PRODUCTIVITY ANALYSIS AND APPLICATION OF IMPROVEMENT TECHNIQUES IN A MANUFACTURING PLANT (REDYMADE GARMENTS INDUSTRY)

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CERTIFICATE OF RESEARCH

This thesis title "PRODUCTIVITY ANALYSIS AND APPLICATION OF IMPROVEMENT TECHNIQUES IN A MANUFACTURING PLANT (REDYMADE GARMENTS INDUSTRY)" submitted by MD. NAEM HOSSAIN (170032102) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Technical Education with Specialization in Mechanical Engineering on November 2019

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Abstract

Productivity is an important fact for every manufacturing industry. It is a vital to decrease the production lead time as well as manufacturing cost. For productivity improvement it becomes essential to decrease the waiting time, process bottlenecks and increase the production line efficiency. Time study and line balancing are effective techniques to reduce the operation time and improve the productivity.

Assembly line balancing technique was used in some manufacturing industries for single production line to identify and remove the no value added activities and increase the productivity. But, it becomes essential to apply time study and line balancing techniques for the number of production lines of various products in small and large RMG industries to improve its productivity.

In this work, a single case study carried out on SK Garments, which is producing T-shirt. The current state of productivity measures in the plant and its effectiveness of the measurement were studied. During study period time study is performed on four different products of RMG industries and production lines are balanced through the distribution of works among the work stations by line balancing. Thus, new production layouts are modeled with the balanced capacity combining both modular line and traditional manufacturing system together. This research report provides pragmatic guidelines for the garments manufacturers to improve their industrial productivity and capacity by applying some essential tools like time study, line balancing etc. This study also suggests the possible improvement techniques that can be applied to improve the productivity of the plant.

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND IMPORTANCE OF THE STUDY

In every production related company, productivity improvement is a prime objective. Productivity is the typical dimension of the production efficiency. All over the world, businesses are now facing ferocious competition because of liberalization of trade and globalization. External competition has spread across almost all industries both in production and service areas. Suitable production management system is required for the significant improvements in managerial and other work force levels. The labor quality is considered as a significant contributing factor for explaining Taiwanese industrial sector's changes in productivity. On the other hand, size and specific interest rate on long-term loans of the firm are also significantly affecting its growth. Besides, the growth factors in China's manufacturing industries are affected by technical improvements. The main attitudinal factors, such as lack of absenteeism, job satisfaction and organizational obligation affect job performance and productivity. These factors change over the time and location, and interrelate to each other, which make analysis and measurement more complex [1].

Productivity measurement is the important for any kinds of industry. Increasing productivity is one of the major issues for enhancing more profit from same kinds of resources. Productivity improvement helps to satisfy customer and reduce time and cost to develop, produce and deliver products. Productivity includes effective relationship to performance measure for method utilization, method output, product prices, and work in process inventory levels and on time delivery. Productivity is considered to be a growth of profit.

Therefore it is essential to know the importance of higher / improved productivity in manufacturing company/ organization.

i. **Productivity is a key to prosperity**. Rise in productivity results in higher production which has direct impact on standard of living. It reduces cost per unit and enables reduction in sale price. It increases wages for workers and increased profit for organization. Higher demand creates more employment opportunities.

ii. **Higher productivity leads to economic growth and social progress**. Higher productivity helps to reduce cost per piece which make product available at cheaper rate. Thus it is beneficial for consumers. Low price increases demand of the product which in turn increases profit of the organization. Higher profit enables organization to offer higher dividend for shareholders. It increases export and increases foreign exchange reserves of a country.

iii. **Higher productivity requires elimination of waste in all forms**. It is necessary to eliminate wastage in raw material, wastage of time in case of men and machinery, wastage of space etc. to improve productivity. Several techniques like work study; statistical quality control, inventory control, operation research, value analysis etc. are used to minimize wastage of resources.

iv. **Improvement in productivity is important for country** like ours because it can Minimize level of poverty and unemployment.

Productivity improvement can be done by sorting of elimination, repairing of ineffective process, simplifying the method, optimizing the system, reducing variation, maximizing turnout up quality or responsiveness and reducing set-up time. Productivity can be also achieved by increasing the value-added content of products, or by decreasing the unit cost of production or decreasing the work content of the production, or line balancing of the production line or by a combination of all. Productivity improvement is the continuous improvement process of any types of activities [2].

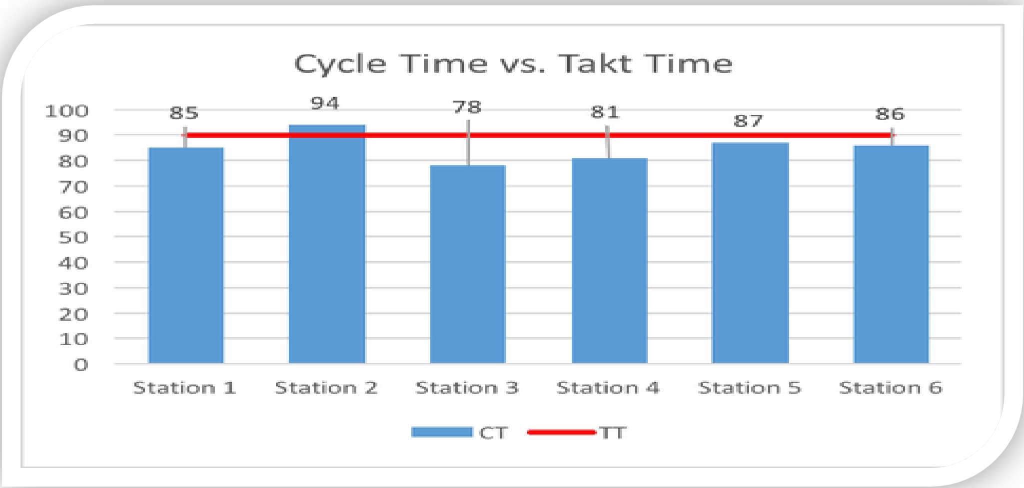
At this point, we can see that the productivity measurement is vital to organization system performance. This study will enhance the productivity of various garment industries. This thesis work aims to improve productivity by using time study method and reducing waste in a garments manufacturing industry.

1.2 PROBLEM STATEMENT

There are ample of different problems and mitigation of that affecting productivity. Most of them are identified through the investigation of surveying in different garments manufacturing factory in Bangladesh. Although Bangladesh is one of the largest garments manufacturing country in the world but it often fails to meet the ultimate production within the lead time. **Problems related to productivity analysis and productivity potential for improvement.**

1. **Lack of study in real manufacturing on deciding the main factors that should be given priority in the improvement process.**
   a. Unable to identify factor with highest productivity potential since management did not apply productivity potential assessment.
   b. More costs and times spent if improvement applied on the low potential factors.

2. Cycle times between the workstations are grossly imbalanced in production line.
   a. There are a few bottleneck workstations with very long cycle time while some of the workstations have short cycle time.
   b. This situation caused low productivity since the productivity dependent on the



production rate of the slowest workstation.

Figure 1.1: A bar chart on cycle time vs workstation.

3. **Use of labor resource in production line is less than optimal.**

a. Operator idled for long duration during machines operating due to improper task scheduling for operator and machines operation.
b. Low labor utilization and low labor productivity caused difficulty to fulfill customer demand.

1.3 OBJECTIVES OF THE STUDY

The main purpose of this study is to compare the current productivity measures in a manufacturing company with the present theories of productivity measures and determine the importance of introduction of modern productivity measurement systems. The specific objectives are given bellow:

1. To identify factor's with highest productivity potential in existing capacity and productivity as selected by an RMG manufacturing plant.

2. To determine workstations with very long cycle time and short cycle time and make balance to improve productivity.

3. To find idle operator/s for proper task and utilize him/them properly to improve labor productivity to fulfill customer demand.

4. To clarify different methods used in manufacturing plant for reducing waste and environmental impact

1.4 SCOPE AND LIMITATION

The RMG sector is the biggest industrial sector in all respects. However, the fundamental purpose of this research is to maximize efficiency to measures existing productivity in garments manufacturing plant and enhance the productivity of through maximizing efficiency by line balancing as well as reducing waste and environmental impact. Productivity can be measured using different measurements in different activities in manufacturing plants which include production, purchasing, inventory, data processing, personnel, finance customer service and sales.

William J. Stevenson [6] lists these steps to productivity improvement:

- ✓ Develop productivity measures for all operations; measurement is the first step in managing and controlling an organization.
- ✓ Look at the system as a whole in deciding which operations are most critical; it is over-all productivity that is important.
- ✓ Develop methods for achieving productivity improvement, such as soliciting ideas from workers (perhaps organizing teams of workers, engineers, and managers), studying how other firms have increased productivity, and reexamining the way work is done.
- ✓ Establish reasonable goals for improvement.
- ✓ Make it clear that management supports and encourages productivity improvement. Consider incentives to reward workers for contributions.
- ✓ Measure improvements and publicize them.
- ✓ Don't confuse productivity with efficiency. Efficiency is a narrower concept that pertains to getting the most out of a given set of resources; productivity is a broader concept that pertains to use of overall resources. For example, an efficiency perspective on mowing the lawn given a hand mower would focus on the best way to use the hand mower; a productivity perspective would include the possibility of using a power mower.

Limitations

The RMG sector is the biggest industrial sector in all respects. However, there are limitations the study as follows:

- Lack of information in terms of financial figures and respect for confidentiality.
- The exact problem of low productivity faced by RMG manufacturing plant cannot be defined clearly without complete analysis of the actual productivity level.
- Only a medium size garments company considered as a sample.

- It is conducted in a short period of time so we are not able to collect much information.
- The suggest improvement techniques and productivity measures were not completely implemented in the RMG manufacturing plant due to their daily production activities and complex working culture of the plant.

Challenges:

- Inadequate work place safety and insufficient workers welfare activities
- Lack of product diversification
- Socio-political instability

1.5 METHODLOGY

Work measurement applies different types of techniques to determine the required time to complete one operation and the total work that can be performed by one operator in a specific time. It provides a fair way of estimating the time to do a skillful operator with plentiful work supply & proper equipment. Different work measurement techniques used by sewing floor managers are stopwatch study or time study, historical time study, predetermined data, standard data, judgment, operator reporting & work sampling. Among them stopwatch study or time study is the most popular. For conducting time study visit at sewing floor had done for several times to muddle through the actual situation of sewing floor. The technique of random sampling used for analysis of the time spent for rendering each phase of various professional work or service performed by worker of service man is known as time measuring or needed time to perform a work [9]. For conducting time study here traditional stop watch method was used. Here 10 cycle time for each operation was recorded and at the same time the name of the operator or helper, performance rating, attachment used and machine type was recorded in a time study template sheet. Before starting the time study, the breakdown of the progress of operation was done. After recording 10 cycle time; average cycle time was calculated from which normal time or cycle time was found.

Average observed time = sum of the time recorded to perform each element/ Number of cycles observed.

Then from cycle time standard minute value (SMV), production per hour, capacity was calculated. With the help of time study excel spread sheet line capacity graph was created. From the line capacity graph, the bottlenecks & capacity variations between the workers were visible clearly. After finding the bottlenecks in layout and imbalance of worker capacity from the worker capacity graph and time study graph, a change in layout and operation breakdown was done for effective flow of product. This changed breakdown shows better performance in case of work in progress and good through put time was achieved by solving the bottleneck points. For balancing the sewing line, here assistant was added or arrange training facility for the bottleneck creating worker or if the work load was too much; then load was divided within the higher capacity processing workers for maximum utilization of labor capacity & increase their productivity. By this way a more balanced & efficient line was found with higher productivity.

1.6 ARRANGEMENT

In this report, various types of relevant contents such as introduction, literature review, research objectives and methodology, data analysis and results, discussion on results and conclusion with scopes for future work are arranged chapter wise here.

Chapter 1 includes introduction part of the research report, research objectives and outlines of the methodology.

Chapter 2 covers literature review of the related work in productivity improvement in RMG Manufacturing plant.

Chapter 3 includes various types of data collection and its analysis with required graphs.

Chapter 4 contains discussions on the results found after the time study and line balancing. The chapter also includes comparisons between existing and proposed situation of the RMG industries to evaluate the improvements after applying various tools and techniques.

Chapter 5 contains conclusion part of the research report which is followed by scopes for future work.

CHAPTER 2 LITERATURE REVIEW

2.1 MEANING OF PRODUCITIVTY

Productivity means a measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Productivity is computed by dividing average output per period by the total costs incurred or resources (capital, energy, material, personnel) consumed in that period. Productivity is a critical determinant of cost efficiency.

2.2 DIFINATION OF PRODUCITIVITY

Productivity is commonly defined as a ratio between the output volume and the volume of inputs. In other words, it measures how efficiently production inputs, such as labor and capital, are being used in an economy to produce a given level of output.

Productivity is the quantitative relation between what we produce and we use as a resource to produce them, i.e., arithmetic ratio of amount produced (output) to the amount of resources (input). [13]

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indicator to how well the factors of production (land, capital, labor and energy) are utilized.

European Productivity Agency (EPA) has defined productivity as, "Productivity is an attitude of mind. It is the mentality of progress, of the constant improvements of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adaptation of economic and social life to changing conditions. It is the continual effort to apply new techniques and methods. It is the faith in progress."

A major problem with productivity is that it means many things to many people. Economists determine it from Gross National Product (GNP), managers view it as cost cutting and speed up, engineers think of it in terms of more output per hour. But generally accepted meaning is that it is the relationship between goods and services produced and the resources employed in their production.

2.3 PRODUCITIVITY AND PRODUCITIVITY IMPROVEMENT

Productivity is the ratio between output and input. It is quantitative relationship between what we produce and what we have spent to produce. Productivity is nothing but reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people. Productivity denotes relationship between output and one or all associated inputs. European Productivity Council states that,, Productivity is an attitude of mind. It is a mentality of progress of the constant improvement of that which exists. It is certainty of being able to do better than yesterday and continuously. It is constant adoption of economic and social life to changing conditions. It is continual effort to apply new techniques and methods. It is faith in human progress‟.. Productivity is the ratio between output of wealth and the input of resources used in the process of production [3].

$$\text{Productivity} = \frac{\textbf{Output}}{\textbf{Input}}$$

Productivity improvement is one of the core strategies towards manufacturing excellence and it also is necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduce time and cost to develop, produce and deliver products and service. Productivity has a positive and significant relationship to performance measurement for process utilization, process output, product costs, and work-in-process inventory levels and on-time delivery. Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time.

In readymade garments industry, “output” can be taken as the number of products manufactured, whilst “input” is the people, machinery and factory resources required to create those products within a given time frame. In fact, in an ideal situation, “input” should be controlled and minimized whilst “output” is maximized. Productivity can be expressed in many ways but mostly productivity is measured as labor productivity, machine productivity or value productivity. Productivity gains are vital to the economy because they allow us to accomplish more with less. The apparel industries need to produce momentous quantities in shorter lead times as apparel product is highly correlated with high level of productivity. In Bangladeshi apparel industry 22% labor productivity was increased by applying line balancing technique [4].

2.3.1 Productivity Improvement Indices

Factor productivity or partial productivity indices are of following types:

2.3.1.1 Labor productivity:

The important function in any production set-up is that the budgeted quantity of work must be achieved over a period of time. Labor productivity depends upon how labors are utilized. Labor productivity can be higher or lower depending on factors like availability of work load, material, working tools, availability of power, work efficiency, level of motivation, level of training, level of working condition (comfortable or poor) etc. Labor productivity can be measured in terms of hours or money.

$$\text{Labor productivity} = \frac{Total\ output}{labor\ input}$$

2.3.1.2 Material productivity

Production system converts raw material into finished product with the help of mechanical or chemical processes. Material productivity plays important role in cost of production. Material productivity depends upon how material is effectively utilized in its conversion into finished product. Material productivity depends upon percentage of rejection, creation of scrap, level of spoilage, obsolescence, work wastage etc. Material productivity is expressed as:

$$\text{Material productivity} = \frac{Tptal\ output}{Material\ input}$$

2.3.1.3 Machine Productivity

Production system converts raw material into finished product through mechanical or chemical process with the help of machines and equipment’s. Machine productivity depends upon availability of raw material, power, skill of workers, machine layout etc.

$$\text{Material productivity} = \frac{Totaloutput}{Materialinput}$$

2.3.1.4 Capital productivity

For any production set-up, facilities of machines, tools, land etc. are required which are assets of organization. Capital is needed for such assets. As huge capital is locked in assets, their effective utilization is absolutely necessary. Capital productivity depends on how effectively assets are utilized. Therefore decision is necessary to take about replacement of fixed assets. Early replacement of fixed assets brings down maintenance cost but requires capital expenses. On the other hand, late replacement of fixed assets improves ratio of production to capital expenditure, but it increases maintenance cost. Therefore proper balance is necessary. Organization spent large amount (direct expenditure) for assets like direct material, direct wages, land, building, equipment etc. But a production system incurs a lot of direct expenditure like salaries of manpower employed in planning, store keeping, record keeping, inspection etc. Indirect labor is also used for material movement, good housekeeping, cleaning etc. Indirect expenditure is incurred on indirect material like tools, oils, lubricant etc.

$$\text{Capital productivity} = \frac{Totaloutput}{Capital\ input}$$

2.4 DIFERENT FACTORS AFFECTING PRODUCTIVITY

- Method
- Design of the work place
- Location
- Inventory
- Capacity Utilization
- Scheduling
- Incentives Plans that reward Productivity
- Technology be uses
- Management System

2.5 DIFFERENT TECHNIQUE USING FOR PRODUCITYVITY IMPROVEMENT

Productivity improvement is to do the right things better and make it a part of continuous process. Therefore it is important to adopt efficient productivity improvement technique so as to ensure individuals and organization’s growth in productivity. In RMG sector productivity improvement is defined as the improvement of the production time and reduction of the wastage. Sometimes specific problems such as machine break down, machine set up time, imbalanced line, continuous feeding to the line, quality problems, performance level and absenteeism of workers may hamper the productivity in RMG industries. Productivity of a RMG industry can be improved by following steps [5]:

1. Task Based Techniques:

    a. Work measurement (Time study)
    b. Motion study/work simplification (Method study)
    c. Job analysis
    d. Job evaluation and merit rating.
    e. Ergonomics (related with human factors)

2. Product Based Technique:

    a. Product classification and coding

b. Research and development
c. Reliability and improvement in product design
d. Product standardization
e. Product simplification
f. Product diversification
g. Product specialization.

3. Technology Based Methods:

    a. Computer aided design
    b. Computer Aided process planning
    c. Computer aided manufacturing
    d. Computer integrated manufacturing (CIM)
    e. Computer aided engineering analysis
    f. Computer aided inspection
    g. Group technology
    h. Robotics & just in time (JIT)
    i. Maintenance management
    j. Reconditioning & life predicting of equipment technology.

4. Material Based Techniques:
    a. Material requirement planning (MRP)
    b. Inventory control
    c. Just in Time concept of inventory management
    d. Material management and quality control
    e. Material handling systems

5. Employee Based Methods:

    a. Incentive schemes for individual employees
    b. Incentive schemes for group of employees
    c. Management by objectives
    d. Fringe benefits for employees and job enlargement
    e. Recognition and punishment of employees

f. Total quality management (TQM)
g. Zero defect benefits for employees.

2.5.1 Time study

Time study is a structured process of directly observing and measuring human work using a timing device to establish the time required for completion of the work by a qualified worker when working at a defined level of performance [7].
It follows the basic procedure of systematic work measurement of:

- Analysis of the work into small, easily-measurable components or elements
- Measurement of those components and
- Synthesis from those measured components to arrive at a time for the complete job.

Time study, when properly undertaken, involves the use of specific control mechanisms to ensure that timing errors are within acceptable limits. Increasingly, timing is by electronic devices rather than by mechanical stopwatch; some of these devices also assist in subsequent stages of the study by carrying out the process of "extending" or converting observed times into basic times. The basic time is the time the element would take if performed at a specified standard rating.

Time study is a very flexible technique, suitable for a wide range of work performed under a wide range of conditions, although it is difficult to time jobs with very short cycle times (of a few seconds). Because it is a direct observation technique, it takes account of specific and special conditions but it does rely on the use of the subjective process of rating. However, if properly carried out it produces consistent results and it is widely used. Additionally, the use of electronic data captures devices and a personal computer for analysis makes it much more cost effective than previously.

The basics steps in a time study are [8]-

- Defining the task to be studied and informing it to the worker.
- Determination of number of cycles to be observed
- Calculating the cycle time and rating the worker’s performance
- Computing the standard time

Time study helps a manufacturing company to understand its production, investigate the level of individual skill, planning and production control system etc. One problem of time study is the Hawthorne effect where it is found that employees change their behavior when they come to know that they are being measured [9].

The different types of production systems are distinct and require different conditions for working. However, they should meet the two basic objectives, that is, to meet the specification of the final product and to be cost-effective in nature. The main aim of any production system is to achieve a minimum possible total production time. This automatically reduces in-process inventory and its cost. The subassembly system reduces temporary storage time to zero by combining temporary storage time with transportation time.

Any production system has four primary factors that make up the system.

Processing time + Transportation time + Temporary storage time + Inspection time = Total Production Time.

Processing time is the sum total of working time of all operations involved in manufacturing a garment. Transportation time involves the time taken to transport semi-finished or finished garments from one department to another or from one operation/machine to another. Temporary storage time is the time during which the garment/bundle is idle as it waits for the next operation or for completion of certain parts. Inspection time is time taken for inspecting semi-finished garments for any defects during manufacturing or inspecting fully finished garments before packing.

In the apparel industry, the most commonly used production systems are make through, modular production and assembly line production **systems.**

2.5.2 Group system - Section or Process system

This is a development of the individual system, with the difference that the operators specialize in one major component and sew it from beginning to end. For example, an operator specializing in backs would assemble the back and yoke, label attaching, etc., and performs all the operations required to finish that particular component.

The sewing room would have a number of sections, each containing multi-talented operators capable of performing all the operations required for a specific component. The sections shown in Figure- are built according to the average garment produced, and include:

- Collar preparation
- Sleeve preparation
- Front preparation
- Back preparation
- Assembling operations (closing, setting collars and sleeves, etc.)
- Finishing operations (buttonholes, blind-stitching, etc.)

2.5.3 SWOT Analysis

SWOT analysis is a framework and very important tool which can be used in marketing management as well as other business applications [Ahamed 2013]. It is a strategic planning tool that segregates influences on a business's future gains into internal and external factors. Environmental factors internal to the company usually can be classified as strengths (S) or weaknesses (W), and those external to the company can be classified as opportunities (O) or threats (T).

In a company, weaknesses are the constraints to pick the opportunities and again strengths resist the vulnerability of the threats. SWOT analysis allows businesses to define realistic goals, improve capability, overcome weaknesses with strengths and identify threats than can be turned into opportunities. The SWOT analysis provides information that is helpful in matching the firm's resources and capabilities to the competitive environment in which it operates.

SWOT analysis helped to identify the challenges, opportunities and threats of textile sector in Bangladesh. According to the analysis, many problem areas were identified in the mill which is related to the global challenges of textile industry such as high prices of quality products, high rated gas, electricity and oil prices, political unrest and inadequate sales center for the local market etc. [Mostafa 2006]. Textile industries of Bangladesh must need to overcome these challenges to expand its market growth locally and internationally.

In India, SWOT analysis was practiced to throw light on it’s present retail scenario and to identify weakness such as multi-diversified business, no bargaining markets etc. and various threats such as increasing competitors, government and local policies, unrecognized modern retailing etc. The analysis also discussed some customer centric initiatives to be taken in future by the retailers [Archana 2012]. SWOT analysis also identified the weakness such as poor infra-structure, poor-quality standards, less productivity, unstable political situation etc. in the Pakistan’s textile industries and recommended alternative solutions and remedies to make the industries more competitive and efficient against its biggest challengers and competitors [Akhlaq2009]. Readymade garment is a leading sector in Bangladesh economy and SWOT analysis should be done on RMG industries to identify the strengths, weakness, opportunities and threats for productivity improvement.

2.5.4 Computer Integrated Manufacturing (CIM)

Computer Integrated Manufacturing (CIM) encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated software packages. CIM is considered a natural evolution of the technology of CAD/CAM. The product data is created during design and this data is transferred from the modeling software to manufacturing software without any loss of data.

This methodological approach is applied to all activities from the design of the product to customer support in an integrated way, using various methods, means and techniques in order to achieve production improvement, cost reduction, fulfillment of scheduled delivery dates, quality improvement and total flexibility in the manufacturing system.

CIM uses a common database wherever feasible and communication technologies to integrate design, manufacturing and associated business functions that combine the automated segments of a factory or a manufacturing facility.

CIM reduces the human component of manufacturing. CIM stands for a holistic and methodological approach to the activities of the manu-facturing enterprise in order to achieve vast improvement in its performance.

CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing.

Manufacturing industries strive to reduce the cost of the product continuously, achieve reduction in inventory, and reduce waste to remain competitive in the face of global competition. In addition, there is the need to improve the quality and performance levels on a continuing basis. Another important requirement is on time delivery.

In the context of global outsourcing and long supply chains cutting across several international borders, the task of continuously reducing delivery times is really an arduous task. CIM has several software tools to address the above need and to increase flexibility in manufacturing to achieve immediate and rapid response to: product changes, production changes, process changes, equipment changes, change of personnel, etc. [15]

CIM is a recent technology being tried in advanced countries and it comprises a combination of software and hardware for product design, production planning, production control, production equipment and production processes.

It is an attempt to integrate the many diverse elements of discrete parts manufacturing into one continuous process- like stream. It would result in increased manufacturing productivity and quality and reduced manufacturing costs.

It employs flexible machining system (FMS) which saves a manufacturer from replacing equipment each time a new part has to be fabricated. The current equipment can be adopted to produce new part (as long it is in the same produce family), with programmable software and some retooling. Thus, this system has the ability to switch from the machining of one component to different one with no down-time for change over.

This system requires NC lathes, machining centers, punch presses etc. which have ability to be readily incorporated into multi-machine cell or a fully integrated manufacturing system. Color graphics display systems having facility of on line interactive generation of geometry form the human-machine interface.

This new technology attempts to exploit all the three methods of increasing productivity, viz. increasing the rate of metal removal, keeping the tool working for a greater proportion of time, and run them longer. Obviously multi-spindle machines with greater horsepower, stiffness and longer speed ranges are the choice for such system.

Automatic tool changers (which change the type of tool in the spindle and also provide means of renewing dulled edges) are must. Lathes employ automatically swappable magazines of tool- racks to supply fresh cutting edges for automatic insertion into turrets.

Tool holders employed are of two-piece concept in which little more than the insert pocket is separable from the shank. This light element—little more than the tool holder nose is stored, transported, swapped and accurately repositioned by the automatic system.

Robot for handling work pieces automatically is another important machine tool peripheral essential for CIM system.

2.6 WASTE AND WASTE MANGGEMENT

Waste is directly linked, both technologically and socially, to the human development. Waste management practices can differ for developed and developing nations, for urban and rural areas, and for residential and industrial manufacturers or producers. This is in order to reduce the negative impacts of wastes on environment and society.

Environment protection could be achieved by adopting state-of-the-art technologies to minimize waste generation, effective treatment of effluent so that the effluent discharge conforms to the expected norms, and recycling the waste several times before dispose or discharge. Textile manufacturers undertake a range of waste-generating activities such as washing/drying, warp preparation, weaving, dyeing, printing, finishing, quality and process control, and warehousing. The major wastes generated by this sector are fibre wastes. These include soft fiber wastes, yarn spinning (hard fibre) wastes, beaming wastes, off-cuts, packaging, spools and cereals. [16]

2.6.1 Reasons of wastage

The main causes of wastage in garment industry can be stated below:

- In efficient, obsolete and conventional technologies.
- Motion.
- Delay/waiting.
- Lack of technical skills and awareness in terms of quality.
- Over processing
- Over production
- Inventory

2.6.2 Benefits of managing wastage

As the growth of population and high consumption of products in the developed world, the global waste problem is increasing day by day. We are producing more waste than the environment can absorb. The benefits of managing waste are given below:

- ✓ Saving resources and energy;
- ✓ Reducing pollution;
- ✓ Increasing the efficiency of production

2.6.3 Waste minimization

Waste minimization means, preventing the waste from occurring in the first place, rather than treating it once it has been produced by end-of-pipe treatment methods. That is, it is a technique that can be applied to all inputs to and outputs from, a process.

According to Environment Wise Governance Guide, “Waste minimization aims to eliminate waste before it is produced and reduce its quantity and toxicity. Prevention is the primary goal, followed by reuse, recycling, treatment and appropriate disposal" Waste minimization can be defined as "Reducing waste at source technically and a systematic way", which means:

- o Prevention and reduction of waste generated;
- o Efficient use of raw materials and packaging;
- o Efficient use of fuel, electricity and water;
- o Improving the quality of waste generated to facilitate recycling;
- o Encouraging re-use, recycling and recovery

Waste minimization or prevention is important than waste treatment, because waste minimization has some benefits as mentioned below:

- ▪ Waste quantities are reduced;
- ▪ Raw material consumption and therefore costs are reduced;
- ▪ Waste treatment costs are reduced;
- ▪ Process efficiency is improved;
- ▪ Efficiency of the employee is improved

2.6.4 Waste management principles (WMP)

One can control the waste not only from garment industry but also from any type of organization, by following two waste management principles

(A) General Waste Management Principles

(B) Some special waste management principles

In order to control cost lost wastage, the following measures must be kept:

- o Finish in time Minimum
- o Changes in original design
- o Least make break/rework
- o Keep check on Labor and Material costs
- o Avoid rework due to bad quality
- o Optimize usage of materials

- Enhance labor productivity through skill training
- Efficient Management Information System (MIS) for timely decision making.

2.6.5 Improvement of waste management in garment industry

For the economic conditions or barriers the reuse is limited with low cost of textile and fast changing fashion. There are however opportunities in that second hand may be a fashion in itself and that the informal second hand market is to a large extent working without any specific policy instruments. Much of the textiles collected by charity organizations are not of a sufficient quality to be sold and reused on the market. This is to some extent solved by exports to less demanding markets outside but also leads to incineration. So the improvement of waste management in garment industry can be viewed mainly two sites. [17]

2.6.6 Zero waste concepts

A Zero waste strategy will leads to faster innovation and movement far beyond incremental approaches that don't include an end point goal. The zero waste strategy leads us to look for inefficiencies in the use of materials, energy and human resources. To achieve a sustainable future, extreme efficiency in the use of all resource will be required in order to meet the needs of all of the world's inhabitants. A zero waste strategy directly supports this requirement [18].

The zero waste strategies have been adopted by large and small business and by both foreign and domestic governments. The result have includes increased profits resulting from significant cost saving, improved environmental performance, and stronger local economies. The result will be economically healthy organizations, healthy communities, and healthy environment for future generations. Zero waste strategies support all phases of the sustainability movement includes,

- ✓ Save money
- ✓ Faster progress
- ✓ Economic well-being
- ✓ Supports sustainability

- ✓ Environmental protection
- ✓ Social well being
- ✓ Improved material flows

2.6.7 Use of garments waste

The unusable parts of clothes are recycled into waste cotton. Mattress, pillows, cushions, seat stuffing and padding in cars and rickshaws are usually done with these recycled clothes and processed cotton. Bandages are also reproduced with leftover white cotton fabrics. While buttons, zippers, elastic fastener, hangers and plastic bags are resold to mini garment accessory sellers, buttons, zipper, elastics fasteners are mostly purchased by local tailors, said an accessory seller.

2.6.8 Environmental and economic benefits of garment recycling

Garment recycling have essential benefits in terms of environmental as well as economical. Some are mentioned below:

- Reduces the need for landfill space
- Reduces pressure on virgin resources
- Aids the balance of payments as we import fewer materials for our needs, which causes less pollution and energy savings, as fibers do not be transported from abroad

- Benefits of reclaiming fiber savings on energy consumption when processing as items do not need to be re-dyed or scoured.
- Less effluent, as unlike raw wool, it does not have to be thoroughly washed using large volumes of water.
- Reduction of demand for dyes and fixing agents and the problems caused by their use and manufacture.

CHAPTER 3 RESEARCH DESIGN

3.1 INTRODUCTION

The study includes productivity measurement and productivity improvement techniques. In order to achieve the objectives of the study, the research was performed using a real data at a SK garments manufacturing plant. In this chapter, the research design is described in detail and acts as framework on how the research will be conducted.

3.2 RESEARCH APPROACH

The main purpose of the research is to study the productivity in readymade garments industries (RMG) plat. We need to know what type of productivity measurement use by RMG plants and how significant the measures were. Besides, we also wanted to know the actual level of productivity performance in the plant in order to improve productivity. Hence data are collected from selected manufacturing plant in which the plant permits the research activities.

3.2.1 Production Line Balancing

The line balancing approach is to create the production lines flexible enough to take up external and internal abnormalities in production. There are two types of line balancing:

Static balance – It is a long-term difference in capacity over a period of several hours or more. Static imbalance could lead to underutilization of machines, men and production lines.

Dynamic balance – It is nothing but short-term changes in capacity like for a minute or an hour maximum. Dynamic imbalance occurs from product mix changes and difference in work time unrelated to product mix.

1. Calculation of labor requirements:

With good work measurement records, the work content of a new garment can be calculated. The number of people required will depend upon the probable efficiency of the line selected and the percentage of the time that they are at work and doing their own specialist jobs.

2. Section allocation

This is the extent to which the manufacture of the garment is split among different operations, in the interest of greater specialization and thus efficiency.

3. Operation breakdown:

This usually takes the form of the element descriptions from the method study, together with the appropriate standard times and a note of the type of machinery required. Special work aids and attachments should also be mentioned on it.

4. Theoretical operation balance:

The elements are grouped together to match the number of people selected, in the calculation of labor requirements. No allowance is made for the varying ability of the people who will man the workstations.

5. Skills inventory:

This consists of a list of the people in the section or factory, which shows their 'expected performance' at various types of work. It provides both a talent list for section/team manning and also a means of planning the growth of the skills of the workforce.

6. Initial balance:

The expected performance of the people available must be taken from the skills inventory, in order to manage the line in a way that smoothest out the potential variations in output between the stations shown in the theoretical balance. It is usual to select 'floaters' at this stage, which will help to cope with absenteeism and imbalance.

7. Balance control:

Balance control is perhaps the most vital skill in a supervisor, with its objective to maintain the highest output and not just to keep people busy. For simplicity, the worked examples in the text and in three of the questions in the next chapter are taken from the same case study.

3.2.2 Group the operations wherever possible

An operator could be given another operation with less work content in case of availability of higher capacity than the target output.

- **Shuffle operators** – For the operations that have low work content, a low performing operator can be allotted and consequently for the operations having higher work content efficient operators could be allotted.
- **Reduce cycle time** – Working aids such as guides or attachment could be used to aid the operator in handling parts during sewing, positioning, cutting and finishing.
- **Improve production layout** – The most significant zone for recuperating output from a particular process is by means of the best production layout and the best working method.
- **More operators in bottleneck operations** – Include one or two extra machines in tougher tasks. Before doing this, evaluate the cost benefits of putting additional machines on the line. In this article I will discuss about how line balancing is done in apparel industry?

3.2.3 Macro-Steps in Line balancing

The method of line balancing can vary from factory to factory and depend on the type of garments manufactured, but in any instance, line balancing concerns itself with two distinct applications. They are ‘setting up’ a line and ‘running’ a line.

1. Setting up a line:

Before a new style is introduced to a production line, it is necessary to establish the operation sequence, the time, the type of equipment and the attachments required to manufacture the order. Management must have this information before the commencement of the order, so that the line can be balanced and laid out in such a way as to maximize productivity.

2. Running a line:

- There should be a reasonable level of work in progress. A recommended level is between 30 minutes to 1 hour between operations. Anything below 30 minutes will not give the supervisor sufficient time to react to a breakdown. Anything above 1 hour's supply is unnecessary.

- Work in progress should always be kept in good order and full view.
- Have a number of additional machinists trained on many operations so that they can be used where necessary to cover for absenteeism. Therefore, if absenteeism is 5%, a squad of skilled operators would be required to cover this amount.
- Space should be made available within the line for spare machines in case of ensure that the mechanics keep the machines regularly serviced.
- If a bottleneck keeps occurring at a particular place in the line, improve the method to eliminate the bottleneck. It is most important to establish where this point is on the line.
- Supervisors must know the capabilities and skills of the operators under their control.
- Supervisors must learn that the amount of work waiting for each operation will increase or decrease over a period of time, and must plan when to take appropriate action.
- Supervisors could carry out balancing duty regularly at 2-hour intervals, checking every operation on the line to ensure that the WIP level is within the correct limits.
- Balancing duties should be carried out on time irrespective of what else the supervisor is doing.
- The supervisor should be able to make up his or her mind about what to do if the levels are not correct, and not have to wait for a manager to make the decision breakdown.

Line Imbalance:

A series of operations is involved in producing a garment. In bulk garment production, generally a group of people works in a particular assembly line and every operator is capable of doing only one specific operation and then hands over the product to the next operator to carry out the next operation. Under some circumstances, in the assembly line it could be observed that work is started to pile up in a particular production line and a few operators are idle.

The main important aspect to be considered for imbalance in a line is the identification of the

bottleneck area in the production process. Each individual operator's capacity should be compared with the target capacity. The operators whose ability is less than the target output are bottleneck operations for the production process. Without improving the bottleneck operation in the production line, it is practically not possible to increase the output of imbalanced line.
Therefore, to remove the bottleneck operation, the following methods could be used depending upon the situation.

3.2.4 Methods of Line Balancing:

(i) The one possibility in the right direction, as far as balancing the line is concerned, would be to increase the output.

(ii) The second possibility is that another product may be sent close to the first one so that some idle machines may be used jointly.

(iii) The third possibility may be to estimate the output of the last work station. This can be taken as the minimum output of all the intermediate work stations.

A balanced layout eliminates bottleneck operations as well as preventing the unnecessary duplication of equipment capacity. Line balancing is a major consideration in layout because a lack of balance can most easily hinder the production.

For balancing it is not essential that output of each operation should be same but the essential is to see that output of fastest ma-chine should be multiple of the output of the remaining other machines.

Two methods can be used to set up a line:

Method 1: Calculating the number of operators necessary to achieve a given production rate per hour.
Method 2: Calculating the number of garments to be produced by a given number of operators.

Using either technique, certain information is required before commencing the calculations, which are given below:

1. The number of operators in the line
2. A list of operations involved in making the garment
3. The standard minute values for each operation
4. Output required from a given group of operators

Further, the following information is required for balancing a line:

- The size of the group
- An operation sequence
- The standard time for each operation
- The total standard time for the garment

The method of calculating the line balance is as follows:

1. Add up the operation times for the whole of the style.
2. Establish the percentage of each operation of the total time.
3. Work out the theoretical balance using each operation's percentage of the total number of operators on the line.
4. Round off the theoretical balance to the nearest half an operator, either up or down.
5. List the type of equipment required for each operation at the side of the rounded figure.
6. The equipment that has half operators could be combined with similar equipment to get 'full' operators.
7. If odd half operators are there, it should be rounded up.
8. The number of garments that would be produced per hour on each operation should be calculated by multiplying the number of operators by 60 (minutes) and dividing by the total minutes for the style.

3.2.5 Goals for Line Balancing

- Meet production schedule
- Avoid the waiting time
- Minimize overtime
- Protect operator earnings

Need for Balancing:

- ✓ Keeping inventory cost low
- ✓ To enable the operator to work at an optimal pace
- ✓ To enable the supervisor to attend other problems
- ✓ To enable better production planning
- ✓ Balancing production line results in on time shipments, low cost and ensures reorders
- ✓

3.3 IMPORTANCE OF LINE BALANCING

1. Determine systematic work procedure which is important for smooth production.

2. It determines exact number of machine and operator in a line.

3. It helps to make ideal work plan.

4. It reduces cost of production.

5. It helps to determine labor requirement in a line.

6. It helps to reduce production time.

7. It increases productivity.

8. It increases profitability.

9. It helps worker and helper to perform job in simple manner.

10. It reduces faults in finished goods.

11. It make easy to achieve target production.

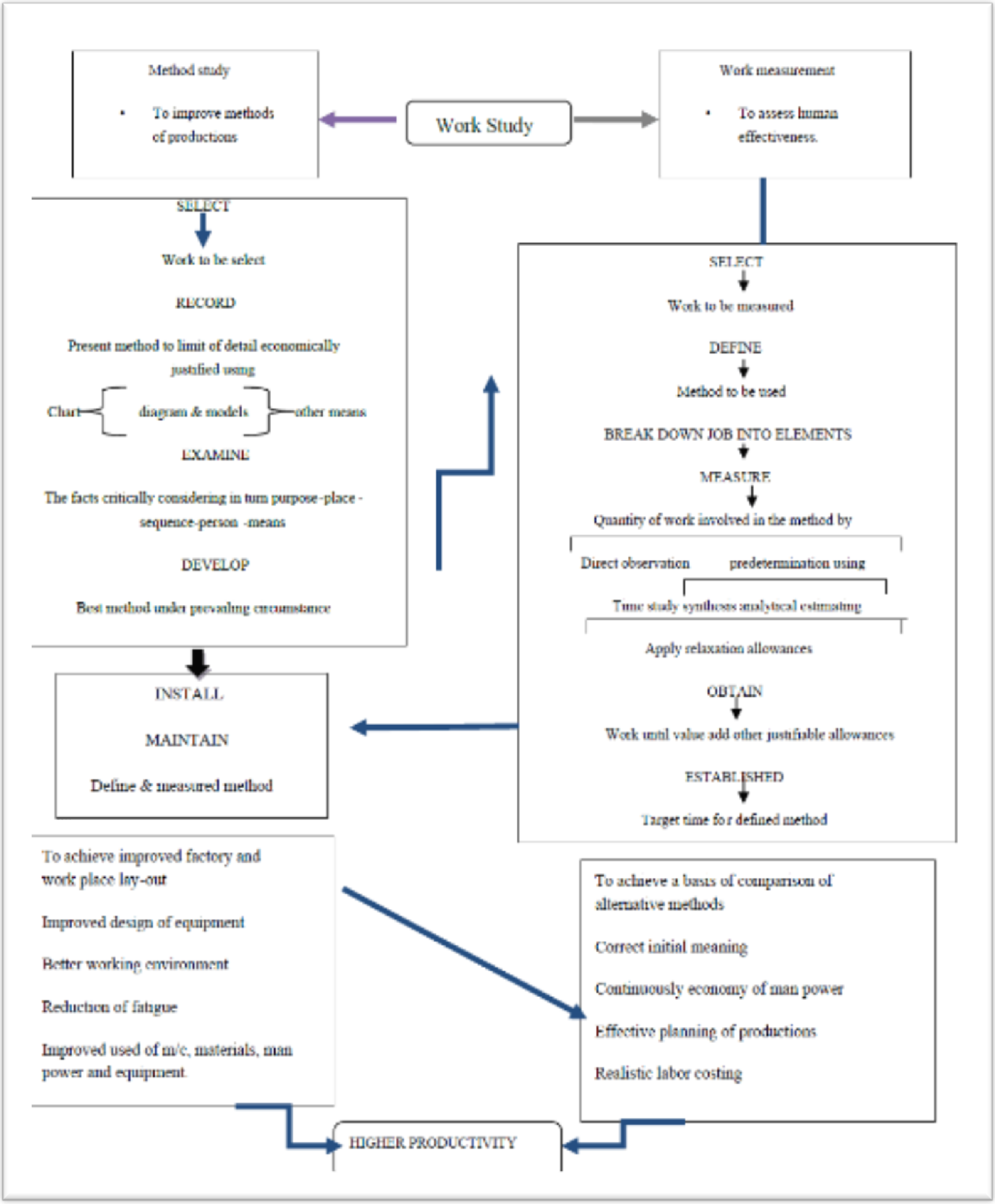


Figure 3.1: Co-ordination procedure for work study for higher productivity (Jain aggarwal)

3.4 LIMITATIONS OF LINE BALLANCING

1. Production lines were designed so that conveyor belts paced the speed of the employees‟ work. This arrangement wasn't appreciated by the employees.
2. Inevitable changes lead to production lines being out of balance.
3. Rebalancing causes disruptions to production

CHAPTER 4 ANALYSIS AND DISCUSSION

4.1 RESULT AND CALCULATION FOR TIME STUDY

A production **line** is said to be in **balance** when every worker's task takes the same amount of time. **Line balancing** is a manufacturing-engineering function in which whole collection of production-**line** tasks **are** divided into equal portions. Well-balanced **lines** avoid labor idealness and improve productivity.

Line balancing is crucial in the efficient running of a production line and the objective of line balancing is to balance the workload of each operation so that the flow of work is smooth, no bottleneck processes are created and the operators could be able to work at higher performance throughout the day. It is intended to cut down the waiting time to a minimum or with the use of work in progress (WIP) to get rid of waiting time completely. Line balancing is defined as ‘the engagement of sequential work activities into production line to achieve a high utilization of labour and equipment and hence minimizes idle time’. Balancing may be accomplished by adjustment of the work stations or by including machines and/or workers at some of the production lines so that all operations take about the same quantity of time.

Garment manufacturing is a traditional industry with global competition. The production process of garments is separated into four main phases: designing or clothing pattern generation, fabric cutting, sewing, and ironing or packing. The most critical manufacturing process is sewing, as it generally involves a great number of operations. The main purpose of line balance planning in sewing lines is to assign tasks to the workstations, so that the machines of the workstation can perform the assigned tasks with a balanced loading. The garment industries must produce momentous quantities in shorter lead times. Garment product is highly correlated with high level of productivity; sewing line should be balanced in shorter possible time and effective way for each style and quantity. [12]

SAM (Standard allowed minute): The amount of time required to complete a specific job or operation under existing condition, using the specified & standard method at a standard pace when there is plenty of repetitive work [11].

Standard time = (Average observed time X Rating %) + Allowance%

Allowance: Different types of allowances are allowed in apparel production floor. Such as personal time allowance, Delay allowances, Fatigue allowances etc.

Bottleneck: A constraint for smooth flow of operation, limits the flow of production rate, productivity, efficiency is usually termed as bottleneck.

Cycle time: Total time taken to do all works to complete one operation, i.e. time from pick up part of first piece to next pick up of the next piece

Cycle time is the time interval at which completed garments leave the production line. When the quantity of output units required per period is specified and the available time per period is given, then

1. Determination of Cycle Time (CT)

Cycle time (CT) = $\frac{\boldsymbol{Available\ time\ per\ period}}{\boldsymbol{Output\ units\ required\ per\ period}}$

2. Determination of the Ideal Number of Workers Required in the Line:

Ideal number of workers required in the assembly line and production line,

$$\frac{(Total\ operation\ or\ task\ time)\ x\ (Output\ units\ required\ per\ period)}{Available\ time\ per\ period\ per\ worker}$$

I.e. $N = \sum t \text{ x } \frac{1}{(CT)} = \frac{\sum t}{CT}$

3. Balancing Efficiency:

A well-organized line balancing system could reduce the idle time and could be determined as

Balancing efficiency (%) = $\frac{\boldsymbol{Output\ of\ task\ time}}{\boldsymbol{Input\ by\ workstation\ times}}$

$= \frac{\sum t}{CT\ x\ N}$

Where,

$\sum$t = Sum of the actual worker times or task times to complete one unit

CT = Cycle time

N = Number of workers or work stations

Efficiency = $\frac{\boldsymbol{Theoretical\ number\ of\ workers}}{\boldsymbol{Actual\ number\ of\ workers}}$

1	1	Front & back part match	Table	0.15	0.14	0.17	330	300
2	2	Right shoulder join with tape & tape attach at left shoulder	OL4	0.23	0.20	0.26	231	220
3	3	Thread cut	Cutter	0.27	0.22	0.26	231	200
4	4	Neck piping joining	OL4	0.18	0.16	0.21	288	200
5	5	Trimming	Scissor	0.13	0.12	**0.16**	385	200
6	6	BK NK piping join and trimming	ILC	0.14	0.13	0.17	355	200
7	7	BK NK piping 1 end point cut	LS	0.20	0.18	0.21	256	200
8	8	Fnt NK Top Stitch	ILC	0.21	0.20	0.26	231	200
9	9	BK NK mark for lbl attach	Chalk	0.21	0.20	0.26	231	200
10	10	Main lbl attach with size lbl	LS	0.15	0.13	0.16	355	200
11	11	BK Nk piping top stitch inst size lbl	LS	0.23	0.20	0.26	231	200
12	12	Thread cut & lbl false stitch remove	Cutter	0.29	0.28	0.36	165	165
13	13	NK close tack	LS	0.18	0.17	0.22	271	165
14	14	Lft Shoulder join	OL4	0.16	0.15	0.19	308	165
15	15	Thread cut & both shldr end pt tack	Cutter	0.26	0.25	0.31	185	165
16	16	Frnt part mark for pkt attach	Chalk	0.28	0.25	0.31	185	165
17	17	PKT mark & body match	Chalk	0.21	0.20	0.26	231	165
18	18	PKT opening hem	ILC	0.12	0.12	**0.16**	385	165
19	19	Thread cut & raw edge finish	Cutter	0.11	0.10	**0.11**	462	165
20	**20**	Pkt ironing	iron	0.48	0.43	0.27	107	85
21	**20**	Pkt ironing	iron	0.42	0.43	0.27	90	**80**
22	**21**	Pkt attach with frnt part	LS	1.17	1.01	0.29	46	40
23	**21**	Pkt attach with frnt part	LS	0.85	0.73	0.29	63	45
24	**21**	Pkt attach with frnt part	LS	0.93	1.05	0.29	44	40
25	**21**	Pkt attach with frnt part	LS	1.16	0.99	**0.29**	47	40
26	**22**	Raw edge & thread cut	HP	0.83	0.71	0.29	65	55
27	**22**	Raw edge & thread cut	Cutter	0.87	0.77	0.29	60	55
28	**22**	Raw edge & thread cut	Cutter	0.66	0.63	0.29	73	55
29	23	Arm hole scissoring	Scissor	0.24	0.23	0.30	201	165
30	24	Slv pair	Table	0.14	0.12	0.16	385	165
31	25	Slv Scissoring	Table	0.46	0.36	0.46	128	145
32	26	Slv & body match	Table	0.17	0.17	0.21	271	145
33	**27**	Slv join	OL4	0.57	0.50	0.30	92	70
34	**27**	Slv join	OL4	0.45	0.43	0.30	107	75
35	28	Thread cut	Cutter	0.30	0.27	0.35	171	145
36	**29**	Sideseam & care lbl attach	OL4	0.84	0.86	0.34	54	48
37	**29**	Sideseam & care lbl attach	OL4	0.75	0.72	0.34	64	52
38	**29**	Sideseam & care lbl attach	OL4	0.89	0.79	0.34	58	45
39	**30**	Thread cut & body turn over	Cutter	0.59	0.57	0.34	81	77
40	**30**	Thread cut & body turn over	Cutter	0.52	0.49	0.34	94	68
41	31	Nk chap tack & thread cut	LS	0.13	0.13	0.16	355	145
42	**32**	Hanger loop attach	LS	0.42	0.43	0.29	107	75
43	**32**	Hanger loop attach	LS	0.53	0.51	0.29	90	70
44	33	Slv Scissoring	Scissor	0.36	0.33	0.41	140	140
45	34	Round slv hem	ILC	0.15	0.13	0.17	355	140
46	**35**	Thread cut	Cutter	0.86	0.78	**0.39**	59	56
47	**35**	Thread cut	Cutter	0.58	0.51	0.39	90	80
48	36	Bottom scissoring	Scissor	0.51	0.46	0.58	100	136
49	37	Bottom hem	ILC	0.26	0.27	0.35	171	136
50	38	Thread cut	Cutter	0.18	0.17	0.20	271	136
Total				[illegible]		[illegible]		

Table 4.1: Time study chart before worker capacity balancing

(International Journal of Textile Sciencep-ISSN: 2325-0119 e-ISSN: 2325-0100)

SL	OP #	Operation	M/c	SMV	Observed Time	Capacity Time	Capacity / Hr.	Prod / Hr.
1	1	Front & back part match & tape counting	Table	0.15	0.14	0.26	231	250
2	2	Right shoulder join with tape & tape attach at left shoulder	OL4	0.23	0.20	0.26	231	220
3	3	Thread cut	Cutter	0.27	0.22	0.28	210	200
4	4	Neck piping joining & trimming	OL4	0.27	0.24	0.32	192	185
5	5	BK NK piping join and trimming	ILC	0.20	0.18	0.23	256	185
6	6	BK NK piping 1 end point cut	LS	0.20	0.18	0.23	256	185
7	7	Fnt NK Top Stitch	ILC	0.21	0.20	0.26	231	185
8	8	BK NK mark for lbl attach	Chalk	0.21	0.20	0.26	231	180
9	9	Main lbl attach with size lbl & care lbl tack	LS	0.26	0.23	0.30	201	180
10	10	BK Nk piping top stitch inst size lbl	LS	0.23	0.20	0.26	231	177
11	11	Thread cut & lbl false stitch remove	Cutter	0.29	0.26	0.34	178	175
12	12	NK close tack	LS	0.19	0.18	0.24	256	175
13	13	Lft Shoulder join & trimming	OL4	0.25	0.22	0.28	210	170
14	14	Fmt part mark for pkt attach	Chalk	0.28	0.25	0.32	185	170
15	15	PKT mark & body match	Pencil	0.21	0.20	0.26	231	170
16	16	PKT opening hem & thread cut	ILC	0.23	0.22	0.27	215	170
17	17	Pkt ironing	Heat iron	0.48	0.43	0.27	107	85
18	17	Pkt ironing	Heat iron	0.46	0.43	**0.27**	107	85
19	18	Pkt attach with fnt part	LS	1.17	1.01	**0.30**	46	40
20	18	Pkt attach with fnt part	LS	0.85	0.73	0.30	63	45
21	18	Pkt attach with fnt part	LS	0.93	1.05	0.30	44	45
22	18	Pkt attach with fnt part	LS	1.16	0.99	0.30	47	40
23	19	Raw edge & thread cut	Cutter	0.83	0.71	0.30	65	55
24	19	Raw edge & thread cut	Cutter	0.87	0.77	0.30	60	55
25	19	Raw edge & thread cut	Cutter	0.66	0.63	**0.30**	73	60
26	20	Arm hole scissoring	Scissor	0.24	0.23	0.30	185	170
27	21	Slv pair	Table	0.14	0.12	0.32	185	160
28	22	Slv Scissoring	Table	0.46	0.36	0.25	128	150
29	23	Slv & body match	Table	0.19	0.19	0.30	180	145
30	24	Slv join	OL4	0.57	0.50	0.35	92	70
31	24	Slv join	OL4	0.45	0.43	0.35	107	75
32	25	Thread cut	Cutter	0.30	0.27	0.34	178	145
33	26	Sideseam & care lbl attach	OL4	0.84	0.86	0.34	54	45
34	26	Sideseam & care lbl attach	OL4	0.75	0.72	0.34	64	55
35	26	Sideseam & care lbl attach	OL4	0.89	0.79	0.34	58	45
36	27	Thread cut & body turn over	Cutter	0.59	0.57	0.25	81	75
37	27	Thread cut & body turn over	Cutter	0.52	0.49	0.25	94	70
38	28	Nk chap tack & thread cut	LS	0.19	0.19	0.30	180	145
39	29	Hanger loop attach	LS	0.42	0.43	0.28	107	75
40	29	Hanger loop attach	LS	0.53	0.51	0.28	90	70
41	30	Slv Scissoring	Scissor	0.24	0.22	0.26	231	145
42	31	Round slv hem	ILC	0.23	0.20	0.32	195	145
43	32	Thread cut	Cutter	0.57	0.52	0.30	89	75
44	32	Thread cut	Cutter	0.58	0.51	0.30	90	70
45	33	Bottom scissoring	Scissor	0.25	0.23	0.35	171	145
46	34	Bottom hem	ILC	0.26	0.27	**0.35**	171	145
47	35	Thread cut	Cutter	0.21	0.20	0.26	231	145
Total				[illegible]		[illegible]		

Table 4.2: Time study chart after worker capacity balancing

(International Journal of Textile Sciencep-ISSN: 2325-0119 e-ISSN: 2325-0100)

Line efficiency = (Total production×SMV×100) / (No of operator ×Working hour ×60)

Before balancing line efficiency:

= (136×11.96×100)/ (50×1×60) =54.22 %

After balancing the line efficiency = (145×11.62×100)/ (47×1×60) =59.74%

Calculation of Sewing Productivity:

Productivity = (output amount/input amount) ×100%

Before balancing productivity = (136/300) ×100%

= 45.33%

After balancing productivity = (145/250) ×100%

= 58%

Calculation of Operation Capacity:

Capacity/hr = (60/Capacity total avg. time) x total manpower.

Before = (60/10.17) ×50 = 294.98

After = (60/10.11) ×4 = 278.93

Capacity achievable = capacity/hr x balance%

Before = 294.98×0.45 = 132.74

After = 278.93×0.85 = 237.09

Calculation of Sewing Line Performance:

Performance = (capacity total time /SMV) x 100

Before = (10.17/11.96) × 100 =85 %

After = (10.11/11.62) × 100 = 87.5%

From the above discussion it is noticeable that by applying time study and balancing techniques here bottlenecks were solved as well as sewing line efficiency is increased from 54.22% to 59.74%. Before balancing the line, the SMV required to complete the garment is 11.96 min whereas after balancing it requires 11.62 min. Manpower (both operator and helper) are reduced, production is increased through utilization of worker capacity that ultimately leads to increase the efficiency.

4.2 LINE BALANCING CALCULATIONS

“Line balancing” “in a layout means arrangement of machine capacity to secure relatively uniform flow at capacity operation.

It can also be said as “a layout which has equal operating times at the successive operations in the process as a whole”. Product layout requires line balancing and if any production line remains unbalanced, machinery utilization may be poor.

Let us assume that there is a production line with work stations x, y and z. Also assume that each machine at x, y and z can produce 200 items, 100 items, and 50 items per hour respectively. If each machine were to produce only 50 items per hour then each hour the machines at x and y would be idle for 45 and 30 minutes respectively. Such a layout will be unbalanced one and the production line needs balancing.

As an another example, a bakery would not be in balance, if the oven continuously baked loaves at the rate of 600 per hour and wrapping machine could only wrap 400 loaves per hour Hence the production line requires balancing.
A product requires 4 operations on 4 work stations in line. The total working hours per month are 150. The required production is of 450 units per month. Suggest how the time should be balanced for maximum utilization of machines. What percentage of each machine time is idle
Working hours/month = 150 = 150 × 60 minutes = 9000 minutes

Production/month = 450 units

Time/unit = 9000/450 = 20 roman minutes

In the question operation time for the last operation 4 is 20 minutes, on the basis of this last operation work station utilization can be calculated.

In this question work station 2 i.e., operation 2 also consumes 20 minutes. Therefore, Work station No. 2 and 4 are 100% engaged while work station No. 1 and 3 are 50 Present 48 operations worked in a line for 8 hours. They produced 160 garments and SAM of the garment is 44.25 minutes.

No. of Operator (A)	Working hours (B)	line output (production) (C)	Garment SAM (D)	Total minutes attended (E=A*B*60)	Total Minute produced (F=C*D)	Line Efficiency (%) (F/E*100)
48	8	160	44.25	23040	7080	30.73
48	11	240	44.25	31680	10620	33.52
34	8	300	25	16320	7500	45.96
35	11	400	25	23100	10000	43.29
35	11	329	25	23100	8225	35.61
34	8	230	25	16320	5750	35.23
34	8	200	35	16320	7000	42.89
35	11	311	35	23100	10885	47.12
34	11	340	35	22440	11900	53.03

Table 4.3: line balancing chart

Here,

Total minutes produced = (160 x 44.25) = 7080 minutes

Total minutes attended = (48 operator x 8 hours x 60) = 23040 minutes

Efficiency% = (7080 x100)/23040 % = 30.729

CHAPTER 5 CONCLUSTION AND RECOMMENDATION

5.1 CONCLUSION

As conclusion, the overall objectives of the study have been achieved and it is summarized as follows:

By the time study, SMV and production capacity of the processes were calculated separately (for four different production lines. Applying time study and balancing techniques here bottlenecks were solved as well as sewing line efficiency is increased from 54.22% to 59.74%. Before balancing the line, the SMV required to complete the garment is 11.96 min whereas after balancing it requires 11.62 min. Manpower (both operator and helper) are reduced, production is increased through utilization of worker capacity that ultimately leads to increase the efficiency.

The overall performance of SK garments plant was not performing well as analyzed by regression analysis and this is related to low productivity in material, energy and labor. The problem was labor productivity which is caused by poor working method and this is analysis by process flow chart.

Different problem areas associated to man, machine, maintenance, material, method, measurement, management and environment were recognized during observation and are obviously indicated by fishbone or cause-effect diagram. These problem areas (causes) are also accountable to enlarge the production time as well as hamper overall productivity (effect). As a result, RMG industries require more lead time for order completion which becomes hard to manage in maximum cases.

The improvement techniques suggested was time study and line balancing. Time study can produce excellent results if performed effectively. The suggested improvement can reduce the waiting time and travel distance by redesigning the plant layout and activity.

Now-a-days, RMG manufacturers of Bangladesh are seeking ways to maximize their resources utilization, increase productivity and minimize production cost. In this respective point of view, this study becomes more important to provide the technical overview about the productivity improvement and reduction of waiting time and production cost

5.2 RECOMMENDATION

Time study and line balancing techniques are only used in the sewing section and the application of those techniques in the cutting and finishing sections will further increase more productivity in the RMG industries. Besides time studies, line balancing and fishbone analysis other effective lean tools like 5S, KAIZEN, JIT, KANBAN, SMED, TPM, VSM etc. may also be employed to the RMG industries for the reduction of excessive wastes, and more production time and to increase the productivity which will help Readymade garments (RMG) industries to compete and survive with less manufacturing cost and higher product quality.

Skilled workers should be entitled for the production processes and that’s why proper training and supervision must necessary to achieve the optimum improvements in productivity and efficiency

More improvement technique can be implemented to solve the problem of poor work method, poor working condition and lack of motivation in SK garments plant. Examples are work measurement to determine the standard time for working time, ergonomic study for improvement in working condition and safety, employee benefits and incentive to improve the motivation of the worker and etc.

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