CHAPTER 1

INTRODUCTION

1.1 PRODUCTION AND QUALITY MANAGEMENT EVOLUTION

The word productivity has become such a buzzword these days that it is almost pervasive to find it mentioned in some context or the other in trade magazines, newspapers, management briefs, political speeches, television news, consultants’ advertisements, conference proceedings, etc. Productivity management is essential for long-term survival of the businesses. However, there are serious obstacles to obtain successful productivity management because many managers do not have the skills or time to analyze productivity and take necessary corrective actions in a timely fashion. Mike Hannula (2002) emphasized the need to find appropriate measures for productivity and total productivity.

Mali (1978) and Sumanth (1984) brought together the terms productivity, effectiveness, and efficiency. This researcher did not define the efficiency in a technical sense, i.e. the ratio of actual output to standard or expected output. Productivity is concerned with the efficient utilization of resources (inputs) in producing goods and/or services (output). In recent years, the pressure of global competition has compelled the firms to focus on strategies for productivity improvements in manufacturing and textile industries. Improving productivity or any other important factor is difficult without knowing the impact of the decisions made. This is why there is a need
for performance measurement. In this context, total productivity measurement is needed in order to improve the internal efficiency and thereby the competitiveness of a business unit. Productivity management is essential for long-term survival of the businesses.

According to Garrigosa and Tatjeh (1992), Inman (1992), Felix (1983) and Gonsalves (1996) and the concepts of productivity and productivity gain over time have played an important role in the theory of production. Partial productivity ratios are widely used in the industry but as such they are too narrow to give a comprehensive picture of the productivity improvements at the business unit level according to Mike Hannula (2002).

1.2 INTRODUCTION ABOUT TEXTILE INDUSTRY

The textile sector is second important concern next to the agriculture sector in India. It plays an important role in Indian economy in terms of its contribution to Gross Domestic Product (GDP), exports and its potential for employment generation. Nearly 2500 textile and its allied industries are functioning in Erode and Tirupur Districts of Tamil Nadu, India. An enormous amount of money is invested in this industry for processing the goods, namely grey fabric and calendared fabric. The textile industries are classified as ginning and processing, spinning, weaving, knitting, woven processing, knit processing, clothing jute, silk, wool, grey fabric cloths, dyeing, calendaring etc.

In the textile fabric industry, grey fabrics are converted into calendared products. Several sequential steps are involved in the process of preparing good fabric such as fabric preparation, desizing, scouring, bleaching, dyeing and calendaring. In fabric preparation, these operations are employed in dye houses according to the customers’ requirements vis-a-vis the fabric preparation. Fabric preparation is a series of treatment steps that
removes various impurities present in the dyeing and finishing of the processes in the fabric. The present work focuses on the processing machines such as Jigger, Squeezing, Stenter and Calendaring Machine as shown in Figure 1.1. The focused function and explanation of these machines are given below.

1.2.1 Jigger Machine

In the simplest term, a Jigger is a dyeing machine. It is used to get the required dye to the grey fabric. The raw or grey fabric passes through the dye bath from the roller and received by another roller. The dye bath consists of chemical dye, water acid and other ingredients. This process is repeated a number of times as the fabrics are batched from one roller to the other. Each such pass is termed as ‘end’. Figure 1.1 illustrates the photographic view of fabric machinery used in textile industry.

A Jigger comprises stainless steel with two guide rollers. In addition, there are two additional guide rollers and two draw rollers on which the cloth is wound on one of the draw rollers on which the cloth is wound and rewound. A suitable length (about 600 to 1000 meters) is wound on the draw rollers. Friction brakes operate on draw rolls during the movement of the cloth from one draw roll to the other. The dye bath can be heated with direct or indirect steam as required. A dial thermometer is suitably mounted to indicate the temperature of the bath.

The jiggers are equipped with the drive to ensure the low or high constant line speed and automatic reversal arrangement. Besides these, expander bars which are curved rollers may be inserted to keep the cloth at open width. The preparatory, dyeing and soaping treatments can be carried out in Jigger. From time to time, a dyer cuts small test patterns out of the
fabric to check the shade matching. It can add further quantities of dye chemicals, if necessary.

![Fabric processing machinery](image1)

**Figure 1.1 Fabric processing machinery used in textile fabric industry**

**1.2.2 Squeezing machine**

Heavy duty Ebonite and rubber rolls are mounted on a well machined Cast Iron. The circumferential wall of the machine squeezes the water while the fabric rolls in the machine. Adjustable mechanical spring loaded pressure system and driving device for machine are used to make the required tightness for maximum squeezing of water.
1.2.3  **Stenter Machine**

Cotton fabrics, after the bleaching process, shrink widthwise and the weft becomes distorted. The main function of the Stenter is to stretch the fabric widthwise and to recover the uniform width. Figure 1.1 shows the view of Stenter machine. The Stenter machine is also used for the following operations.

i)  To dry the fabric.

ii) To give heat setting to synthetics and blended fabrics.

iii) To give soft finish to the fabric.

iv) To give curing treatment for some special finishes such as resin finishing, water repellent etc.

v)  To stretch the fabric to the required width.

1.2.4  **Calender Machine**

The Calender machine is used to get smooth and glossy finish of the fabric. Seven or five bowls are mounted in this machine as shown in Figure 1.1. The calendaring effect produced depends on the moisture content of the fabric, the number of bowls used in the calendar, the composition of the bowls, the arrangement of the bowls, temperature, pressure and speed of the machine.

After bleaching or dyeing or washing and after drying, the fabrics will have wrinkles and creases. To remove these wrinkles, the fabric is ironed to enable easy cutting. Technically, this ironing method is called Calendaring. This is done with steam pressure to get smooth, glossy finish of fabric. Also, this will help the fabric to maintain its diameter.
1.3 CHALLENGES FACED BY TEXTILE INDUSTRY

The Indian textile industry faces a host of constraints such as low production due to facts high power costs, rising interest rates, transaction costs, unfriendly labor laws, logistical disadvantages in terms of shipping costs and time posing serious threats to its growth. The Indian textile and apparel industry will continue to grow rapidly and so also the consciousness of the international and domestic consumers. The textile industry is a significant contributor to many national economies, encompassing both small and large scale operations worldwide. In terms of its output or production and employment, the textile industry is one of the largest industries in the world

Beyond the day-to-day uses of textiles fabrics in home furnishing, apparels etc, the demand for textile materials for various purposes is increasing but the industries such as chemical and allied industries especially dyeing and calendaring industry are undergoing a stage of degradation because of low utilization and maintenance of resources. So consumers who are conscious of high quality but less cost are expecting more and more in terms of performance of the materials. In order to satisfy all customers and survival in the market, the industries are subjected to increase the productivity with quality of fabric.

1.4 BACKGROUND OF THE RESEARCH WORK

Ahire et al (1996), Felix (1983) and Zimmermann (1999) explained sufficient conceptual and case studies available about the method of improving production and implementation of quality management. There is an insufficiency of empirical studies in chemical and manufacturing industries. Globalization of markets and the increased interdependence of economy need the improvement of productivity by meeting the National and International competitive environment. The textile industries that are experiencing
increased production and quality of fabric on their products and services are affected by the competitive environment.

In small and medium scale textile industries, the problem of implementing production techniques compared with other production organizations is very slow to adopt production and quality management tools stated by Felix and Riggs (1983) but industries have not implemented the Total Productivity Model (TPML).

In the recent years, various instruments have been studied to identify the dimensions of failure with regard to productivity and quality. In their research work, Mike Hannula (2002) designed various instruments for improving productivity especially for hotel and aircraft industry. However, in their study, they failed to implement certain dimensions such as supplier performance and benchmarking. The different dimensions with respect to productivity and quality level are referred by Sureshchandar et al (2001) in the Indian banking sector. Josephiene and Adrian (2003) also failed to encompass certain dimensions like benchmarking and maintenance instruments. Babakus and Boller (1992) and Stewart (1980) who examined this aspect reasoned that critical dimensions may vary depending upon the type of industry.

Mike Hannula (2002) and Gonsalves (1992) designed an instrument in order to measure the knowledge, outcomes and perceptions of college students about the method of delivering throughput and quality. Drew et al (2003) studied and validated the four types of production and quality oriented sector. Similarly, Ashworth (1988) mentioned about the several tasks with inputs and outputs of productivity along with maintenance techniques and its a few procedures. Zimmermann and Hommel (1999) proposed modeling the structure and work plans.
Production and Quality Management as an umbrella of concepts and ideas are distributed in various contexts related to the field by Dale et al (2001). Hernandez (2006) discussed the need for systematic methodology and a coherent analysis for productivity measurement of the system. But the system was not insisted TPML. The information system, managing the decision system, controlling the physical system, input and output have been highlighted by researchers such as Chen et al (2009) and Cheng et al (2005).

Extensive theoretical work and delivering production method are delineated by Woon (2000) and Sila and Ebrahimpour (2005). They have been also addressed with respect to production dimensions such as technological instruments, continuous improvement, innovation top management commitment, leadership, employee training, team work, employee involvement, customer focus, customer satisfaction and benchmarking.

However, in the recent years, some of the industries had to be closed because they were unable to meet the environmental requirements or to satisfy the government regulations. Apart from these government regulations, the major problems are sickness, low yield, fluctuation of output, labor problems, accumulation of stock, deficiencies in the quality of fabric, high input but low throughput etc., in these sick textile industries.

Under the circumstances cited above, the present study attempts to analyze the issues involved in productivity and quality delivery from the customer’s viewpoint. It proposes a robust framework model which consists of measurement, evaluation, planning and improvement phases of partial and total productivity of the firms. An analysis between productivity indexes and break even indexes gives a performance of the firm when applying research tools.
1.5 NEED FOR THE STUDY

The success of the product is generally measured by the satisfaction of the customer who seeks good quality. The profit and long run of industries are also measured by throughput and maintenance of resources. So, quality is the prime factor in the success of the product. However, failure in production is mainly due to poor planning and utilization of resources.

By making the optimum use of different configuration of plant resources, Felipe et al (2002) proved that the total average cycle time could be reduced by 18%. The resource configuration needed to reach this result was obtained by evaluating just 1.6% of the total number of possible combinations. The downtime loss in fabric dyeing processing industry leads to the loss in the availability of the equipment and this in turn leads to the less Overall Equipment Effectiveness (OEE).

The downtime loss results in the shutdown of the particular equipment which decreases the OEE. This is considered to be one of the major losses to the company. Pierreval (1997) and Kumar (1995) made use of this technique for optimization of air traffic delay cost. So it became possible to reduce the downtime loss in order to increase the productivity of the particular equipment.

Many manufacturing systems operate at a lower capacity with the consequence that there is higher cost in producing the products. In the Fabric dyeing process industry, the production process requires non-stop operation of automatic production line equipment. A stoppage in a production line, due to the failure of the equipment, causes a drop in the production rate and quality problems on the products. Low productivity is the result of the worst function of the production lines. This can be a result of imperfect maintenance of the machines and utilization of resources.
Empirical based research (Ghobadian and Gallear 1996) has shown that the use of a structured approach, such as TQM, to guide the team-based efforts in improving operations is more effective than an unstructured or ad hoc approach. Hence, the present work focuses on using Total Productivity Model (TPML), Total Productive Maintenance (TPM), Theory of Constraints (TOC) and Quality Function Deployment (QFD) as a mechanism to improve productivity in declining industries. Many companies have successfully implemented and continue to innovate based upon the TOC five-step focusing process Noreen et al (1995) and Mabin and Balderstone (2000).

Goldratt (1994) developed a set of logic trees or cause and effect diagrams that are collectively known as the Theory of Constraints (TOC) and Thinking Processes (TP) tool. There is also no research about the use of the method mentioned above to raise production in chemical and its allied industries, especially the dyeing and calendaring industries that have an important role in Indian textile industry. A systematic work has been undertaken with integration of an empirical, fuzzy analysis and productivity tools.

1.5.1 Research Gap from the Literature Review

A few research works have been reported in the literature collections. They emphasized the effective implementation of Total Quality Management (TQM) in manufacturing industries. However, the same results and findings may not apply directly to textile processing industries due to certain constraints among the industries. Moreover, there seems to be a scarcity of research studies addressing the various issues of the textile fabric organizations. Hence, in order to overcome the above problem, this research work has undertaken an empirical study to address the validity and reliability of Productivity and Quality Dimensions (PQD). It is also planned to identify the high risk priority dimension in the textile fabric industry sector from the
perspective of productivity. The study proposes a robust implementation framework for improving the productivity. It has been implemented in industry and ensured the framework.

1.6 PROBLEM DEFINITION AND OBJECTIVE OF RESEARCH

The main objective of the present work is to develop a robust framework for improving productivity and the quality dimensions of fabric in textile fabric organization in order to fulfill these paradigms of the modern yet waning textile industry, the following definition, objectives and outline of the research are proposed.

1.6.1 Problem Definition

Among the process industries, it is estimated that more than 900 textile processing fabric industries in Erode, Tirupur districts and a few industries of Karur districts of Tamil Nadu, South India. These industries are affected, partially closed and shut down off for various reasons such as poor management, poor supplier performance, lack of planning for productivity, fluctuation of output, poor investment, waste analysis, labor problems, capital/labor ratio, accumulation of stocks, poor maintenance of resources, deficiencies in the quality of fabric, low capacity utilization, age of plant and equipment, high investment and input but low throughput, poor research and development, lack of energy, workers’ fear of loss of jobs, work force mix and work ethic.

The main objective of this work is to analyze the existing conditions in textile fabric sector, validate, design and implement a robust framework for improvement of productivity and quality dimensions in the fabric processing industry. Such a framework needs to be compatible with the
reality of textile and fabric processing industries. The highly risky events from productivity and quality dimension were found by fuzzy systems and the results are wrapped up among the textile fabric processing industry.

1.6.2 Objectives of the Research

The primary focus of this research study is to develop a robust framework for improvement of productivity through an empirical study of productivity and quality dimensions. In order to meet the above requirements, the following objectives are proposed and they have been successfully implemented in the industries:

- To identify and array the measurement instrument through identification of the critical risk priority dimensions for productivity and quality improvement and to evaluate their operating measures.
- To validate the measurement instrument from the data which are collected from the industry experts through questionnaire.
- To identify and investigate the influence of an age of productivity and the quality of sick textile industries.
- To investigate the success of robust framework implementation and issues related to successful implementation for the achievement of better performance of organizations.
- To compare and conclude the results with benchmark industries.
1.6.3 Outline of the Research Work

The dimensions arrived at from this work have been taken into consideration to increase the productivity of such sick fabric industries. The total investment of this sick fabric industry is approximately 50 million rupees. But the total productivity of this industry is not up to the planned level due to the improper applications of scientific and engineering procedures. The data collection and validation were carried out from May 2007 to May 2008 and subsequently the implementation phase got started on the basis of the results from December 2008 to December 2010 in various industries.

This empirical study has identified ten critically successful dimensions for the improvement of Productivity and Quality Dimensions (PQD) such as Management Principle (MP), Research and Development and Capital Utilization (RDCU), Supplier Performance (SP), Fabric Quality (FQ), Order and Customer Perception (OCP), Lack of Planning for Productivity (LPP), Labour and Work Force mix (LWF), Technical Instruments and Technology (TIT), Benchmarking (BM) and Maintenance of Assets (MA). This present work was converted into three stages.

Stage 1: In the first phase of research work involving an extensive literature review, the study identified ten dimensions for the failure of fabric in the processing industries. An instrument for measuring the total productivity of firms, with specific reference to the textile fabric sector has been arrayed, analyzed and validated using Confirmatory Factor Analysis (CFA) based on the data collected from the textile fabric engineers, executives, directors and also field specialists in Erode and Tirupur districts. Further, the influencing characteristics of the organizations are analyzed based on the results.
**Stage 2:** In the second phase of the research, the validated Cronback alpha dimensions were taken and instrument risk priority numbers were calculated based on the collected data. The traditional FMEA determines the risk priorities of failure modes which require the risk factors like the occurrence (O), severity (S) and detection (D) of each failure mode to be precisely evaluated. This may not be realistic in real applications. Different combinations of O, S and D may produce exactly the same value of Risk Priority Number (RPN), but their hidden risk implications may be totally different. This may cause waste of resources and time or in some cases a high risk event may not even be noticed. These three risk factors are assumed to be equally important. This may not be the case when considering a practical application of failure Mode and Effect Analysis (FMEA). These three factors are difficult to be precisely estimated. Much information in FMEA can be expressed in a linguistic way such as likely, important or very high and so on.

To overcome the above drawbacks, fuzzy logic has been widely applied in FMEA. This method requires a vast amount of expert knowledge and expertise. The present work deals with Fuzzy Weighted Geometric Mean Method (FWGMM) for risk evaluation and prioritization of failure modes in FMEA. This method can overcome both the drawbacks of the crisp RPN and fuzzy if–then rules. Fuzzy risk priority numbers are calculated for ten failure mode dimensions, ten failure modes and all $\alpha$ levels, where the $\alpha$ levels are set as 0, 0.1, 0.2,……1.0 and solved by Linear Programming (LP) model. The results of LP models are depicted in Figure 4. The lack of productivity planning (Failure Mode 6 (FM6)) from Productivity and Quality Dimensions (PQDs) is without doubt an example of the failure mode with the maximum overall risk and it should be given top risk priority.

**Stage 3:** In the third phase, the prioritized fuzzy RPN dimensions are analyzed and discussed with experts regarding the implementation of
robust framework for improvement of productivity. The productivity cycle concept was introduced in order to solve the high prioritized fuzzy RPN dimensions. It consists of productivity Measurement, Evaluation, Planning and Improvement (MEPI) phases. In addition, a Total Productivity Model (TPML) and Productivity Evaluation Tree (PET) have been used for the Measurement and Evaluation in Productivity Cycle (PC) respectively. Total Productive Maintenance (TPM), Theory of Constraint (TOC), Thinking Process (TPs) tools and Quality Function Deployment (QFD) are used in the improvement phase. The robust framework has been implemented in the sick textile industries and the results are discussed against those of another industry which does not implement the productivity cycle. Further, it has been discussed vis-a-vis the benchmark industries and then the results are compared.

To sum up, this research study will be of immense use to the textile processing and allied industries for improving the key performance indicators. Hence, the present research work attempts to address the issues of productivity and quality dimensions in the developing economy of India with a specific focus on the textile fabric industries. It satisfies the customers with a high quality fabric that is made available by means of the effective utilization of resources.

1.7 STRUCTURE OF THE THESIS

An attempt has been made to develop in this research work by considering the need for managing the productivity and analysis of the profit loss ratio in the declining textile industry. The outcome of the research work has been consolidated and compiled into a thesis as detailed below. This thesis is organized into seven chapters.
Chapter 1 provides an introduction to the research work. It also outlines the background of the problem, statement of the problem, need, importance, assumptions and scope of the study.

Chapter 2 focuses on the literature review on measurement instrument, a critical review of the chemical and allied industries such as small and medium scale industries which are declining and partially successful industries. The collection of literature reviews discusses Productivity Management and Measurement, Fuzzy Risk Priority Analysis, Total Quality Management (TQM), Total Productivity Model (TPML), Quality Function Deployment (QFD), Total Productivity Maintenance (TPM) and Theory of Constraints (TOC).

Chapter 3 informs the methodology of research study, survey, data collection and its analysis tool of Productivity and Quality Dimensions (PQD) in the already successful and unsuccessful industries.

Chapter 4 validates and analyses the collection of questionnaire and survey results respectively on the production measurement in dyeing and calendaring industry as the first case study. It also analyses the framework of present techniques and implementation of tools for improving production by applying the proposed framework in the industry.

Chapter 5 describes the traditional FMEA analysis with TPM.

Chapter 6 explains the fuzzy and robust framework by integrating production techniques discussed in chapters 3, 4, 5 and 6. A detailed description of the framework’s working mechanisms is found in this chapter. The proposed robust model is implemented through various industries by way of case studies.
Chapter 7 consolidates all the findings of the research, the major conclusions and suggests scope for further research.

The reference section includes the studies and the additional materials used in the thesis while supporting data for the research are given in the Appendix.