CHAPTER 2
LITERATURE REVIEW

This literature review part of the study is segmented to ten modules, which throw a lime light on both the extensive and diverse literatures pertaining to world class manufacturing and related best practices adopted by the manufacturing firms in the journey toward achieving world class performance.

2.1 PREAMBLE

Because of the globalisation of markets, technological advances and the changing needs and demands of consumers have forced the nature of competitive paradigms to change continuously (Singh et al., 2010a, b). In this age of agile manufacturing, the global competition characterised by both technology push and market pull has forced the manufacturing companies to adopt a state-of-the-art world class manufacturing system to achieve world class performance through continuous improvement in their products and business processes (Sharma and Kodali 2008). Keeping ahead of the game is tougher than ever with manufacturing industries.

Competition has become worldwide, and markets are fast becoming price sensitive. In today’s competitive market, manufacturing firms are facing tremendous pressure of customer’s expectations about product quality, cost reduction, constant innovations, demand responsiveness, and product variety (Singh et al., 2010a, b). These challenges force companies to implement various productivity improvement efforts like JIT, Six-sigma,
TPM, TQM and WCMS to meet the needs of the ever-changing market demand and requirements (Nachiappan and Anantharaman 2006).

A review of literature reveals that there is no universally recognized definition of World Class Manufacturing (Kodali et al., 2004; Maskell 1992). The term ‘world-class manufacturing’ was coined by Hayes and Wheelwright (1984) to describe organizations that achieved a global competitive advantage through the use of their manufacturing capabilities as a strategic weapon. The study of World Class Manufacturing (WCM) has evolved, reflecting an increasing scope. Early researchers proposed fundamental areas of WCM that have been augmented and refined (Hayes and Wheelwright 1984; Gifli et al., 1990; Schonberger 1986, 1990a,b, 1996). There are a number of other studies that have examined salient aspects of world class manufacturing within the context of operations strategy (See, for example, Flynn et al., 1999; Miller and Roth 1994; Schroeder et al., 1986). The manufacturing practices examined in these studies and their conclusions are relevant to the objectives pursued in our study.

2.2 AN OVERVIEW OF WORLD CLASS MANUFACTURING (WCM)

The term “World Class Manufacturing” was first introduced by Hayes and Wheelwright in 1984 (Hayes and Wheelwright 1984). Since then, various researchers in the field of manufacturing operations have embraced and expanded this concept. Although Hayes and Wheelwright originally coined the term ‘World Class Manufacturing’, the global manufacturing environment has undergone many changes since their work. In the study, the researcher seeks to determine whether the practices of WCM which they described are still relevant in today’s manufacturing environment. The researcher also looks at their list of competitive priorities and examine
whether they function as tradeoffs, as Hayes and Wheelwright suggested, or whether there are synergies between them.

Schonberger (1986) defined WCM as analogous to the Olympic Games ‘motto citius, altius, and fortius’, which translates to ‘faster, higher, and stronger’. The WCM equivalent is continual and rapid improvement. Schonberger (1986) argued that it consists of changes in several areas such as ‘management of quality, job classifications, labour relations, training, staff support, sourcing, supplier and customer relations, product design, plant organization, scheduling, inventory management, transport, handling, equipment selection, equipment maintenance, the product line, the accounting system, the role of the computer, automation and others’. WCM seems to affect almost every aspect of production (Lind 2001).

WCM was described as a collective term for a number of production processes and organizational strategies that all have flexibility as their primary concern (Haynes 1999). Oliver et al (1994) observed that to qualify as world class, a plant had to demonstrate outstanding performance on measures of both productivity and quality. Todd (1995) defined WCM as being the best in the world in one’s particular sector of industry. He also added that this must be supported by a combination of product design, quality, low manufacturing cost, innovation, shorter lead time, and reliable delivery performance and customer service. Maskell (1992) outlined four specific attributes which should always be included in WCM implementations: ‘a new approach to quality, JIT manufacturing techniques, changes in management of the work force, and more flexible approaches to meeting customer needs’.

According to several writers, WCM is more than just a technique and can more accurately be described as a management philosophy (Schonberger 1987; Foster and Horngren 1988; Maskell 1992; Lind 2001). However, a review of the literature reveals that production managers in
manufacturing companies have seen the implementation of WCM as a panacea, which will cure the previous mentioned ills. Hence, the Government of most less developed countries understands the importance of WCM in the development of the national economy and has been investing heavily for the fast growth and development of WCM in the countries.

The World Class Manufacturing was used to construct measures to correspond to the practices and performance measures of the manufacturing plants suggested by Hayes and Wheelwright. The results indicated that Hayes and Wheelwright’s practices were related to competitive performance, and that the addition of new manufacturing practices resulted in further improvements in competitive performance. Thus, Hayes and Wheelwright’s practices are robust and have provided a foundation for the use of new manufacturing practices. In addition, there was strong support for the notion that the use of world class manufacturing practices, alone and in combination with new manufacturing practices, leads to the achievement of simultaneous competitive advantages, supporting the synergies perspective.

Hayes and Wheelwright (1984) developed their concept of world class manufacturing based on in depth analysis of the practices implemented by Japanese and German firms, as well as U.S. firms which had competed equally with the Japanese and German firms. The term ‘world class manufacturing’ was used because these firms were associated with outstanding performance in their global industries, resulting in their being described as ‘World Class’. According to Hayes and Wheelwright (1984), WCM is composed of six dimensions: (i) workforce skills and capabilities; (ii) management technical competence; (iii) competing through quality; (iv) workforce participation; (v) rebuilding manufacturing engineering; and (vi) incremental improvement approaches. By comparing the practices of Japanese and German manufacturers with US manufacturers, Hayes and
Wheelwright claimed that the US plants must focus on these six broad categories of practices in order to achieve their WCM status. Schonberger (1986) provided a list of 16 principles of WCM which fall into eight categories: general, design, operations, human resources, quality and process improvement, information for operations and control, capacity, promotion and marketing. Schonberger actually asked managers to evaluate their own plants based on these 16 principles. He warned those plants that scored low on the 16 principles to identify their problems and make an effort to improve these practices to keep up with the competition.

However, the phrase “world class manufacturing” is one of the most overworked terms in management glossaries at present. Often, it is a name given to a novel development that is taking place in most competitive manufacturing operations across the globe. Schonberger (1987) used it to refer to many techniques and technologies designed to enable a company to match its best competitors. These techniques includes for example, JIT, Quality Circles (QC), Kanban, Material Requirements Planning (MRP), Flexible Manufacturing System (FMS), Computer- Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), Manufacturing Resource Planning (MRPII), Total Quality Control (TQC), Total Productive Maintenance (TPM)/Preventive Maintenance, TQM, Simultaneous Engineering, Benchmarking, Intelligent Manufacturing, Electronic Commerce, Business Process Re-engineering (BPR), Enterprise Resource Planning (ERP), Electronic Data Interchange (EDI) and Supply Chain Management (SCM).

WCM determines a set of activities, practices, principles, and techniques need to be undertaken by manufacturing firms to compete globally. Moreover, WCM itself involves many factors systematically related to operations performance, for example, raw materials, energy, machinery,
labour, and management. Furthermore, World class companies optimize the problem-solving abilities of their employees in applying both modern techniques and traditional engineering process.

2.3 MANUFACTURING OPERATIONS

This section is split into five parts. The first part covers a brief introduction about manufacturing operations. The second part discusses the manufacturing and business strategies adopted by manufacturing companies. The third part describes the manufacturing practices adopted by manufacturing firms. The fourth part covers advanced manufacturing technology. The fifth part discusses manufacturing performance of the company.

2.3.1 General

Research in manufacturing operations during the past three decades has been guided by ideas developed earlier in the work of Skinner (1969). He took the first step in assigning the manufacturing function a strategic rather than a merely tactical role. His aim was to end the separation of this function from the rest of the functions as well as from a firm’s competitive strategy. Other authors, such as Hayes and Schmenner (1978), Buffa (1984), Hayes and Wheelwright (1984), Anderson et al (1989), Leong et al (1990) and Hill (2000), have supported this approach and have clarified Skinner’s initial contributions. All of these authors consider that the manufacturing operations can contribute to a firm’s success as long as it reinforces the implementation of the competitive strategy. To do this, the firm needs to formulate explicitly some operations objectives or competitive priorities and implement the policies or decisions required to accomplish these objectives (Diaz-Garrido et al., 2007).
The strategic importance of manufacturing operations has long been recognised by Skinner (1974). The theoretical reference framework of competitiveness in manufacturing operations starts from resource-based view of a firm for case study (Wernerfelt 1984; Menguc, Auh and Shih 2007). Companies should typically utilize multi-focused competitive strategies in a holistic way based on their business strategies (Porter 1980). Competitive priorities belong to the first phase of manufacturing strategies, which act as the bridge between business strategy and the manufacturing objectives (Kim and Arnold 1996). Competitive priorities are the crucial decisive variables to manage manufacturing operations in global context and indicate strategies emphasized on developing certain manufacturing capabilities that improve the operational competitiveness. Takala (2002) presents justification of multi-focused manufacturing strategies.

The increasing pace of technological change and the accelerating globalisation of business have increased competition worldwide. Manufacturers are facing unprecedented levels of pressure resulting from competition from foreign products, new product introductions by competitors, rapid technological innovation and shorter product life, unanticipated customer shifts, and advances in manufacturing and information technology. Competitive advantage for many manufacturing companies now lies in their ability to effectively implement on-going product and process innovation, superior manufacturing, continual improvement of quality and reliability (Q&R) of existing products and developing a continual stream of quality new products. Market pressures have forced companies to look beyond cost and to emphasise speed, quality, agility and flexibility of their manufacturing facilities (Nahm et al., 2006 and Yusuf et al., 2004).
2.3.2 Manufacturing Strategy

This literature offers a great variety of papers dealing with the subject of business strategy and manufacturing strategy. Manufacturing strategy as a concept was first recognised by Skinner (1969), referring to a manufacturing strategy as to exploit certain properties of the manufacturing function to achieve competitive advantages. Skinner (1969) mainly builds the foundation for the discussion of this important issue in operations management, stressing the importance of the linkage between business strategy and manufacturing. Hayes and Wheelwright (1984) define manufacturing strategy as a consistent pattern of decision-making in the manufacturing function linked to the business strategy. Based on the basic idea that manufacturing plays a strategic role for competitive advantage, Hayes and Wheelwright (1979, 1985) add two important concepts to the academic discussion of manufacturing strategy. On the one hand, they introduce the popular concept of the product–process matrix that describes the interplay of products with their underlying processes and integrates the product life cycle and the process life cycle (Hayes and Wheelwright 1979 and 1984). On the other hand, they developed the four stages of the strategic role of manufacturing i.e., market-based, product-based, capability-based, and price-based (Wheelwright and Hayes 1985).

Swamidass and Newell (1987) describe manufacturing strategy as a tool for effective use of manufacturing strengths as a competitive weapon for achievement of business and corporate goals. Platts et al (1998) develop a working definition: “...a pattern of decisions, both structural and infrastructural, which determine the capability of a manufacturing system and specify how it will operate, in order to meet a set of manufacturing objectives which are consistent with the overall business objectives”.
Dangayach and Deshmukh (2001) viewed manufacturing strategy as consisting of market requirements and manufacturing decision categories and capabilities. Leong et al (1990) describe manufacturing strategy as consisting of two elements: decision areas that are of long-term importance in the manufacturing function, and competitive priorities based on corporate and/or business unit goals. Similar structures are used by Dangayach and Deshmukh (2001), Miller and Roth (1994) and Miltenburg (1995). Here, they provide two perspectives on competitive priorities: the market perspective in terms of market requirements, and the manufacturing perspective in terms of manufacturing capabilities. Thereby we can distinguish between what the market needs and what the manufacturing function provides.

Furthermore, manufacturing strategy must be communicated to the plant personnel that it is to be used as a guide in decision making for successfully implementation of the world class manufacturing operations (Bates et al., 1995). In this way, the production function is capable of providing appropriate support to business strategy. Consequently, properly implemented and well-aligned manufacturing strategy in a plant should include aspects such as the anticipation of new technology, and a link between manufacturing strategy and business strategy, a formal strategic planning process which involves the plant management, and communication of the manufacturing strategy to plant personnel.

Thus, we shall consider these four manufacturing strategy practise dimensions in this study. Manufacturing strategy contributes to the creation of economic value by providing the firm with two types of competitive advantage: cost leadership and differentiation. Cost leadership and differentiation are in turn a byproduct of what Porter (1990) first described as a collection of value adding activities that can be described in terms of a “value-chain.” A vast body of literature has described the prevailing
Operations Strategy framework, building on Skinner (1978) and Hayes and Wheelwright’s (1984) work. The two central elements in the framework are competitive priorities and the decision categories from which the pattern of decisions comprising the manufacturing strategy have to be made (Hayes and Wheelwright 1984). This basic framework for Operations Strategy presented in 1984 is still used in research papers (e.g., Boyer and Lewis 2002).

2.3.3 Manufacturing Practices

As the importance of high-quality production in establishing and maintaining a global competitive position is realised, there has been an increasing interest in manufacturing practices that lead to improved performance (Flynn et al., 1995). A large number of studies have examined the relationships between various manufacturing practices and the impact of such practices on quality performance (Anderson et al., 1995; Filippini 1997; Flynn et al., 1995, 1996; Forza and Filippini 1998; Hendricks and Singhal 2001; Ibusuki and Kaminski 2007). Boston University Manufacturing Futures Group has been gathering data on manufacturing strategy practices in the United States, Western Europe, Japan and some other industrialised countries since 1981 (De Meyer et al., 1989; Kim and Miller 1992; Roth and Miller 1992). Schroeder and his group is using survey data from the United States and other developed countries to determine which practices are associated with world-class manufacturing (Flynn et al., 1997, 1999; Schroeder et al., 1992). Similarly, Voss of the London Business School has conducted many studies on manufacturing practices and performance in a number of European countries (Voss and Blackmon 1996; Voss et al., 1995).

The term ‘world class manufacturing’ was first used by Hayes and Wheelwright (1984) to describe organizations that achieved a global competitive advantage through use of their manufacturing capabilities as a strategic weapon. They identified six critical practices, including development
of the workforce, developing a technically competent management group, competing through quality, stimulating worker participation and investing in state-of-the-art equipment and facilities, and termed them as world class manufacturing practices. Their study was based on practices implemented by successful large firms in Germany, Japan and the USA.

In this study, attempts are made to explore and investigate widely the most important manufacturing practices that have been implemented by the manufacturing firms in Chennai to achieve world class performance. The relationships between manufacturing practices and manufacturing performance measures are presented in order to assess the effectiveness of the practices within manufacturing industries. Competitive objectives for the manufacturers are identified and analyzed from the perspectives of the implementation of WCM practices.

2.3.4 Advanced Manufacturing Technology (AMT)

AMT is defined as an umbrella term to describe a variety of technologies that utilize the computers in the manufacturing activities either directly or indirectly (Boyer et al., 1996). Examples of such technologies are computer-aided design, computer-aided manufacturing, computer-aided engineering, computer-aided process planning, enterprise resource planning, electronic data interchange, warehouse management system, product data management, and materials requirement planning. Non-computer related technologies might also be considered as AMT technologies if they complement the usage of other AMT technologies.

Previous studies have categorized AMT in several ways. Adler (1988) and Boyer et al (1996, 1997) categorize AMT into three classes: Design AMT, Manufacturing AMT, and Administrative AMT. Kotha and Swamidass (2000) and Swamidass and Kotha (1998) group AMT into four
dimensions: information exchange and planning technology, product design technology, low-volume flexible automation technology, and high-volume automation technology. In this research, the various IT measurement scales used are similar to the three categories of design and administrative AMTs in Boyer et al (1997).

Design AMTs include Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE). The focus is on product and process design. Manufacturing AMTs refer to computer- controlled processes in the fabrication/ assembly industries, automatic material handling, automatic storage, and retrieval systems. The measurements used in this study include computerized numerical control, computer-aided manufacturing, robotics, real-time process control system, flexible manufacturing systems, automated material handling system, environment control system, and bar coding/automatic identification.

The focus is on actual production of the products. Administrative AMTs include computerized shop-floor tracking systems. The measurements used in this study comprise Product Lifecycle Management (PLM), Product Data Management (PDM), Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), HR Information System, Financial Management System (FMS), Design Systems (CAD, CAE, CAPP, etc.), Materials Requirements Planning (MRP), Manufacturing Resource Planning (MRP II), Electronic Data Exchange (EDI), Advanced Planning and Scheduling (APS), Warehouse Management System (WMS), and Manufacturing Execution System (MES). The focus is on facilitating and monitoring manufacturing operations effectively.

Many researchers highlight the flexibility of AMT, whereby firms can produce wide varieties of products at low volumes without added costs or penalties (e.g., Kaplinsky 1984; Goldhar and Jelinek 1985; Adler 1988; Dean
and Snell 1991, 1996; Gerwin 1993; Gerwin and Kolodny 1992; Parthasarthy and Sethi 1992; Swamidass and Kotha 1998; Kotha and Swamidass 2000). In addition, the ability of AMT to increase manufacturing productivity has been well cited (Ettlie 1984; Dean and Snell 1991; Swamidass and Kotha 1998). Routine tasks can be embedded into AMT hardware and software, thereby reducing direct labor costs, rework costs, and work-in-process inventories (Zummato and O’Connor 1992).

There is a general trend towards an increase in the use of technology in manufacturing plants, due to the belief that it will improve some performance measures (e.g. reductions in costs or human resources, improved quality or flexibility). However, these investments are often criticised for not creating the desired results, i.e., technology investments often lead to neither effective deployment of new practices nor the desired performance outcomes being reached fast enough. For this to be understood, it is necessary to take into account that the interconnection between technology and performance is influenced by a number of factors, some of which can be controlled, and others which cannot, but, nonetheless, they are all important for the final result.

2.3.5 Manufacturing Performance (MP)

There are many different ways of measuring manufacturing performance. However, the most predominant approach in the literature is to use cost, quality, delivery, and flexibility as the four basic dimensions of manufacturing performance. In some studies, these dimensions have been expanded to include several additional measures (Hayes et al., 1998; Miller and Roth 1994). They have considered these four basic dimensions (such as cost, quality, delivery, and flexibility) for analyzing the manufacturing performance of the plant. In our study, we have seven performance indicators which are used to measure the manufacturing performance of an organization.
They include improving quality constantly, reducing costs gradually, reducing time to market, constant innovation in products and services, improving efficiency and productivity, having flexibility in operations, and offering quality services/products at affordable price.

The use of four basic dimensions to measure manufacturing performance can be traced back to Skinner (1969) who launched the current interest in analyzing manufacturing strategy and its effect on manufacturing performance of the plant. Skinner has been followed by many others who have also advocated the four basic dimensions, including Schroeder (1993) and Ward et al (1995). These authors have sometimes referred to the four dimensions as competitive priorities or manufacturing capabilities.

According to the operations management literature, technology improves operational performance of manufacturing company (Maier 1997a, 1997b, 1998a, 1998b; Maier and Schroeder 2001; Heine et al., 2003; Matsui 2002a,b). Furthermore, some empirical support exists for this statement. Bates and Flynn (1995) have shown that high manufacturing performance results from the use of technological innovations. Regarding the production benefits to be gained from information systems, Matsui and Sato (2001) have revealed some positive results; Mallick and Schroeder (2003) have empirically studied product development performance. Meanwhile, Heine et al (2003) have reviewed 16 models from the literature on the impact of technology on manufacturing performance and proposed a seventeenth model. These models represent some of the foremost current academic opinion on the role of technology and they provide reasonable (empirical and theoretical) justification for the relationship between technology and manufacturing performance.
2.4 LEAN MANUFACTURING (LM)

This domain is generally divided into three parts. The first part provided a bird’s eye view on lean manufacturing. The second part briefly describes the prevailing lean manufacturing practices, techniques and tools implemented by manufacturing companies. The third part discusses the relationship between lean manufacturing practices and operational performance.

2.4.1 Bird’s Eye View on LM

The concept of LM was pioneered by a Japanese automotive company, Toyota, during 1950’s which was famously known as Toyota Production System (TPS). The primary goals of TPS were to reduce the cost and to improve productivity by eliminating wastes or non-value added activities (Womack et al., 1990). During 1980’s there was an intense interest on LM implementation among the western manufacturers because of growing Japanese imports. It became a serious concern to the western producers (Holweg 2007). After the oil crises in the early of 1990’s, in a published book named The Machine that Changed the World (Womack et al., 1990) by International Motor Vehicle Programme (IMVP), such intense interest of LM concept was again aroused. Then, the concept of LM was transferred across the countries and industries due to its global superiority in cost, quality, flexibility and quick respond (Schonberger 2007).

From Ford Production System (FPS) to Toyota Production System (TPS), it means manufacturers compete in heterogeneous global markets where competitors have access to diverse labor, capital, and supply conditions. Lean production is a multi-dimensional approach that encompasses a wide variety of management practices, including just-in-time, quality system, work teams, cellular manufacturing, supplier management,
etc. in an integrated system (Shah and Ward 2003). LM is a manufacturing strategy that aimed to achieve smooth production flow by eliminating waste and by increasing the activities value. Some analysts even pointed out that if an organisation ignores the LM strategy, the company would not be able to stand a chance against the current global competition for higher quality, faster delivery and lower costs (Flott 2002; Srinivasaraghavan and Allada 2006). In a large cross-country analysis done by Oliver et al (1996) proves that LM principles could produce high performance firms.

2.4.2 LM Practices, Techniques and Tools

LM consists of a large number of techniques and tools. Shah and Ward (2003) identified twenty two LM practices that are frequently mentioned in literatures and categorised them into four bundles associated with Just-in-Time, Total Quality Management, Total Preventive Management and Human Resource. Some other researchers also categorised the lean tools and techniques according to the area of implementation such as internally and externally oriented lean practices (Shah and Ward 2003; Olsen 2004; Panizzolo 1998).

Panizzolo (1998) divided the lean practices into six areas which are process and equipment; manufacturing, planning and control; human resources; product design; supplier relationships; and customer relationships. The first four areas are grouped as internal oriented lean practices, whereas supplier relationships and customer relationships are under external oriented lean practices. This study also confirms that, many firms seem to have difficulty in adopting lean tools that concern with external relationships with suppliers and customers even for high performance firms. Empirical results from this study also prove that lean tools in internal areas are adopted most widely in the firms, where the operation and management methods are more direct.
The change from traditional manufacturing system to lean manufacturing is not an easy task. Achanga et al (2006) suggested that the success of LM implementation depends on four critical factors: leadership and management; finance; skills and expertise; and supportive organisational culture of the organisation. Some researchers also suggested that applying the full set of lean principles and tools also contribute to the successful LM transformation (Herron and Braiden 2007; James 2006).

Lean manufacturing which derived from Toyota Production System is a philosophy for structuring, operating, controlling, managing and continuously improving industrial production systems (Sahoo et al., 2008). Some of the standard lean tools, like Value Stream Mapping (VSM), Production Smoothing (Heijunka), Continuous Improvement (Kaizen), 5S, Single-Minute Die Exchange (SMED), Total Quality Management, Just-In-Time, etc., have been conceived by TPS. The goal of lean manufacturing is to minimize waste in terms of non-value added activities, such as waiting time, motion time, set-up time, and WIP inventory, etc. (Liker 1998).

The successful application of various lean practices had a profound impact in a variety of industries, such as aerospace, computer and electronics manufacturing, forging company (Liker 1998) process industry (steel), and automobile manufacturing (Macduffie et al., 1996). Their methodology is similar, using lean tools, and they are adapted to the study variables, but the improvement point and the results achieved are different. Considering the available literature, the present work is the first attempt that explores the degree of use of lean principles in manufacturing industry and provides direction for future continuous improvement.
2.4.3 Lean Practices and Operational Performance

Many articles have been published in the 1990s on relationships between lean practices and performance (Dangayach and Deshmukh 2001). Generally, it is believed that JIT practices will lead to shorter lead times and lower inventories, and that TQM practices will improve quality. Despite that many empirical studies have been made, very few has been on Lean Manufacturing as a concept. Cua et al (2001) mention that only few have considered Lean Manufacturing’s major pillars, JIT, TQM and TPM in concert. “While researchers recognize the value of investigating interrelated entities simultaneously (these being JIT, TQM and TPM), there is no study that provides empirical examination of the joint implementation of TQM, JIT and TPM practices” (Cua et al., 2001).

Based on a literature review, they assigned practices to the three factors, TQM, JIT and TPM. It turned out that some practices were common, and these were gathered in their own factor “Human- and Strategic-Oriented Common Practices”. It is worth noting that the TQM factor is fairly broad, comprising product design, supplier and customer relations, while the JIT and TPM factors look more coherent. The performance measures reflect the traditional competitive priorities, here specified as quality conformance, unit costs, on-time delivery and flexibility to volume changes.

Cua et al (2001) then analysed which practices that best explained the differences in performance. This was done on two levels: on a summated scale level (TQM, JIT, TPM and common practices) and on a single practice level. The results showed that all factors (JIT, TPM, TQM and Common) were significant in explaining all performance metrics. On a single practice level, not all practices contributed to explain performance (Cua et al., 2001). Hence, the conclusion relevant to this paper is that JIT, TPM and TQM as factors all contribute to operations performance on various measures.
Reviewing the backgrounds and literatures, lean production is most frequently associated with elimination of waste commonly held by firms as excess inventory or excess capacity to ameliorate the effects of variability in supply, processing time, or demand (Shah and Ward 2003). In phase of practices, lean practices are generally shown to be associated with high performance in a number of studies of world-class manufacturing (e.g., Sakakibara et al., 1997; Giffi et al., 1990). The most commonly cited benefits related to lean practices are improvement in labor productivity and quality, along with reduction in customer lead time, cycle time, and manufacturing costs (Schonberger 1982; White et al., 1999). Most of the empirical studies focusing on the impact of lean implementation on operational performance are constrained to facets of lean, often just-in-time (JIT), total quality management (TQM), and total preventive maintenance (TPM) programs (Cua et al., 2001).

2.5 TOTAL QUALITY MANAGEMENT (TQM)

This domain is segmented into six parts. The first part provided a brief view on TQM. The second part briefly describes the prevailing TQM Practices adopted by manufacturing companies. The third part discusses Quality Management System (QMS). The fourth part portrays the relationship between TQM Principles and operational performance.

2.5.1 General Introduction

In view of the global level competition, companies have emphasized that quality should be integrated into all aspects of products, processes, and services within their management system. Hence, Total Quality Management (TQM) has become increasingly popular as one of the managerial tools in ensuring continuous improvement so as to improve customer satisfaction and retention, as well as, to ensure its product or service
quality. A study has been undertaken to know the extent of the use of TQM practices in implementing world class manufacturing system by manufacturing firms in Chennai.

TQM is a manufacturing program aimed at continuously improving and sustaining quality products and processes by capitalizing on the involvement of management, workforce, suppliers, and customers, in order to meet or exceed customer expectations (Dean and Bowen 1994; Hackman and Wageman 1995; Powell 1995). A comparison of the practices of TQM discussed in six empirical studies (Saraph et al., 1989; Flynn et al., 1994; Powell 1995; Ahire et al., 1996; Black and Porter 1996; Samson and Terziovski 1999) leads to the identification of nine practices that are commonly cited as part of a TQM program. These practices are cross-functional product design, process management, supplier quality management, customer involvement, information and feedback, committed leadership, strategic planning, cross-functional training, and employee involvement. In the literature, quality management frameworks typically stress the importance of cross-functional product design and systematic process management. Furthermore, they emphasize the involvement of customers, suppliers and employees to insure quality products and processes. Finally, quality management programs all emphasize the importance of management commitment and a well-established strategy.

2.5.2 TQM Practices

TQM has the potential to not only increase competitiveness and organizational effectiveness but also improve product quality and organizational performance (Ahire 1996). Powell (1995) suggests that there are significant relationships between TQM, competitive advantage and business excellence. A study by Simmons and White (1999) concluded that ISO 9000 registered companies are more competitive and profitable than non-
ISO 9000 companies. The overall results point to the significant and positive impact of TQM on competitive advantage and customer satisfaction, which, in turn, significantly improves the performance of these companies. Hence, quality has been seen as a fundamental capability for enterprises to develop. Quality advocates have identified several critical principles for successful TQM practices like: top management role, customer focus, supplier relationship, benchmarking, quality-oriented training, employee focus, zero-defects, process improvement and quality measurement (Saraph et al., 1989). Although, TQM is a well-established field of study for business excellence the success rate of TQM implementation is not very high. The major reason for TQM failure is owing to the tendency to look at TQM as tool and not as a system.

The critical factors of TQM are almost invariant across countries. The critical success factors of TQM identified for this study are leadership and top management commitment, vision and plan statement, supplier quality management, system process quality improvement, total employee involvement, education and training, performance appraisal and recognition, customer focus satisfaction, evaluation, work environment and culture, continuous improvement, and Communication, with a perspective on how to use critical factors as the foundation for driving transformational orientation in order to create a sustainable performance of business excellence.

2.5.3 Quality Management System (QMS)

Quality management has been recognized as single most critical success factor in Japan’s manufacturing (Imai 1986 and Ohno 1988). Quality management in Japan is characterized as company-wide participation, emphasis on employees training, quality circles, quality diagnoses, statistical methods, and national-wide campaign. People from all levels of management and workers are involved in the company-wide quality management or total
quality management (Schroeder and Flynn 2001; Matsui 2002b; Schonberger 1986, 2007). This concept intends to not only control quality levels of products by applying statistical methods and other analytical techniques, but also manage all kinds of work properly centered on quality.

While the emergent trends in Japanese management are studied and presented in several academic papers and articles regarding manufacturing strategy (Fujimoto 2004), business restructuring by vertical and horizontal alliances (Kono and Clegg 2001), supplier involvement in product development (Takeishi 2001), and transforming individual skills to organizational capability (Sako 1999), there is a little evidence on how Japanese quality management is longitudinally maintained for enhancing the efficiency and effectiveness of manufacturing companies which are coping with fierce competition in developing economies like India.

In order to address this need, this study presents results of an empirical study on how quality management practices help the manufacturing companies to achieve the world class performance. This study provides empirical evidence that the manufacturing companies in Chennai explore quality management practices as a strategic weapon for implementing WCM principles to improve competitive advance. The evidence of outstanding performance of Japanese manufacturers in the late 1970s and the 1980s led to the development of world Class Manufacturing (WCM) and High Performance Manufacturing (HPM) perspectives (Hayes and Wheelwright 1984; Schroeder and Flynn 2001).

These perspectives suggest that the ability to develop simultaneously different competitive advantages is achieved through development of an infrastructure of practices focused on designing, controlling, and continuously improving processes to produce high-quality product. Excellent quality is regarded as a platform for achieving other
competitive edges such as cost, delivery, cycle time, and flexibility. For successful implementation of quality management, several daily practices should be conducted in manufacturing plants such as process management, customer focus, supply quality involvement, and small group activity (Flynn et al., 1995). Characteristics of quality management have been analyzed in several empirical studies. Matsui (2002a,b), using survey data from 46 manufacturing plants in the 1990s, found the similarity in quality management practices among machinery, electrical and electronics, and automobile in Japan and significant contribution of customer involvement, cleanliness and organization, and supplier quality involvement on performance indicators such as fast delivery, inventory turnover, and cycle time.

Schroeder and Flynn (2001) comparatively studied quality practices in 164 plants located in the United States, Japan, Germany, Italy, and United Kingdom during the 1990s and found that Japanese manufacturers took advantage of quality management over other countries in term of shop floor activities such as process control, information feedback, and small group activities. It was also detected that US plants more emphasized on customer satisfaction and relationship than Japanese plants. To continue the previous studies of Schroeder and Flynn (2001) and Matsui (2002b), this study empirically analyzes the relationship between quality management and WCMS and their effect on competitive performance of manufacturing plants through extensive questionnaires.

2.5.4 TQM Principles and Operational Performance (OP)

To achieve world class performance, a set of ten scales is constructed to measure the degree of implementation of TQM Principles in Chennai manufacturing plants. The selection of this set of quality management practices is based on the suggestion from recent empirical
quality management studies such as Anderson et al (1995), Flynn et al (1995), Choi and Liker (1995), Forza and Flippini (1998), Dow et al (1999), Samson and Terziovski (1999), Das et al (2000), Cua et al (2001), Matsui (2002b), Kaynak (2003), Yeung et al (2005), and Parast et al (2006). These empirical studies clearly indicated that the main quality management practices that have a significant impact on the operational performance of the manufacturing plans are: (i) management/leadership commitment; (ii) customer focus; (iii) employee involvement; (iv) continuous process improvement; (v) supplier partnership; (vi) performance management; (vii) training and education; (viii) cross-functional teams; (ix) empowerment and teamwork; and (x) Statistical Process Control (SPC).

2.6 INFORMATION TECHNOLOGY (IT)

This domain is divided into three phases. The first phase discusses global competition and its influence on Information Technology. The second phase briefly describes the role of IT in new manufacturing environment. The third phase determines the applications of information systems in the manufacturing operations.

2.6.1 Global Competition

The world of manufacturing has reached a turning point because of the influence and impact of Information Technology (IT). Some refer to it as the “New Manufacturing Era” (Panchak 1998). Manufacturers must compete in the global market to be successful today. This trend is going to continue. Manufacturing executives see their role more broadly as creators of value and wealth. The manufacturing industry is changing to make profits for the company, employees, and the stockholders. After a decade of downsizing and restructuring, most American businesses have cut about all the costs they can (Cohan 1997). Managers have come to the conclusion that long-term health
will depend on growth achieved through competition. The Key is innovation – companies who excel in innovation can achieve remarkable growth and profits.

2.6.2 New Manufacturing Environment

The new-manufacturing environment consists of combining technological advances with strategic management insight to reach a company’s goals and potential. One must look at the fundamental changes in the workforce. Technology is leading management to a decentralized/flatter organizational structure (Laudon 2000). Middle management has been reduced and workers have been empowered to resolve issues themselves. Managers now identify needed skills and provide workers with the resources to solve problems rather than give orders. This is the era of the Integrated Product Team (IPT). Workers in a manufacturing plant manage the production process and decide the most efficient way to get the job done. Suppliers are part of the manufacturing process. Employees, managers, suppliers, and customers work as a team. Alliances are unfolding. Customers and suppliers are working side by side in the same office or manufacturing plant and also temporary employees are given as much responsibilities as full-time employees.

People are more skilled today than in the past. Nearly two-thirds of the workplace jobs that will be created in the coming years will require education beyond high school and be tied to the use of Information Technology (IT) (Verespej 1998). Management is aware that reducing costs is a benefit of IT. Company’s goals are to automate tasks where appropriate. Companies can control their inventory and production. Chrysler has used IT to implement Just-In-Time (JIT) manufacturing and lean production to reduce costs (Lucas 1997). Boeing also claims to have reduced costs as well as improve quality. The new Boeing 777 airliner was the first “paperless
airplane” designed using sophisticated computer-aided design programs (Lucas 1997). Companies have to move quickly to compete because with information technology it takes only days to gain or lose a competitive advantage.

2.6.3 Manufacturing Information Systems

Manufacturing information systems today support the production/operation functions of companies. Production/operation functions include the activities concerned with planning and control of the processes used in producing goods and services. Computers are at the root of these processes. Computer-based manufacturing information systems use several major techniques to support Computer-Integrated Manufacturing (CIM). Computer-Integrated Manufacturing is an overall process that stresses the goals of computer use for factory automation and must include the following (O’Brien 1997):

- Simplify/reengineer production processes, product designs, and factory automation.
- Automate production processes and the business functions with computers and robots.
- Integrate all production and support process using computers and the telecommunications network.

To improve manufacturing processes, manufacturing engineers use computerized systems such as Computer-Aided Engineering (CAE), Computer-Aided Design (CAD), and Computer-Aided Process Planning (CAPP). To aid in the manufacturing of products, Computer-Aided Manufacturing (CAM) is employed. Computers are also used to identify and plan the material requirements needed to produce a product. This is referred
to as Material Requirements Planning (MRP). Integrating MRP with production schedules and shop floor control functions is referred to as Manufacturing Resource Planning (MRPII). Computers and robotics are used to fabricate assemble and package products. Monitoring and controlling the production process in a factory (shop floor control) are accomplished by directly controlling a physical process (process control), a machine tool (machine control/numerical control), or a machine with humanistic capabilities (robots) (O’Bien 1997).

Artificial Intelligence (AI) may have a large impact on the manufacturing sector (Miller 1985). AI enables information integration for decision making from conceptual design, engineering, planning, scheduling, fabrication, testing, shipping, and customer service (Meyer 1987). Other AI topics include: Expert Systems, Artificial Vision, Natural Voice Recognition, and Voice Recognition. These are just some of the ways information technology is and will be used in the manufacturing process. With the introduction of the Internet and the World Wide Web, companies have access to a global market place. The Telecommunications industry is providing a way to access this technology. The manufacturing industry will now use IT to enhance their competitive edge and more effectively compete in the global market.

2.7 MAINTENANCE FUNCTION

This domain is divided into three tiers. The first tier offers a bird’s eye view on maintenance function. The second tier discusses the importance of equipment maintenance. The third tier describes the significance of TPM in equipment maintenance and effectiveness. The fourth tier relates to Overall Equipment Effectiveness (OEE) and productivity.
2.7.1 Rationale

Today, the global market has become increasingly competitive in recent times and the recent competitive trends have pushed manufacturing firms to reconsider the impact and importance of increasing equipment availability and utilisation, increasing maintenance productivity, resource utilisation and increasing quality and responsiveness of maintenance services in achieving world class status to meet global competition. For many years, maintenance has been treated as a dirty, boring, ad hoc and a neglected job. In the past several decades, maintenance problems have been studied intensely. The study highlights the achievements of manufacturing organisation through successful implementation of strategic maintenance initiatives like Total Productive Maintenance (TPM) and demonstrates the true potential of TPM in achieving manufacturing excellence via overall equipment effectiveness. The maintenance processes can be streamlined to eliminate waste and produce breakthrough performance in areas valued by customers (Hammer and Champy 1993).

In the highly competitive environment, to be successful and to achieve World Class Manufacturing (WCM), organizations must possess both efficient maintenance and effective manufacturing strategies. The effective integration of maintenance function with engineering and other manufacturing functions in the organization can help to save huge amounts of time, money and other useful resources in dealing with reliability, availability, maintainability and performance issues (Moubray 2003). Strategic investments in the maintenance function can lead to improved performance of manufacturing system and enhance the competitive market position of the organization (Coetzee 1999; Jonsson and Lesshammar 1999). This has provided the impetus to the leading organizations worldwide to adopt effective and efficient maintenance strategies such as Condition Based
Maintenance (CBM), Reliability Centered Maintenance (RCM) and Total Productive Maintenance (TPM), over the traditional fire fighting reactive maintenance approaches (Sharma et al., 2005).

2.7.2 Equipment Maintenance

Equipment maintenance represents a significant component of the operating cost in transportation, utilities, mining, and manufacturing industries. The potential impact of maintenance on the manufacturing performance is substantial. Maintenance is responsible for controlling the cost of manpower, material, tools, and overhead (Pintelon and Gelders 1992; Foster and VanTran 1990). In financial terms, maintenance can represent 20 to 40 per cent of the value added to a product as it moves through the plant (Hora 1987 and Eti et al., 2006). Further, a survey of manufacturers found that full-time maintenance personnel as a percentage of plant employees averaged 15.7 per cent of overall staffing in a study involving manufacturing organizations (Dunn 1988), whereas in refineries, the maintenance and operations departments are often the largest and each may comprise about 30 per cent of total staffing (Dekker 1996). It has been found that in the UK manufacturing industry, maintenance spending accounts for a significant 12 to 23 per cent of the total factory operating costs (Cross 1988). With sobering figures like these, manufacturers are beginning to realize that maintenance organization and management, and design for maintainability and reliability are strategic factors for success in 1990s (Yoshida et al., 1990). Thus the effectiveness of maintenance function significantly contributes towards the performance of equipment, production and products (Macaulay 1988 and Teresko 1992).

The rapidly changing needs of modern manufacturing and the ever increasing global competition has emphasized upon the re-examination of the role of improved maintenance management towards enhancing organization’s
competitiveness (Riis et al., 1997). Confronted with such reality, organizations are under great pressure to enhance their competencies to create value to customers and improve the cost effectiveness of their operations on a continuous basis. In the dynamic and highly challenging environment, reliable manufacturing equipment is regarded as the major contributor to the performance and profitability of manufacturing systems (Kutucuoglu et al., 2001). Its importance is rather increasing in the growing advanced manufacturing technology application stages (Maggard and Rhyne 1992).

Therefore, equipment maintenance is an indispensable function in a manufacturing enterprise (Ahmed et al., 2005). The recent competitive trends and ever increasing business pressures have been putting maintenance function under the spotlight as never before (Garg and Deshmukh 2006). For maintenance to make its proper contribution to profits, productivity, and quality, it must be recognized as an integral part of the plant production strategy (Kumar et al., 2004). Thus achieving excellence in maintenance issues has to be treated as a strategic issue for manufacturing organizations to create world class manufacturers (Brah and Chong 2004).

2.7.3 Total Productive Maintenance (TPM)

In today’s turbulent business environment global competition characterised by both a technology push and a market pull had forced organisations to compete on various platforms, such as faster delivery, price tags, state-of-the-art technology and higher quality dimensions (Sharma et al., 2007). During recent years, organisations have been adopting strategies for enhancing the maintenance quality of products and processes as a means to excel in today’s competitive world (Pramod et al., 2006). One of the current strategies being adopted in this direction by modern organisations is TPM (Ahmed et al., 2005; Wang and Hwang 2005). TPM is a unique Japanese philosophy, which has been developed based on the Productive Maintenance
concepts and methodologies. This concept was first introduced by M/s Nippon Denso Co. Ltd. of Japan, a supplier of M/s Toyota Motor Company, Japan in the year 1971. Total Productive Maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving total workforce (Bhadury 2000).

According to Nakajima (1988), vice-chairman of Japan Institute of Plant Maintenance, TPM is a combination of US preventive maintenance and Japanese concepts of TQM and total employee involvement. TPM is a methodology originated by Japan to support its lean manufacturing system. TPM is a proven manufacturing strategy that has been successfully employed globally for achieving the organisational objectives of core competence in the competitive environment. TPM implementation methodology provides organisations with guidelines to transform fundamentally their shop-floor by integrating culture, process and technology. TPM initiatives in production help in streamlining the manufacturing and other business functions, and garnering sustained profits (Ahuja and Khamba 2007).

A strategic approach to improve the performance of maintenance activities is to effectively adapt and implement strategic TPM initiatives in the manufacturing organizations. TPM seeks to engage all levels and functions in an organization to maximize the overall effectiveness of production equipment. This method further tunes up existing processes and equipment by reducing mistakes and accidents. TPM is a world class manufacturing (WCM) initiative that seeks to optimize the effectiveness of manufacturing equipment (Shirose 1995). Whereas maintenance departments are the traditional center of preventive maintenance programs, TPM seeks to involve workers from all departments and levels, including the plant-floor to senior executives, to ensure effective equipment operation.
TPM is a new philosophy of continuous improvement and teamwork that focuses on achieving improvement of maintenance functions in an organisation, which involves its entire human resources (Patra et al., 2005). TPM is about communication. It mandates that operators, maintenance people and engineers collectively collaborate and understand each other’s language (Witt 2006). TPM describes a synergistic relationship among all organisational functions, but particularly between production and maintenance, for continuous improvement of product quality, operational efficiency, productivity and safety. TPM initiative is targeted to enhance competitiveness of the enterprises and encompasses a powerful structured approach to change the mindset of employees, thereby making a visible change in work culture of the organisations (Ahuja 2009). TPM paves the way for excellent planning, organising, monitoring and controlling practices through its unique eight pillar methodology involving: autonomous maintenance; focused improvement; planned maintenance; quality maintenance; education and training; safety, health and environment; office TPM and development management (Rodrigues and Hatakeyama 2006).

2.7.4 Overall Equipment Effectiveness (OEE)

OEE is a production-driven improvement methodology that is designed to optimise equipment reliability and ensure efficient management of plant assets (Robinson and Ginder 1995). The benefits arising from OEM can be classified in six categories including productivity (P), quality (Q), cost (C), delivery (D), safety (S) and morale (M). OEE has been envisioned as a comprehensive manufacturing strategy to improve equipment productivity. The ultimate objective of Overall Equipment Effectiveness (OEE) is to enable an organisation to realise zero breakdown, defect, machine stoppage, accidents and pollution. OEE has been proposed by Nakajima (1988) as the key metric to support TPM, and is now a widely accepted way to monitor the
actual performance of the equipment, in relation to its nominal capabilities under optimal operating conditions. OEE is a better choice to evaluate efficiency and gives a consistent measure of the real value added production for manufacturing equipment (Braglia et al., 2009). OEE is the key measure of both TPM and lean maintenance (Anvari et al., 2010).

The changing needs of the physical assets and equipments over time have been putting tremendous pressures on the maintenance management to adapt proactively for meeting the fast changing requirements of the production systems. Maintenance, being an important support function in businesses with significant investments in plants and machinery, plays an important role in meeting this tall order. Consequently, the equipment management has passed through significant changes in the recent times. In the present manufacturing scenario, the maintenance function has become an integral part of the overall profitability of an organization. It has been accepted beyond any doubt that maintenance, as a support function in businesses, plays an important role in backing up many emerging business and operation strategies like lean manufacturing, just-in-time production, total quality control and six-sigma programs (Pun et al., 2002). To that end, the effectiveness of maintenance needs to be improved (Murthy 2002).

2.8 COMPETITIVE ADVANTAGE

This domain is broken up into two segments. The first segment summarises about competitive priorities pursued by manufacturing companies. The second segment determines the operational performance of an organization.
2.8.1 Competitive Priorities

The concept of competitive priorities is often used as a notation for both goals and objectives for manufacturing as well as requirements posed on the company from the marketplace (see e.g., Hayes and Wheelwright 1984; Dangayach and Deshmukh 2001; Da Silveira 2005). However, Slack and Lewis (2002) differentiate between internal and external benefits from what is denoted as performance objectives, such that the external benefits are linked to market requirements. The market requires only what it can assess and the customer only assesses what is seen. We group these requirements into quality, delivery speed and reliability, price and product range.

Competitive priorities in operations refer to those objectives that manufacturing units must reach if the company is to be able to compete, achieve the capabilities established for the activity, and reinforce its competitive advantage (Hayes and Wheelwright 1984; Anderson et al., 1989). The term competitive advantage is used to describe the choices that operations managers make from among the key competitive capabilities of this functional area (Skinner 1969). Furthermore, these choices constitute the expression of a firm’s competitive strategy in terms that the manufacturing personnel can understand. It has been pointed out in operations management literature that the term ‘‘competitive priority’’ stresses both the strategic importance of the manufacturing function and its responsibility in achieving improved corporate success, and consequently, in attaining a global competitive advantage.

On the question of identifying what elements can become competitive priorities for manufacturing firms, Skinner’s initial work (Skinner 1969) offers the following competitive priorities: short delivery cycles, quality, on-time delivery, flexibility, and low cost. However, different authors consider other elements apart from these basic objectives, for example:
innovation, which involves introducing new products and production processes (Hayes and Wheelwright 1984; Leong et al., 1990; Corbett and Van Wassenhove 1993; Kathuria 2000; Tan et al., 2007); and customer service (Da Silveira 2005). By contrast, some authors exclude one or another aspect of the four main competitive priorities commonly accepted (Fine and Hax 1985; Ward et al., 1995). Therefore, taking previous literature on manufacturing strategy as a reference, this research adds more recent aspects such as after-sales service and environmental protection to the four classical competitive priorities of quality, cost, delivery, innovation, flexibility, price, and service.

### 2.8.2 Operational Performance

Manufacturing plants do not directly control measures of performance indicators such as profit, sales or market outcomes, because they are mainly cost centers and do not have specific accounting records of this kind at the plant level; therefore, the use of financial measures may be inappropriate, except in the case of plants which are profit centers. Therefore, this research uses basic production measures controlled at the plant level, such as the competitive priorities: costs, quality, delivery (speed and dependability) and flexibility (Hayes and Wheelwright 1984; Ferdows and De Meyer 1990; Ketokivi and Schroeder 2004).

Specifically, this study will make use of some of the plant competitive performance indicators from the operations management literature (Skinner 1969; Hayes and Wheelwright 1984; Schroeder and Flynn 2001), such as unit cost of manufacturing, standard product quality, on-time delivery, fast delivery, flexibility in changing the product mix and flexibility in changing volume, etc. These six indicators represent different measures of the four above mentioned basic production measures (Skinner 1969; Ferdows
and De Meyer 1990) and can be measured from two perspectives: internal and external.

The internal perspective represents measures which are useful for the control and internal management of the production process, whereas the external perspective entails customer-related dimensions. We will use a combination of both types. To conclude this sub-section, some remarks are made on the basic goals/dimensions and on the six measures which are used in this paper. In general terms, the measures selected are those which are most frequently used in an OM (Skinner 1969; Hayes and Wheelwright 1984; Ferdows and De Meyer 1990; Cua et al., 2001; Schroeder and Flynn 2001; Ahmad and Schroeder 2003).

- **Cost**: For many authors, the most important of all the operational performance measures is cost performance (Schroeder and Flynn 2001; Slack and Lewis 2002; Hallgren 2007). This research focuses on unit cost of manufacturing.

- **Quality**: Although quality is a very broad term, in production operations, the most influential measure is conformance, which means the process’ ability to manufacture products which conform to predefined reliability and consistency specifications (Garvin 1987; Ward et al., 1996; Slack and Lewis 2002; Hallgren 2007). This research therefore focuses on product conformance with specifications.

- **Delivery**: The two basic delivery measures are reliability and speed (Berry et al., 1991; Ward et al., 1996; Hallgren 2007). This study focuses on both: the former through on-time delivery (i.e. the ability to complete the delivery as planned), and the latter through fast delivery.
- **Flexibility**: Flexibility has many measures, but the two most influential in the operations area are the ability to change volume and product mix (Slack 1983; Olhager 1993; Hallgren 2007; Hutchison and Das 2007), and both are included in this study.

Companies operating in different competitive environments may have different performance objectives and that the competitive strategy must fit the specific needs of the company and its customers. Stable environment consists of reutilized operations focused on building efficient and lean operation flows. Their operations are dedicated to functional products with long life cycles and a low degree of innovation, such as in stable consumer goods industries. Their performance priorities start with quality, followed by cost, delivery time, innovation, price, and flexibility. Companies in dynamic environment should focus on agility and market-responsiveness. They enable the production of innovative products with short life cycles such as in emergent industries with rapid technological change (Silveira and Cagliano 2006).

Therefore, their major performance objective is flexibility, followed by quality and delivery. Considering these facts, the researchers used to assess the operation performance of organizations as competitive advantage using the following as the major variables (Silveira and Cagliano 2006): (i) quality; (ii) cost; (iii) delivery; (iv) price; (v) innovation; (vi) flexibility. Quality may involve both conformance and performance issues appeared to suggest that stable operations system aimed at quality ‘sustainability’ (conformance) levels, which might not be as high as the quality ‘supremacy’ (performance) levels of the system. Cost is determined by the scale of economies, capacity utilization, and inventory turnover. Delivery involves performance in lead times and supply reliability. Price is
determined by the ability of the company to offer the products/services at affordable prices to the customers. Flexibility means the ability of the production system to quickly change from producing one product/service to producing another. Quality, cost, delivery, price, innovation, and flexibility have become widely used as indicators of the competitive dimensions of manufacturing. In each market in which the company operates it should identify those criteria that win orders against the competition (Voss 1995).

Competitiveness generally refers to the ability of a business organization to survive in a competitive marketplace by offering products or services that attract and satisfy customers (Fujimoto 2004). For manufacturing organizations, quality, cost, delivery, flexibility, and time are recognized as the core of manufacturing capabilities that leads to their competitiveness (Schroeder and Flynn 2001). This study uses seven competitive performance indicators to evaluate the competitiveness of each manufacturing plant as: (i) Quality, (ii) Cost, (iii) Delivery speed, (iv) Innovation, (v) Productivity, (vi) Flexibility, and (vii) Affordable price. These indicators have been widely use in World Class Manufacturing (WCM) and High Performance Manufacturing (HPM) framework and other quality management studies to measure whether implementation of quality management practices can simultaneously improve different dimensions of competitive performance (Flynn et al., 1995; Cua et al., 2001; Matsui 2002b; Kaynak 2003).

2.9 DRIVERS AND BARRIERS TO WCM IMPLEMENTATION

Drivers and barriers to WCM implementation in general have been classified in various ways. For example, Assiri et al (2006), Avlonitis and Karayanni (2000), Eid and Trueman (2004) and Poon and Jevons (1997) talk about external drivers, i.e., global competition, international customers’ needs, developments in IT. Chan and Swatman (2000) includes internal drivers, i.e., changes in the organisational strategies and savings. Others talk
about WCM barriers, i.e., need for cost justification, resistance to change, lack of management support, lack of knowledge, lack of appropriate monitoring and lack of employee education and training (Porter 2001 and Skinner 1999).

2.9.1 Drivers to WCM Implementation

External drivers, internal drivers, or both motivate WCM implementation. Naturally, external drivers relate to the increased level of global competition, the changes in the international customers’ needs, recent developments in IT, and competition (Chan and Swatman 2000; Cronin 1996; Eid and Trueman 2004; Hollensen 2001; Poon and Jevons 1997; Skinner 1999; Hsu and Lin 2006). Internal drivers are mainly related to changes in the organisational strategies and cost savings (Chan and Swatman 2000; Cronin 1996; Skinner 1999). Perhaps, one of the strongest drivers is the increasing level of competition in the global markets. This has emphasised the need for organisations to innovate if they are to cope with global standards of products and services. Therefore, increasing knowledge and coordination of the company’s processes that cross its manufacturing functions become the main requirements of many companies seeking a competitive advantage. Gilgeous and Gilgeous (1999), Kasul and Motwani (1995), Kreitner (1995) approach the WCM as a tool to dramatically improve business performance and gain or maintain a competitive position. Similarly, Salaheldin (2005) and Saxena and Sahay (2000) also believe that WCM is driven by the never-ending needs of customers who are looking for better services and products. Finally, competitors’ use of the WCM techniques and their ability to respond to customers has a strong effect on the adoption of the WCM.

On the other hand, technology drives organisational change at process, communications, and strategic level. Changes in organisational strategy may involve WCM use to bring about new strategic goals. For
example, it may wish to broaden the use of existing electronic trading technology to include an advanced manufacturing technique as an alternative medium (Chan and Swatman 2000). Reducing costs by substituting the WCM for other traditional techniques is yet another driver for WCM use since it is associated with cost savings. For example, Skinner (1999) states that sellers can obtain cost savings in “finding new customers” and “administration costs” generated through timesaving and the reduction in staff numbers.

2.9.2 Barriers to WCM Implementation

There is a widespread recognition that WCM is a necessary technique for the achievement of competitiveness. It combines a system of knowledge, techniques, experiences, skills, and organisational characteristics that are needed to produce, utilise and control output. WCM is crucial to competition, because the techniques and resources it combines can create new opportunities. Such an approach is given added impetus by rapid technological changes and fierce competition, requiring manufacturers to consider the adaptation of modern techniques which can be classified under the overall umbrella term of WCM. However, many authors have argued that WCM implementation has a number of limitations that are needed to be addressed in the manufacturing strategy (Hollensen 2001; Porter 2001; Skinner 1999; Wilson and Abel 2002). When implementing the WCM techniques, there may be different barriers: such as partial implementation of WCM techniques (Becker 1993), overly optimistic expectations (Doyle 1992) and implementation of WCM to conform to societal norms rather than for its instrumentality (Campbell 1994).

However, some of the prominent problems in WCM implementation include partial implementation, lack of a well-defined routine for attaining the objectives of implementation, cultural resistance to change, lack of training and education, and lack World class manufacturing
techniques of organizational communication (Crawford et al., 1988; Becker 1993; Patterson et al., 1995; Westphal et al., 1997). These problems reflect the lack of a clear understanding of what are the fundamental and complementary manufacturing practices. It can also be inferred that companies that encountered failure in their program implementation neglected the development of practices that support the implementation of WCM techniques. Moreover, Safayeni et al (1991) contend that failure of WCM implementation is partly due to confusion over what exactly constitutes WCM and its implementation within an existing organization structure that does not provide the necessary support. The major barrier that will possibly affect WCM implementation is the inability of a company to coordinate its human resource practices, management policies and technology (Fredendall et al., 1997). Together, these problems reflect the lack of a system that supports the implementation of WCM programs.

2.10 SUMMARY

Companies engaging in WCM strategies focus on improving operations, strive to eliminate waste and create lean organization. This often results in higher productivity. But these companies also focus on speed of total throughput from order capture through delivery setting new standards for delivery without the heavy dependence on inventory. In WCM, sequential methods of performing work are being replaced with concurrent methods to compress time, and functional and hierarchical divisions of duties are being replaced by team-driven activities. World class manufacturers are those that demonstrate industry best practices.