, or stipulated output, necessary correct measures should be taken in order to avoid such occurrence. Necessary diagnosis must be performed to identify and subsequently remove their causes throughout the complete value chain functions, such as, procurement, design, production, maintenance, delivery, logistics, etc.. which influence customer satisfaction.

4. Planning for improvements. As control functions have significant impact on quality, necessary plans must be formulated for future better quality control.

This seems fairly similar to Plan-Do-Check-Act (PDCA) cycle of TQM, which has been discussed thoroughly in TQM section of this book. Effective and efficient control is the key in management success. If control fails, the organization fails to operate. [5]

2.7 CONCLUSION

The consequences of poor quality are grave and of many folds in business term. Poor quality means many things, which are sometimes irrecoverable. Some are worth explaining:

1. Lower productivity

2. Loss of productive time

3. Loss of material

4. Loss of business

5. Liability

Productivity and quality are closely related, thus, inseparable. Since, poor quality means rework and rejection; it adversely affects productivity in manufacturing process. Studies have shown that garments companies in Bangladesh have rework rate as high as 10%, which approximately means 10% loss in productivity (though productivity calculation is not this straight forward).Productivity in Japanese industries is very high for many reasons, one being the philosophy - 'Right the First Time', which means no defectives at all, even no loss of time through trial and error.

In many cases, the defective products can not be reworked for further use. This may mean rejection, which not only means loss of material, but also loss of other resources and useful time spent in producing those products The most severe problem of bad quality is loss of business. Failure of a product while in use can severely damage the organization's image, which is detrimental for business.

A potentially devastating consequence to the bottom line is the reaction of the consumer who receives a defective or otherwise unsatisfactory product or service. A recent study showed that, while a satisfied customer will tell a few people about his or her good experience, a dissatisfied person will tell an average of 19 others. Loss of image can be detrimental to organization's survival. It must be remembered that image or brand is created over the years of reputation, while one or two defective products may destroy the image in a moment.

Poor quality increases certain other costs. These include liability costs in terms of warranty cost, replacement and repair cost after purchase, and any other costs expended in transportation, inspection in the field, and payments to customers or discounts used to offset the inferior quality. In some instances, the costs can be substantial. Liability claims and legal expenses are perhaps obvious. Other costs can also be substantial. [5]

2.8 PRODUCTION MANAGEMENT

Production or operation management refers to the complex set of management activities involved in planning, organizing, landing and controlling an organization's operations. At one time, operations management was considered the back water of management activities- a dirty, drab necessity. This view has changed in recent years as more and more managers realize how operations can be a 'beehive' of activity with major financial consequences for any organizations. Production management is important to an organization's managers for at least two reasons. First, it can improve productivity which improves an organization's financial health. Second, it can help an organization to meet its customer's competitive priorities. [9]

Production or operation refers to the way that members of an organization transform inputs- labor, money, supplies, equipment and so on- into outputs- goods or services. Any organization can be viewed as a system, a set of related and interacting subsystems that perform functions directed at reaching a common goal. These subsystems can, in turn, be viewed as separate systems. This idea is shown in figure 2.4

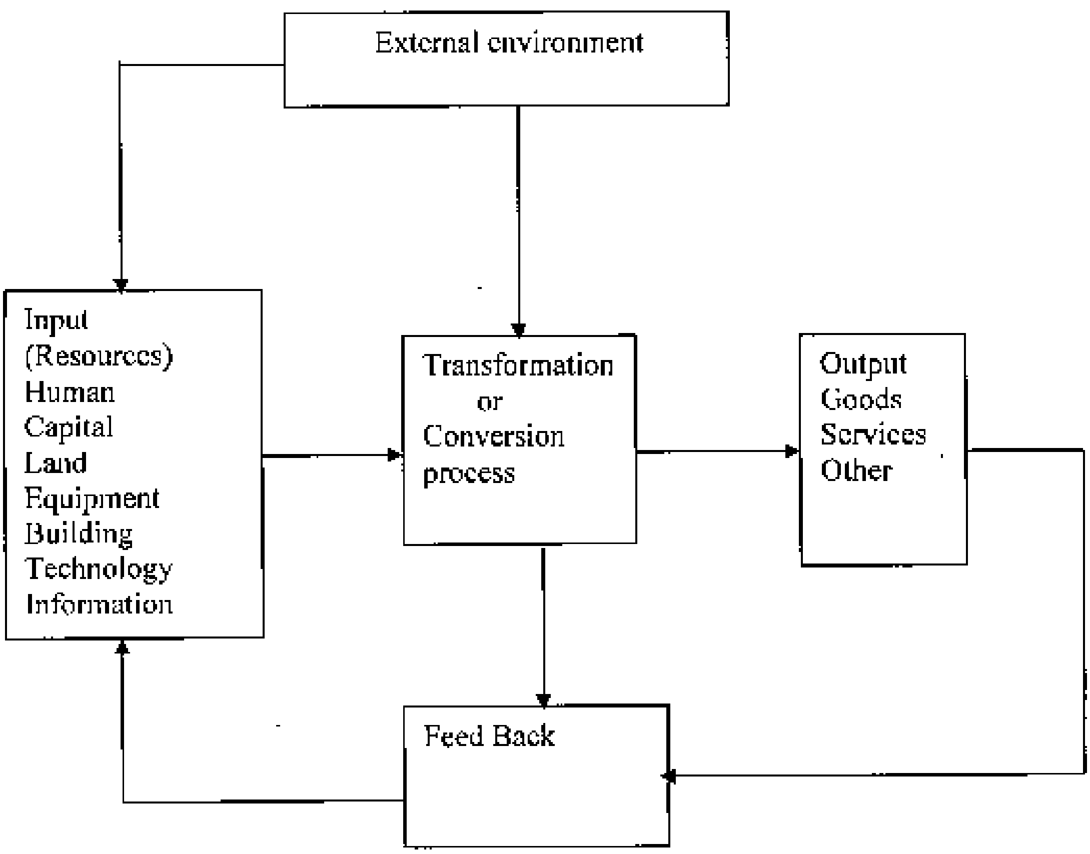

Figure 2.4 Model of Production management

To manage productive resources is critical to strategic growth and competitiveness. Operation or production management is the managing of these productive resources. It may be defined as the design, operation, and improvement of the production systems that create the firm's primary products or services. It entails the design and control of systems responsible for the productive use of raw materials, human resources, equipment, and facilities in the development of a product or service.

Operation strategy is concerned with setting board policies and plans for using the resources of the firm to best support the firm's long-term competitive strategy. A firm's operations strategy is comprehensive through its integration with corporate strategy. The strategy involves a long time process that must foster inevitable change. Operation strategy refers manufacturing operations. An operations strategy involves decision that relate to the design of a process and the infrastructure needed to support the process. Operation strategy can be viewed as part of planning process that coordinates operational goals with those of the larger organization. Since the goals of the larger organization change over time, the operation strategy must be designed to anticipate future needs. The operations capabilities of a firm are a portfolio best suited to adapt to the changing product or service needs of the firm's customers. Keys to success in operations strategy lie in identifying what the priority choices are. in understanding the consequence of each choice. and in the trade-offs involved. These priorities include cost, product quality and reliability, delivery speed, delivery reliability, ability to cope with changes in demand, flexibility and new product introduction speed. and other criteria particular to a given product.

Cost: Within every industry, there is usually a segment of the market that buys strictly on the basis of low cost. To successfully compete in this niche, a firm must be the low cost producer. but even doing this does not always guarantee profitability and success. Products sold strictly on the basis of cost are typically commodity-like in nature. In other words, customers can not distinguish the product of one firm from those of another. As a result, customer use cost as the primary determinant for making a purchase. However, this segment of the market is frequently very large, and many companies are lured by the potential for significant profits, which they associate with the large unit volumes of product. As a consequence, competition in this segment is fierce- and so is the failure rate. After all, there can only be one low cost producer, which usually establishes the selling price in the market.

Product quality and reliability: Quality can be divided into two categories as product quality and process quality. The level of quality in a product's design will vary with the market segment to which it is aimed. The goal in establishing the proper level of product quality is to focus on the requirements of the customers. Over designed products with too much quality will be viewed as being prohibitively expensive. Under designed products, on the other hand, will lose customers to products that cost a little more but are perceived by the customers as offering greater benefits. Process quality is critical as it relates directly to the reliability of the product. The goal of process quality is to produce error free products. Product specifications, given in dimensional tolerances, precisely define how the product is to be made. Adherence to these tolerances is essential to ensure the reliability of the product as defined by its intended use.

Delivery speed and delivery reliability: This priority relates to the ability of the firm to supply the product or service on or before a promised delivery due date. Coping with changes in demand: In many markets, a company's ability to respond to increases and decreases in demand are an important factor in their ability to compete. It is well known that a company with increasing demand can do little wrong. When demand is strong and increasing, cost are continuously reduced due to economies of scale, and investments in new technologies can be easily justified. Scaling back when demand decreases may require many difficult decisions relating to lying off employees and related reduction in assets. The ability to effectively deal with dynamic market demand over the long term is an essential element of operations strategy.

Flexibility and new product introduction speed: Flexibility, from a strategic perspective, refers to the ability of a company to offer a wide variety of products to its customers. An important element of this ability to offer different products is the time required for a company to develop a new product and to convert its process to offer the new product.

Other product-specific criteria: The priorities described above are certainly most common. There are often other priorities that relate to specific products or situations. These are often provided to augment the sales of manufactured products.

Technical liaison and support: A supplier may be expected to provide technical assistance for product development particularly during the early stages of design and manufacturing.

Meeting a launch date: A firm may be required to coordinate with other firms on a complex project. In such cases, manufacturing may take place with development work is still being completed. Coordinating work between firms and working simultaneously on a project will reduce the total time required to complete the project.

Supplier after sales support: An important priority may be the ability of the firm to support the product after the sale. This involves the availability of replacement parts and, possible, the modification of order, existing products to new performance levels. Speed of response to these after sale needs is often important as well.

Other priorities: These typically include such factors as colors available, size, weight, location of the fabrication site, customization available, and product mix options.

The notion of trade-offs: Central of the concept of operations op production strategy during the late 1960s and 1970s was the notion of operations focus and trade-offs. This logic was that an operation could not excel simultaneously on all performance measures. Consequently, management had to decide which parameters of performance were critical to the firm's success, and the concentrate of focus the resources of the firm on those particular characteristics. High quality was also viewed as a trade –off low cost. For those firms with large existing manufacturing facilities, it is suggested the creation of a plant-with-a-plant concept, in which different locations within the facility would be allocated to different product lines, each with their own operations strategy. Under PWP concept. Even the workers would be separated to minimize the confusion associated with shifting from one type of strategy to another. The concepts of factory focus and PWP are still widely employed today. The notion of trade-offs has given way to the need to do everything well, and the issue has instead become one of determining priorities. [9]

The production system (function) of an organization is the part that produces the organization product. In some organization the product is a physical good while in others it is a service. The basic element of production system is shown in figure 2.2. It has a conversion process, some resource inputs into that process, the outputs resulting from the conversion of the inputs, and information feedback about the activities in the operations system.

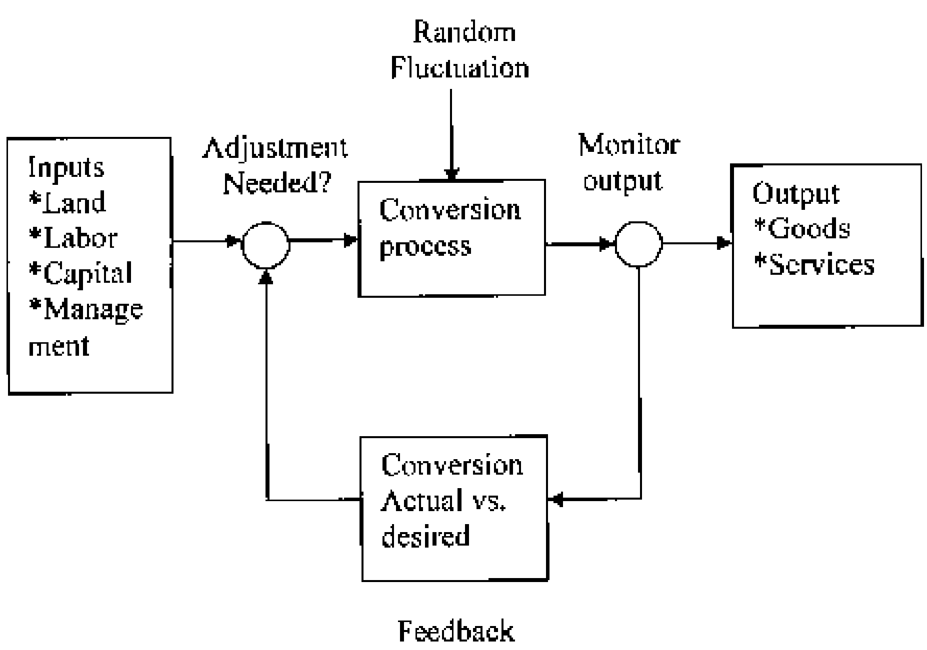

Figure 2.5 The operation system for an organization.

Main production function is the transformation of resources into goods and services. For all production systems the general goal is to create some kind of value added, so that the outputs are worth more to consumers than just some of the individual inputs. Product quality is the direct result of the coupling of inputs and conversion process.

The random fluctuations listed in figure 2.3 consist of unplanned or uncontrollable influences that cause the actual output to differ from the expected output. It can arise from external sources (fire, floods, lighting etc.) or they can result from internal problems such as imperfections in materials and equipments or simple human error. The feedback loop in figure 2.3 provides key information to manager. Without feedback, managers cannot control productions because they do not know the results of their decisions. [2]

Two general types of strategies exist for creating products that meet or exceed customer needs and expectations: 1) Process focused and 2) product focused. In general, a process focused strategy concentrates on process integrity in a proactive manner. A process focus is more concerned with how we design and build our product rather than with what we design and build. A product focus is more concerned with exactly what we design and build rather than how we design and build it.

Process improvement thinking has evolved over the years. Initially, process improvement consisted of isolated and functionalized applications of methods engineering, time study, line balancing, flowcharting, motion study, and other classical engineering tools. Today, process improvement consist of integrated applications of the classical tools, as well as statistical methods of process control and off-line experimentation applied at critical process "bottlenecks" or "choke points." This new approach makes up a large part of total quality management. Today we see integrated quality planning, training, analysis, corrective action, and information system networks throughout production facilities. In many cases, the processes necessary to design and build a product are more complicated than the product itself. The input and the processes determine, to a large extent, the quality, performance, cost, and delivery time that our customers experience for any given product.

Product performance has always been recognized as a critical component in establishing a competitive edge in a market driven economy. Now more than ever before, process improvement and process quality control are also recognized as critical factors in establishing a competitive edge. Process transforms the inputs or resources to the outputs and is linkage between resources and products. Processes involved in all phases of the product life cycle. That is, processes exist for pro-duct definition, design, development, production, delivery, sales and service, use and, disposal. The more effective and efficient our conversion processes are, the more competitive our organization will be within it's market. Process improvement consists of improving our means of converting resources to products. In process improvement analysis, there are a five level hierarchy to guide our creative effort to enhance process performance. This hierarchy is depicted in figure 2.6.

1. Elimination: Organization seeks to eliminate non-value added activities. Sometimes we may not totally eliminate, but replace, the functional essence of the activity with a superior technology.

2. Combination: Next, Organization seeks to combine4 activities in order to extract process improvement.

3. Change of sequence: It is examined the sequence to see if a reordering will provide improvement.

4. Simplification: Here it is examined that the activities with the expectation of improvement through simplifying the activities themselves.

5. Addition: In some cases where processes are clearly ineffective, it may need to add a process step; but additions are last resort.

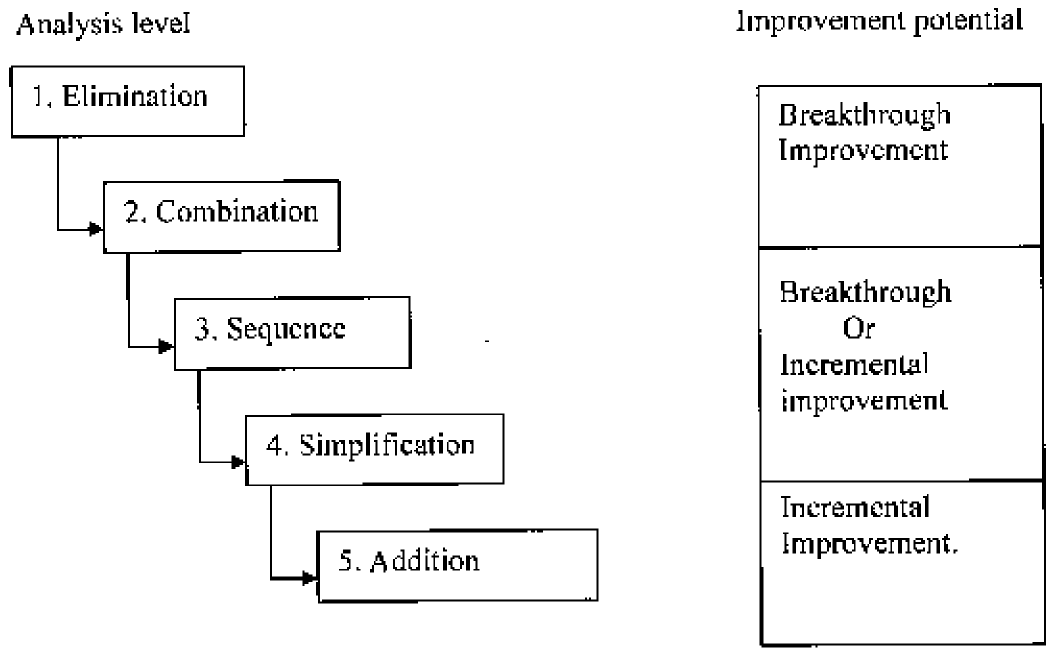

Figure 2.4 The process improvement analysis hierarchy. [8]

Three approaches such as planning, organizing and controlling are needed to construct a framework for managing operations or productions.

1. Planning: The productions manager defines the objectives of the productions subsystem of the organization, and the policies, programs and, procedures for achieving the objectives. This stage includes clarifying the role and focus of productions in the organization's overall strategy. It also involves product planning, facilities designing, and using the conversion process.

2. Organizing: Production managers establish a structure of roles and the flow of information within the production subsystem. They determine the activities required to achieve the productions subsystem's goals and assign authority and responsibility for carrying them out.

3. Controlling: To ensure that the plans for the production subsystem are accomplished, the production manager must also exercise control by measuring actual outputs and

comparing them to planned outputs. Controlling costs, quality, and scheduling are at the very heart of production management. [2]

Production managers plan, organize, and control the conversion process they encounter many problems and must make many decisions. They can frequently simplify these difficulties by using many planning models. To produce effectively and efficiently, management must establish goals for evaluating employee performance. These goals are translated into standards. A production and operations standard is a quantified criterion for measuring or judging output. The standard can be set for quantity, quality, or any other attribute of output, and it is the basis of control. Standards at various levels in the organization are:

Individual standards: The terms standard, labor standard, production standard, labor tome standard, and time standard are often used interchangeably in production or operation management. A labor standard is simply the output expected from an average worker under average working conditions for a given time period. It is the concept of a fair day's work. A standard for workers at the lowest level within the organization is expressed in terms of time allowed per unit of out put or, conversely, out put required per unit of time.

Departmental standard: Several workers may perform as a unit, thus forming a team assembly operation. These teams may have one standard for the team's out put. By adding all the individual and team standards together, manager can set department standard for quality, quantity, cost, and delivery dates.

Production and operations, one of the basic units of accountability is the department; the supervisor of the department is often evaluated in terms of his or her ability to manage the department efficiently. Frequently this evaluation is made against5 an expectation to operate at or near hundred percent labor efficiency, the comparison of "actual" labor hours to "standard" labor hours. For every actual labor hour used directly in operations, an expected number of pieces should be produced; this expected number is the standard. If this labor standard is achieved, we say hundred percent efficiency is achieved. If the standard is exceeded, more than hundred percent efficiency is achieved; and if the standard is not achieved. less than hundred percent efficiency is achieved. [2]

Plant standards: At the plant, or comparable service unit (such as hospital or school), a specified volume of goods or services must be produced; labor, materials, and overhead standards must be maintained, and at the same time their cost must be controlled. If manager is familiar with cost accounting systems, he realizes the need for accurate cost system for labor, materials, and overhead. Likewise, quality levels must be maintained commensurate with product objectives. So production managers have multiple goals, and they must account for them with multiple standards. [2]

2.9 CONCLUSION

The operation or production manager's job is a challenging in today's complex environment. The diversity of the worker force's cultural and educational background, coupled with frequent organization restructuring, calls for a much higher level of people management skills than have been required in even the recent past. The objective of managing personnel is to obtain the highest productivity possible without sacrificing quality, service or responsiveness. The interrelated issues facing operation or production manager are summarized bellow:

Speeding up the time it takes to get new product into production: This calls for coordination between product designers, process engineers, and production. To be effective, such specialties must work as a team to avoid the common silo effect in which each group worries only about its particular function. Completing activities concurrently rather than sequentially is an important ingredient to reducing the time it takes to deliver new products.

Developing flexible production systems to enable mass customization of products and services: In virtually every industry, there is a broadening of product lines to provide the variety of choices that customers want or at least, that marketers say they want.

Managing global production networks: This issue has three aspects. One is assuring that components produced outside, meet the design and quality requirements. This entails careful selection of suppliers and anticipating local labor and government actions. The second is managing the logistics of shipping and receiving parts. The third is developing the information system to track and monitor the first two.

Developing and integrating new process technologies into existing production system: Technology is abundant, but applying it effectively is often difficult. Sometimes the problem lies in the complexity of linking computer based systems. Other times it involves cost accounting measures that force high utilization of expensive equipment, even if some less expensive machine could perform the task just as well. A common example here is dedicating expensive flexible manufacturing machinery to making long runs of a single product model rather than using cheaper in flexible equipment.

Achieving high quality quickly and keeping it up in the face of restructuring: TQM is here to stay, but companies do not have the luxury of the long development periods to achieve quality partly with the competition. Likewise, it is hard to maintain workforce enthusiasm for quality when their jobs are at risk.

Managing a diverse workforce: Multiple languages and multiple cultures are common on U.S shop floors as well as in other developed countries. For example, 26 different cultures are represented among the 420 workers at Toyota Auto body of California's truck bed assembly plant in long beach. Only four of these workers are Japanese, and they are staff advisers on assignment from Japan.

Conforming to environmental constraints, ethical standards, and government regulations: Issues of social responsibility affect all parts of the organization, but operation is often the focal point because it is the prime user of physical resources that may lead to pollution and other safety hazards. Companies are now developing so-called green strategies as part of their corporate planning.

A company that is considered to be world class recognizes that its ability to compete in the market place depends on developing a production or operation strategy that is properly aligned with its mission of serving the customer. A company's competitiveness refers to its relative position in comparison to other firms in the local or global market place. In this case productions or operations are a dominant competitive weapon. [9]

CHAPTER THREE

COMPANY PROFILE AND PRODUCT DESCRIPTION

3.1 LOCATION

Fatullah Fashion Garment, under this study is situated at Khizirpur, Fatullah on Narayangonj in Bangladesh.

3.2 DESCRIPTION OF THE COMPANY

Fatullah Fashion Garments established in 1998 is a 100% export oriented garments manufacturing company with a mission to be best export in providing from the Bangladesh to our valued customers around the world. Fatullah Fashion Garments has concentrated all it's strength and resources in developing and producing a wide range of quality garments for the international market. Our management believes on professionalism and ensure hard working and sound man is committed to deliver quality garments to it's customer well in time. It has capability to handle substantial volume of orders with reasonable time. This company is committed to produce high quality, sophisticated products and continuously try to improve in quality management with every year to come.

This factory adheres to all of major merchandising as per local & abroad, factory certification and labor compliances from 3rd party as per local law or buyer requirements. Utmost importance has been given to production layout and the quality control department, which gives us 100% quality assurance with inventory check, in-line inspection & final inspection before final inspection / shipment by Buyer or 3rd party. Fatullah Fashion Garments Company is one of the on going leading garment factory in Bangladesh where we providing local law facilities, dining facilities, prayer room & medical facilities for workers on time. Even our factory is giving a wonderful circumstance facility for worker. Also we are providing some facilities for Buyer / representative such as living, dining and rest room. We take pride in our dedication to achieve the best possible results for our clients.

3.3 COMPANY PROFILE

Name of the Company: Fatullah Fashion Garments Ltd.

Address: Khizir Pur, Fatullah, Narayangonj, Bangladesh.

Key persons: 1. Abdul Awal
Executive Director
2. Shibly Ahamed
Managing Director
3. Md. Mizanur Rahman
Director

Year of Establishment: 1996

Banker Name : Sonali Bank, Local office
Motijheel C/A, Dhaka,
Bangladesh.

Employees: Cutting 50
Sewing 200
Finishing 100

Total Machinary: Cutting 50
Sewing 200
Finishing 50
Total 300

Production Capacity: 5200 PCS per day

Business type : Manufacturer and Exporter

Annual Sales Range: US$ 1 Million – US$ 1.5 Million

Geographic Markets: World wide

3.4 FACTORY SPECIFICATION

Fatullah Fashion Garments company is a four storied building. It's every floor space is 12000 square feet. Total floor space is 48000 square feet. The ground floor is allotted for raw material stock. The first floor is allotted for cutting section. The second floor is allotted for sewing section and third floor is allotted for finishing and quality inspection section. Entry and exit points from each section is same. It tries to meet all fire code regulations. Salary payment date is 5^{th} on every month. It provides free factory uniform to workers. It has five wash rooms for workers in factory floors.

3.5 PRODUCTS DESCRIPTION

Fatullah Fashion Garments produces men's, ladies and children's wear. It produces T-shirt, Pique Polo shirt, Auto stripe, Long sleeve Tuttle neck shirt. Shorts, Tank top, Vest etc for men's, children's, ladies. Knitted night dress, Sweet shirt, Roll neck T-shirt etc.

CHAPTER FOUR

TIME STUDY AND WORKER RATING

4.1 TIME STUDY

In every apparel industry the processing time exists simply because the process requires tasks and motion. To put it in a different way, the working method and the number of work components are closely related to the net processing time. The time study begins by measuring the number of seconds required to "lift, sew and place" something. It then proceeds to making improvements based on time values, and ends by defining the differences in the time values caused by the individual differences of the workers. [7]

4.2 PURPOSE OF TIME STUDY

1. To understand the production capacity of the apparel industry, and to draw up plans for an appropriate target output, suitable range of divided labor and optimum production, scheduling, personnel planning or equipment planning.

2. To investigate the level of individual skill.

3. To determine the time value for each work component under the motion study, which support improvement and standardization?

4. For use as a yardstick in evaluating the operation.

5. To draw up plans and make estimates for a change of product or for the construction of a new or additional factory.

6. To obtain an evaluation standard for order receiving planning, using the time study as the basis of the cost estimate and control.

7. For use as the basis for determining the unit cost of manufacture and the wage rate.

8. For use as the basis for introducing a production control system.

To produce products, manufacturing processes are divided into several workers and each worker carries out the same work allotted to him/her in a short period of time to increase efficiency in production. This system is called the rating of worker. The rating of worker helps to achieve simplification, specialization and standardization for rationalization to Increase in production. A method to allot the workload evenly to each worker so that Products are produced at a consistent speed is called "flow production system." To successfully carry out the flow production system, synchronization in the rating of workers is necessary to create the situation where required goods are provided at required time by required quantity.

Reference value for synchronization in the rating of worker is called the pitch time (PT). Pitch time provides the average time allotted to each worker. PT is also called average actual cycle time. The rating of worker is synchronized by referring to pitch time that is calculated on the basis of numerical data.

Pitch Time = (Sum of times recorded to perform each element) / (Number of cycles obsc - erved)

Operator performance rating or Observed Rating (OR) is calculated as

OR = (Units of work actually produced by worker) / (Units of work which could be produced at standard performance)

Standard Pitch Time or Standard processing Time (SPT) is the average standard processing time allotted to each worker where allowance rate is included

Basic pitch time (BPT) means the average basic processing time allotted to each worker where allowance rate is excluded.

BPT = Observed time (OR) x Observed rating (OT)

Standard Processing Time = BPT x (1 + allowance rate). For light manual work range of allowance is (12 to 14) %. In this thesis allowance rate is taken 13 %

For the pitch time, the similar relation exists and is expressed with the following formula. SPT = BPT x (1 + allowance rate) Here SPT is the standard processing time separately for each process. [7]

In this thesis Average time or Pitch time, Basic Pitch time, Standard processing time and worker rating for every individual process, of a T-Shirt of a sewing section have been studied before splitting and after splitting. Also adopting the technique of Method Study, Average time or Pitch time, Basic Pitch time, Standard processing time and worker rating for every individual process, of a T-Shirt of a sewing section have been studied before splitting and after splitting These expressions are presented in Table 4.1, 4.2, 4.3. 4.4, 4.5, 4.6, 4:7. 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, 4.17, 4.18. 4.19, 4.20

4.3 TIME STUDY: SITUATION I

At first Pitch Time of all workers of all work stations of a sewing section of a T-Shirt have been collected. Then using the Pitch Time worker's per hour production, worker rating and Standard processing time of all work stations have been calculated. These expressions are presented in Table 4.1, Table 4.2, Table 4.3 and Table 4.4

Table 4.1: Pitch Time of a T-Shirt of sewing section

Serial No	Machine Name	Operation Name	Operator Name	Observed Time								Average Time, Sec	Total average Time, Sec
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	30 48	30.17	29 9	29 58	29 22	29 42	29 12	28 61	29 56	29 437
			1B	30 31	30	29 6	29 32	29	29 18	28 76	28 34	29 314	
2	Over Lock M/C	Neck Join	2A	30	29 81	29 5	29 31	29	29 2	28 79	28 34	29 249	29.187
			2B	30	29 77	29.4	29 11	28.84	29	28 68	28 19	29 125	
3	Flat lock M/C	Back neck Tap Join	3A	30 58	30 38	30 1	29 78	29 39	29 57	29 34	28 92	29.76	29 805
			3B	30 68	30 47	30 2	29 88	29 5	29 63	29 4	29	29 85	
4	Flat lock M/C	Neck Tap Sewing	4A	29 56	29 36	29 1	28 86	28 55	28.63	28 36	28	28 804	28 858
			4B	29 66	29 43	29 2	28 94	28 68	28 73	28 46	28 19	28 911	
5	Plane M/C	Neck Top Sewing	5A	31.53	31 23	31	30 84	30.52	30 68	30 32	30	30 765	30.86
			5B	31 77	31 48	31.2	31	30 72	30 88	30 45	30 12	30 954	
6	Flat lock M/C	Sleeve Hem Sewing	6A	31.22	31 06	30 8	30 59	30 32	30 47	30 2	29 92	30 57	30 5
			6B	31 1	30 91	30 6	30 41	30 13	30 33	30 09	29 78	30 423	
7	Over Lock M/C	Sleeve Join	7A	36 23	36	35 8	35 55	35 23	35 4	35 11	34 89	35 524	35 47
			7B	36 24	36	35 7	35.45	35 11	35 2	34 92	34 67	35 411	
8	Flat lock M/C	Arm Hole Top Sewing	8A	36	36	35 8	35 5	35 25	35 32	35	34 7	35 44	35.48
			8B	36 12	36	35 9	35 62	35 3	35 38	35 09	34.7	35 51	
9	Plane M/C	Sleeve Tack Inner	9A	27	26 77	26 6	26 39	26.12	26 21	26	25.91	26.37	26 44
			9B	27.19	27	26 8	26 5	26.23	26 32	26 1	25 92	26 51	
10	Over Lock M/C	Side Seam Sewing	10A	42 33	42 1	41 7	41.46	41.18	41 3	41	40 76	41 48	41.58
			10B	42 44	42 21	42	41.81	41 44	41 6	41.31	41	41 73	
			10C	42 32	42 14	41 8	41 5	41.24	41.39	41.1	40 81	41.54	
11	Flat lock M/C	Body Hem Sewing	11A	35.69	35 42	35 2	34 89	34.5	34 65	34 28	34	34.83	34 87
			11B	35 72	35 48	35 3	34 93	34 6	34 73	34.39	34 1	34 9	
12	Plane M/C	Sleeve Tack Outer	12A	26 91	26 72	26 5	26 34	26	26 22	25.94	25 79	26 31	26 38
			12B	27	26.88	26 7	26 4	26 15	26.35	26 12	25 92	26 44	

Table 4.2: Observed Units of Per Hour Operation of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Per Hour Operation								Average Units	Total average Units
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	107	111	115	117	121	118	122	124	116 88	117.63
			1B	108	113	117	118	123	120	123	125	118.38	
2	Over Lock M/C	Neck Join	2A	110	112	115	117	120	119	123	125	117.63	118 13
			2B	110	113	116	119	121	120	124	126	118.63	
3	Flat lock M/C	Back neck Tap Join	3A	107	109	113	115	118	115	120	122	114.875	114.56
			3B	106	108	112	114	119	115	119	121	114 25	
4	Flat lock M/C	Neck Tap Sewing	4A	112	113	115	119	122	120	124	126	118 88	118.51
			4B	112	112	114	118	121	119	124	125	118 13	
5	Plane M/C	Neck Top Sewing	5A	100	100	103	105	108	107	109	112	105 5	105.125
			5B	99	100	102	104	108	106	108	111	104.75	
6	Flat lock M/C	Sleeve Hem Sewing	6A	102	105	107	109	111	108	111	115	108 5	108.94
			6B	102	106	108	110	112	109	112	116	109.38	
7	Over Lock M/C	Sleeve Join	7A	90	93	94	95	98	96	99	101	95 75	95 5
			7B	90	93	95	95	99	97	99	102	96.25	
8	Flat lock M/C	Arm Hole Top Sewing	8A	91	91	92	94	95	94	97	99	94.13	94 07
			8B	90	91	91	93	95	94	98	100	94	
9	Plane M/C	Sleeve Tack Inner	9A	123	126	128	131	134	132	135	137	130 75	130.5
			9B	123	125	127	130	134	131	134	138	130 25	
10	Over Lock M/C	Side Seam Sewing	10A	77	78	80	81	84	82	84	87	81.63	80.71
			10B	76	76	78	79	82	80	81	83	79.38	
			10C	77	77	79	80	84	82	84	86	81 13	
11	Flat lock M/C	Body Hem Sewing	11A	91	92	94	95	98	95	100	103	96	95.69
			11B	90	92	93	95	97	94	99	103	95 38	
12	Plane M/C	Sleeve Tack Outer	12A	120	123	125	129	134	131	135	137	129.25	128 94
			12B	119	123	124	128	133	132	134	136	128 03	

Table 4.3: Observed Worker Rating of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	No of per hour standard units	Observed per Hour Rating								Average Observed Rating	Observed Rating
					1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	190	0.563	0.584	0.605	0.616	0.637	0.621	0.642	0.653	0.615	0.619
			1B	190	0.568	0.595	0.616	0.621	0.647	0.632	0.647	0.658	0.623	
2	Over Lock M/C	Neck Join	2A	180	0.611	0.622	0.639	0.65	0.667	0.661	0.683	0.694	0.653	0.656
			2B	180	0.611	0.628	0.644	0.661	0.672	0.667	0.689	0.7	0.659	
3	Flat lock M/C	Back neck Tap Join	3A	170	0.629	0.641	0.665	0.676	0.694	0.676	0.706	0.718	0.676	0.674
			3B	170	0.624	0.635	0.659	0.671	0.7	0.676	0.7	0.712	0.672	
4	Flat lock M/C	Neck Tap Sewing	4A	190	0.589	0.595	0.605	0.626	0.642	0.632	0.653	0.663	0.626	0.624
			4B	190	0.589	0.589	0.6	0.621	0.637	0.626	0.653	0.658	0.622	
5	Plane M/C	Back Neck Tap Sewing	5A	150	0.667	0.667	0.667	0.7	0.72	0.713	0.727	0.747	0.703	0.701
			5B	150	0.66	0.667	0.68	0.693	0.72	0.707	0.72	0.74	0.698	
6	Flat lock M/C	Sleeve Hem Sewing	6A	160	0.638	0.656	0.669	0.681	0.694	0.675	0.694	0.719	0.678	0.681
			6B	160	0.638	0.663	0.675	0.688	0.7	0.681	0.7	0.725	0.684	
7	Over Lock M/C	Sleeve Join	7A	140	0.643	0.664	0.671	0.679	0.7	0.686	0.707	0.721	0.684	0.686
			7B	140	0.643	0.664	0.679	0.679	0.707	0.693	0.707	0.729	0.688	
8	Flat lock M/C	Arm Hole Top Sewing	8A	130	0.7	0.7	0.71	0.72	0.73	0.72	0.75	0.76	0.72	0.72
			8B	130	0.69	0.7	0.7	0.72	0.73	0.72	0.75	0.77	0.72	
9	Plane M/C	Sleeve Tack Inner	9A	210	0.586	0.6	0.61	0.624	0.638	0.629	0.643	0.652	0.623	0.622
			9B	210	0.586	0.595	0.605	0.619	0.638	0.624	0.638	0.657	0.62	
10	Over Lock M/C	Side Seam Sewing	10A	130	0.592	0.6	0.615	0.623	0.646	0.631	0.646	0.669	0.628	0.621
			10B	130	0.585	0.585	0.6	0.608	0.631	0.615	0.623	0.638	0.611	
			10C	130	0.592	0.592	0.608	0.615	0.646	0.631	0.646	0.662	0.624	
11	Flat lock M/C	Body Hem Sewing	11A	145	0.63	0.63	0.65	0.66	0.68	0.66	0.69	0.71	0.664	0.661
			11B	145	0.62	0.63	0.64	0.66	0.67	0.65	0.68	0.71	0.658	
12	Plane M/C	Sleeve Tack Outer	12A	200	0.6	0.62	0.63	0.65	0.67	0.66	0.68	0.69	0.65	0.65
			12B	200	0.6	0.62	0.62	0.64	0.67	0.66	0.67	0.68	0.64	

Table 4.4: Basic Pitch Time and Standard Processing Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time	Observed Rating	Basic Pitch Time Sec	Allowance Rate 13%	Standard Processing Time Sec	Average Standard Processing Time Sec	Capacity Per Hour (Pieces/ Hour)
1	Over Lock M/C	Shoulder Join	1A	29 56	0 615	18 179	0 13	20.54	20.585	174.93
			1B	29 314	0 613	18 26	0 13	20.63		
2	Over Lock M/C	Neck Join	2A	29 249	0.653	19.099	0 13	21 582	21.632	166.42
			2B	29 125	0 659	19.193	0 13	21.688		
3	Flat lock M/C	Back neck Tap Join	3A	29 76	0.676	20.118	0.13	22 733	22.7	158 59
			3B	29 85	0 672	20.059	0 13	22 667		
4	Flat lock M/C	Neck Tap Sewing	4A	28 804	0.626	18 03	0.13	20.374	20 35	176 9
			4B	28 911	0 622	17 983	0.13	20.32		
5	Plane M/C	Neck Top Sewing	5A	30 765	0.703	21 628	0 13	24 44	24 43	147.36
			5B	30 954	0 698	21 61	0 13	24.42		
6	Flat lock M/C	Sleeve Hem Sewing	6A	30 57	0.678	20.726	0 13	23.42	23 47	153 39
			6B	30.423	0 684	20.81	0 13	23 52		
7	Over Lock M/C	Sleeve Join	7A	35 524	0 684	24.298	0 13	27 46	27.495	130 93
			7B	35 411	0.688	24.363	0 13	27.53		
8	Flat lock M/C	Arm Hole Top Sewing	6A	35 44	0.72	25.517	0 13	28.83	28 86	124 74
			8B	35 51	0.72	25 567	0 13	28.89		
9	Plane M/C	Sleeve Tack Inner	9A	26 37	0 623	16 429	0.13	18 56	18.57	193 86
			9B	26 51	0.62	16 44	0.13	18.58		
10	Over Lock M/C	Side Seam Sewing	10A	41.48	0 628	26 05	0.13	29 44	29 18	123 37
			10B	41 73	0 611	25 5	0 13	28 82		
			10C	41 54	0.624	25.921	0 13	29.29		
11	Flat lock M/C	Body Hem Sewing	11A	34 83	0.664	23.127	0 13	26.134	26 042	138.24
			11B	34 9	0 658	22.964	0.13	25.949		
12	Plane M/C	Sleeve Tack Outer	12A	26 31	0 65	17.102	0 13	19.33	19.23	187 21
			12B	26 44	0.64	16 92	0 13	19.12		

Table 4.1 and Table 4.4 show that highest pitch time or observed time is 41.58 second and standard processing time is 29.18 Second. So here bottleneck time is 41.58 second for observed time and 29.18 second for standard time.

4.4 TIME STUDY: SITUATION II

But to reduce bottleneck time, the operation "Side Seam Sewing" can be splitted into two parts as Side Seam Sewing Left side and Side Seam Sewing right side. After splitting this operation, Pitch Time of workers of this station has been collected. Then worker's per hour production, worker rating and Standard processing time of all work stations have been calculated. These expressions are presented in Table 4.5, Table 4.6, Table 4.7 and Table 4.8

Table 4.5: Pitch Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time								Average Time, Sec	Total aveage Time, Sec
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	30 48	30.17	29 88	29 58	29.22	29 42	29.12	28 61	29.56	29 437
			1B	30 31	30	29 6	29.32	29	29 18	28.76	28 34	29 314	
2	Over Lock M/C	Neck Join	2A	30	29.81	29 54	29 31	29	29.2	28 79	28 34	29 249	29.187
			2B	30	29 77	29 41	29 11	28.84	29	28 68	28.19	29 125	
3	Flat lock M/C	Back neck Tap Join	3A	30.58	30 38	30.12	29 78	29 39	29 57	29 34	28.92	29 76	29 805
			3B	30 68	30 47	30 2	29 88	29 5	29 63	29 4	29	29 85	
4	Flat lock M/C	Neck Tap Sewing	4A	29 56	29 36	29 11	28 86	28 55	28 63	28 36	28	28 804	28 858
			4B	29 66	29 43	29 2	28 94	28 68	28 73	28.46	28 19	28 911	
5	Plane M/C	Back Neck Tap Sewing	5A	31 53	31.23	31	30 84	30 52	30 68	30 32	30	30 765	30 86
			5B	31 77	31 48	31 21	31	30 72	30 88	30 45	30 12	30 954	
6	Flat lock M/C	Sleeve Hem Sewing	6A	31.22	31.06	30.78	30 59	30 32	30 47	30 2	29 92	30 57	30 5
			6B	31.1	30 91	30 63	30 41	30 13	30 33	30 09	29 78	30 423	
7	Over Lock M/C	Sleeve Join	7A	36 23	36	35 78	35.55	35 23	35 4	35.11	34 89	35.524	35 47
			7B	36 24	36	35 7	35 45	35.11	35 2	34 92	34 67	35 411	
8	Flat lock M/C	Arm Hole Top Sewing	8A	36	36	35 76	35 5	35 25	35 32	35	34.7	35 44	35 48
			8B	36 12	36	35 88	35 62	35 3	35 38	35 09	34 7	35 51	
9	Plane M/C	Sleeve Tack Inner	9A	27	26 77	26.56	26 39	26 12	26 21	26	25 91	26 37	26 44
			9B	27.19	27	26 78	26 5	26 23	26 32	26 1	25 92	26 51	
10	Over Lock M/C	Side Seam Sewing Left Side	10A	21 22	21 11	21	20 9	20 7	20.8	20 64	20 5	20 86	20 81
			10C	21 16	21	20.9	20 74	20 6	20 68	20 52	20 4	20.75	
11	Over Lock M/C	Side Seam Sewing Right Side	11A	21.2	21 1	21	20 89	20 68	20 8	20.65	20 48	20.85	20.8
			11B	21 17	21	20 91	20 73	20 58	20 67	20 51	20 39	20 75	
12	Flat lock M/C	Body Hem Sewing	12A	35 69	35.42	35.18	34 89	34 5	34 65	34.28	34	34 83	34 87
			12B	35 72	35.48	35 26	34 93	34 6	34 73	34 39	34 1	34 9	
13	Plane M/C	Sleeve Tack Outer	13A	26 91	26 72	26 53	26 34	26	26 22	25 94	25 79	26 31	26 38
			13B	27	26 88	26 69	26 4	26 15	26 35	26 12	25 92	26.44	

Table 4.6: Observed Units of Per Hour Operation of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Per Hour Operation								Average Units	Total Average Units
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	107	111	115	117	121	118	122	124	116 68	117.63
			1B	108	113	117	118	123	120	123	125	118 38	
2	Over Lock M/C	Neck Join	2A	110	112	115	117	120	119	123	125	117.63	118.13
			2B	110	113	116	119	121	120	124	126	118.63	
3	Flat lock M/C	Back neck Tap Join	3A	107	109	113	115	118	115	120	122	114.88	114.56
			3B	106	108	112	114	119	115	119	121	114 25	
4	Flat lock M/C	Neck Tap Sewing	4A	112	113	115	119	122	120	124	126	118 88	118 51
			4B	112	112	114	118	121	119	124	125	118 13	
5	Plane M/C	Neck Top Sewing	5A	100	100	103	105	108	107	109	112	105.5	105 125
			5B	99	100	102	104	108	106	108	111	104 75	
6	Flat lock M/C	Sleeve Hem Sewing	6A	102	105	107	109	111	108	111	115	108.5	108.94
			6B	102	106	108	110	112	109	112	116	109 38	
7	Over Lock M/C	Sleeve Join	7A	90	93	94	95	98	96	99	101	95 75	95.5
			7B	90	93	95	95	99	97	99	102	96 25	
8	Flat lock M/C	Arm Hole Top Sewing	8A	91	91	92	94	95	94	97	99	94.13	94.07
			8B	90	91	91	93	95	94	98	100	94	
9	Plane M/C	Sleeve Tack Inner	9A	123	126	128	131	134	132	135	137	130 75	130.5
			9B	123	125	127	130	134	131	134	138	130 25	
10	Over Lock M/C	Side Seam Sewing Left Side	10A	152	152	156	158	164	160	162	166	158.75	160.5
			10C	154	154	158	160	168	164	168	172	162.25	
11	Over Lock M/C	Side Seam Sewing Right Side	11A	152	152	156	158	164	160	162	166	158.75	160.5
			11B	154	154	158	160	168	164	168	172	162 25	
12	Flat lock M/C	Body Hem Sewing	12A	91	92	94	95	98	95	100	103	96	95.69
			12B	90	92	93	96	97	94	99	103	95.38	
13	Plane M/C	Sleeve Tack Outer	13A	120	123	125	129	134	131	135	137	129.25	128.94
			13B	119	123	124	128	133	132	134	136	128 63	

Table 4.7: Observed Worker Rating of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Number of Per Hoour Standard Units	Observed Per Hour Rating								Average Observed Rating	Observed Rating
					1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	190	0.563	0.584	0.605	0 616	0.637	0.621	0 642	0 653	0 615	0 619
			1B	190	0 568	0.595	0.616	0.621	0 647	0.632	0.647	0 658	0 623	
2	Over Lock M/C	Neck Join	2A	180	0 611	0.622	0.639	0 65	0 667	0.661	0 683	0 694	0.653	0 656
			2B	180	0 611	0.628	0 644	0 661	0.672	0 667	0.689	0.7	0 659	
3	Flat lock M/C	Back neck Tap Join	3A	170	0 629	0 641	0 665	0.676	0.694	0.676	0 706	0.718	0 676	0 674
			3B	170	0.624	0 635	0.659	0 671	0.7	0 676	0.7	0.712	0 672	
4	Flat lock M/C	Neck Tap Sewing	4A	190	0 589	0 595	0 605	0.626	0 642	0 632	0.653	0.663	0 626	0 624
			4B	190	0.589	0.589	0 6	0.621	0.637	0.626	0.653	0 658	0 622	
5	Plane M/C	Neck Top Sewing	5A	150	0.667	0 667	0 687	0 7	0.72	0 713	0.727	0.747	0.703	0 701
			5B	150	0.66	0.667	0 68	0.693	0.72	0.707	0.72	0.74	0.698	
6	Flat lock M/C	Sleeve Hem Sewing	6A	160	0 638	0 656	0.669	0 681	0 694	0 675	0.694	0.719	0 678	0 681
			6B	160	0.638	0.663	0 675	0 688	0.7	0 681	0 7	0 725	0 684	
7	Over Lock M/C	Sleeve Join	7A	140	0 643	0 664	0.671	0.679	0.7	0 686	0.707	0.721	0 684	0 686
			7B	140	0.643	0 664	0 679	0.679	0.707	0 693	0 707	0 729	0.688	
8	Flat lock M/C	Arm Hole Top Sewing	8A	130	0.7	0 7	0 71	0.72	0.73	0 72	0 75	0.76	0 72	0 72
			8B	130	0 69	0.7	0.7	0 72	0 73	0 72	0.75	0.77	0.72	
9	Plane M/C	Sleeve Tack Inner	9A	210	0 586	0 6	0.61	0.624	0 638	0 629	0.643	0 652	0 623	0 622
			9B	210	210	0.586	0.595	0 605	0.619	0.638	0 624	0 638	0.657	
10	Over Lock M/C	Side Seam Sewing Left Side	10A	260	0 585	0.585	0.6	0.608	0.631	0.615	0 623	0 638	0.611	0 618
			10C	260	0 592	0 592	0.608	0.615	0 646	0 631	0.646	0 662	0 624	
11	Over Lock M/C	Side Seam Sewing Right side	11A	260	0 585	0.585	0.6	0.608	0 631	0 615	0 623	0 638	0.611	0 618
			11B	260	0 592	0.592	0 608	0 615	0.646	0 631	0.646	0.662	0 624	
12	Flat lock M/C	Body Hem Sewing	12A	145	0 63	0.63	0 65	0 66	0.68	0.68	0.69	0 71	0.664	0 661
			12B	145	0.62	0 63	0.64	0 66	0.67	0 65	0.68	0 71	0 658	
13	Plane M/C	Sleeve Tack Outer	13A	200	0 6	0 62	0 63	0.65	0.67	0 66	0.68	0 69	0 65	0 65
			13B	200	0.6	0 62	0 62	0.64	0.67	0 66	0 67	0 68	0.64	

Table 4.8: Basic Pitch Time and Standard Processing Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time Sec	Observed Rating	Basic Pitch Time Sec	Allowance Rate 13%	Standard Processing Time Sec	Average standard Processing Time Sec	Capacity Per Hour (Pieces Per Hour)
1	Over Lock M/C	Shoulder Join	1A	29.56	0 615	18 179	0.13	20 54	20.585	174 93
			1B	29.314	0.613	18.26	0.13	20 63		
2	Over Lock M/C	Neck Join	2A	29 249	0 653	19 099	0.13	21.582	21 632	166 42
			2B	29.125	0.659	19.193	0.13	21 688		
3	Flat lock M/C	Back neck Tap Join	3A	29.76	0 676	20.118	0.13	22 733	22 7	158 59
			3B	29.85	0.672	20 059	0.13	22 667		
4	Flat lock M/C	Neck Tap Sewing	4A	28.804	0.626	18 03	0.13	20.374	20.35	176.9
			4B	28.911	0.622	17 983	0.13	20 32		
5	Plane M/C	Back Neck Tap Sewing	5A	30.765	0.703	21.628	0.13	24 44	24 43	147.36
			5B	30.954	0.698	21 61	0.13	24 42		
6	Flat lock M/C	Sleeve Hem Sewing	6A	30.57	0.678	20 726	0.13	23 42	23 47	153 39
			6B	30.423	0.684	20.81	0.13	23.52		
7	Over Lock M/C	Sleeve Join	7A	35 524	0 684	24 298	0.13	27 46	27.495	130 93
			7B	35 411	0 688	24 363	0 13	27 53		
8	Flat lock M/C	Arm Hole Top Sewing	8A	35.44	0.72	25 517	0.13	28.83	28 86	124 74
			8B	35.51	0.72	25 567	0.13	28 89		
9	Plane M/C	Sleeve Tack Inner	9A	26.37	0 623	16.429	0.13	18.56	18 57	193.86
			9B	26.51	0.62	16 44	0.13	18.58		
10	Over Lock M/C	Side Seam Sewing Left Side	10A	20 86	0.611	12.745	0.13	14.4	14.515	248
			10C	20 75	0.624	12.948	0.13	14.63		
11	Over Lock M/C	Side Seam Sewing Right Side	11A	20 85	0 611	12 739	0.13	14 395	14 513	248
			11B	20 75	0 624	12.948	0.13	14.63		
12	Flat lock M/C	Body Hem Sewing	12A	34.83	0 664	23.127	0 13	26.134	26 042	138.24
			12B	34.9	0 658	22 964	0.13	25 949		
13	Plane M/C	Sleeve Tack Outer	13A	26.31	0.65	17 102	0.13	19 33	19 23	187.21
			13B	26.44	0 64	16.92	0 13	19 12		

Table 4.5 and Table 4.8 show that highest pitch time or observed time is 35.48 second and standard processing time is 28.86 Second. So here bottleneck time is 35.48 second for observed time and 28.86 second for standard processing time. So bottleneck time is reduced 14.67 % for observed time compare to existing observed time. Standard bottle neck time is lower than observed bottle neck time.

4.5 TIME STUDY: SITUATION III

But Table 4.5 shows that the operations no 1, 6, 7, 8, 9, 13 can also be splitted into small part as Shoulder joint left side and right side, Sleeve hem sewing left side and right side, Sleeve joint left side and right side, Armhole top sewing left side and right side, Sleeve tack inner left side and right side, Sleeve tack final (outer) left side and right side. After splitting these operations. Pitch Time of workers of these work stations have been collected. Then worker's per hour production, worker rating and Standard processing time of these work stations have been calculated. These expressions are presented in Table 4.9, Table 4.10, Table 4.11 and Table 4.12

Table 4.9: Pitch Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time 1	2	3	4	5	6	7	8	Average Time, Sec	Total average Time,Sec
1	Over Lock M/C	Shoulder Join Left Side	1A	15 24	15,08	14 9	14 77	14 58	14 71	14,54	14 29	14 766	14 706
			1B	15 14	15	14 8	14 63	14 48	14 58	14 38	14 15	14,646	
2	Over Lock M/C	Shoulder Join Right Side	2A	15,25	15	14 9	14.77	14 56	14 7	14 54	14 27	14 749	14 694
			2B	15 14	15	14 8	14 62	14 48	14,58	14 36	14 13	14 638	
3	Over Lock M/C	Neck Join	3A	30	29 81	29 5	29 31	29	29.2	28 79	28 34	29 249	29 187
			3B	30	29 77	29 4	29 11	28 84	29	28 68	28 19	29.125	
4	Flat lock M/C	Back neck Tap Join	4A	30 58	30 38	30 1	29 78	29 39	29 57	29 34	28 92	29 76	29 805
			4B	30 68	30 47	30 2	29 88	29 5	29 63	29.4	29	29 85	
5	Flat lock M/C	Neck Tap Sewing	5A	29 56	29.36	29 1	28 86	28 55	28 63	28 36	28	28 804	28 858
			5B	29 66	29 43	29 2	28 94	28 68	28 73	28 46	28 19	28,911	
6	Plane M/C	Back Neck Tap Sewing	6A	31 53	31 23	31	30 84	30.52	30 68	30 32	30	30 765	30 86
			6B	31 77	31.48	31 2	31	30 72	30 88	30 45	30,12	30.954	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	15.6	15 53	15,4	15 28	15 15	15 22	15,1	14 94	15 274	15,23
			7B	15 54	15 42	15 3	15 2	15	15 14	15 03	14 86	15 186	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	15 61	15,55	15 4	15 26	15 15	15 2	15 1	14 92	15 269	15 231
			8B	15 54	15 41	15 3	15 2	15	15 15	15 07	14 87	15 193	
9	Over Lock M/C	Sleeve Join Left Side	9A	18.1	18	17 9	17 75	17 6	17,7	17 52	17.42	17 746	17 718
			9B	18 12	17 97	17 8	17,7	17 53	17 58	17 45	17 32	17 689	
10	Over Lock M/C	Sleeve Join Right Side	10A	18 1	18	17 9	17.74	17 59	17 72	17 51	17 4	17 74	17 71
			10B	18 13	18	17,8	17 68	17 51	17 58	17,44	17,33	17 688	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	18	18	17 9	17 73	17 63	17 66	17 48	17,33	17.714	17 732
			11B	18 08	18	17.9	17 8	17,62	17 7	17.54	17 33	17,749	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	18	18	17 9	17 71	17 6	17 65	17,46	17 32	17 701	17.725
			12B	18 04	18 04	17 9	17 81	17,6	17 72	17 52	17.33	17 748	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	13 52	13 38	13 3	13 18	13	13 1	13	12 93	13 171	13 205
			13B	13 58	13 52	13 4	13 23	13,1	13,16	13	12 93	13 239	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	13 53	13 37	13 3	13 16	13	13,11	12 98	12.9	13 164	13 195
			14B	13 57	13 5	13 4	13 21	13 11	13 14	13	12 9	13 226	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	21,22	21 11	21	20 9	20 7	20 8	20.64	20 5	20 86	20 805
			15B	21 16	21	20 9	20 74	20 6	20 68	20 52	20 4	20 75	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	21,2	21.1	21	20 89	20,68	20 8	20 65	20 48	20.85	20 8
			16B	21.17	21	20 9	20 73	20,58	20 67	20 51	20 39	20.75	
17	Flat lock M/C	Body Hem Sewing	17A	35 69	35,42	35 2	34 89	34 5	34 65	34 28	34	34 83	34 865
			17B	35 72	35 48	35 3	34 93	34 6	34 73	34 39	34,1	34 9	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	13 46	13 37	13 2	13 15	13	13.1	12 96	12 88	13.145	13 171
			18B	13 52	13 42	13 3	13 18	13 03	13 15	13	12,94	13,196	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	13,44	13 37	13 2	13 13	12,97	13 11	12.98	12,86	13,136	13 162
			19B	13 54	13 43	13 3	13 15	13	13 15	13	12,93	13 188	

Table 4.10: Observed Units of Per Hour Operation of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Per Hour Operation								Average Units	Total average Units
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join Left Side	1A	214	222	230	217	242	236	244	248	231.63	234 26
			1B	216	226	234	237	246	240	246	250	236.88	
2	Over Lock M/C	Shoulder Join Right Side	2A	214	222	230	217	243	236	244	249	231.88	234 63
			2B	216	226	235	238	246	240	247	251	237.38	
3	Over Lock M/C	Neck Join	3A	110	112	115	117	120	119	123	125	117.63	118 13
			3B	110	113	116	119	121	120	124	126	118 63	
4	Flat lock M/C	Back neck Tap Join	4A	107	109	113	115	118	115	120	122	114.88	114 56
			4B	106	108	112	114	119	115	119	121	114 25	
5	Flat lock M/C	Neck Tap Sewing	5A	112	113	115	119	122	120	124	126	118 88	118 51
			5B	112	112	114	118	121	119	124	125	118.13	
6	Plane M/C	Back Neck Tap Sewing	6A	100	100	103	105	108	107	109	112	105 5	105 13
			6B	99	100	102	104	108	106	108	111	104.75	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	204	210	214	218	222	216	222	230	217	217 88
			7B	204	212	216	220	224	218	224	232	218 75	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	204	209	214	219	222	216	222	231	217 13	217 88
			8B	204	212	216	220	224	217	224	232	218.63	
9	Over Lock M/C	Sleeve Join Left Side	9A	180	187	188	190	196	192	198	203	191 75	192 25
			9B	180	186	190	191	198	194	199	204	192 75	
10	Over Lock M/C	Sleeve Join Right Side	10A	180	187	189	190	196	193	198	204	192.13	192.51
			10B	180	186	190	192	199	194	199	203	192 88	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	182	182	184	188	190	188	194	198	188.25	188 13
			11B	180	182	182	186	190	188	196	200	188	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	182	182	184	189	191	188	195	198	188.63	188 44
			12B	180	182	182	186	191	188	197	200	188 25	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	246	252	256	262	268	264	270	274	261.5	261
			13B	246	250	254	260	268	262	268	276	260 5	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	246	252	256	263	268	264	271	276	262	261 57
			14B	246	251	254	261	268	263	268	278	261.13	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	152	152	156	158	164	160	162	166	158 75	160 5
			15B	154	154	158	160	168	164	168	172	162 25	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	152	152	156	158	164	160	162	166	158.75	160 5
			16B	154	154	158	160	168	164	168	172	162 25	
17	Flat lock M/C	Body Hem Sewing	17A	91	92	94	95	98	95	100	103	96	95 69
			17B	90	92	93	95	97	94	99	103	95 38	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	240	246	250	256	268	262	270	274	258 5	257 88
			18B	238	246	248	256	266	264	268	272	257.25	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	241	246	251	259	269	263	271	274	259 25	258 32
			19B	237	247	249	256	266	264	268	272	257.38	

Table 4.11: Observed Worker Rating of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Number of Per Hour Standard Units	Observed Per Hour Worker Rating								Average Observed Rating	Observed Rating
					1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join Left Side	1A	380	0.56	0.58	0 61	0 57	0.64	0.62	0 64	0 65	0.609	0 617
			1B	380	0.57	0 59	0.62	0.62	0 65	0 63	0.65	0 66	0.624	
2	Over Lock M/C	Shoulder Join Right Side	2A	380	0.56	0.58	0 61	0.57	0 64	0.62	0.64	0.66	0.61	0 618
			2B	380	0 57	0 59	0 62	0.63	0 65	0 63	0 65	0 66	0 625	
3	Over Lock M/C	Neck Join	3A	180	0 61	0 62	0.64	0.65	0.67	0.66	0.68	0.69	0 653	0.656
			3B	180	0.61	0 63	0.64	0.66	0.67	0.67	0.69	0 7	0.659	
4	Flat lock M/C	Back neck Tap Join	4A	170	0 63	0.64	0.67	0 68	0.69	0.68	0.71	0 72	0 676	0 676
			4B	170	0 62	0.64	0 66	0.67	0 7	0 68	0 7	0.71	0.673	
5	Flat lock M/C	Neck Tap Sewing	5A	190	0 59	0 6	0.61	0.63	0.64	0 63	0.65	0.66	0 626	0 625
			5B	190	0.59	0 59	0.6	0.62	0 64	0 63	0 65	0.66	0 623	
6	Plane M/C	Neck Top Sewing	6A	150	0.67	0.67	0.69	0 7	0 72	0.71	0.73	0.75	0.705	0 702
			6B	150	0 66	0.67	0 68	0.69	0 72	0.71	0 72	0.74	0.699	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	320	0.64	0 66	0 67	0 68	0.69	0 68	0 69	0 72	0 679	0 682
			7B	320	0 64	0.66	0.68	0 69	0 7	0.68	0.7	0 73	0 685	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	320	0.64	0 65	0.67	0.68	0.69	0.68	0.69	0 72	0.678	0 682
			8B	320	0.64	0 66	0 68	0 69	0.7	0.68	0 7	0 73	0 685	
9	Over Lock M/C	Sleeve Join Left Side	9A	280	0 64	0.67	0.67	0 68	0.7	0.69	0.71	0 73	0.686	0 687
			9B	280	0.64	0 68	0 68	0.68	0.71	0 69	0 71	0 73	0 688	
10	Over Lock M/C	Sleeve Join Right Side	10A	280	0.64	0 67	0 68	0.68	0.7	0 69	0 71	0.73	0 688	0 689
			10B	280	0 64	0 66	0.68	0.69	0 71	0 69	0.71	0.73	0 689	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	260	0.7	0.7	0 71	0.72	0.73	0 72	0 75	0.76	0 724	0 724
			11B	260	0 69	0.7	0.7	0 72	0.73	0.72	0.75	0.77	0.723	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	260	0.7	0 7	0.71	0 73	0.73	0.72	0.75	0 76	0.725	0 725
			12B	260	0.69	0 7	0 7	0.72	0.73	0.72	0.76	0 77	0.724	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	420	0 59	0.6	0.61	0 62	0.64	0.63	0.64	0 65	0 623	0 622
			13B	420	0 59	0 6	0.6	0.62	0 64	0 62	0.64	0 66	0.621	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	420	0.59	0 6	0 61	0.63	0.64	0.63	0 65	0 66	0 626	0 625
			14B	420	0.59	0.6	0 6	0.62	0 64	0.63	0.64	0 66	0.623	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	260	0.59	0 59	0.6	0.61	0.63	0 62	0 62	0.64	0 613	0 619
			15B	260	0 59	0.59	0.61	0.62	0 65	0.63	0.65	0.66	0.625	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	260	0.59	0.59	0.6	0 61	0.63	0 62	0 62	0.64	0 613	0 619
			16B	260	0 59	0 59	0 61	0.62	0.65	0.63	0 65	0.66	0.625	
17	Flat lock M/C	Body Hem Sewing	17A	145	0 63	0.63	0.65	0 66	0.68	0 66	0.69	0 71	0 664	0 661
			17B	145	0.62	0.63	0.64	0 66	0.67	0.65	0.68	0 71	0 658	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	400	0.6	0.62	0.63	0.65	0 67	0 66	0.68	0.69	0 65	0 648
			18B	400	0.6	0.62	0 62	0.64	0.67	0.66	0 67	0 68	0 645	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	400	0 6	0.62	0 63	0 65	0 67	0.66	0.68	0 69	0.65	0 647
			19B	400	0.59	0.62	0 62	0 64	0.67	0.66	0 67	0 68	0 644	

Table 4.12: Basic Pitch Time and Standard Processing Time of a T-Shirt of a sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time Sec	Observed Rating	Basic Pitch Time Sec	Allowance Rate 13%	Standard Processing Time Sec	Average Standard Processing Time Sec	Capacity Per Hour (Pieces Per Hour)
1	Over Lock M/C	Shoulder Join Left Side	1A	14.766	0.609	8 992	0.13	10.162	10 245	351.39
			1B	14.646	0 624	9 139	0.13	10 327		
2	Over Lock M/C	Shoulder Join Right Side	2A	14.749	0 61	8 997	0.13	10 166	10.252	351 15
			2B	14.638	0 625	9 149	0.13	10 338		
3	Over Lock M/C	Neck Join	3A	29 249	0 653	19.1	0 13	21.583	21 636	166.39
			3B	29.125	0.659	19 193	0.13	21.689		
4	Flat lock M/C	Back neck Tap Join	4A	29.76	0.678	20 177	0.13	22.8	22 751	158.23
			4B	29 85	0.673	20.089	0.13	22 701		
5	Flat lock M/C	Neck Tap Sewing	5A	28 804	0.626	18.031	0.13	20 375	20.364	176 78
			5B	28.911	0 623	18.012	0.13	20.353		
6	Plane M/C	Back Neck Tap Sewing	6A	30 765	0.705	21.689	0.13	24 509	24.48	147 06
			6B	30.954	0 699	21.637	0.13	24 45		
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	15 274	0.679	10.371	0.13	11.719	11.737	306 72
			7B	15.186	0.685	10.402	0 13	11.755		
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	15 269	0 678	10.352	0.13	11.698	11.729	306 93
			8B	15.193	0.685	10.407	0 13	11 76		
9	Over Lock M/C	Sleeve Join Left Side	9A	17.746	0.686	12.174	0.13	13 756	13 754	261 74
			9B	17.689	0 688	12 17	0.13	13 752		
10	Over Lock M/C	Sleeve Join Right Side	10A	17 74	0 688	12.205	0.13	13 792	13 782	261 21
			10B	17 688	0 689	12.187	0.13	13.771		
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	17 714	0.724	12 825	0.13	14.492	14.497	248 33
			11B	17.749	0.723	12.833	0.13	14.501		
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	17.701	0.725	12.833	0.13	14.502	14 511	248 09
			12B	17.748	0 724	12.85	0.13	14 52		
13	Plane M/C	Sleeve Tack Inner Left Side	13A	13.171	0.623	8.206	0.13	9.272	9 281	387.89
			13B	13.239	0 621	8 221	0.13	9 29		
14	Plane M/C	Sleeve Tack Inner Right Side	14A	13 164	0 626	8.241	0.13	9.312	9.312	386 6
			14B	13 226	0.623	8 24	0 13	9 311		
15	Over Lock M/C	Side Seam Sewing Left Side	15A	20 86	0 613	12.787	0.13	14.45	14.553	247 37
			15B	20.75	0 625	12 969	0.13	14.655		
16	Over Lock M/C	Side Seam Sewing Right Side	16A	20.85	0 613	12 781	0.13	14.443	14 549	247 42
			16B	20 75	0 625	12.969	0.13	14.655		
17	Flat lock M/C	Body Hem Sewing	17A	34.83	0.664	23.127	0.13	26 134	26.042	138 24
			17B	34.9	0 658	22.964	0.13	25 949		
18	Plane M/C	Sleeve Tack Outer Left Side	18A	13.145	0.65	8.544	0.13	9 655	9 637	373.56
			18B	13 196	0.645	8.511	0.13	9.618		
19	Plane M/C	Sleeve Tack Outer Right Side	19A	13.136	0.65	8.538	0.13	9.648	9.623	374 1
			19B	13 188	0 644	8.493	0.13	9.597		

Table 4.9 and Table 4.12 show that highest pitch time or observed time is 34.865 second and standard processing time is 26.042 Second. So here bottleneck time is 34.865 second for observed time and 26.042 second for standard processing time. So bottleneck time is reduced 16.15 % for observed time compare to existing bottle neck observed time. Standard bottle neck time is lower than observed bottle neck time.

4.6 TIME STUDY: SITUATION IV

But by adopting the technique of Method Study, it is also found that the observed processing time or Pitch Time of all the operations can be also reduced by reducing excess marking, excess Sewing Burst, improvement of Slow Movement and also by Motivation. As a result of adoption and application of these techniques before splitting of these operations, Pitch Time of workers of all work stations have been collected. Then worker's per hour production, worker rating and Standard processing time of these work stations have been calculated. These expressions are presented in Table 4.13, Table 4.14, Table 4.15, and Table 4.16

Table 4.13: Pitch Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time								Average Time Sec	Total average Time,Sec
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	27 19	27	26 6	26 38	26.17	26 34	26 1	25 41	26 4	26 35
			1B	27 21	27	26 5	26 32	25 92	26,22	25 76	25 34	26 29	
2	Over Lock M/C	Neck Join	2A	25 22	24 87	24 5	24,27	24	24 16	23 91	23 62	24 32	24 26
			2B	25 1	24 77	24 4	24 15	23.89	24.1	23 71	23 49	24 2	
3	Flat lock M/C	Back neck Tap Join	3A	25 51	25 34	25 1	24 72	24 42	24 53	24.28	23.94	24.73	24 765
			3B	25 68	25 49	25 2	24 82	24 5	24 58	24.26	23 92	24 8	
4	Flat lock M/C	Neck Tap Sewing	4A	24.84	24 66	24 4	24 26	23 96	24 12	23 66	23.34	24.16	24 03
			4B	24 67	24,41	24 2	23 97	23 78	23 63	23 39	23 19	23.9	
5	Plane M/C	Back Neck Tap Sewing	5A	27.71	27 57	27 4	27 29	27	27.15	26 94	26 79	27.24	27 335
			5B	27 78	27.65	27 5	27.34	27.11	27 26	27	27.84	27.43	
6	Flat lock M/C	Sleeve Hem Sewing	6A	27 32	27 1	26 8	26 51	26 28	26.37	26 06	25 71	26 52	26 445
			6B	27.12	26 88	26 6	26 35	26 1	26 22	26	25 71	26.37	
7	Over Lock M/C	Sleeve Join	7A	31 78	31.52	31 3	30.98	30 76	30 85	30 62	30 38	31 02	30.97
			7B	31,61	31 42	31 2	30 91	30 65	30.78	30 54	30 29	30 92	
8	Flat lock M/C	Arm Hole Top Sewing	8A	32 23	32 09	31.9	31 69	31,31	31 39	31 1	30 83	31 56	31 6
			8B	32 33	32 11	31.9	31.76	31,42	31 52	31.18	30 92	31 64	
9	Plane M/C	Sleeve Tack Inner	9A	22 34	22 12	21.9	21.6	21 32	21 41	21.18	20 87	21 59	21 545
			9B	22 24	22.1	21.7	21 49	21 2	21 32	21 11	20 77	21 5	
10	Over Lock M/C	Side Seam Sewing	10A	33 88	33 51	33 3	33 1	32 79	32 89	32 57	32 34	33.05	32.95
			10B	33 79	33 43	33 2	33	32 68	32 74	32 45	32 21	32.94	
			10C	33.74	33 37	33 2	32 91	32 53	32 69	32 4	32 18	32 87	
11	Flat lock M/C	Body Hem Sewing	11A	29 79	29 64	29 5	29 3	29 13	29.2	29	28 88	29 3	29 27
			11B	29 71	29.58	29 4	29.22	29 08	29 15	28 96	28.79	29.24	
12	Plane M/C	Sleeve Tack Outer	12A	22 72	22 57	22 3	22	21 82	22	21 77	21 45	22.08	22 07
			12B	22.78	22 6	22 4	22 1	21.85	22 08	21.82	21,49	22 06	

Table 4.14: Observed Units of Per Hour Operation of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Per Hour Operation								Average Units	Total average Units
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	132	133	135	136	137	136	137	141	135.88	136 19
			1B	132	133	135	136	138	137	139	142	136.5	
2	Over Lock M/C	Neck Join	2A	142	144	146	148	150	149	150	152	147.63	148
			2B	143	145	147	149	150	149	151	153	148.38	
3	Flat lock M/C	Back neck Tap Join	3A	141	142	143	145	147	146	148	150	145.25	145
			3B	140	141	142	145	146	146	148	150	144.75	
4	Flat lock M/C	Neck Tap Sewing	4A	144	145	147	148	150	149	152	154	148.63	149 44
			4B	145	147	149	150	151	152	153	155	150 25	
5	Plane M/C	Back Neck Tap Sewing	5A	129	130	131	131	133	132	133	134	131.63	131 19
			5B	129	130	130	131	132	132	133	129	130 75	
6	Flat lock M/C	Sleeve Hem Sewing	6A	131	132	134	135	136	136	138	140	135 25	135 625
			6B	132	133	135	136	137	137	138	140	136	
7	Over Lock M/C	Sleeve Join	7A	113	114	115	116	117	116	117	118	115 75	115 75
			7B	113	114	115	116	117	116	117	118	115.75	
8	Flat lock M/C	Arm Hole Top Sewing	8A	111	112	113	113	114	114	115	116	113.5	113 44
			8B	111	112	112	113	114	114	115	116	113.38	
9	Plane M/C	Sleeve Tack Inner	9A	161	162	164	166	168	168	169	172	166 25	166 565
			9B	161	162	165	167	169	168	170	173	166 88	
10	Over Lock M/C	Side Seam Sewing	10A	106	107	108	108	109	109	110	111	108 5	108.75
			10B	106	107	108	109	110	109	110	111	108 75	
			10C	106	107	108	109	110	110	111	111	109	
11	Flat lock M/C	Body Hem Sewing	11A	120	121	122	122	123	123	124	124	122.38	122 565
			11B	121	121	122	123	123	123	124	125	122 75	
12	Plane M/C	Sleeve Tack Outer	12A	158	159	161	163	164	163	165	167	162.5	161
			12B	158	159	160	162	164	163	164	167	159 5	

Table 4.15: Observed Worker Rating of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	No of per hour standard units	Observed per Hour Rating								Average Observed Rating	Ovserved Rating
					1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join	1A	190	0.695	0.7	0.71	0.716	0.721	0.716	0.721	0.742	0.715	0.717
			1B	190	0.695	0.7	0.71	0.716	0.726	0.721	0.732	0.747	0.718	
2	Over Lock M/C	Neck Join	2A	180	0.789	0.8	0.81	0.822	0.833	0.828	0.833	0.844	0.82	0.822
			2B	180	0.794	0.806	0.82	0.828	0.833	0.828	0.839	0.85	0.824	
3	Flat lock M/C	Back neck Tap Join	3A	170	0.829	0.835	0.84	0.853	0.865	0.859	0.871	0.882	0.854	0.853
			3B	170	0.824	0.829	0.84	0.853	0.859	0.859	0.871	0.882	0.851	
4	Flat lock M/C	Neck Tap Sewing	4A	190	0.758	0.763	0.77	0.779	0.789	0.784	0.8	0.811	0.782	0.787
			4B	190	0.763	0.774	0.78	0.789	0.795	0.8	0.805	0.816	0.791	
5	Plane M/C	Back Nec Tap Sewing	5A	150	0.86	0.867	0.87	0.873	0.887	0.88	0.887	0.893	0.878	0.875
			5B	150	0.86	0.867	0.87	0.873	0.88	0.88	0.887	0.86	0.872	
6	Flat lock M/C	Sleeve Hem Sewing	6A	160	0.819	0.825	0.84	0.844	0.85	0.85	0.863	0.875	0.845	0.848
			6B	160	0.825	0.831	0.84	0.85	0.856	0.856	0.863	0.875	0.85	
7	Over Lock M/C	Sleeve Join	7A	140	0.807	0.814	0.82	0.829	0.836	0.829	0.836	0.843	0.827	0.827
			7B	140	0.807	0.814	0.82	0.829	0.836	0.829	0.836	0.843	0.827	
8	Flat lock M/C	Arm Hole Top Sewing	8A	130	0.854	0.862	0.87	0.869	0.877	0.877	0.885	0.892	0.873	0.873
			8B	130	0.854	0.862	0.86	0.869	0.877	0.877	0.885	0.892	0.872	
9	Plane M/C	Sleeve Tack Inner	9A	210	0.767	0.771	0.78	0.79	0.8	0.8	0.805	0.819	0.792	0.794
			9B	210	0.767	0.771	0.79	0.795	0.805	0.8	0.81	0.824	0.795	
10	Over Lock M/C	Side Seam Sewing	10A	130	0.815	0.823	0.83	0.831	0.838	0.838	0.846	0.854	0.835	0.837
			10B	130	0.815	0.823	0.83	0.838	0.846	0.838	0.846	0.854	0.837	
			10C	130	0.815	0.823	0.83	0.838	0.846	0.846	0.854	0.854	0.838	
11	Flat lock M/C	Body Hem Sewing	11A	145	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.845	0.846
			11B	145	0.83	0.83	0.84	0.85	0.85	0.85	0.86	0.86	0.846	
12	Plane M/C	Sleeve Tack Outer	12A	200	0.79	0.795	0.81	0.815	0.82	0.815	0.825	0.835	0.813	0.812
			12B	200	0.79	0.795	0.8	0.81	0.82	0.815	0.82	0.835	0.811	

Table 4.16: Basic Pitch Time and Standard Processing Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time	Observed Rating	Basic Pitch Time Sec	Allowance Rate	Standard Processing Time Sec	Average Standard Processing Time Sec	Capacity Per Hour (Pieces Per Hour)
1	Over Lock M/C	Shoulder Join	1A	26.4	0 715	18 876	0 13	21.33	21.33	168 78
			1B	26.29	0 718	18.876	0 13	21 33		
2	Over Lock M/C	Neck Join	2A	24 32	0.82	19.942	0 13	22.535	22 534	159 76
			2B	24.2	0 824	19 941	0 13	22 533		
3	Flat lock M/C	Back neck Tap Join	3A	24 73	0 854	21.119	0 13	23.865	23 857	150 9
			3B	24 8	0.851	21 105	0 13	23 848		
4	Flat lock M/C	Neck Tap Sewing	4A	24.16	0.782	18.893	0 13	21.349	21.356	168 57
			4B	23.9	0.791	18 905	0 13	21.363		
5	Plane M/C	Back Neck Tap Sewing	5A	27.24	0 878	23.917	0 13	27 026	27.03	133 19
			5B	27 43	0 872	23.919	0 13	27.028		
6	Flat lock M/C	Sleeve Hem Sewing	6A	26 52	0.845	22.409	0 13	25.323	25 326	142 15
			6B	26.37	0 85	22 415	0 13	25 328		
7	Over Lock M/C	Sleeve Join	7A	31 02	0.827	25 654	0 13	28.989	28 942	124 39
			7B	30.92	0.827	25.571	0 13	28 895		
8	Flat lock M/C	Arm Hole Top Sewing	8A	31.56	0.873	27.552	0 13	31.134	31.156	115 55
			8B	31.64	0.872	27 59	0 13	31.177		
9	Plane M/C	Sleeve Tack Inner	9A	21.59	0.792	17 099	0 13	19.322	19 319	186 35
			9B	21.5	0 795	17.093	0 13	19 315		
10	Over Lock M/C	Side Seam Sewing	10A	33.05	0.835	27 597	0 13	31 184	31 155	115 55
			10B	32 94	0 837	27.571	0 13	31.155		
			10C	32.87	0 838	27 545	0 13	31.126		
11	Flat lock M/C	Body Hem Sewing	11A	29 3	0 845	24.759	0.13	27.978	27 966	128 73
			11B	29.24	0 846	24 737	0.13	27 953		
12	Plane M/C	Sleeve Tack Outer	12A	22.08	0 813	17.951	0 13	20 285	20 251	177 77
			12B	22.06	0.811	17.891	0 13	20.216		

Table 4.13 and Table 4.16 highest pitch time or observed time is 32.95 second and standard processing time is 31.156 Second. So here bottleneck time is 32.95 second for observed time and 31.156 second for standard processing time. So bottleneck time is reduced 20.76 % for observed time compare to existing bottle neck observed time. Standard bottle neck time is lower than observed bottle neck time.

4.7 TIME STUDY: SITUATION V

Again by adopting the technique of Method Study, after splitting of these operations, observed processing time or Pitch Time of workers of all the work stations have been collected. Then workers per hour production, worker rating and Standard processing time of these work stations have been calculated. These expressions are presented in Table 4.17, Table 4.18, Table 4.19 and Table 4.20.

Table 4.17: Pitch Time of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time								Average Time,Sec	Total average Time Sec
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join Left Side	1A	13.14	12.94	12.72	12.57	12.28	12.35	12 11	11.92	12.5	12.54
			1B	13.18	12.96	12.78	12.65	12.39	12.48	12.2	12	12.58	
2	Over Lock M/C	Shoulder Join Right Side	2A	13.1	12.91	12.72	12.52	12.22	12.38	12.14	12 9	12.61	12.63
			2B	13.11	12.9	12.72	12.59	12.32	12.41	12.21	12.97	12 65	
3	Over Lock M/C	Neck Join	3A	25.22	24.87	24.5	24.27	24	24.16	23.91	23.62	24.32	24.26
			3B	25.1	24.77	24.41	24 15	23.89	24.1	23.71	23.49	24 2	
4	Flat lock M/C	Back neck Tap Join	4A	25.51	25.34	25.1	24.72	24.42	24.53	24.28	23.94	24.73	24.765
			4B	25 68	25.49	25.18	24.82	24.5	24.58	24.26	23.92	24 8	
5	Flat lock M/C	Neck Tap Sewing	5A	24.84	24.66	24.41	24.26	23.96	24 12	23.66	23.34	24.16	24 03
			5B	24.67	24.41	24.16	23.97	23.78	23.63	23.39	23.19	23 9	
6	Plane M/C	Back Neck Tap Sewing	6A	26.41	26.23	26	25.81	25.58	25 69	25.32	25	25.76	25.685
			6B	26.27	26.1	25.89	25 61	25.38	25.48	25.22	24.94	25.61	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	13.91	13.78	13.6	13 43	13.22	13.32	13 1	12.88	13 41	13 445
			7B	13.97	13.88	13.71	13.51	13.27	13.38	13 17	12.95	13 48	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	13.88	13 73	13.6	13.4	13.2	13 3	13.11	12.87	13.39	13.41
			8B	13 95	13 82	13.65	13.44	13.22	13.34	13.13	12.91	13.43	
9	Over Lock M/C	Sleeve Join Left Side	9A	15.35	15.22	15.11	14.93	14.79	14.89	14.69	14 51	14.94	14 95
			9B	15.4	15.26	15 14	14.95	14.82	14.9	14.69	14.5	14 96	
10	Over Lock M/C	Sleeve Join Right Side	10A	15.29	15.14	15	14 85	14.7	14.82	14.63	14.45	14.88	14.885
			10B	15.33	15.21	15.1	14.91	14.78	14.86	14.63	14.47	14.91	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	16 34	16.21	16.1	15 94	15.8	15.88	15.69	15.52	15 94	15.96
			11B	16.4	16.28	16.13	15.96	15.83	15.9	15.75	15.59	15 98	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	16.38	16.27	16.15	15.96	15.84	15.91	15.71	15.57	15 97	16
			12B	16.43	16.33	16 19	16	15.87	15 96	15.79	15.65	16.03	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	10.95	10.84	10.7	10.61	10 5	10 56	10.43	10.32	10.61	10.615
			13B	11	10.85	10.73	10.62	10 5	10.58	10.41	10.28	10 62	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	10.9	10.79	10.68	10.54	10.43	10.53	10.39	10.29	10 57	10.58
			14B	10.96	10.82	10.7	10.59	10.47	10.55	10 38	10.25	10 59	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	16 35	16.17	16	15.85	15.68	15.73	15.59	15.41	15.85	15.87
			15B	16.38	16 2	16.06	15.88	15.71	15 78	15.64	15.47	15 89	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	16.3	16.15	16	15.83	15.63	15.74	15.6	15.4	15 83	15.835
			16B	16.33	16 16	15.98	15.83	15.69	15.75	15.6	15 38	15.84	
17	Flat lock M/C	Body Hem Sewing	17A	29.79	29 64	29 5	29 3	29 13	29 2	29	28 88	29 3	29.27
			17B	29 71	29 58	29 4	29 22	29 08	29.15	28 96	28 79	29.24	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	11.1	10.92	10.8	10 65	10.5	10.58	10 46	10.32	10.67	10.645
			18B	11	10.88	10.76	10.62	10 48	10.54	10.41	10.29	10 62	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	11 15	10.95	10.84	10.68	10.52	10.64	10.48	10 34	10.7	10.68
			19B	11 11	10.9	10.77	10.64	10.5	10.58	10.44	10 33	10.66	

Table 4.18: Observed Units of Per Hour Operation of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Per Hour Operation								Average Units	Total average Units
				1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join Left Side	1A	273	276	283	286	293	291	297	302	287 88	286.94
			1B	273	277	281	284	290	288	295	300	286.00	
2	Over Lock M/C	Shoulder Join Right Side	2A	274	278	283	287	294	290	296	279	285.13	284.69
			2B	274	279	283	285	292	290	294	277	284.25	
3	Over Lock M/C	Neck Join	3A	142	144	146	148	150	149	150	152	147 63	148
			3B	143	145	147	149	150	149	151	153	148.38	
4	Flat lock M/C	Back neck Tap Join	4A	141	142	143	145	147	146	148	150	145 25	145
			4B	140	141	142	145	146	146	148	150	144.75	
5	Flat lock M/C	Neck Tap Sewing	5A	144	145	147	148	150	149	152	154	148 63	149 44
			5B	145	147	149	150	151	152	153	155	150 25	
6	Plane M/C	Back Neck Tap Sewing	6A	136	137	138	139	140	140	142	144	139 50	139.82
			6B	137	137	139	140	141	141	142	144	140.13	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	258	261	264	268	272	270	274	279	268.25	267.50
			7B	257	259	262	266	271	269	273	277	266.75	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	259	262	264	268	272	270	274	279	268 50	268.07
			8B	258	260	263	267	272	269	274	278	267.63	
9	Over Lock M/C	Sleeve Join Left Side	9A	234	236	238	241	243	241	245	248	240 75	240 44
			9B	233	235	237	240	242	241	245	248	240 13	
10	Over Lock M/C	Sleeve Join Right Side	10A	235	237	240	242	244	242	246	249	241.88	241.44
			10B	234	236	238	241	243	242	246	248	241.00	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	220	222	223	225	227	226	229	231	225 38	225 13
			11B	219	221	223	225	227	226	228	230	224.88	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	219	221	222	225	227	226	229	231	225 00	224.625
			12B	219	220	222	225	226	225	227	230	224.25	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	328	332	336	339	342	340	345	348	338.75	338.625
			13B	327	331	335	338	342	340	345	350	338 50	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	330	333	337	341	345	341	346	349	340.25	339 875
			14B	328	332	336	339	343	341	346	351	339 50	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	220	222	225	227	229	228	230	233	226.75	226 50
			15B	219	222	224	226	229	228	230	232	226 25	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	220	222	225	227	230	228	230	233	226.88	226.88
			16B	220	222	225	227	229	228	230	234	226 88	
17	Flat lock M/C	Body Hem Sewing	17A	120	121	122	122	123	123	124	124	122.38	122.565
			17B	121	121	122	123	123	123	124	125	122 75	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	324	329	333	338	342	340	344	348	337 25	337 815
			18B	327	330	334	338	343	341	345	349	338.38	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	322	328	332	337	342	338	343	348	336.25	336.875
			19B	324	330	334	338	342	340	344	348	337.50	

Table 4.19: Observed Worker Rating of a T-Shirt of sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Number of Per Hour Standard Units	Observed Per Hour Worker Rating								Average Observed Rating	Observed Rating
					1	2	3	4	5	6	7	8		
1	Over Lock M/C	Shoulder Join Left Side	1A	380	0.72	0.73	0.74	0.75	0.77	0.77	0.78	0.79	0.758	0.756
			1B	380	0.72	0.73	0.74	0.75	0.76	0.76	0.78	0.79	0.753	
2	Over Lock M/C	Shoulder Join Right Side	2A	380	0.72	0.73	0.74	0.76	0.77	0.76	0.78	0.73	0.75	0.749
			2B	380	0.72	0.73	0.74	0.75	0.77	0.76	0.77	0.73	0.748	
3	Over Lock M/C	Neck Join	3A	180	0.8	0.8	0.81	0.82	0.8	0.83	0.83	0.84	0.82	0.822
			3B	180	0.8	0.81	0.82	0.83	0.8	0.83	0.84	0.85	0.82	
4	Flat lock M/C	Back neck Tap Join	4A	170	0.8	0.84	0.84	0.85	0.9	0.86	0.87	0.88	0.85	0.853
			4B	170	0.8	0.83	0.84	0.85	0.9	0.86	0.87	0.88	0.85	
5	Flat lock M/C	Neck Tap Sewing	5A	190	0.8	0.76	0.77	0.78	0.8	0.78	0.8	0.81	0.78	0.787
			5B	190	0.8	0.77	0.78	0.79	0.8	0.8	0.81	0.82	0.79	
6	Plane M/C	Back Neck Tap Sewing	6A	150	0.9	0.87	0.87	0.87	0.9	0.88	0.89	0.89	0.88	0.875
			6B	150	0.9	0.87	0.87	0.87	0.9	0.88	0.89	0.86	0.87	
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	320	0.8	0.82	0.83	0.84	0.9	0.84	0.86	0.87	0.84	0.836
			7B	320	0.8	0.81	0.82	0.83	0.9	0.84	0.85	0.87	0.83	
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	320	0.8	0.82	0.83	0.84	0.9	0.84	0.86	0.87	0.84	0.838
			8B	320	0.8	0.81	0.82	0.83	0.9	0.84	0.86	0.87	0.84	
9	Over Lock M/C	Sleeve Join Left Side	9A	280	0.8	0.84	0.85	0.86	0.9	0.86	0.88	0.89	0.86	0.859
			9B	280	0.8	0.84	0.85	0.86	0.9	0.86	0.88	0.89	0.86	
10	Over Lock M/C	Sleeve Join Right Side	10A	280	0.8	0.85	0.86	0.86	0.9	0.86	0.88	0.89	0.86	0.863
			10B	280	0.8	0.84	0.85	0.86	0.9	0.86	0.88	0.89	0.86	
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	260	0.9	0.85	0.86	0.87	0.9	0.87	0.88	0.89	0.87	0.866
			11B	260	0.8	0.85	0.86	0.87	0.9	0.87	0.88	0.88	0.87	
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	260	0.8	0.85	0.85	0.87	0.9	0.87	0.88	0.89	0.87	0.864
			12B	260	0.8	0.85	0.85	0.87	0.9	0.87	0.87	0.88	0.86	
13	Plane M/C	Sleeve Tack Inner Left Side	13A	420	0.8	0.79	0.8	0.81	0.8	0.81	0.82	0.83	0.81	0.807
			13B	420	0.8	0.79	0.8	0.8	0.8	0.81	0.82	0.83	0.81	
14	Plane M/C	Sleeve Tack Inner Right Side	14A	420	0.8	0.79	0.8	0.81	0.8	0.81	0.82	0.83	0.81	0.809
			14B	420	0.8	0.79	0.8	0.81	0.8	0.81	0.82	0.84	0.81	
15	Over Lock M/C	Side Seam Sewing Left Side	15A	260	0.85	0.85	0.87	0.87	0.88	0.88	0.88	0.9	0.872	0.871
			15B	260	0.84	0.85	0.86	0.87	0.88	0.88	0.88	0.89	0.87	
16	Over Lock M/C	Side Seam Sewing Right Side	16A	260	0.85	0.85	0.87	0.87	0.88	0.88	0.88	0.9	0.873	0.873
			16B	260	0.85	0.85	0.87	0.87	0.88	0.88	0.88	0.9	0.873	
17	Flat lock M/C	Body Hem Sewing	17A	145	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.845	0.846
			17B	145	0.83	0.83	0.84	0.85	0.85	0.85	0.86	0.86	0.846	
18	Plane M/C	Sleeve Tack Outer Left Side	18A	400	0.81	0.82	0.83	0.85	0.86	0.85	0.86	0.87	0.843	0.845
			18B	400	0.82	0.83	0.84	0.85	0.86	0.85	0.86	0.87	0.846	
19	Plane M/C	Sleeve Tack Outer Right Side	19A	400	0.81	0.82	0.83	0.84	0.86	0.85	0.86	0.87	0.841	0.843
			19B	400	0.81	0.83	0.84	0.85	0.86	0.85	0.86	0.87	0.844	

Table 4.20: Basic Pitch Time and Standard Processing Time of a T-Shirt of a sewing section.

Serial No	Machine Name	Operation Name	Operator Name	Observed Time Sec	Observed Rating	Basic Pitch Time Sec	Allowance Rate 13%	Standard Processing Time Sec	Average Standard Processing Time Sec	Capacity Per Hour (Pieces Per Hour)
1	Over Lock M/C	Shoulder Join Left Side	1A	12.5	0.758	9.475	0.13	10.707	10.706	336.26
			1B	12.58	0.753	9.473	0.13	10.704		
2	Over Lock M/C	Shoulder Join Right Side	2A	12.61	0.75	9.458	0.13	10.687	10.69	336.76
			2B	12.65	0.748	9.462	0.13	10.692		
3	Over Lock M/C	Neck Join	3A	24.32	0.82	19.942	0.13	22.535	22.534	159.76
			3B	24.2	0.824	19.941	0.13	22.533		
4	Flat lock M/C	Back neck Tap Join	4A	24.73	0.854	21.119	0.13	23.865	23.857	150.9
			4B	24.8	0.851	21.105	0.13	23.848		
5	Flat lock M/C	Neck Tap Sewing	5A	24.16	0.782	18.893	0.13	21.349	21.356	168.57
			5B	23.9	0.791	18.905	0.13	21.363		
6	Plane M/C	Back Neck Tap Sewing	6A	25.76	0.878	22.617	0.13	25.558	25.397	141.75
			6B	25.61	0.872	22.332	0.13	25.235		
7	Flat lock M/C	Sleeve Hem Sewing Left Side	7A	13.41	0.838	11.238	0.13	12.698	12.701	283.44
			7B	13.48	0.834	11.242	0.13	12.704		
8	Flat lock M/C	Sleeve Hem Sewing Right Side	8A	13.39	0.839	11.234	0.13	12.695	12.691	283.67
			8B	13.43	0.836	11.227	0.13	12.687		
9	Over Lock M/C	Sleeve Join Left Side	9A	14.94	0.86	12.848	0.13	14.519	14.512	248.07
			9B	14.96	0.858	12.836	0.13	14.504		
10	Over Lock M/C	Sleeve Join Right Side	10A	14.86	0.864	12.839	0.13	14.508	14.507	248.16
			10B	14.91	0.861	12.838	0.13	14.506		
11	Flat lock M/C	Arm Hole Top Sewing Left Side	11A	15.94	0.867	13.82	0.13	15.617	15.619	230.49
			11B	15.98	0.865	13.823	0.13	15.62		
12	Flat lock M/C	Arm Hole Top Sewing Right Side	12A	15.97	0.865	13.814	0.13	15.61	15.621	230.46
			12B	16.03	0.863	13.834	0.13	15.632		
13	Plane M/C	Sleeve Tack Inner Left Side	13A	10.61	0.807	8.562	0.13	9.675	9.674	372.13
			13B	10.62	0.806	8.56	0.13	9.672		
14	Plane M/C	Sleeve Tack Inner Right Side	14A	10.57	0.81	8.562	0.13	9.675	9.672	372.21
			14B	10.59	0.808	8.557	0.13	9.669		
15	Over Lock M/C	Side Seam Sewing Left Side	15A	15.85	0.872	13.821	0.13	15.618	15.62	230.47
			15B	15.89	0.87	13.824	0.13	15.621		
16	Over Lock M/C	Side Seam Sewing Right Side	16A	15.83	0.873	13.82	0.13	15.616	15.621	230.46
			16B	15.84	0.873	13.828	0.13	15.626		
17	Flat lock M/C	Body Hem Sewing	17A	29.3	0.845	24.759	0.13	27.978	27.966	128.73
			17B	29.24	0.846	24.737	0.13	27.953		
18	Plane M/C	Sleeve Tack Outer Left Side	18A	10.67	0.843	8.995	0.13	10.164	10.159	354.37
			18B	10.62	0.846	8.985	0.13	10.153		
19	Plane M/C	Sleeve Tack Outer Right Side	19A	10.7	0.841	8.999	0.13	10.169	10.168	354.05
			19B	10.66	0.844	8.997	0.13	10.167		

Table 4.17 and Table 4.20 show that highest pitch time or observed time is 29.27 second and standard processing time is 27.966 second. So here bottleneck time is 29.27 second for observed time and 27.966 second for standard processing time. From Table 4.9, it is found that after splitting previous observed bottle neck time is 34.865 second. So bottleneck time is reduced 16.04 % for observed time compare to this new existing observed bottleneck time after splitting. From Table 4.1, it is found that existing observed bottle neck time is 41.58 second. So bottle neck time is reduced 29.61% compare to this existing observed bottle neck time. In this developed production system standard bottle neck time is lower than observed bottle neck time.

Method Study is based on assumption that actual per hour production is always same as calculated per hour production due to no fatigue of machine and worker and smooth continuous supply chain system of raw material. But generally in any existing production system, actual per hour production is always less than calculated per hour production due to fatigue of machine and worker and discontinuity of supply chain system of raw material. So during Method Study it is found that pitch time or observed time always decrease compare to existing pitch time. As a result per hour production increases and worker rating also increases. But in a same production process (existing or developed) generally standard time is always less than observed time. So for an adopted production system (existing or developed by Method Study) standard time is more efficient, more effective and more productive. In this case, Method Study is carried out before splitting and after splitting. It is found that standard time is less than observed time. It is also clear that in a production system developed by Method Study, observed time must be reduced than previous existing production time of production system.

CHAPTER FIVE
METHOD STUDY

5.1 METHOD STUDY

Method Study may be defined as the systematic investigation (ie, recording and creating investigation) of 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 and at lower cost. This is generally achieved by eliminating unnecessary motions involved in a critical procedure or by changing the sequence of operation or the process itself. [6]

Method study is carried out on T-Shirt of a sewing section before splitting and after splitting. By using Table 4.1 to table 4.20, the results of Method Study are shown in tabular form in Table 5.1 and Table 5.2. The results of Method Study are also presented bellow in graphical form by using C-Control Chart.

Table 5.1: Result of Method Study of a T-Shirt of a sewing section before splitting.

Seri-al No	Mach-ine Name	Operat-ion Name	Oper-ator Name	No. of Sewing Burst		Required time			Production			Remarks
				Exist-ing	After Devel-oped	Exist-ing	After Devel-oped	Impro-vement %	Exist-ing	After Devel-oped	Impro-vement %	
1	Over Lock MC	Shoulder Joint	1A	1+1	1+1	29 56	26 40	10 69	116.88	135.88	16.26	Improve slow movement and motivation
			1B	1+1	1–1	29 314	26 29	10 32	118 38	136 50	15 31	
2	Over Lock Mc	Neck Joint	2A	3	2	29 249	24 32	16 85	117.63	147.63	25.50	Reduce sewing burst & Improve slow movement
			2B	3	2	29.125	24 20	16 91	118 63	148 38	25 08	
3	Flat Lock MC	Back Neck Tap Joint	3A	1	1	29 76	24.73	16 90	114 87 5	145.25	26.44	Improve slow movement and motivation
			3B	1	1	29 85	24.80	16 92	114.25	144.75	26.70	
4	Flat Lock MC	Neck Tap Sewing	4A	1	1	28.804	24 16	16.12	118.88	148 63	25 03	Improve slow movement and motivation
			4B	1	1	28 911	23.90	17 33	118 13	150 25	27 19	
5	Plane MC	Neck Top Sewing	5A	3	2	30 765	27.24	11.46	105.5	131.63	24.77	Reduce sewing burst & Improve slow movement
			5B	3	2	30 954	27.43	11 38	104 75	130 75	24 82	
6	Flat Lock MC	Sleeve Hem Sewing	6A	2+2	1+1	30 57	26 52	13 25	108 5	135 25	24 65	Reduce sewing burst & marking & improve slow movement
			6B	2+2	1+1	30 423	26 37	13 32	109 38	136 00	24 34	
7	Over Lock MC	Sleeve Joint	7A	2+2	1+1	35 524	31.02	12 68	95.75	115 75	20 89	Reduce sewing burst & Improve slow movement
			7B	2+2	1–1	35.411	30 92	12.68	96 25	115.75	20.26	
8	Flat Lock MC	Armhole Hole Top Sewing	8A	2+2	1+1	35 44	31.56	10 95	94.13	113 50	20 58	Reduce sewing burst & Improve slow movement
			8B	2+2	1+1	35 51	31.64	10 90	94	113 38	20 62	
9	Plane MC	Sleeve Tack (Inner)	9A	–	–	26 37	21.59	18 13	130.75	166 25	27 15	Improve slow movement and motivation
			9B	–	–	26 51	21.50	18.90	130.25	166.88	28.12	
10	Over Lock MC	Side Seam Sewing	10A	5+5	3+3	41 48	33.05	20 32	81.63	108 5	32 92	Reduce sewing burst & Improve slow movement & motivation
			10B	5+5	3+3	41 73	32.94	21.06	79 38	108 75	37.00	
			10C	5+5	3+3	41 54	32.87	20 87	81.13	109	34 35	
11	Flat Lock MC	Body Hem Sewing	11A	6+6	4+4	34 83	29 30	15.88	96	122.38	27.48	Reduce sewing burst & marking Improve slow movement
			11B	6+6	4+4	34 90	29.24	16 22	95 38	122 75	28.70	
12	Plane MC	Sleeve Tack Final (Outer)	12A	–	–	26 31	22.08	16 08	129.25	162 5	25.73	Improve slow movement and motivation
			12B	–	–	26.44	22.06	16.57	128.63	159 5	24.00	

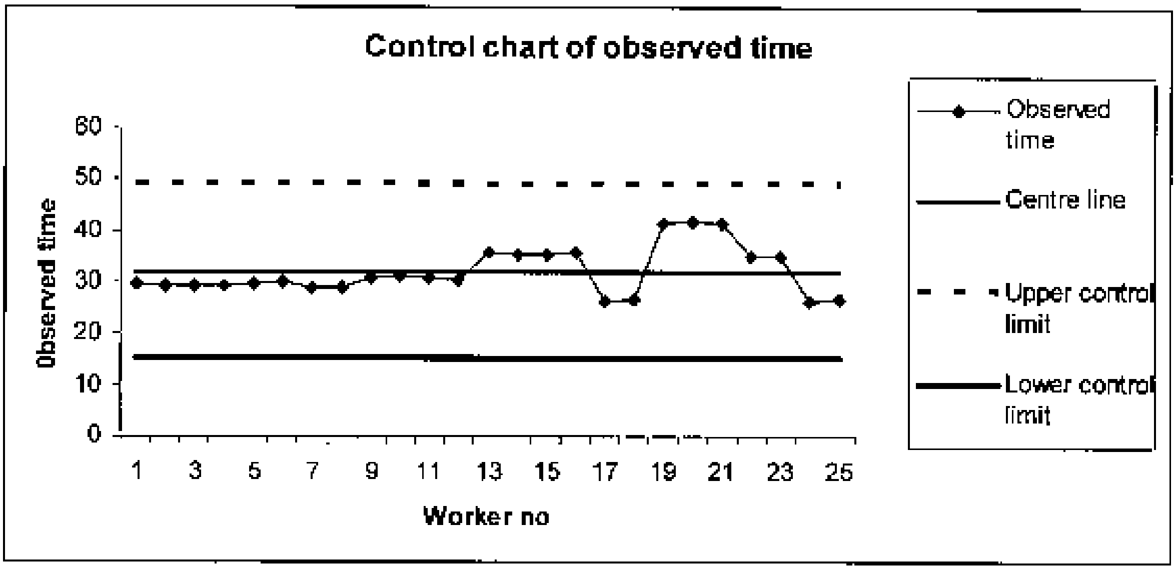

Figure 5.1: Control Chart of existing Observed time before splitting.

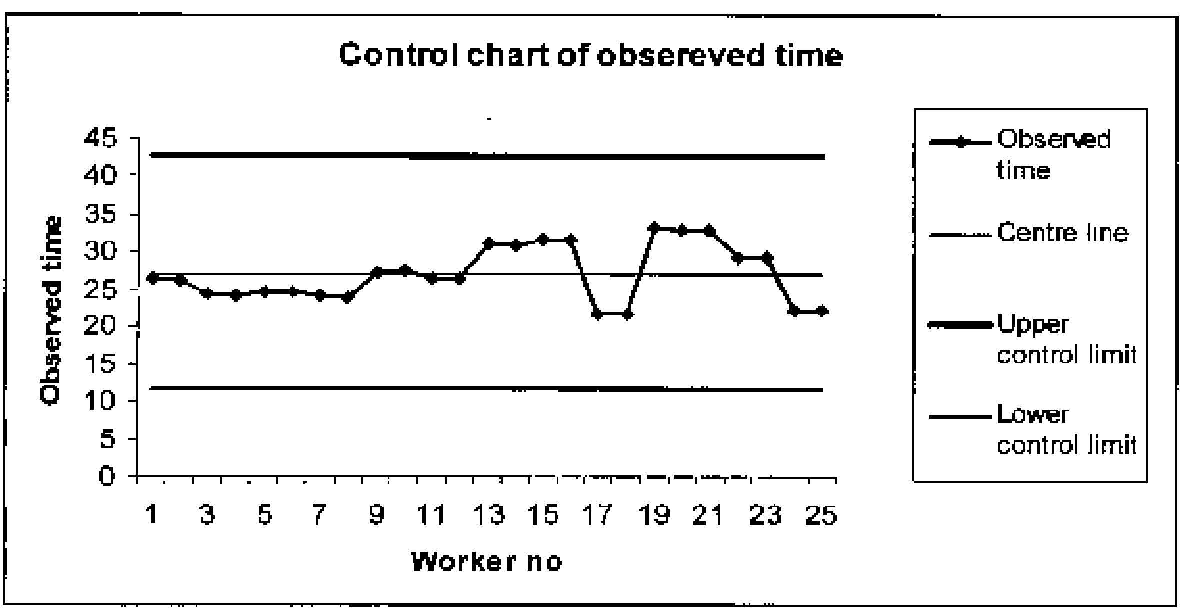

Figure 5.2: Control Chart of developed Observed time before splitting.

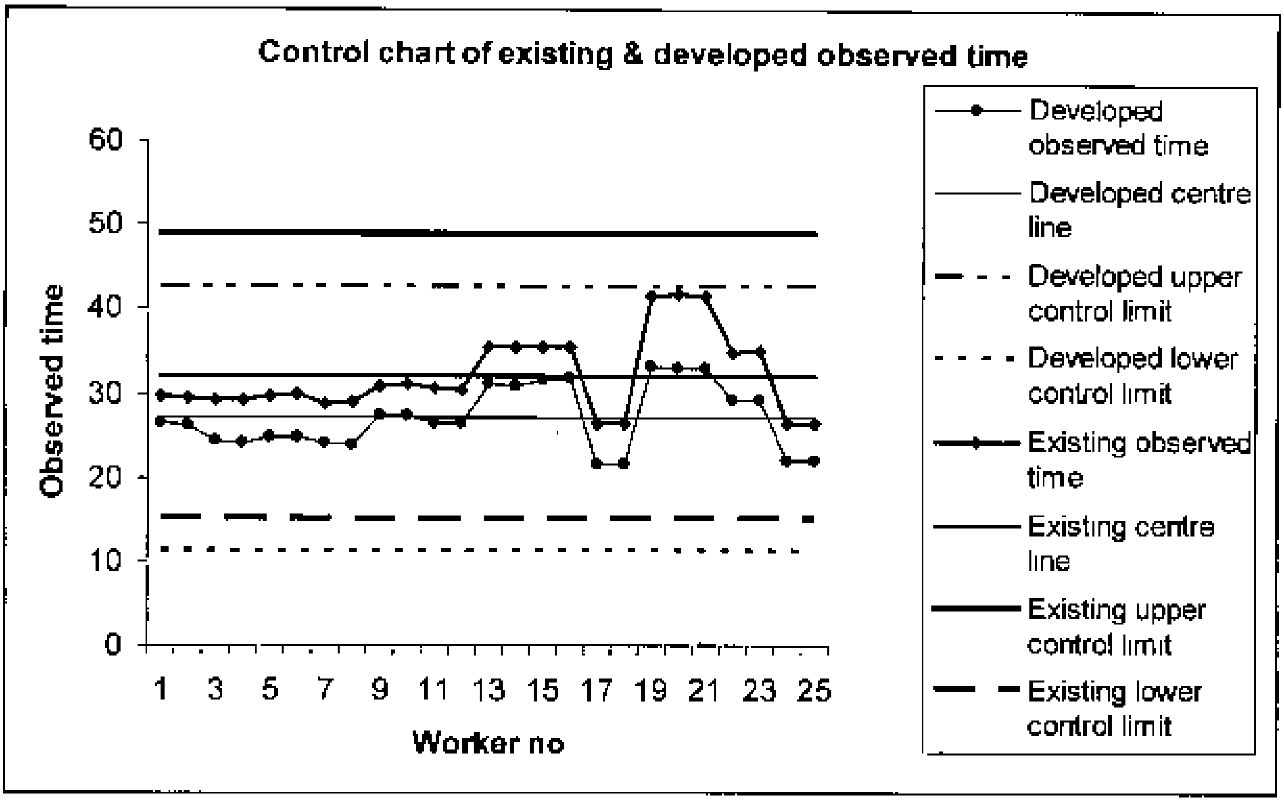

Figure 5.3: Control Chart for Existing & Developed Observed Time before Splitting.

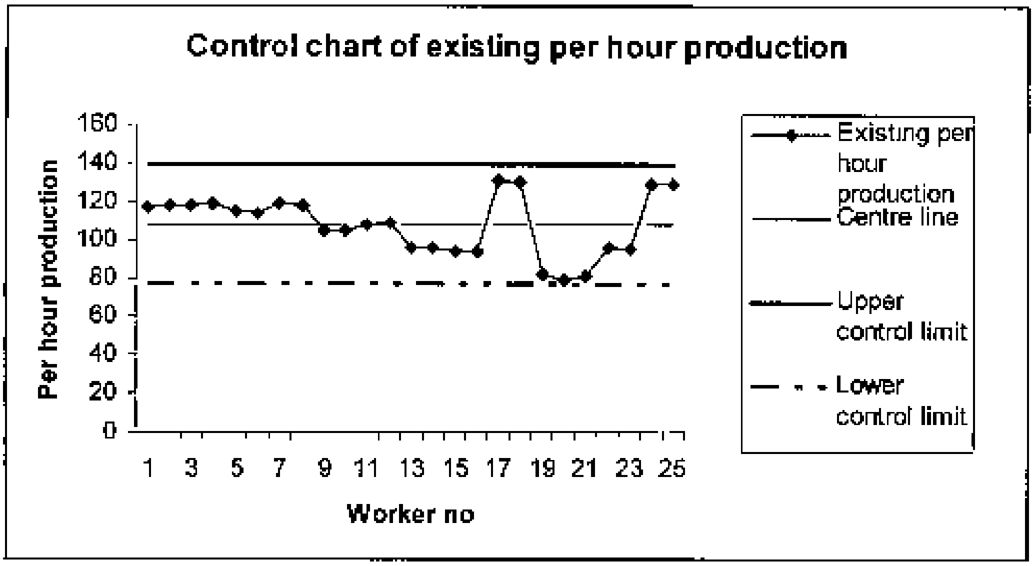

Figure 5.4: Control Chart of existing per hour production before splitting.

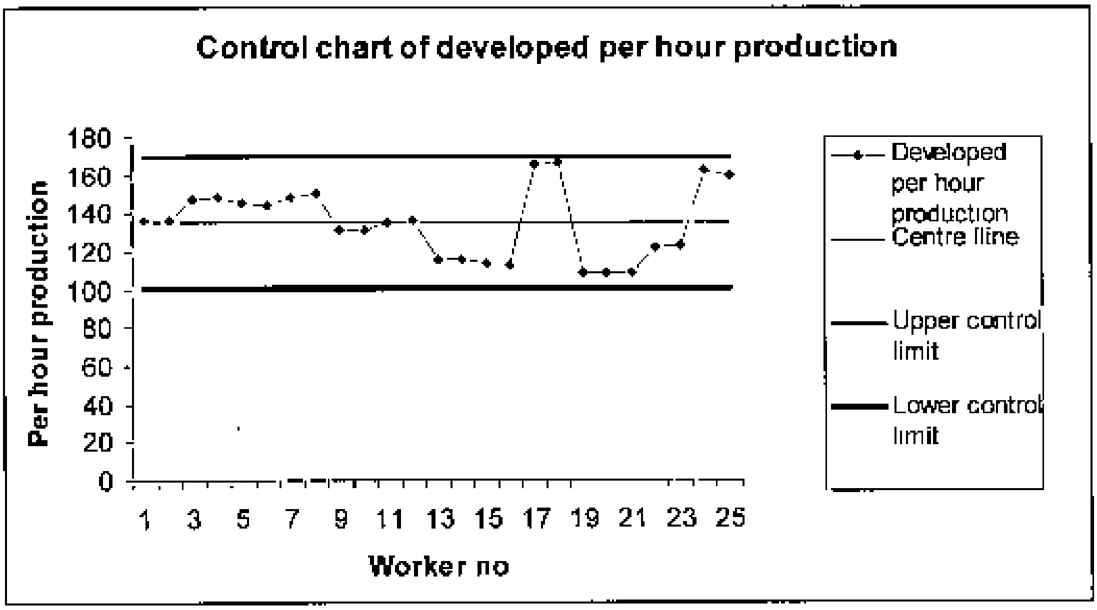

Figure 5.5: Control Chart of developed per hour production before splitting.

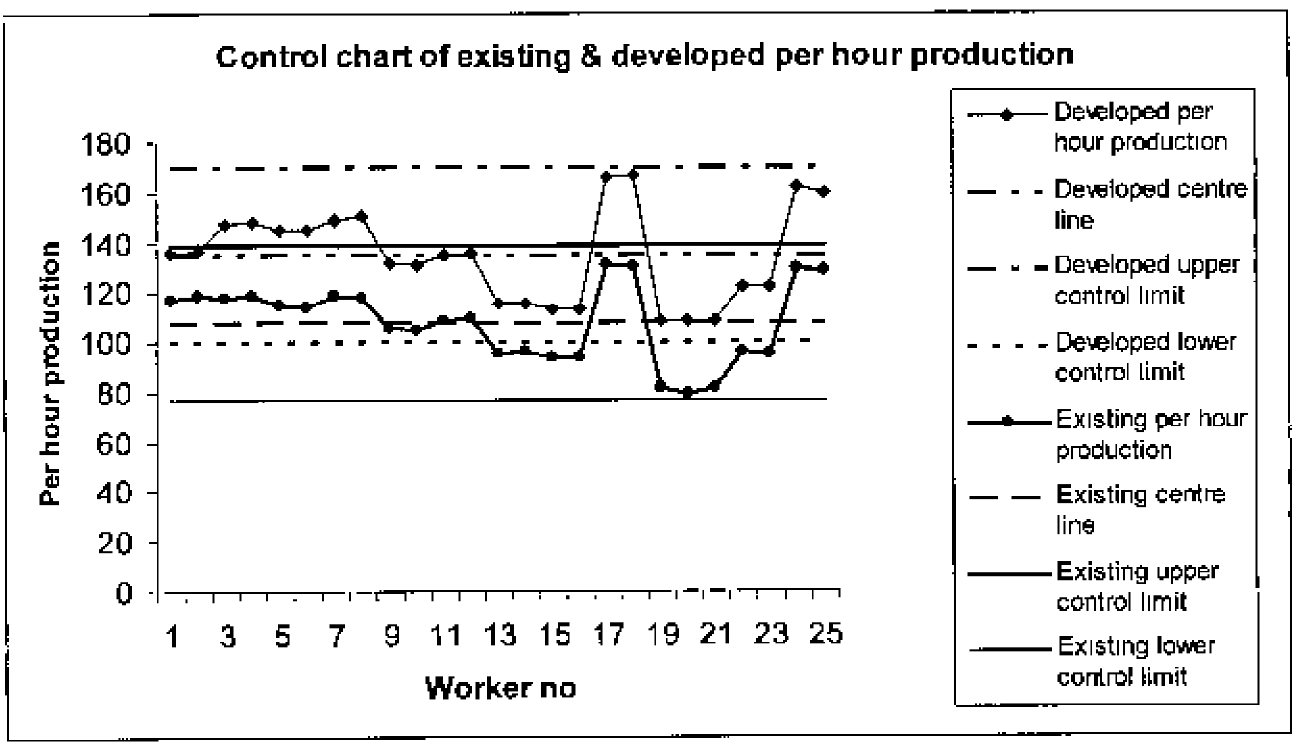

Figure 5.6: Control Chart of Existing & Developed per hour production before Splitting.

Table 5.2: Result of Method Study of a T-Shirt of a sewing section after splitting.

Serial No	Machine Name	Operation Name	Operator Name	No. of Sewing Burst: Existing	No. of Sewing Burst: After Developed	Required time: Existing	Required time: After Developed	Required time: Improvement %	Production: Existing	Production: After Developed	Production: Improvement %	Remarks
1	Over Lock MC	Shoulder Joint Left Side	1A	1	1	14 766	12 5	15 35	231 63	287 88	24 28	Improve slow movement & motivation
			1B	1	1	14.646	12.58	14 11	236 88	286	20 74	
	Over Lock MC	Shoulder Joint Right Side	2A	1	1	14 749	12 61	14 50	231.88	285.13	22.96	Improve slow movement & motivation
			2B	1	1	14.638	12 65	13 58	237 38	284 25	19 74	
3	Over Lock MC	Neck Joint	3A	3	2	29 249	24.32	16.85	117 63	147.63	25 50	Reduce sewing burst & improve slow movement
			3B	3	2	29 125	24 2	16 91	118 63	148.38	25.08	
4	Flat Lock MC	Back Neck Tap Joint	4A	1	1	29.76	24 73	16 90	114 88	145.25	26.44	Improve slow movement & motivation
			4B	1	1	29 85	24.8	16 92	114.25	144 75	26 70	
5	Flat Lock MC	Neck Tap Sewing	5A	1	1	28 804	24.16	16.12	118.88	148 63	25.03	Improve slow movement & motivation
			5B	1	1	28.911	23.9	17.33	118.13	150 25	27 19	
6	Plane MC	Neck Top Sewing	6A	3	2	30 765	25.76	16.27	105 5	139.5	32.23	Reduce sewing burst & improve slow movement
			6B	3	2	30 954	25 61	17.26	104 75	140 13	33 78	
7	Flat Lock MC	Sleeve Hem Sewing Left Side	7A	2	1	15.274	13.41	12 20	217	268 25	23 62	Reduce sewing burst & marking & improve slow movement
			7B	2	1	15 186	13 48	11 23	218 75	266 75	21.94	
8	Flat Lock MC	Sleeve Hem Sewing Right Side	8A	2	1	15.269	13.39	12 31	217 13	268 5	23 66	Reduce sewing burst & marking & improve slow movement
			8B	2	1	15 193	13 43	11 60	218 63	267 63	22.41	
9	Over Lock MC	Sleeve Joint Left Side	9A	2	1	17 746	14 94	15.81	191.75	240.75	25 55	Reduce sewing burst & improve slow movement
			9B	2	1	17 689	14 96	15 43	192 75	240.13	24.58	
10	Over Lock MC	Sleeve Joint Right Side	10A	2	1	17 74	14.86	16.23	192.13	241.89	25.89	Reduce sewing burst & improve slow movement
			10B	2	1	17 688	14 91	15 71	192.88	241	24.95	
11	Flat Lock MC	Armhole Hole Top Sewing Left Side	11A	2	1	17.714	15.94	10 01	188.25	225 38	19 72	Reduce sewing burst & improve slow movement
			11B	2	1	17.749	15.98	9.97	188	224 88	19 62	
12	Flat Lock MC	Armhole Hole Top Sewing Right Side	12A	2	1	17.701	15.97	9.78	188.63	225	19 28	Reduce sewing burst & improve slow movement
			12B	2	1	17 748	16 03	9 68	188 25	224 25	19.12	
13	Plane MC	Sleeve Tack(Inner) Left Side	13A	–	–	13 171	10 61	19 44	261.5	338.75	29.54	Improve slow movement & motivation
			13B	–	–	13.239	10 62	19 78	260 5	338 5	29 94	
14	Plane MC	Sleeve Tack(Inner) Right Side	14A	–	–	13 164	10 57	19.71	262	340 25	29 87	Improve slow movement & motivation
			14B	–	–	13 226	10 59	19 93	261 13	339.5	30.01	
15	Over Lock MC	Side Seam Sewing Left Side	15A	5	3	20.86	15.85	24.02	158 75	226 75	42 83	Reduce sewing burst & improve slow movement & motivation
			15B	5	3	20 75	15 89	23.42	162.25	226.25	39.45	
16	Over Lock MC	Side Seam Sewing Right Side	16A	5	3	20 85	15 83	24 08	158.75	226 88	42.92	Reduce sewing burst & improve slow movement & motivation
			16B	5	3	20 75	15 84	23.68	162.25	226.88	39.83	
17	Flat Lock MC	Body Hem Sewing	17A	6	4	34 83	29.3	15 88	96	122 38	27.48	Reduce sewing burst & marking & improve slow movement
			17B	6	4	34 9	29.24	16 22	95 38	122.75	28.70	
18	Plane MC	Sleeve Tack Final (Outer) Left Side	18A	–	–	13 145	10.67	18.83	258 5	337 25	30.46	Improve slow movement & motivation
			18B	–	–	13 196	10.62	19.52	257.25	338.38	31 54	
19	Plane MC	SleeveTack Final (outer) Right Side	19A	–	–	13 136	10.7	18.54	259 25	336 25	29 70	Improve slow movement & motivation
			19B	–	–	13.188	10 66	19.17	257 38	337.5	31.13	

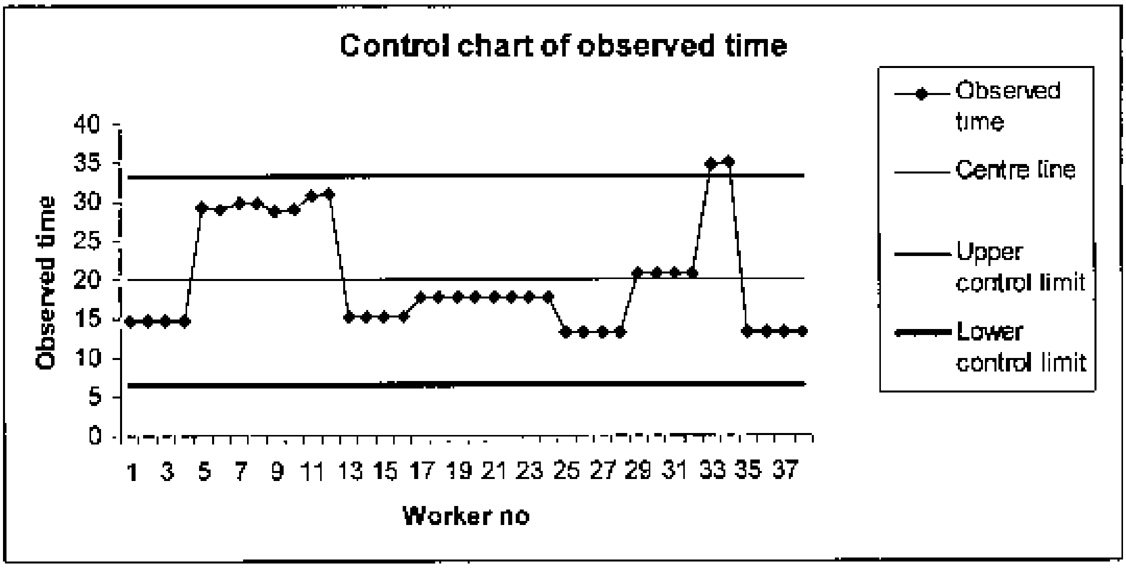

Figure 5.7: Control Chart of existing Observed time after splitting.

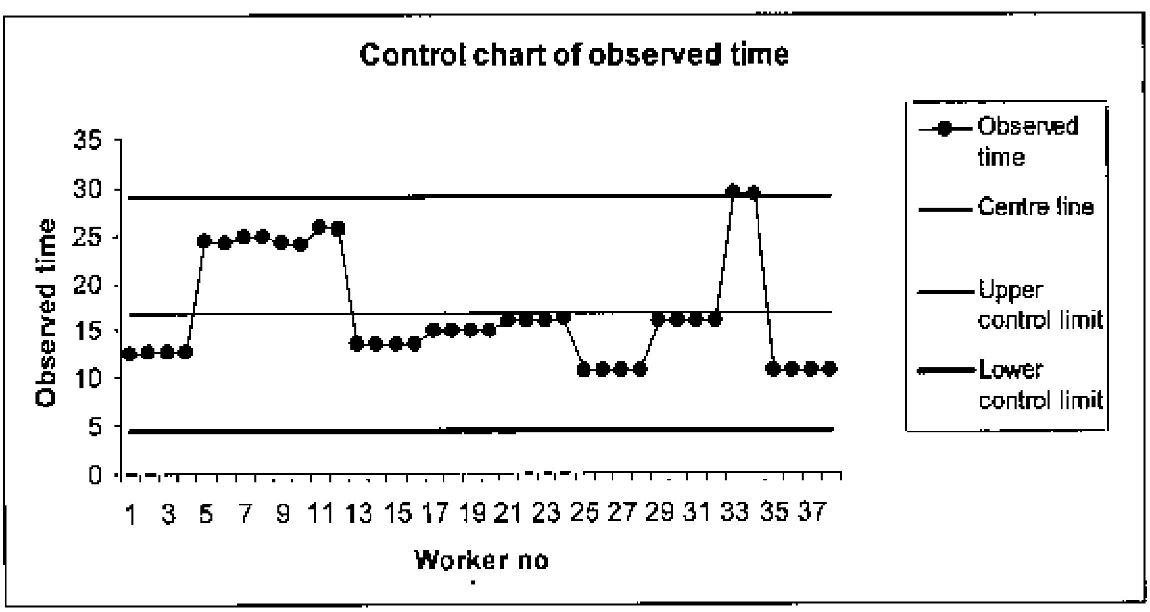

Figure 5.8: Control Chart of developed Observed time after splitting.

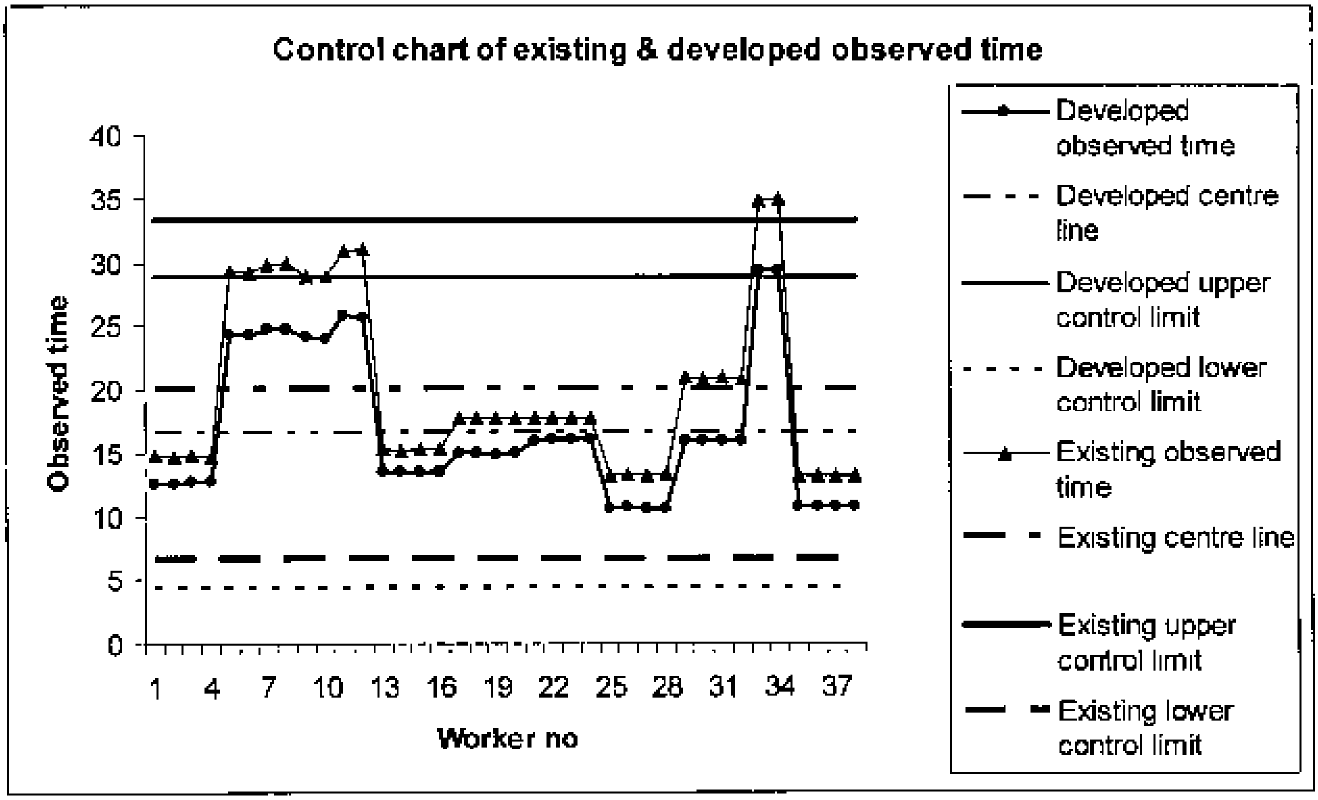

Figure 5.9: Control Chart of Existing & Developed Observed Time after Splitting.

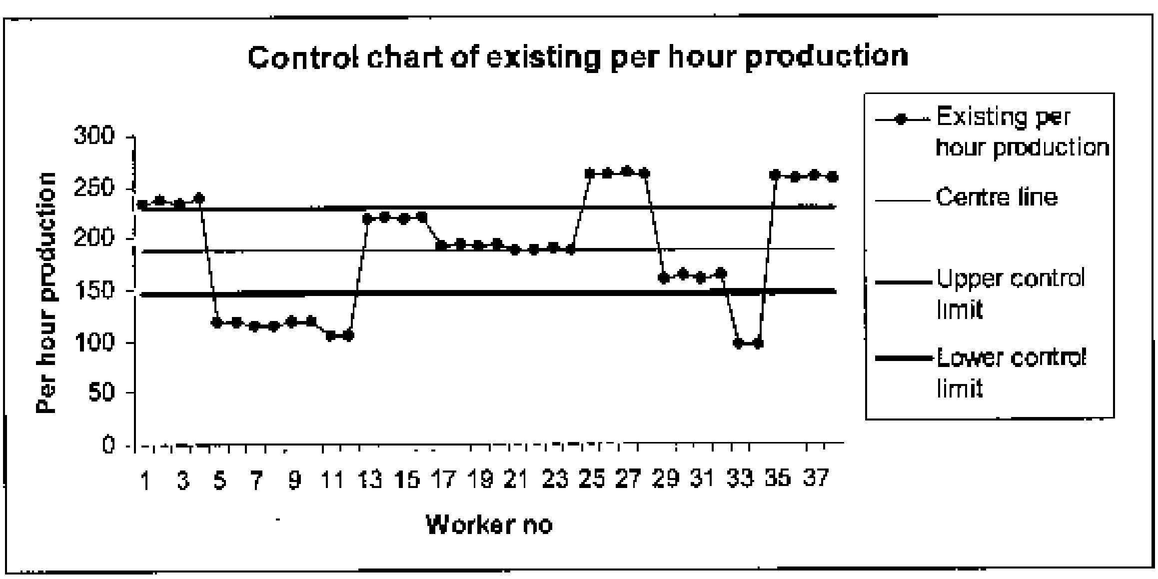

Figure 5.10: Control Chart of existing per hour production after splitting.

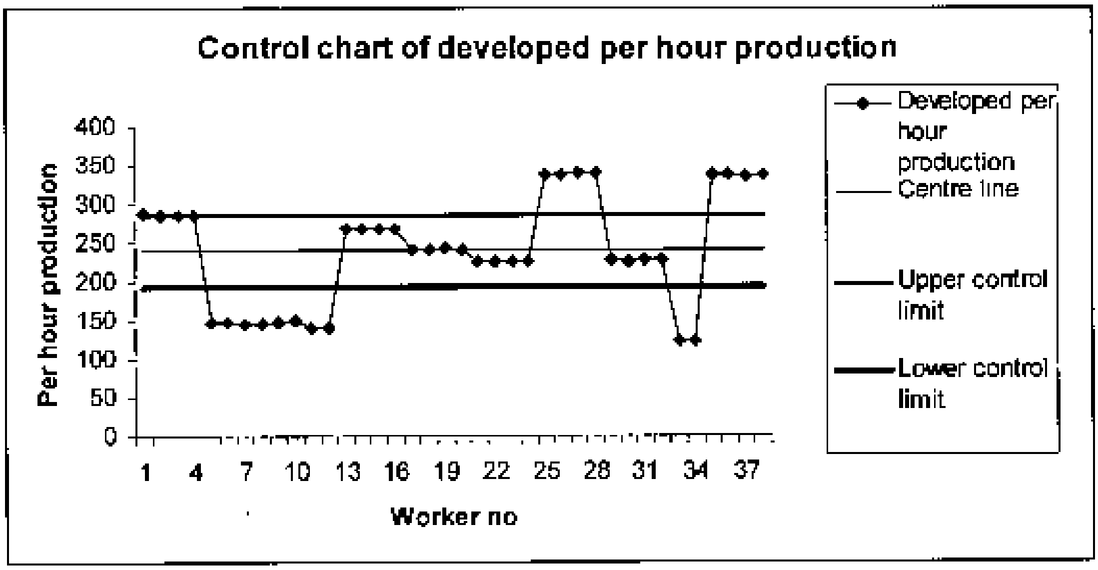

Figure 5.11: Control Chart of developed per hour production after splitting.

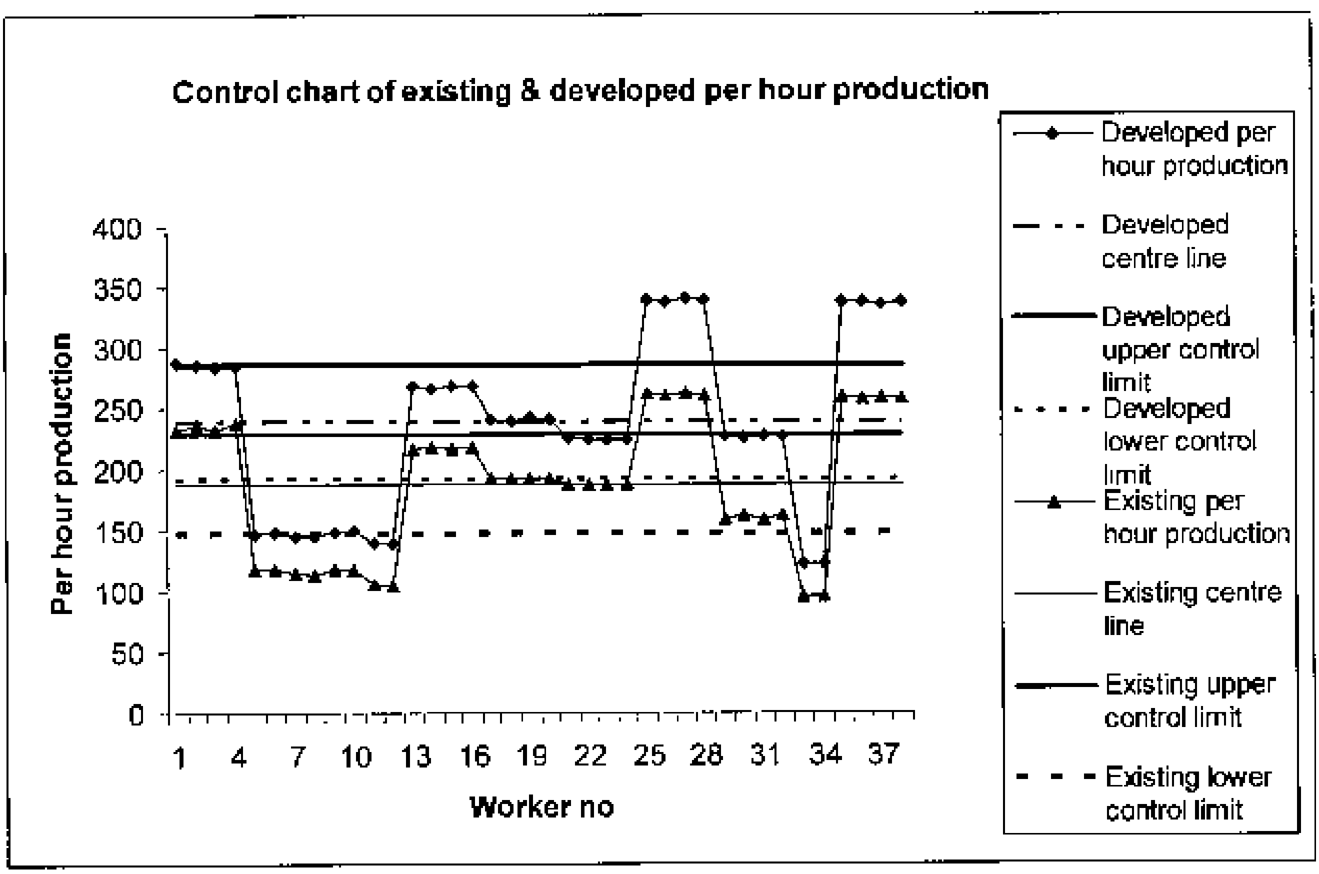

Figure 5.12: Control Chart of Existing & Developed per hour production after Splitting.

CHAPTER SIX

LINE BALANCING

6.1 LINE OF BALANCE

Line balancing is a manual planning and scheduling Technique similar in nature to Material Resource Planning. It is most appropriate for assembly operations involving a number of distinct components. In essence, it employs the principle of management-by-exception through a comparison of progress of individual components with the time schedule for completed assemblies. Regular progress checks reveal the future effect of any current delays and indicate the .degree of urgency for corrective action. Line balancing is not directly concerned with the resources expanded but it is utilized in determining production progress in terms of percent of tasks completion. Major bottlenecks in the production process are emphasized. The objective of this technique being to study the progress of jobs at regular intervals, to compare progress on each operation with the progress necessary to satisfy the eventual delivery requirements, and to identify those operations in which progress is unsatisfactory. It is particularly useful where large batches of fairly complex items, requiring many operations, are to be completed or delivered over a period of time. [6]

In the flow production system, it is one of the principles, from mass production point of view to eliminate unnecessary transfer or holdup to achieve smooth production flow using the observed time (pitch time) as the reference value for synchronization. To grasp the actual conditions of the line balance, it is essential to find the time required to complete the work by division of labor (by worker) to arrange the results following the normal order of process and present them in graphical form in pitch diagram. With investigation of the bottleneck process, control limit using the pitch diagram must be calculated with organization efficiency 85%.

Upper control limit of pitch diagram (UCL) = Average observed Time / Target Organization efficiency

Centre line (CL) = Average of observed time

Lower control limit (LCL) = 2 x (Average of observed time) - Upper control limit

Organization efficiency = 100 x (Average observed time) / Bottle neck process time

Maximum daily output = Available time / Cycle time [7]

6.2 EXISTING LINE BALANCE

Now existing line balance of a T-Shirt of a sewing section, calculated by observed time, using Table 4.1 is presented bellow.

Table 6.1: Existing Line Balancing of a T-Shirt of a sewing section.

Work Station	Preceding Work Station	Machine Name	Task Assigned	Task Require Predecessor	Task Time/Per Unit, Second
1	-	Over Lock Machine	A1, Shoulder Joint	None	29.437
2	1	Over Lock Machine	A2, Neck Joint	A1	29.187
3	2	Flat Lock Machine	A3, Back Neck Tap Joint	A2	29.805
4	3	Flat Lock Machine	A4, Neck Tap Sewing	A3	28.858
5	4	Plane Machine	A5, Neck Top Sewing	A4	30.86
6	5	Flat Lock Machine	A6, Sleeve Hem Sewing	A5	30.5
7	6	Over Lock Machine	A7, Sleeve Joint	A6	35.47
8	7	Flat Lock Machine	A8, Arm Hole Top Sewing	A7	35.48
9	8	Plane Machine	A9, Sleeve Tack Inner	A8	26.44
10	9	Over Lock Machine	A10, Side Seam Sewing	A9	41.58
11	10	Flat Lock Machine	A11, Body Hem Sewing	A10	34.87
12	11	Plane Machine	A12, Sleeve Tack Outer	A11	26.38

Total time = 378.867 Second

Average time = 31.573Second

From the above Table 6.1 it is found that highest processing Time is 41.58 second at station 10. Now Bottle Neck Time is 41.58 second. So cycle time of this line is 41.58 second.

Maximum daily out put = Available time / Cycle time

= 3600 x 12 / 41.58

= 1038.96 Pieces

= 1039 Pieces

Table 6.2: Calculation of labor utilization efficiency for 41.58 second cycle time.

Work station	Employee time available (cycle time, second)	Productive time(Task time, expended each cycle)	Idle time each cycle
1	41 58	29.437	12 143
2	41 58	29 187	12 393
3	41.58	29 805	11.775
4	41 58	28.858	12 722
5	41 58	30.86	10.72
6	41 58	30 5	11.08
7	41.58	35.47	6.11
8	41.58	35.48	6.1
9	41.58	26 44	15 14
10	41.58	41 58	0
11	41.58	34 87	6 71
12	41 58	26 38	15.2
Total time	498 96 second	378.867 second	120.093 second
Efficiency		(378 867 /498 96) x100 = 75 93 % Utilization	(120.093/498 96) x 100 =24 07 % idleness

Now organization efficiency = 100 x 31.573 / 41.58

= 75.93 %

Now Pitch diagram and Schematic of existing assembly line balance of a T-Shirt of a sewing section, using Table 6.2 are shown bellow.

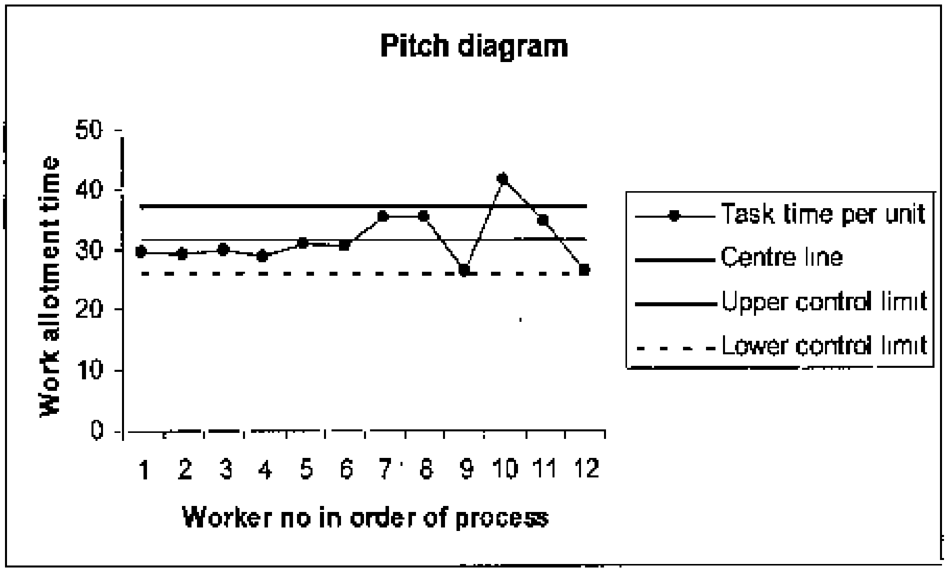

Figure 6.1: Pitch diagram of existing line balance of a T-Shirt Sewing Section.

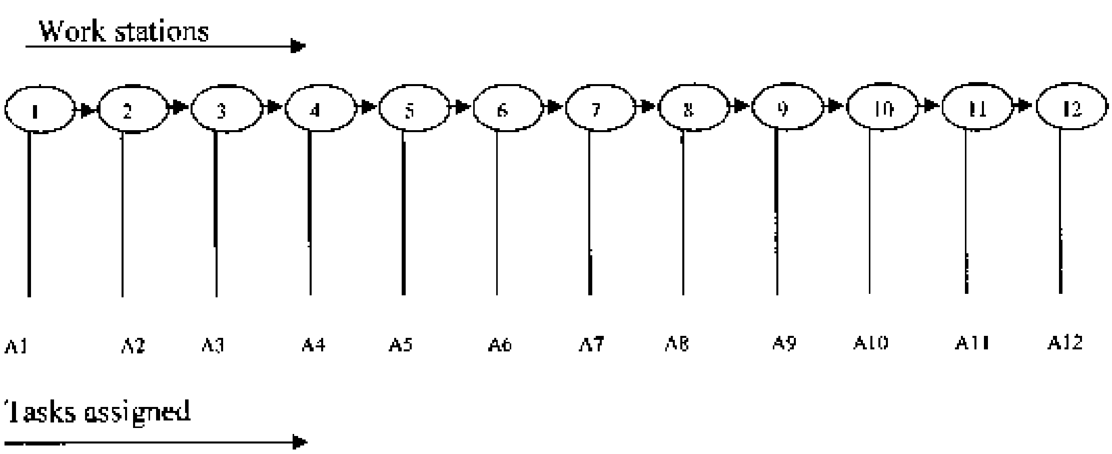

Figure 6.2 Schematic of existing assembly line of a T-Shirt of a Sewing Section.

6.3 PROPOSED LINE BALANCE: SITUATION 1

Now proposed line balance of a T-Shirt of a sewing section before splitting and after method study, calculated by observed time, using Table 4.13 is presented below.

Table 6.3: The job times and precedence relationships of a T-Shirt of a sewing section.

Work Station	Preceding Work Station	Task Assigned	Task Require Predecessor	Task Time/Per Unit, Second
1	–	A1, Shoulder Joint	None	26.35
2	1	A2, Neck Joint	A1	24 26
3	2	A3, Back Neck Tap Joint	A2	24.765
4	3	A4, Neck Tap Sewing	A3	24.03
5	4	A5, Neck Top Sewing	A4	27.335
6	5	A6, Sleeve Hem Sewing	A5	26.445
7	6	A7, Sleeve Joint	A6	30.97
8	7	A8, Arm Hole Top Sewing	A7	31 6
9	8	A9, Sleeve Tack Inner	A8	21.545
10	9	A10, Side Seam Sewing	A9	32.95
11	10	A11, Body Hem Sewing	A10	29.27
12	11	A12, Sleeve Tack Outer	A11	22.07

Total time = 321.59 Second

Average time = 26.80 Second

From the above Table 6.3 it is found that highest processing time is 32.95second at station 10. Now Bottle Neck Time is 32.95 second. So cycle time of this line is 32.95 second. So the minimum number of workstations is the ratio of 321.59 / 32.95 = 9.76 rounded to next larger integer, which is 10. But this does not mean that a ten- stations balance necessarily exists. Now the tasks are assigned sequentially, and assignments are made only as long as the precedence constraints are not violated.

Table 6.4: Line Balance and labor utilization efficiency of a T-Shirt of a sewing section.

Heuristic step	Station	Eligible tasks assigned	Machine Name	Productive time	Employee time available(cycle time, second)	Idle time, second, each cycle
1	1	A1	Over Lock Machine	26.35	32.95	6.6
2	2	A2	Over Lock Machine	24.26	32.95	8.69
3	3	A3	Flat Lock Machine	24.765	32.95	8.185
4	4	A4	Flat Lock Machine	24.03	32.95	8.92
5	5	A5	Plane Machine	27.335	32.95	5.615
6	6	A6	Flat Lock Machine	26.445	32.95	6.505
7	7	A7	Over Lock Machine	30.97	32.95	1.98
8	8	A8	Flat Lock Machine	31.6	32.95	1.35
9	9	A9	Plane Machine	21.545	32.95	11.405
10	10	A10	Over Lock Machine	32.95	32.95	0
11	11	A11	Flat Lock Machine	29.27	32.95	3.68
12	12	A12	Plane Machine	22.07	32.95	10.88
Total time			395.40 second		321.59 second	73.81 second
Efficiency					(321.59 / 395.40) x 100 = 81.33 % Utilization	(73.81/395.40) x 100 =18.67% idleness

From the above Table 6.4 it is found that highest processing Time is 32.95 second at station 10. Now Bottle Neck Time is 32.95 second. So cycle time of this line is 32.95 second.

Maximum daily out put = Available time / Cycle time

= 3600 x 12 / 32.95

= 1311.07 Pieces

= 1311 Pieces

But existing daily out put is 1039 pieces. So after Method Study, before splitting, Line balance calculated by observed time, has increased daily production 26.18%.

Now organization efficiency = (100 x 26.80) / (32.95)

= 81.33 %

Now Pitch diagram and Schematic of existing assembly line balance of a T-Shirt of a sewing section, before splitting, using Table 6.4 are shown bellow.

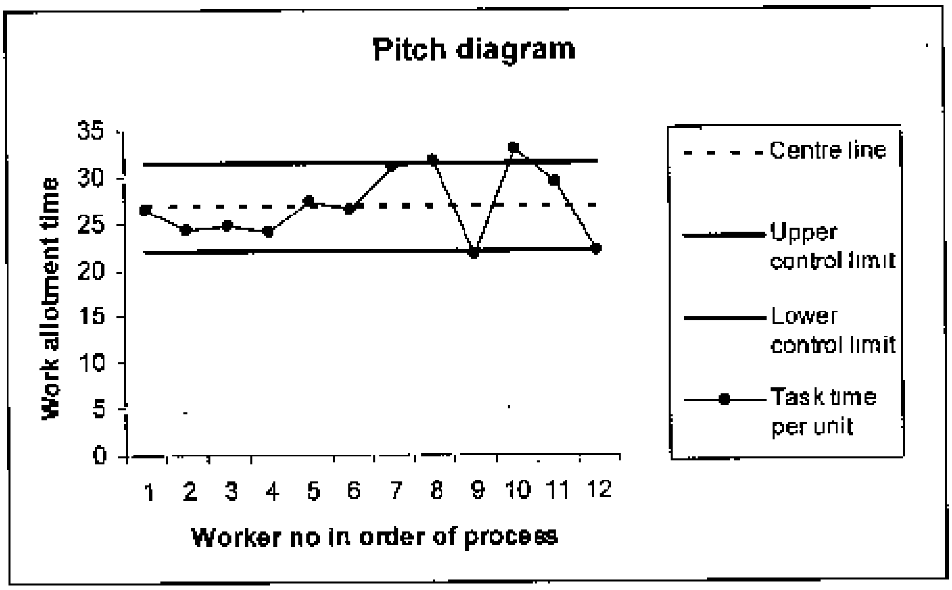

Figure 6.3: Pitch diagram of proposed line balance of a T-Shirt of a Sewing Section.

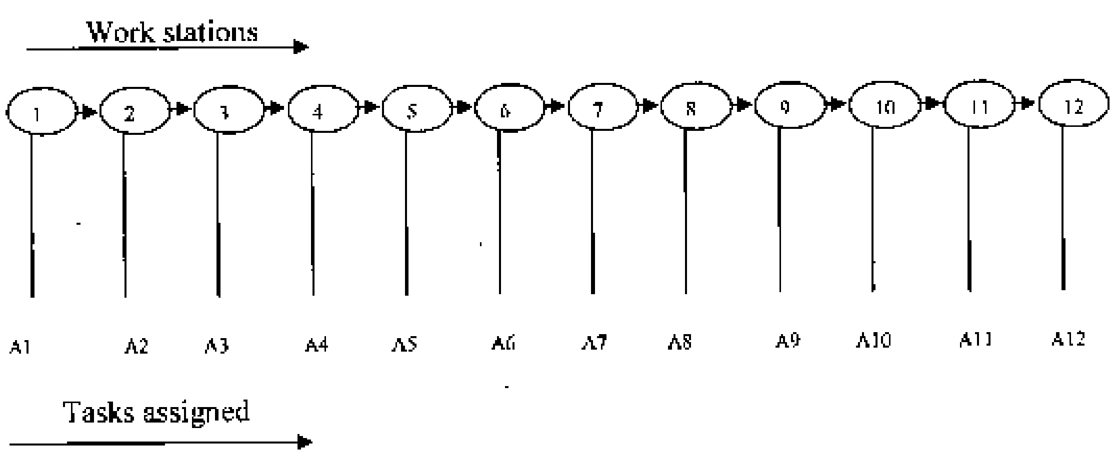

Figure 6.4: Schematic of proposed assembly line of a T-Shirt of a Sewing Section.

6.4 PROPOSED LINE BALANCE: SITUATION II

Now proposed line balance before splitting and after Method Study, calculated by standard time, using Table 4.16 is presented below.

Table 6.5: The job times and precedence relationships of a T-Shirt of a sewing section.

Work Station	Preceding Work Station	Task Assigned	Task Require Predecessor	Task Time/Per Unit, Second
1	-	A1. Shoulder Joint	None	21.33
2	1	A2, Neck Joint	A1	22.534
3	2	A3, Back Neck Tap Joint	A2	23.857
4	3	A4. Neck Tap Sewing	A3	21 356
5	4	A5, Neck Top Sewing	A4	27.03
6	5	A6, Sleeve Hem Sewing	A5	25 326
7	6	A7, Sleeve Joint	A6	28.942
8	7	A8, Arm Hole Top Sewing	A7	31.156
9	8	A9, Sleeve Tack Inner	A8	19.319
10	9	A10, Side Seam Sewing	A9	31 155
11	10	A11, Body Hem Sewing	A10	27 966
12	11	A12, Sleeve Tack Outer	A11	20 251

Total time = 300.222 Second

Average time = 25.0185 Second

From the above Table 6.5 it is found that highest processing time is 31.156 second at station 10 Now Bottle Neck Time is 31.156 second. So cycle time of this line is 31.156 second. So the minimum number of workstations is the ratio of 300.222 / 31.156 = 9.64 rounded to next larger integer, which is 10. But this does not mean that a ten- stations balance necessarily exists. Now the tasks are assigned sequentially, and assignments are made only as long as the precedence constraints are not violated.

Table 6.6: Line Balance and labor utilization efficiency of a T-Shirt of a sewing section.

Heuristic step	Station	Eligible tasks assigned	Productive time	Employee time available(cycle time, second)	Idle time, second, each cycle
1	1	A1	21 33	31 156	9.826
2	2	A2	22 534	31 156	8 622
3	3	A3	23 857	31.156	7 299
4	4	A4	21.356	31 156	9 8
5	5	A5	27.03	31.156	4 126
6	6	A6	25 326	31.156	5.83
7	7	A7	28.942	31 156	2.214
8	8	A8	31.156	31 156	0
9	9	A9	19.319	31 156	11 837
10	10	A10	31.155	31 156	0.001
11	11	A11	27.966	31 156	3.19
12	12	A12	20 251	31.156	10.905
Total time			300.222 second	373 872 second	73.65 second
Efficiency				(300.222 x 100) / 373.872 = 80.30 % Utilization	(73.65 x 100) / 373.872 = 19.70% idleness

From the above Table 6.6 it is found that highest processing Time is 31.156 second at station 8. Now Bottle Neck Time is 31.156 second. So cycle time of this line is 31.156 second.

Maximum daily output = Available time / Cycle time

= 3600x 12 / 31.156

= 1386.57 Pieces

= 1387 Pieces

Now organization efficiency = (100 x 25.0185) / (31.156)

= 80.30 %

After Method Study, before splitting, Line balance calculated by standard time. has increased daily production 33.49 % compare to existing daily production.

Now Pitch diagram and Schematic of suggested assembly line balance of a T-Shirt of a Sewing Section, before splitting, using Table 6.6 are shown bellow.

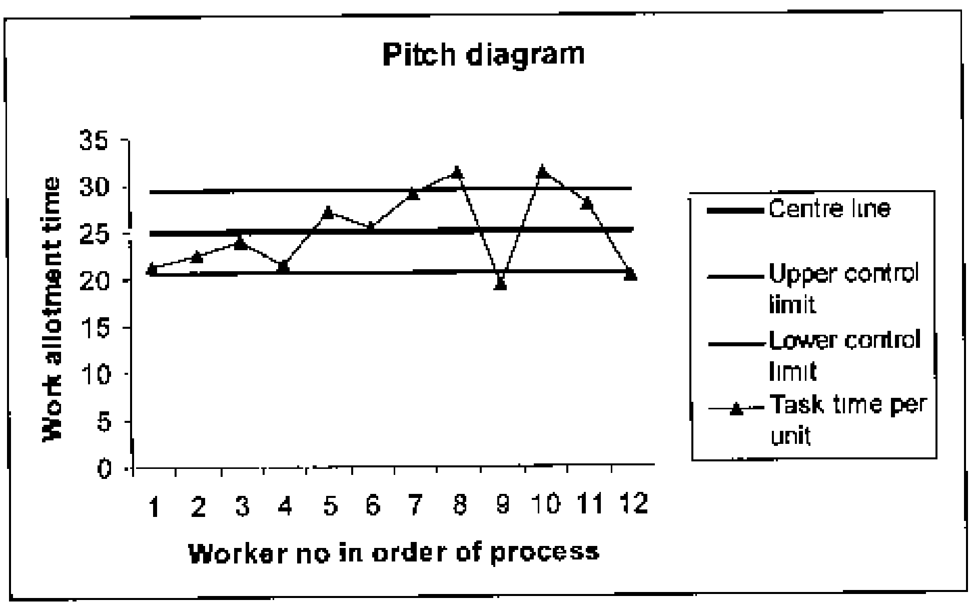

Figure 6.5: Pitch diagram of proposed line balance of a T-Shirt of a Sewing Section

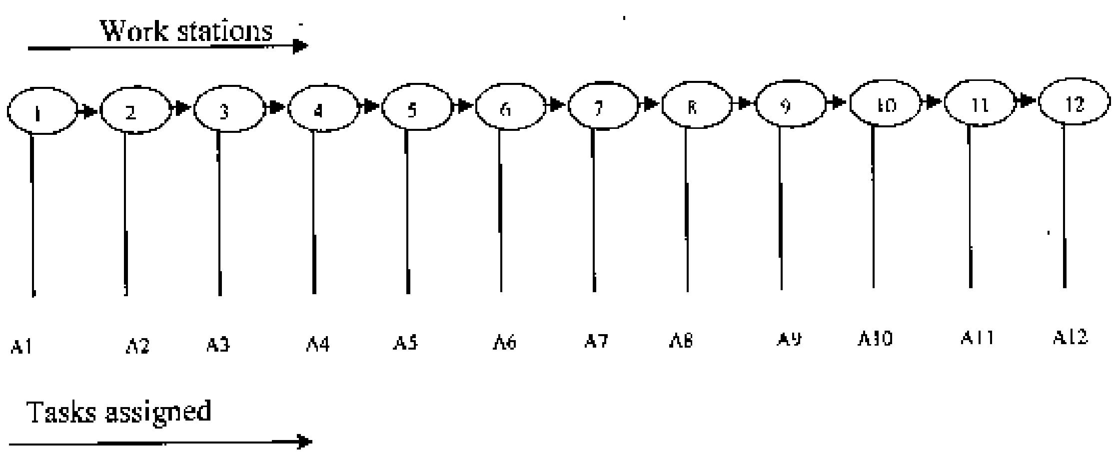

Figure 6.6: Schematic of proposed assembly line of a T-Shirt of a Sewing Section.

6.5 PROPOSED LINE BALANCE: SITUATION III

Now proposed line balance after splitting and Method Study, calculated by observed time. using Table 4.17 is presented below.

Table 6.7: The job times and precedence relationships of a T-Shirt of a sewing section.

Work Station	Preceding Work Station	Task Assigned	Task Require Predecessor	Task Time/Per Unit, Second
1	–	A1, Shoulder Joint Left Side	None	12.54
2	1	A2, Shoulder Joint Right Side	A1	12 63
3	2	A3, Neck Joint	A2	24.26
4	3	A4, Back Neck Tap joint	A3	24.765
5	4	A5, Neck Tap Sewing	A4	24.03
6	5	A6, Neck Top Sewing	A5	25 685
7	6	A7, Sleeve Hem Sewing Left Side	A6	13 445
8	7	A8, Sleeve Hem Sewing Right Side	A7	13.41
9	8	A9, Sleeve joint Left Side	A8	14 95
10	9	A10, Sleeve Joint Right Side	A9	14.885
11	10	A11, Arm Hole Top Sewing Left Side	A10	15.96
12	11	A12, Arm Hole Top Sewing Right Side	A11	16
13	12	A13, Sleeve Tack Inner Left Side	A12	10 615
14	13	A14, Sleeve Tack Outer Right Side	A13	10.58
15	14	A15, Side SEAM Sewing Left Side	A14	15.87
16	15	A16, Side Seam Sewing Right Side	A15	15 835
17	16	A17, Body hem Sewing	A16	29 27
18	17	A18, Sleeve Tack Final Outer Left Side	A17	10 645
19	18	A19, Sleeve Tack Final Outer Right Side	A18	10.68

Total time = 316.07 Second
Average time = 16.64 Second

From the above Table 6.7 it is found that highest processing time is 29.27 second at station 17. Now Bottle Neck Time is 29.27 second. So cycle time of this line is 29.27 second. So the minimum number of workstations is the ratio of 316.06 / 29.27 = 10.798 rounded to next larger integer, which is 11. But this does not mean that an elevenstations balance necessarily exists. Now the tasks are assigned sequentially, and assignments are made only as long as the precedence constraints are not violated.

Table 6.8: Line Balance and labor utilization efficiency of a T-Shirt of a sewing section.

Heuristic step	Station	Eligible tasks assigned	Machine name	Productive time	Employee time available(cycle time, second)	Idle time, each cycle
1	1	A1,A9	Over Lock Machine	27 49	29.27	1.78
2	2	A2,A10	Over Lock Machine	27.52	29 27	1.75
3	3	A3	Over Lock Machine	24.26	29.27	5 01 .
4	4	A4	Flat Lock Machine	24.765	29.27	4 505
5	5	A5	Flat Lock Machine	24 03	29 27	5.24
6	6	A6	Plane Machine	25 685	29 27	3.585
7	7	A7, A8	Flat Lock Machine	26 86	29.27	2 41
8	8	A11	Flat Lock Machine	15 96	29 27	13 31
9	9	A12	Flat Lock Machine	16	29 27	13 27
10	10	A15	Over Lock Machine	15.87	29.27	13.4
11	11	A16	Over Lock Machine	15 835	29.27	13 435
12	12	A13,A18	Plane Machine	21 26	29.27	8.01
13	13	A14,A19	Plane Machine	21.26	29 27	8.01
14	14	A17	Flat Lock Machine	29 27	29.27	0
Total time				316.07 second	409.78 second	93.72 second
Efficiency					(316.06 x 100) / 409.78 = 77.13 % Utilization	(93 72 x 100) / 409.78 =22.87 % Idleness

From the above Table 6.8 it is found that highest processing Time is 29.27 second at station 17. Now Bottle Neck Time is 29.27 second. So cycle time of this line is 29.27 second.

Maximum daily out put = Available time / Cycle time

= 3600 x 12 / 29.27

= 1475.91 Pieces

= 1476 Pieces

Now organization efficiency = (100 x 316.07) / (29.27 x 14)

= 77.13 %

So after Method Study and after splitting, line balance calculated by observed time, has increased daily production 42.06 % compare to existing daily production.

Now Pitch diagram and Schematic of assembly line balance of a T-Shirt of a sewing section, after splitting, using Table 6.8 are shown bellow.

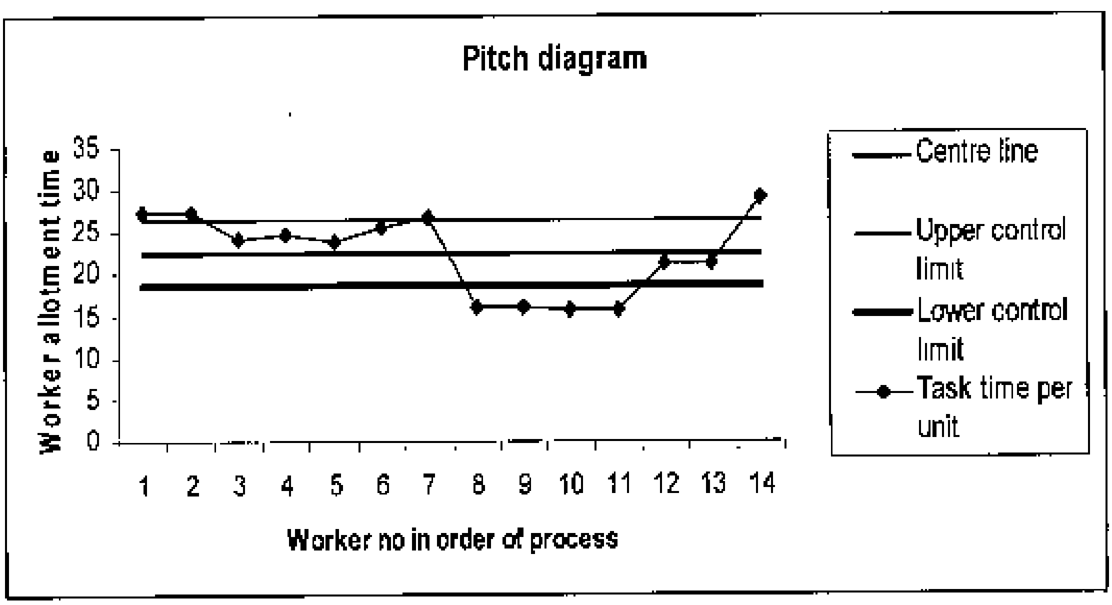

Figure 6.7: Pitch diagram of proposed line balance of a T-Shirt of a Sewing Section.

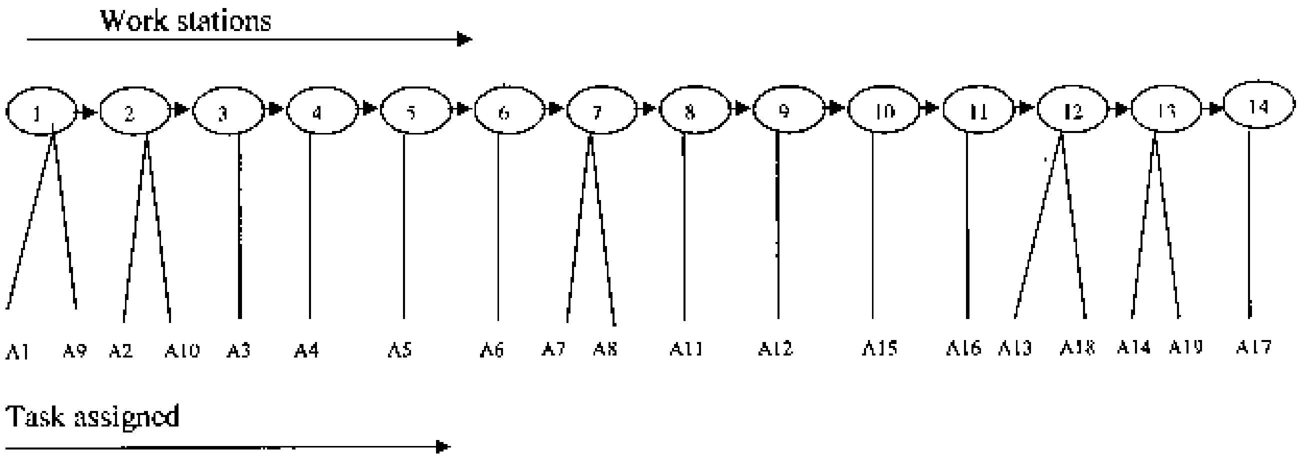

Figure 6.8: Schematic of proposed assembly line of a T-Shirt of a Sewing Section.

6.6 PROPOSED LINE BALANCE: SITUATION IV

Now proposed line balance calculated by standard processing time, after splitting and after Method Study, using Table 4.20 is presented below.

Table 6.9: The job times and precedence relationships of a T-Shirt of a sewing section.

Work Station	Preceding Work Station	Task Assigned	Task Require Predecessor	Task Time/Per Unit, Second
1	-	A1, Shoulder Joint Left Side	None	10.706
2	1	A2, Shoulder Joint Right Side	A1	10.69
3	2	A3, Neck Joint	A2	22.534
4	3	A4, Back Neck Tap joint	A3	23.857
5	4	A5, Neck Tap Sewing	A4	21.356
6	5	A6, Neck Top Sewing	A5	25.397
7	6	A7, Sleeve Hem Sewing Left Side	A6	12.701
8	7	A8, Sleeve Hem Sewing Right Side	A7	12.691
9	8	A9, Sleeve joint Left Side	A8	14.512
10	9	A10, Sleeve Joint Right Side	A9	14.507
11	10	A11, Arm Hole Top Sewing Left Side	A10	15.619
12	11	A12, Arm Hole Top Sewing Right Side	A11	15.621
13	12	A13, Sleeve Tack Inner Left Side	A12	9.674
14	13	A14, Sleeve Tack Outer Right Side	A13	9.672
15	14	A15, Side SEAM Sewing Left Side	A14	15.62
16	15	A16, Side Seam Sewing Right Side	A15	15.621
17	16	A17, Body hem Sewing	A16	27.966
18	17	A18, Sleeve Tack Final Outer Left Side	A17	10.159
19	18	A19, Sleeve Tack Final Outer Right Side	A18	10.168

Total time = 299.071 Second
Average time = 15.74 Second

From the above Table 6.9 it is found that highest processing time is 27.966 second at station 17 Now Bottle Neck Time is 27.966 second. So cycle time of this line is 27.966 second. So the minimum number of workstations is the ratio of 299.071 / 27.966 = 10.69 rounded to next larger integer, which is 11. But this does not mean that a ten-station balance necessarily exists. Now the tasks are assigned sequentially, and assignments are made only as long as the precedence constraints are not violated.

Table 6.10: Line Balance and labor utilization efficiency of a T-Shirt of a sewing section.

Heuristic step	Station	Eligible tasks assigned	Machine name	Productive time	Employee time available(cycle time, second)	Idle time, each cycle
1	1	A1,A9	Over Lock Machine	25.22	27 966	2.746
2	2	A2,A10	Over Lock Machine	25 20	27 966	2.766
3	3	A3	Over Lock Machine	22.524	27.966	5.442
4	4	A4	Flat Lock Machine	23 857	27.966	4.109
5	5	A5	Flat Lock Machine	21.356	27 966	6.61
6	6	A6	Plane Machine	25.397	27.966	2.569
7	7	A7, A8	Flat Lock Machine	25.392	27.966	2.574
8	8	A11	Flat Lock Machine	15.619	27.966	12.347
9	9	A12	Flat Lock Machine	15.621	27.966	12 345
10	10	A15	Over Lock Machine	15 62	27.966	12.346
11	11	A16	Over Lock Machine	15 621	27.966	12.345
12	12	A13,A18	Plane Machine	19 833	27.966	8.133
13	13	A14,A19	Plane Machine	19.84	27 966	8.126
14	14	A17	Flat Lock Machine	27.966	27 966	0
Total time				299 07 second	391 524 second	92 458 second
Efficiency					(299.07 x 100) / 391.524 = 76 39 % Utilization	(92.458 x 100) / 391.524 =23.61 % Idleness

From the above Table 6.10 it is found that highest processing Time is 27.966 second at station 17. Now Bottle Neck Time is 27.966 second. So cycle time of this line is 27.966 second.

Maximum daily out put = Available time / Cycle time

= 3600 x 12 / 27.966

= 1544.73 Pieces

= 1545 Pieces

Now organization efficiency = (100 x 299.071) / (27.966 x 14)

= 76.39 %

So after Method Study and after splitting, line balance calculated by standard time, has increased daily production 48.70 % compare to existing daily production. So this line balance is more effective, more productive compare to all previous line balance. So it is clear that Method Study is prerequisite condition to increase daily production and possible splitting or small division of every operation must be done before line balance. Also line balance must be calculated by standard processing time though idle time may increase.

Now Pitch diagram and Schematic of assembly line balance of a T-Shirt of a Sewing Section, after splitting, using Table6.10 are shown bellow.

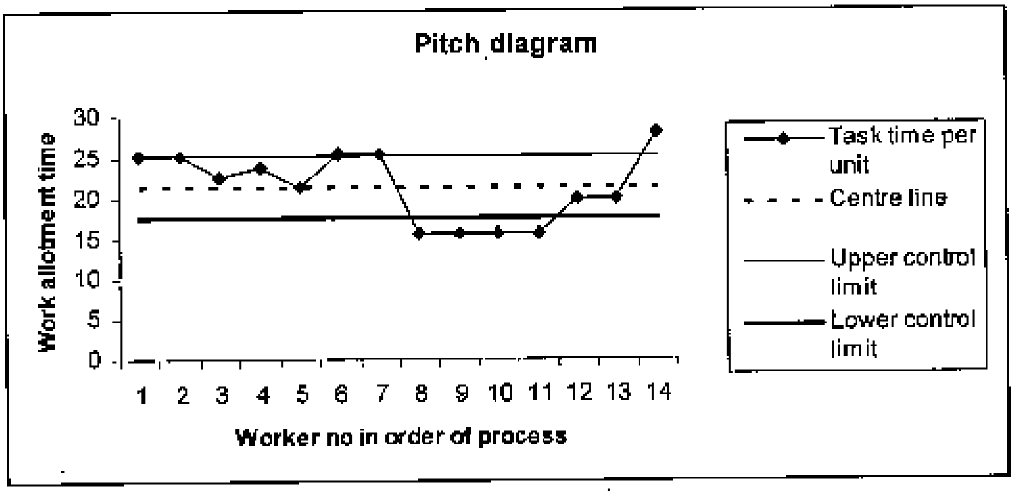

Figure 6.9: Pitch diagram of proposed line balance of a T-Shirt of a Sewing Section.

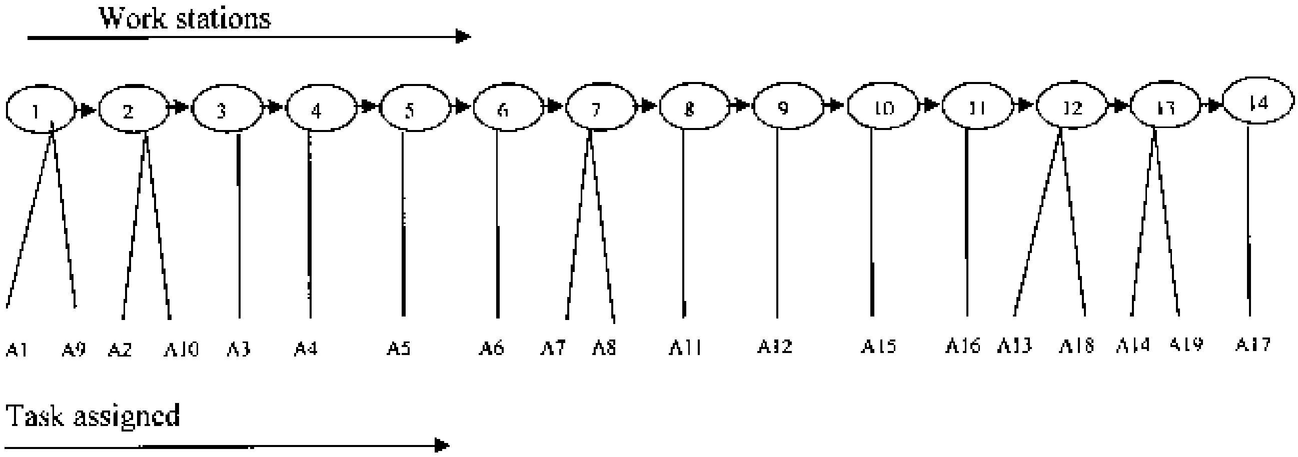

Figure 6.10: Schematic of proposed assembly line of T-Shirt of a Sewing Section.

CHAPTER SEVEN
RESULTS AND DISCUSSION

7.1 RESULTS AND DISCUSSION

The thesis presents the results of analysis and development of a frame work for selected functions of quality and productivity in an apparel company. In this thesis Time Study, Method Study and Line Balance have been studied to find out the parameters which affect the rate of production and hence quality.

In chapter four Table 4.1, Table 4.2, Table 4.3 and Table 4.4 present existing operation time or pitch time, worker rating, per hour production and standard processing time of each process of a T-Shirt of a sewing section Table 4.1 and Table 4.4 show that existing observed bottle neck time is 41.58 second at station10 and existing standard bottle neck time is 29.28 second at station 10. But after splitting the operation "Side Seam Sewing" into two parts as Side Seam Sewing Left side and Side Seam Sewing right side, it is found that observed new bottle neck time is 35.48 second at station 8 in Table 4.5 and standard new bottle neck time is 28.86 second at station 8 in Table 4.9. So bottle neck time is reduced 14.67 % for observed time compare to existing observed bottle neck time. Standard new bottle neck time is lower than observed new bottle neck time.

But after splitting the operations no 1, 6, 7, 8, 9, 13 into Shoulder joint left side and right side, Sleeve hem sewing left side and right side, Sleeve joint left side and right side, Armhole top sewing left side and right side, Sleeve tack inner left side and right side, Sleeve tack final (outer) left side and right side, it is found that observed bottle neck time becomes 34.865 second at station 17 in Table 4.9 and standard bottle neck time becomes 26.046 second at station 17 in Table 4.12. So observed bottleneck time is reduced 16.15 % compare to existing observed bottle neck time. Standard bottle neck time is lower than observed bottle neck time.

But by adopting the technique of Method Study. it is also found that the observed processing time of these operations can be also reduced by reducing excess marking. Excess Sewing Burst, Improvement of Slow Movement and also by Motivation. As a result of adoption and application of these techniques before and after splitting of these operations, observed processing time of these operations has been reduced. Results. before splitting are shown in Table 4.13, Table 4.14, Table 4.15, Table 4.16, and after splitting are shown in Table 4.17, Table 4.18, Table 4.19 and Table 4.20.

Table 4.13 shows that observed bottle neck time is 32.95 second at station 10 and standard bottle neck processing time is 31.156 second at station 10 in Table 4.16. So observed bottleneck time is reduced 20.76 % compare to existing observed bottle neck time. Standard bottle neck time is lower than observed bottle neck time.

Table 4.17 shows that observed bottle neck time is 29.27 second at station 17 and Table 4.20 shows that standard bottle neck processing time is 27.966 second at station17. So observed bottleneck time is reduced 16.04 % compare to new existing observed bottle neck time of Table 4.9 at station 17 and reduced 29.61 % compare to initial existing observed bottle neck time of Table 4.1 at station 10. In this developed production system standard bottle neck time is lower than observed bottle neck time.

In chapter Five, results of Method Study, before and after splitting are shown in tabular form and in graphical form using C- Control chart. Table 5.1 shows that before splitting, operation time of different operations have been reduced minimum10.32 % and maximum 21.06 % and per hour production have been increased of different operation minimum 15.31% and maximum 37 %. Table 5.2 shows that after splitting, operation time of different operations have been reduced minimum9.68 % and maximum 24.08 % and per hour production have been increased of different operation minimum 19.12% and maximum 42.92 %. These improvements have occurred by motivation and by reducing excess sewing burst, excess marking and slow movement. Graphical presentations show that all the values of production time and per hour production of different operations are within or very near to Upper control limit and Lower control limit.

In chapter Six, it is found that after Method Study, per hour production and organization efficiency may also be increase and worker's idle time may also be decreased by adopting the technique of line balance. This chapter shows that after Method Study, before splitting, line balance calculated by observed time and standard time have increased production 26.18% and 33.49% compare to existing production system. This chapter also shows that after Method Study, after splitting, line balance based on observed time and standard time, have increased daily production 42.06 % and 48.70 % compare to existing daily production. Assuming target organization efficiency 85% the results of line balance have been presented by graphical form in pitch diagram. Pitch diagrams present that all values are within or very near to upper control limit and lower control limit. So from these analysis, it is clear that line balance after splitting calculated by standard processing time is more effective, more productive compare to all previous line balance.

CHAPTER EIGHT

CONCLUSSIONS AND RECOMMENDATION

8.1 CONCLUSSIONS

The thesis is carried out for the purpose of analysis and development of a frame work for selected functions of quality and productivity in an apparel company. In this thesis results are presented for Time Study, Method Study and Line Balance. For an apparel company, main target is focused on how to increase per hour production without any defect.

It is noted that per hour production is inversely proportional to bottle neck time. Bottleneck time can be reduced by Time Study, Worker Rating and splitting of individual process. It is also noted that by Method Study production time of every individual process can be reduced by motivation and by reducing excess sewing burst, excess marking and slow movement of workers. For the same processing time of individual operation, line balance also increases per hour production and reduces worker's idle time and opportunity loss.

8.2 RECOMMENDATION

To increase productivity in an apparel company, the following recommendations have been concluded:

1. A team always carries on Time Study and Method Study and will classify the workers by their performance. The result of Time Study and Method Study must be implemented on the workers properly.

2. Bottle Neck time must be found out soon. High performance rated worker must be placed at Bottle Neck station and low performance rated worker must be placed at the less complex operation station to reduce Bottle Neck time instantaneously.

3. Continuous supply of raw material from cutting section to sewing must be ensured for getting continuous production.

4. To continue non stop operation in every work station from beginning of the working day, authority may start monthly financial reward system for the workers to ensure their timely attendance.

5. Managerial positions must be filled up by Industrial and Production Engineers who will see the problems, related to production from engineering management point of view and will engage engineering management tools for solving those problems to increase productivity rather than exercising whimsicality and power over the workers.

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