Impact of the Lean Manufacturing Tools on ISO 9001 Quality Management System.
The Praxair Surface Technologies' case study
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Introduction

Praxair is a World-Wide-Company with 27,000 employees and operations in more than 30 countries. With 2006 sales of $8.3 billion, Praxair, Inc. (NYSE:PX) is a global, Fortune 300 company that supplies atmospheric, process and specialty gases, high-performance coatings, and related services and technologies to a wide diversity of customers.
Praxair's primary products are:

- atmospheric gases - oxygen, nitrogen, argon and rare gases (produced when air is purified, compressed, cooled, distilled and condensed);
- process & specialty gases - carbon dioxide, helium, hydrogen, semiconductor process gases, and acetylene (produced as by-products of chemical production or recovered from natural gas).

Praxair Surface Technologies (PST) is a subsidiary that applies metallic and ceramic coatings and powders to metal surfaces in order to resist wear, high temperatures and corrosion.
Praxair and Praxair Surface Technologies have applied both Six Sigma and Lean Manufacturing in many plants, including the Italian plants.
But How the Lean Tools can affect the Quality System? Which ISO 9001 processes are involved? This paper aims to answer, in a deductive way, to the questions above.

Lean Thinking

Lean thinking is a name derived from a 1990's book called *The Machine That Changed the World : The Story of Lean Production1 (*Womack, James P., Daniel T. Jones, and Daniel Roos, 1990). This book chronicles the movement of automobile manufacturing from mass production to lean production. It tells the story of how Henry Ford standardized automobile parts and assembly

techniques, so that low skilled workers and specialized machines could make cheap cars for everybody (Jones, 2003). The book goes on to describe how mass production provided cheaper cars, but resulted an explosion of indirect costs such as production control, handling, inspection, reworking, inventory management, etc. Then the book explains how Toyota wanted to make cars, but it could not afford enormous investments in labour and machines; nor could it afford the inventory or large amount of indirect labour that seemed necessary for mass production, including inspection . So Toyota invented a better way to do things, using very low inventory and moving decision-making to production workers (Lecker, 2004). Now this Japanese company has grown into a large company, and the Toyota Production System has become known as 'Lean Manufacturing'. Womack and the other authors, in the book write:

"The mass-producer uses narrowly skilled professionals to design products make by unskilled or semiskilled workers tending expensive, single-purpose machines. These churn out standardized products at high volume. Because the machinery costs so much and is so intolerant of disruption, the mass-producer adds many buffers – extra supplies, extra workers, and extra space – to assure smooth production…. The result: The customer gets lower costs but at the expense of variety and by means of work methods that most employees find boring and dispiriting."

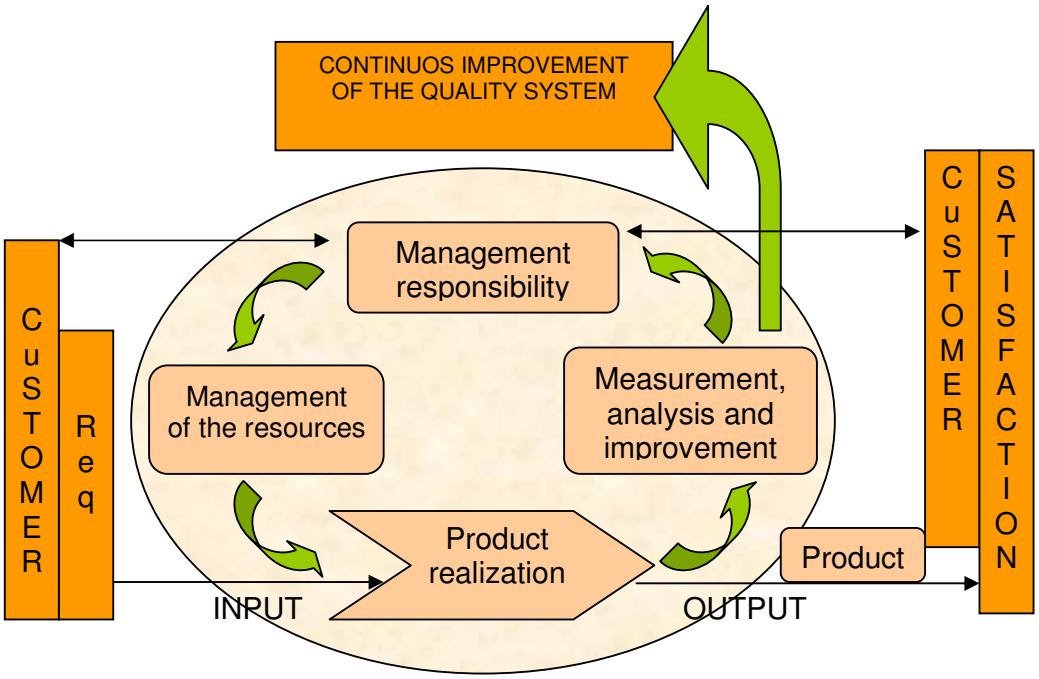
Taiichi Ohno, past Toyota Production manager invented the Toyota Production System and identified seven types of manufacturing wastes (Ohno, 1988):

- Overproduction
- Inventory
- Extra Processing Steps
- Motion
- Defects
- Waiting
- Transportation.

To relate the Toyota Productive System to TQM, it is important to analyse the 14 TPS principles, and compare them to ISO 9001 requirements. In 2004 Liker, in the book "The Toyota Way" , enounced the principles that underpinning TPS, as shown in the table.

Principle 1: base your management decisions on a long-term philosophy, even at the expense of short-term financial goals;
Principle 2: create continuous process flow to bring problems to the surface;
Principle 3: Use "Pull" systems to avoid overproduction;
Principle 4: level out the workload;
Principle 5: build a culture of stopping to fix problems, to get quality right the first time;
Principle 6: standardised tasks are the foundations for continuous improvement and employee empowerment;
Principle 7: use visual control so no problems are hidden;
Principle 8: use only reliable, thoroughly tested technology that serves your people and processes;
Principle 9: grow leaders who thoroughly understand the work, live the philosophy and teach it to others;
Principle 10: develop exceptional people and teams who follow your company's philosophy;
Principle 11: respect your extended network of partners and suppliers by challenging them and helping them improve;
Principle 12: Go and see for yourself to thoroughly understand the situation;
Principle 13: make decisions slowly by consensus, thoroughly considering all options and implement decisions rapidly;
Principle 14: become a learning organisation through relentless reflection.

It is possible so, to link the fourteenth principles with the classic ISO 9001 process approach.
The ISO 9000 standards process model is depicted in the figure below. According to the ISO process model, any activity, or set of activities, that uses resources to transform inputs to outputs can be considered a process. For a company to effectively implement a quality management system, such as Praxair, it needs to identify and manage various processes and their interactions. The output of one process is an input to another process. To implement a companywide quality management system, the company must implement process management at each process (function or subsystem) level.
To manage a process, the process owner needs to control inputs, in process, and output as shown in the figure. The process owner must not only understand the requirements but also be able to receive, produce, or supply according to the requirements, including Lean tools.



Process-based quality management system

Today, hundreds of thousands of organisation have obtained ISO 9000 certification and the most common benefits of implementing ISO 9000 quality systems include:

- standardization, and repeatability of processes; this is important, for example, at the end of all the Kaizen Events, so as standardizing the results achieved;
- improvement of customer satisfaction;
- reduction of costs of poor quality, including most of the seven Lean Wastes.

In the management literature there is a lack of books or peer-reviewed papers concerning the link between ISO 9001 processes and the Lean Tools. This paper aims to answer, in a deductive way, to the questions above.

Lean Manufacturing and ISO 9001 in Praxair, analyzing the correlations

Praxair Italian plants launched, in 2006, the Lean Enterprise project, involving mainly the operations. The plants are ISO 9001 certified with an Italian Body and applied a typical Quality System with:

- a Quality Manual (in cross reference with the ISO 9001:2000 requirements);
- a Quality Policy;
- Procedures that describing the main processes;

- Work Instructions.

The Lean Project is based on the use of the classical tools (Mann, 2005) as a whole (Lean strategy): SMED, TPM, 5s, Heijunka and Takt Time, Jidoca, etc.

Each of the tools affect, directly or indirectly, the Quality System processes (George, 2003).

A dedicated Praxair's team has improved the process documentation after the implementation of the Lean tools.

The impact of the Lean Manufacturing tools can be related to each of relevant ISO 9001 requirements:

- quality management system;
- management responsibility;
- resource management;
- product realization;
- measurement, analysis and improvement.

In particular, analyzing the first requirement, quality management system, Lean manufacturing could affect the so called "management of the processes" and the measurement through Key Performance Indicators (KPIs). Regarding these last, PST has introduced new KPIs and reviewed the previous ones. The current structure of KPIs concerns, substantially, the areas below:

- Safety;
- Productivity;
- Quality;
- Continuous improvement;
- Customer Satisfaction;

You should notice that the Lean tools cannot only improve the processes of the quality, but also those of the management safety. Examples of KPIs regarding the areas above are listed following in the record predisposed by Praxair with the purpose of the collection of the results. The record divides the KPIs according to the areas above and according to levels quoted as "ground, bronze, silver and gold". The relative values have been omitted for reasons of confidence, but it can be revealed how such levels are useful to verify if the different manufacturing cells go forward the continuous improvement.

Always regarding the ISO 9001 requirement of the quality management system, PST has re-designed the structure of the manufacturing processes in manufacturing cells, following the principle of the one-piece-flow and the group technology. This system of benchmark among cells through the levels contained in the chart is called OPX (OPerational eXcellence PST system).

		Ground	Bronze	Silver	Gold
Safety	Lost Work Case injuries (# in previous 12 months)				
	Recordable injuries (#in previous 12 months)				
	Corporate A & B Assessments				
Productivity	Savings ; % of Cost Stack				
	Performance Trend				
	Cost of Poor quality (CoPQ; %of Sales)				
Quality	Customer Quality Escapes (#in previous 12 months)				
	Corporate Quality Assessments Results (Findings)				
	First Pass Yield (6sigma Level)				
Continuous Improvement	Critical Equipment TPM Programs				
	Kaizen Newspaper Item Closure				
	5S Scores				
Customer Satisfaction	On Time Delivery (OTD to customer requirements; %)				
	Turn Time ; %Improvement				
	Market Feedback Analysis				

Concerning the ISO 9001 requirements that describe the management responsibility PST, through the Lean, has introduced new roles in the organization chart, particularly:

- one Lean Specialist (new role, one for country);
- one SixSigma Black Belt;
- one Continuous Improvement Engineer (at least one for plant);
- one Application Engineer (at least one for plant);

The existing figures that belong to the Quality Department, besides, have been involved in the Lean Organization. The principal system to involve the whole personnel, independently from the roles, it is based on the Kaizen Events. Those in PST are events managed by mixed teams with the purpose to reduce the seven wastes of the Lean. Almost all the PST staff has been interested at least once in the participation to a Kaizen Event, since Lean Organization means involvement to every level. Before the launching of the Kaizens Events, PST has received a special training, according to the points of the following program :

- Two weeks in Indianapolis (Headquarter) regarding Lean Manufacturing for the Plant Managers;
- Focus on Lean Manufacturing for Lean Specialists
- Two weeks in Italy dedicated how to manage to

Workshop Kaizen;

- Many others specific courses (e.g. Value Stream Mapping Meeting in Germany, etc.).

Scope of the training in PST has been, in particular:

- achieving the largest involvement;
- raising skills and awareness;
- getting to proactive approach on the shop floor;
- using everyday Lean Tools;
- implementing a real LEAN System;

The Kaizen Events were useful for the design of the manufacturing cell, and for the introduction in the cells of the typical Lean tools, particularly 5S, SMED, Kanban and Heijunka. Each of the Kaizen Events has brought an improvement in the shops floor processes, improvement that has subsequently been formalized in the procedures and work instructions.

Finally, the application of the Lean Tools, has tied notably on ISO 9001 requirements concerning the continuous improvement. PST, in fact, has predisposed a specific process of reduction of the defects founded on corrective/preventive actions, called QPCP
(Quality Control Process Control). The QCPC activity is a tool used by Quality Department to assist Kaizen Teams with:

- identification of problems;
- prioritization of dates;
- improvement of project selection.

Substantially it is an improvement of the process of resolution of the not typical conformities ISO 9001.

Conclusions

Praxair Surface Technologies (PST) ISO 9001 certified company, has applied the Lean Tools with the purpose to improve the Quality System. The research conducted in the PST plant of Fornovo Taro - Italy, has put in evidence that exists a remarkable impact of the Lean tools on the ISOs 9001 requirements. It is enough intuitive to understand that the tools affect meaningfully on the shops floor processes linked to the "product realization" requirement, since Lean Manufacturing concentrate on these ones. The research in PST has, instead, put in evidence that exists an impact on the remaining requisites ISO 9001 such as quality management system, management responsibility, resource management, measurement, analysis and improvement. The following table synthesizes the results obtained.

	Lean Tools	Impact
Quality Management System	Cellular Manufacturing Design	Process redesign Cell-KPIs
Management responsibility	Measurement of OEE, Lead Time, Takt-Time, etc	New KPIs New Roles
Management of the resources	Kaizen Events TPM	Enlargement of the skills and training Team for Kaizen Events
Product realization	SMED, 5S, Kanban, Heijunka	One-piece-flow, visual mangement, cell-manufacturing, neatness and cleanliness, production order driven, reduction of the lead time, inventories and work in process
Measurement, analysis and improvement	Kaizen Events, Jidoca, etc. QCPC	Reduction of the 7 wastes in the company as a whole

Finally, it is important to notice how the Lean introduction has also improved the safety processes, through specifics KPs and the introduction of a better order and cleaning in the cells (by 5S tool).

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