LITERATURE REVIEW

World-Class Manufacturing – The Concept

World Class Manufacturing is a different set of concepts, principles, policies and techniques for managing and operating a manufacturing company. It is driven by the results achieved by the Japanese manufacturing resurgence following World War II, and adapts many of the ideas used by the Japanese in automotive, electronics and steel companies to gain a competitive edge. It primarily focuses on continual improvement in quality, cost, lead time, flexibility and customer service.

World Class Manufacturing is a process-driven approach where implementations usually involve the following philosophies and techniques:

- Make-to-order/JIT Manufacturing
- Small lot sizes
- Cellular manufacturing
- Poka-yoke
- 5–S
- 6–Sigma
- Total Quality Management (TQM)
- Total preventive maintenance (TPM)
- Quick changeover/Single Minute Exchange of Dies (SMED)
- Zero Defects
- Just-in-time (JIT)
- High employee involvement
- Cross functional teams
Multi-skilled employees
Visual signaling
Statistical process control (SPC)

**Important World-Class Manufacturing Practices: Birds eye view**

6-Sigma

6-Sigma refers to a quality improvement and business strategy concept started by Motorola in the United States in 1987. In statistical terms, 6-Sigma is the abbreviated form of 6 standard deviations from the mean, which mathematically translates to about 2 defects per billion. Thus, strictly speaking, your process is said to have achieved 6-sigma if it is producing no more than 2 defects per billion parts produced.

If Sigma quality level equals six, chances for defective products are 3.4 ppm. Achieving Six Sigma quality level involves leadership, infrastructure, appropriate tools and methods, while quality have to become a part of corporate business plan (Sokovic, 2006)

Tools and methodology within Six Sigma deal with overall costs of quality, both tangible and intangible parts, trying to minimize it, while, in the same time, increasing overall quality level contribute to company business success and profitability.(Basu, 2004)

Linderman et. al. emphasized the need for a common definition of Six Sigma and proposed: Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates.
6-Sigma encourages leanness, simplicity, and doing things right the first time, so that wastes and corresponding costs are avoided (Breyfogle, 1999).

**Lean Manufacturing**

**Lean Manufacturing**, or Lean Production, refers to a business concept wherein the goal is to minimize the amount of time and resources used in the manufacturing processes and other activities of an enterprise, with emphasis on eliminating all forms of wastage. Lean manufacturing/production has been a term that has been in widespread usage since the early 1990’s when Womack and Jones first used it to describe the Toyota Production System.

Because manufacturing environments vary due to differences in their purpose, design and control, there is no single set of management procedures that can be universally adopted to govern them (Hayes, Pisano, Upton, & Wheelwright, 2005). Manufacturers are under tremendous pressure to improve productivity and quality while reducing costs. This has led many organizations to implement the Toyota Production System (TPS), otherwise known as lean manufacturing (Liker, 2004; Womack, 2003).

TPS uses several different tools to strategically align not only their production facilities but their supplier’s facilities in the elimination process of these wastes (Bergmiller and McWright, 2009). Lean manufacturing uses less of everything compared to mass production - half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product (Womack et al., 1990).
Lean manufacturing is most frequently associated with the elimination of seven important wastes to ameliorate the effects of variability in supply, processing time or demand (Shah and Ward, 2007).

Sawhney, Teparakul, Aruna, and Li (2007) show the connection between lean manufacturing and the environmental movement stating that “it is natural that the lean concept, its inherent value-stream view and its focus on the systematic elimination of waste, fits with the overall strategy of protecting the environment”, which they call Environmental Lean (En-Lean).

According to lean manufacturing, the following are forms of 'waste' and should be eliminated:
1) Waiting;
2) Inventories;
3) Transport of inventories;
4) Over production;
5) Over processing;
6) Unnecessary motion;
7) Defective units.

Total Quality Management (TQM)

Total Quality Management is a structured system for managing the quality of products, processes, and resources of an organization in order to satisfy its internal and external customers, as well as its suppliers. TQM is indeed, agreed upon as one of the ways of managing organizations to improve efficiency and effectiveness (Zhang et al., 2000).
TQM is known as a set of techniques and procedures implemented to minimise or remove variation from a production process or service delivery system so that the level of efficiency, reliability and quality could be enhanced (Steingard and Fitzgibbons, 1993).

Total Quality Management (TQM) is an important concept that describe the process that leads to satisfying customer’s needs and to as well enable a firm achieve product differentiation target (Iwarere 2009).

TQM may be considered as a collection of principles and processes that have been proven to be effective in business quality management over time. It goes back to the teachings of Drucker, Juran, Deming, Ishikawa, etc, who each have studied and developed ideas for improving organizational management.

**Principles of TQM**

- Quality can and must be managed.
- Everyone has a customer to delight.
- Processes, not the people, are the problem.
- Every employee is responsible for quality.
- Problems must be prevented, not just fixed.
- Quality must be measured so it can be controlled.
- Quality improvements must be continuous.
- Quality goals must be based on customer requirements.
Total Productive Maintenance (TPM) refers to a management system for optimizing the productivity of manufacturing equipment through systematic equipment maintenance involving employees at all levels.

The history of TPM is inseparably linked with Japan although the first system actions aimed at the improvement of equipment operation were taken in USA at the beginning of 21st century. The name of TPM as first defined and used by Japan Institute of Plant Engineers in 1971. The history of TPM development can be outlined as follows:
2. The 50s – Preventive Maintenance and Productive Maintenance.
3. The 60s – Corrective Maintenance.
4. 1971 - Total Productive Maintenance
5. The 80s – Predictive Maintenance
(Nakajima, 2008)

Under TPM, everyone is involved in keeping the equipment in good working order to minimize production losses from equipment repairs, assists, set-ups, and the like.

In the 1970’s, the concept of ‘productive maintenance’ emerged, rolling into one system the following: preventive maintenance, equipment reliability engineering, equipment maintainability engineering, and equipment engineering economics. Under this system, the technical or engineering group still has the main responsibility for equipment maintenance.

The concept of ‘true’ TPM wherein everyone from the operator to top management owns equipment maintenance came about shortly after. TPM
embraces various disciplines to create a manufacturing environment wherein everyone feels that it is his or her responsibility to keep the equipment running and productive.

TPM has 8 key strategies: 1) Focused Improvements (Kaizen); 2) Autonomous Maintenance; 3) Planned Maintenance; 4) Technical Training; 5) Early Equipment Management; 6) Quality Maintenance; 7) Administrative and Support Functions Management; 8) Safety and Environmental Management.

**Just-In-Time (JIT) Manufacturing**

Just-In-time manufacturing, or JIT, is a management philosophy aimed at eliminating manufacturing wastes by producing only the right amount and combination of parts at the right place at the right time.

According to Drury (1990), JIT attempts to manufacture products from start to finish, the first task in applying JIT production, is to rearrange the factory floor layout away from batch production toward a product layout using flow lines.

Kaplan and Atkinson (1989) revealed that the JIT philosophy revolves around four major points: the elimination of activities that do not add value to a product or service; a commitment to a high level of quality; a commitment to continuous improvement in the efficiency of an activity; and an emphasis on simplification and increased visibility to identify activities that do not add value.
JIT finds its origin in Japan, where it has been in practice since the early 1970’s. It was developed and perfected by Taiichi Ohno of Toyota, who is now referred to as the father of JIT. Taiichi Ohno developed this philosophy as a means of meeting customer demands with minimum delays. Thus, in the olden days, JIT is used not to reduce manufacturing wastage, but primarily to produce goods so that customer orders are met exactly when they need the products.

**Kaizen**

Kaizen (jap. kai – do, change, zen – well) is a kind of thinking and management, it is a philosophy being used not only in management field but also in the everyday life in Japan. It means gradual and continuous progress, increase of value, intensification and improvement (Masaki Imai, 1986)

The basis of kaizen are constituted by 5s concept, defined by Japanese specialists as a set of good customs and manners, deriving from the traditional manner of behavior in house and school. (Kraszewski, 2005)

**5 - S**

The greatest feature of 5S approach is that it is simple; for that reason it easily finds area of application. Forming a ground for the other improvement activities, 5S is an important term that carries priority in improvement at a company (Celebi, 1997).

Through the proper application of 5S activities, a visible change occurs within the factory. Since it is executed in order to use the factory’s area and the equipments in a more efficient manner, it improves the efficiency of the company (Sevim, 2005).
"5S" was invented in Japan, and stands for five (5) Japanese words that start with the letter 'S': Seiri, Seiton, Seiso, Seiketsu, and Shitsuke. Table shows what these individual words mean. An equivalent set of five 'S' words in English have likewise been adopted by many, to preserve the "5S" acronym in English usage. These are: Sort, Set (in place), Shine, Standardize, and Sustain.

**Table: 5 - S Definitions**

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<thead>
<tr>
<th>Japanese Term</th>
<th>English Equivalent</th>
<th>Meaning in Japanese Context</th>
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<tbody>
<tr>
<td><strong>Seiri</strong></td>
<td>Tidiness</td>
<td>Throw away all rubbish and unrelated materials in the workplace</td>
</tr>
<tr>
<td><strong>Seiton</strong></td>
<td>Orderliness</td>
<td>Set everything in proper place for quick retrieval and storage</td>
</tr>
<tr>
<td><strong>Seiso</strong></td>
<td>Cleanliness</td>
<td>Clean the workplace; everyone should be a janitor</td>
</tr>
<tr>
<td><strong>Seiketsu</strong></td>
<td>Standardization</td>
<td>Standardize the way of maintaining cleanliness</td>
</tr>
<tr>
<td><strong>Shitsuke</strong></td>
<td>Discipline</td>
<td>Practice 'Five S' daily - make it a way of life; this also means 'commitment'</td>
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