CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The export competition prevailing worldwide due to the variety of products, their increased complexities, varying customer expectations, and the life-cycles of the products are imposing a different and new manufacturing situation for the exporting companies. Singh and Mahmood (2014) in a recent article suggested that this new manufacturing order calls for the alignment of manufacturing strategy to export performance. They concluded that the adoption of manufacturing strategy by the managers of manufacturing SMEs would lead to a competitive advantage over their rivals in higher export performance. The new business environment created by the export competition is also compelling manufacturing organizations to change their traditional methods to overcome the global competition by improving their product quality, reliability, delivery schedules with cost reductions and customer satisfaction to stay in the more competitive business arena.

Manufacturing industries have been forced to change from the traditional methods and develop more efficient manufacturing systems for their products to compete with quality, cost and service due to the worldwide competition of the industries. This has stimulated manufacturing systems to move to the corporate functioning level from the operation functioning level during the last decade. The achievement of service improvement and cost reduction can be visualized only through an efficient manufacturing system.
During the last two decades, many global organizations are driving towards the goal of achieving productivity improvement through product analysis, optimization and integration of processes.

1.2 THE NEED FOR THE PRESENT RESEARCH

Due to global competition in the last decade, manufacturing enterprises were under pressure to cope up with the rapidly changing competitive market towards environmental standards, product varieties and their life-cycles with the dynamic change of customer demands. Export-oriented units found the productivity measurement and monitoring as a mechanism that allowed them to respond to these environmental changes, to give top priority for this on their agenda of industrial and service business strategy. The reduction of production time and cost, increase of customer service level and improvement of quality and competitiveness in today’s market place, all make it as a challenge for a company to handle them. Business organizations have started to address this challenge by concentrating on the productivity techniques. Different organizations with diverse objectives towards a common goal can be effectively integrated and coordinated by productivity engineering.

An important field in productivity engineering and management is considered to be the productivity measurement and monitoring (Sumanth, 1994; Hannula, 2002; Huang et al., 2002,2003). Ultimately, enhancement of the product and service provided to the customer is done by the effective and efficient measurement and monitoring throughout the manufacturing enterprise. The determination of material value and total machining value at every stage of the product is very necessary to ensure minimum cost of the product. Reduction of material and machining time during the entire manufacturing process ultimately minimizes the total cost of the product. To
obtain the final optimum solution, management of manufacturing should effectively use productivity engineering principles.

Productivity engineering accounts for a minimum material cost of products at every stage of the manufacturing process. During implementation, excess material and machining time over all the stages of manufacturing is a serious issue due to its dynamic nature. Further, multiple products and more machines make the productivity improvement method, a cumbersome one due to the complexity of the problem.

During the pursuance of the doctoral work reported in this thesis, these issues of productivity engineering have been addressed and newer methods and processes based on feasibility have been analyzed and adopted. Due to the availability of the varied information, non-uniformity in events occurring and system randomness affecting the performance, all make performance prediction more difficult and post a challenge in taking decisions because of the complexity in nature of the productivity engineering techniques.

1.3 PRODUCTIVITY ENGINEERING

Stimulated by the definition of Industrial Engineering in 1955 by the American Institute of Industrial Engineers (currently referred to as the Institute of Industrial Engineers) and by the functions that engineers responsible for productivity in organizations do, Sumanth (1994) proposed the definition of productivity engineering. Productivity engineering was defined as being concerned with the design, development and maintenance of productivity measurement, evaluation, planning and improvement systems in manufacturing and service organizations (Sumanth, 1994).
In evaluation, monitoring and the performance improvement of a manufacturing operation, productivity engineering is used as an important tool. To provide an analysis on the productivity is the purpose.

This thesis mainly comprises of two major sections. First, to develop some consensus about the techniques that can be adopted, the theory of productivity measurement is examined and evaluated through several stages. Second, based on the availability of different techniques for measuring productivity, particular case and field studies are analyzed to demonstrate the technique, an organization can adopt to improve the performance of the products.

During the initial stages of the doctoral work reported in this thesis, the literature was surveyed to identify the advanced and extended techniques of productivity engineering. Subsequently, those techniques were applied in three export-oriented manufacturing companies to investigate their practicality, viability and cost benefits. The details of these result-oriented practical investigations are presented in the following part of the research work.

Overall equipment effectiveness (OEE) is widely adopted as a quantitative metric for measuring the productivity of a component, equipment, machine, tool or process in a manufacturing system. It is a routine quantitative tool used for the measurement of productivity. At present, it is still very difficult to analyze the overall performance of the manufacturing system due to the complex nature of most manufacturing operations. To increase productivity, it is necessary to identify problems and the underlying improvement needs. This could be achieved using OEE as inputs in terms of overall throughout effectiveness (OTE). The performance of a manufacturing system is known through a new approach to modeling. (Huang et al., 2002).
Productivity improvement opportunities are identified with the help of analysis and theory of constraints. In a defined timeframe of one day or one shift, if productivity is increased, overall added value of the product within this defined timeframe is also increased, among other things. Lesser production time in a manufacturing process results in a higher output, thereby a higher productivity and overall added value within this given period of time is also increased. On the other hand, the same overall added-value is achieved in a shorter period of time in the value stream. Therefore, to create added-value as fast as possible is the aim of designing a process. More time is available in this given period of time for producing more output because of the new faster process.

A value stream includes all activities that are necessary to create a product. Value stream mapping (VSM) is a simple and very effective method which considers the entire operating time. Methods time measurement (MTM) is the time required to execute a particular activity based on the method performed on the activity. For performance of manual tasks, MTM is an internationally valid performance standard and most common predetermined time system. Inventory and process time are reduced and productivity is increased by the joint application of VSM and MTM (Kuhlang et al., 2008).

1.4 PRODUCTIVITY CYCLE

A schematic of the productivity cycle is as follows (Figure 1.1):
1.4.1 Factors Affecting Productivity

Two main factors are attributable to productivity changes:

(i) Technological development; and

(ii) Employees performance

These are further explained in the sub-section below:

1.4.1.1 Technological development

Technological development as a factor affecting productivity, the following items are considered:

- Plant;
- Research and Development;
- Plant and Product Lay-out;
• Machine and Equipment Design;
• Production processes;
• Power, raw materials, etc., and
• Scientific management techniques

1.4.1.2 Employees performance

The performance of employees is a significant factor affecting productivity under the following items:

• Ability;
• Motivation; and
• Physical conditions of work

Productivity is one of the most important performance measurements, which is critical for long-term business survival. Failure in applying the measurement methods in the evaluation of productivity improvement, failure in analyzing productivity improvement and failure in allocating sufficient resources for productivity improvement are the main bottlenecks for productivity improvement (Starr, 1987). Measurement, interpretation, evaluation, choice of corrective or improvement solutions and implementation of chosen solutions are the various stages in productivity engineering.

1.5 PRODUCTIVITY MEASUREMENT AND ANALYSIS

Productivity is the one which is measuring the efficiency of economy and analyses whether inputs are economically turned into outputs in an efficient manner or not. Output refers to the products manufactured or
services rendered and input means capital, energy utilized, materials, and labour. Productivity, quality, innovations, efficiency, effectiveness, profitability and quality of life determine the performance of an organization. Total factor productivity is measured by organizations whereas labor productivity is focused by economists.

Productivity measurement and improvement are both sides of a coin. One that cannot be measured, cannot be improved. Performance metric methods, system analysis methods, operations research methods and continuous improvement methods are various methods used for measurement of manufacturing system productivity and improvement. Measurement and then improvement yield competitiveness and success, by way of profitability, effectiveness, efficiency and performance leading to productivity. Productivity of a production unit is the ratio of its output to the input used over a given time period. Only partial productivity ratios are used in industries to measure productivity.

In the last two decades, the pressure of worldwide competition has driven firms to address productivity improvement strategies. This calls for the need to find suitable measures for total productivity. Finding a practical total productivity measurement method with acceptable validity is the present day challenge of productivity measurement (Hannula, 2002).

The ratio of outputs produced to resources consumed is the commonly used productivity measurement. However, with respect to the scope and nature of both the outputs and resources, many different choices are considered. Resources measured are in terms of effort or cost, whereas outputs measures are in terms of delivered product or functionality. A baseline against which performance improvement could be referenced
promotes the effectiveness of productivity measurement. Better decisions about tools, methods and process are taken with the help of productivity measurement.

Quality choice and requirement changes affect the result of productivity measurement and hence, a wide range of possible inputs and outputs are to be measured. More specifically, productivity must be viewed and measured from multiple perspectives. Productivity and quality goes hand in hand and cannot be dealt with separately. Therefore, mass manufacturing needs a thorough analysis of productivity. The relationship between productivity and the technological change, appropriate input and output data and their availability are needed for the accurate measurement of productivity.

Using primarily, input and output cost of materials for productivity measurement is having a number of shortcomings. Gunasekaran et al. (1994) stated that various functional groups of a manufacturing organization and concepts of CIM, FMS, TQM and JIT manufacturing technologies are integrated during the development of a multifactor productivity measurement. Improving productivity and quality in manufacturing systems depend mainly on support systems and workers participation. Global competition compelling the productivity improvement is the current challenge of finding a practical productivity measurement method with validity to illustrate and implement in practice with the approval and acceptance.

Profitability and productivity measurement of the whole firm are the major concern. Total factor productivity growth is measured with usage of the linear programming method. Significant differences in productivity levels varying from 3 to 20% are noticed between exporting and non-exporting companies when productivity output levels are measured. Systems,
productivity engineering principles and strategies are the basis for all the productivity improvement methods. Change in the output mix improves the productivity in favor of products manufactured. Overall results rather than the individual activities are focused in the multifactor productivity measurement.

1.6 EVALUATION AND PLANNING FOR PRODUCTIVITY IMPROVEMENT

The gap of what is possible and what is actually accomplished enables the provision for productivity improvement. For the last 50 years, a lot of productivity movements are taking place. Methodologies, productivity strategies and a number of techniques have been developed. An effective program that is inclusive, holistic and set within the corporate strategy, provides a set of simple guidelines, setting within a systems framework to effect the application of productivity improvement. Profitability, growth and pricing strategy represent income and profit figure during the productivity measurement. Organizational performance is measured by individual productivity and attitudes to productivity.

In the productivity change index, data on inputs and outputs are used to measure the productivity change. For the growth and survival of an organization, cause and effect diagrams are used for taking actions towards the improvement of productivity. Availability of various techniques and consensus about techniques constitute the analysis for productivity. System improvement strategies, utilization and efficiency with a quality factor are the concepts of productivity. Many obstacles are avoided in utilizing resources efficiently by the implementation of JIT in the productivity improvement. An investigation of the causes of problems in resource allocation, linear programming, analysis in taken period data usage, are used in profit linked
total factor productivity. Machine data and machine setting aids are used in the implementation of CIM and considerable reduction in production time is achieved successfully (Scott, 1999). Focused resource allocation, lead time and output are measured for productivity improvement in manufacturing. The relationship of productivity levels, inputs and outputs, analyses of the main types of productivity measures, namely, total factor productivity, and average labor productivity and then productivity is measured, managed and promoted.

Organizational strength is assessed by means of productivity measurement and accordingly, planning is done to increase the productivity of the organization. The ratio of output to worked hours by the labour is referred to as average labor productivity (ALP) and is based on the three sources:

i) Machine services / hour referred to as capital

ii) Labor input / hour referred to as labor quality, and

iii) Growth of total factor productivity.

Total productivity measurement is only preferred by organizations (Kemppila and Lonnqvist, 2003). Comparing to complex measurements, only labour productivity is preferred by economists. For the success of organizations, the influence of productivity is the main factor. But profit and economic growth influences productivity. Management and promotion of productivity is carried out by the following four methods:

i) Good infrastructure with better tools and machines

ii) Machining process improvement;

iii) Reduction of wastage and rejecting; and

iv) New technological adoption
Sink (1985) discussed the theory, research results and practical techniques about the management of productivity. Issues regarding planning, measurement, evaluation, control and improvement were treated strategically. The work presented among other things, a methodology that incorporates the nominal group technique and the delphi technique. Also discussed is the total factor productivity model.

1.7 EXPORT-ORIENTED UNITS

Export-oriented units are businesses and production organizations with outward-oriented trade policies (Lal, 1999; Trung et al., 2008). In scientific papers, the term “units” is often interchanged with “enterprises” or “organizations”. For example, Trung et al.(2008) used the nomenclature “enterprises” and investigated empirically the factors supporting export participation by manufacturing SMEs as well as the performance of export-oriented manufacturing SMEs. The authors shed light on measures that would stimulate the participation of SMEs in global trade, particularly from the post-WTO perspective.

Although each paper in export-oriented units literature is independent of others, the features that characterize most of the scientific papers are: (1) linkages of export-oriented units, export behavior and trade (Cohen, 1975; Stem et al., 1981; Hughes, 1986; Willmore, 1992; Aitken et al., 1997; Bernard and Jensen, 1997; Moreno, 1997); (2) association with productivity performance and cost (Lall, 1986, Lal, 1996; Noland, 1997; Hashim, 2004); and (3) concerns for the textile manufacturing and clothing industry (Hufbauer, 1996; Keesing and Wolf, 1981). In India, export-oriented units hold a prime position in the nation’s economy as these units are important India’s foreign exchange earners. Hashim(2004) contributed to the understanding of cost and productivity of the country’s textile industry through theoretical and empirical relationship modeling between unit cost and
productivity. Lal (1999) study the factors that influence the export performance of Indian garment manufacturing firms, grounding his investigation on a data sample of seventy-four firms in Okhla.

1.8 SCOPE AND MOTIVATION

Price sensitiveness is increasing very fast in the present day market and worldwide competition is also increasing. Hence, today’s manufacturing industries are finding it tougher than ever to stay ahead in the market. This ever changing market demand is forcing companies to take the challenge of implementing various efforts for productivity improvement. To operate in an orderly and efficient manner is the main requirement of a company to remain competitive. Usage of output to input formula may be sometimes deceiving in the determination of the overall performance. Companies should reflect an operational strategy to develop a suitable performance measurement for usage.

No one method is clearly pointed out for any company based on the theoretical and empirical relations. However an objective source of information, in general, about long-term operating trends on problems of performance can provide an inspiration for useful exchange of ideas to draw a productivity measurement, monitoring and comparison method. Motivation to the workforce towards higher output is contributed by the factors of likeness of physical surroundings in the workplace, working with a good team and a good boss with a favorable working environment. Indeed, for a favorable working environment, availability of food and drink at the workplace, a sustainable compensation package and job security are considered as principal indicators. Increased manufacturing productivity at the work place is
contributed by the presence of all these factors which boost up the morale of the workers (Islam and Shazali, 2011).

A strong association between productivity and favorable working environment is noticed, in a study by Huang et al. (2003). The authors stated that productivity is at its highest level when all factors operate at the optimum level. The important components of a manufacturing system are process layout design, material movement planning and production schedule. R and D activities of the manufacturing enterprise decide the quality of these parameters. Eventually, the process capability of manufacturing systems are improved by R and D which is contributing to the manufacturing process towards the reduction of non-value-added inputs. Higher outputs are achieved by the increase of process capability due to the intensity of vital role played by R and D in the manufacturing industries (Lu et al., 2010).

1.9 OBJECTIVES

Some of the objectives of a factory, which leads to a better performance are:

(i) minimized total time for completion all the jobs;
(ii) minimized set-up costs; and
(iii) minimized mean time in the shop and minimized machine idle time (Sumanth, 1994)

In this context, by drawing inference, the following objectives were set:

- To carry out literature survey on productivity engineering applications;
• To carry out the measurement of the existing productivity;

• To carry out the analysis of the production process for improvement opportunities;

• To apply newer methods for productivity improvement;

• To validate and establish the result for improved productivity in the export-oriented units.

The above objectives were attained by following the research methodology presented in the next section.

1.10 RESEARCH METHODOLOGY

Bottleneck detection is the main objective of the research. This task is done by analyzing various processes and the utilization of the different machines in the manufacturing system. Main factors that are having an impact on the performance of processes and machines are considered in analyzing improvement opportunities in the system while conducting a study on design of experiments. System’s productivity is selected as the measure of effectiveness. Product-oriented models have been considered in current thesis.

A full-factorial experimental design is constructed using all the information gathered. In the analysis, a total number of experimental factors are to be included during the requirement of such type of design. Improvement opportunities are analyzed during the usage of simulation and design of experiments. Analysis is to be done in such a way that it is possible by the application of minor changes in operational conditions, a 25 % system productivity is improved.
In manufacturing plants, total quality management (TQM), six sigma (60), theory of constraints (TOC), lean manufacturing (LM) and agile manufacturing (AM) are some of the established methodologies (Tamneez, 2004). Just-in-time automation (JIT) and total productive maintenance (TPM) are two other concepts. During design, the strategies focused on are the improved return on investment by the better utilization of expensive capital and better quality with improved productivity of the enterprise. World class manufacturing has to include ways and means to bring out changes in the workforce management, newer production techniques with new approach to product quality. Availability of resources and their uses are closely related to productivity. In short, due to improper use of its resources, a company’s productivity is reduced.

Creation of the product value is closely connected to productivity. Thus, if resources and activities in the transformation of a manufacturing process add value to the product or service, higher productivity is achieved. Therefore, an important conclusion to improve productivity is to eliminate wastage during the entire manufacturing process. Wastage is to be considered detrimental to the productivity improvement. The relationship between ratios of output to the inputs of production is considered as a technical concept. The relationship between the actual and potential process output is considered as an engineering concept and the efficiency of resource utilization is considered as an economic concept.

1.11 ORGANIZATION OF THE THESIS

The thesis of the research work has been structured with nine chapters, as depicted in Figure 1.2. The need for the present research and motivation that lead to the formation of the objectives of the research and the methodology proposed for accomplishing the objectives of the research are elaborated in chapter 1.
Followed by this, the literature surveyed during the beginning of this research work has been explained in chapter 2.

An analysis of the swaging process for its deployment in the manufacture of textile spindles is described in chapter 3.

Further extension of it to design a swaging process setup is explained in chapter 4.

Design analysis and optimization for productivity of textile spindles is detailed in chapter 5.

Simplex method of analysis as an OR technique for obtaining an optimum productivity solution for textile doffer and carding cylinder manufacturing is presented in chapter 6.

Optimization of turbo motor productivity using analysis of variance and regression analysis for minimizing cutting loss of stator coils are elaborated in chapter 7.

In chapter 8, the results and discussions are presented. In this chapter, the efforts made to validate the optimization and productivity engineering techniques for productivity improvement at export-oriented units have been explained.

This thesis is concluded with the contributions of the research and potentials for further pursuit of the research work, summarized in chapter 9.

Following by these chapters, the references, list of publications of the research scholar have been appended.
Figure 1.2 Organization of the thesis
The organization of the thesis is as shown in Figure 1.2 and organized in such a way that it is very easy to be referred to and put into use and practice by both practitioners and theoreticians. Both practitioners and researchers may be attracted to the usage of refer and read the thesis due to the usage of lucid languages throughout it.

1.12 CONCLUSION

In the manufacturing enterprises, analysis of process data, optimization and monitoring of interrelated set of process operations for development are the major concerns for productivity. In pursuance of a competitive benefit in the global market, the enterprise is to be supported by combining material, human resource capacity, technology and fine tuning of all the operations and process management to ultimately minimize the production cost.

In the current global market, the main factor for a booming business is the application of productivity engineering principles. In the recent times, due to global competition and increasing market, the role of productivity improvement is mainly concentrated by export-oriented industries. Productivity engineering is very necessary to minimize the undesirable wastage and scrap. For several decades, the management of export oriented manufacturing units are considering productivity improvement as an important pre-requisite. By holistically looking into the data from across the extended network of manufacturing and analyzing process and machine performance, opportunities would be revealed by productivity engineering techniques to cut cost of production. Overall productivity is increased by identifying smarter processes, newer manufacturing technologies and optimization techniques.
Productivity management in diverse products is typically problematic and may have an enormous impact on production cost at the enterprise level. Nevertheless, determinations of the benefits of these productivity improvement mechanisms are vast. In the decision making process of managers and consultants, productivity engineering is helping as an important tool. Based on powerful mathematical model and solution techniques, sophisticated decision support systems are needed along with advances in information and communication technologies capable of responding to the challenges of integration. The importance of designing and managing the entire manufacturing system as a single entity, needs solving complex manufacturing related problems using productivity engineering as an important tool. Concerns about export-oriented economy have been shown in a number of articles across the globe. Scholars have written on Japan (Eichengreen and Hatase, 2007), China (Wang et al., 2013), Turkey(Saygili and Saygili, 2011), India (Lal, 2004), Nigeria (Adeoti, 2012).