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Improving Competitiveness in Craft Manufacturing
- Quality Improvement in the Automotive and leisure Boat Industry

By

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Abstract
High quality craft manufacturers adapting industrialized approaches to design and manufacturing face the challenge of maintaining the unique quality in their craft manufacturing while realizing improvements in efficiency through their industrialization process. We studied how quality is ensured and built into the products of one highly industrialized lean manufacturer and one craft manufacturer in order to better understand these challenges, comparing and contrasting the two companies' approaches to quality. Based on our empirical study of the two companies, we discuss how the craft manufacturer could adopt lean principles without sacrificing the company's product- and customer knowledge and its unique product quality, thus improving the competitive position of the company.

1 Introduction

Competition in modern craft industries require craft manufacturers and their supply chains to innovate, improve, and increasing their efficiency to meet the challenges from globalization and other forces for change (O'Sullivan, Rolstadås and Filos, 2009). The leisure boat industry is one such example where manufacturers are facing increased competition. In particular, the advance of industrialized leisure boat manufacturers is putting even high quality craft based "high end" manufacturers under strong competitive pressure. These manufacturers and their supply chains are now grappling with the challenge of how to meet this competitive pressure while preserving their unique quality of craft production.

The quality reputation of craft manufactured Norwegian leisure boats is generally high. However, this quality is to a large extent dependent on time-consuming adjustments of each produced boat. Little documentation and systematic descriptions of quality and processes exist, in stark contrast to e.g. manufacturers in lean automotive value chains. In this paper we compare a leisure boat manufacturer with a lean manufacturing company in the automotive industry with respect to how quality improvement is conducted. We outline how leisure boat manufacturing could adapt principles and methods from lean manufacturing in their quality improvement activities without giving up their unique craft production quality.

Our analysis is based on a comparative case study in the leisure boat industry and the truck manufacturing industry. Data collection consisted of 4 observations periods in the leisure boat industry and 2 in the automotive industry. A total of 6 in-depth interviews were conducted in the leisure industry and 10 in the automotive industry in the period 2007 to 2009. We also studied strategic documents as well as measurement-, quality-, and planning systems. Finally, we actively participated for change and improvement in projects with the companies - that is our work had elements of action research (Reason and Bradbury, 2007).

2 Quality Improvement

What is Quality

David Garwin (1984) found that most definitions of quality were either: transcendent[1], product-based, user-based, manufacturing-based or value-based. He

[1] Intuitively understood, difficult to define (Foster, 2006)

developed a list of quality dimensions of product quality: *performance, features* (attributes of a product that supplement the product's basic performance), *reliability* (probability for the product to perform consistently over its useful design life), *durability*, *serviceability, aesthetics* and *perceived quality*.

The dimensions and definitions of quality have evolved in line with new and broader perspectives on quality. Examples are the focus on commitment and actions of employees in TQHRM[2] and the environment in ISO 14000.

The contingency theory presupposes that there is no method for operating a business or making strategy that can be applied in all instances. According to this theory definitions and dimensions of quality applied within organisations could vary according to the specific context, but they should be consistent (Foster, 2007).

PDCA- Cycle: Plan-Do- Check-Act

The roots of quality management can be traced back to the early 1920's manufacturing quality control ideas, and notably the concepts developed in Japan in the late 1940's and 1950's, pioneered by Americans such as Joseph Juran and Edward Deming. Deming (1986) was a proponent for the iterative problem-solving process PDCA[3], typically used in continuous improvement. Anderson, Rungtsanatham, and Schroeder (1994) propose in Figure 5 a theoretical causal model underlying the Deming management methods and principles.

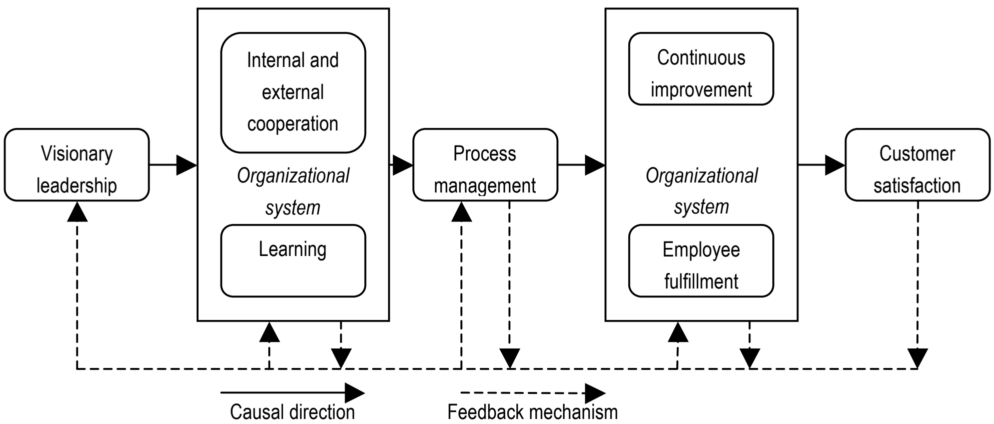

Figure 1: Theoretical model underlying the Deming management methods and principles (Anderson, J., Rungtusanatham, M., and Schroeder, R. 1994)

Quality improvement is related to knowledge of how things are and could be improved. A ground assumption is that knowledge appears in tacit and explicit forms, and that the one can be transformed into the other. Nonaka and Takeuichi (1995) describe a knowledge creation spiral, conversing tacit to explicit knowledge to be able to learn from different contexts, but also how explicit knowledge has to be decoded and made relevant in a particular working situation. Kennedy (2010) indicates a link between the knowledge creation spiral (Nonaka and Takeuchi, 1995) and the PDCA improvement circle (Deming, 1986). He sees PDCA as a learning process where the

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[2] TQHRM: Total Quality Human Resource Management

[3] PDCA: Plan –Do-Check-Act

plan (P) and do (D) is a learning phase, and check (C) and act (A) is standardizing. The standardizing of knowledge is according to Kennedy (2010) necessary to be able to use it in another project or context.

3 The two Cases

Leisure Boat Industry

We studied two companies in a leisure boat manufacturing supply chain. One manufactures major parts and components for leisure boats. It has a turnover of approximately €20 million and 150 employees (2007). The company is located in an agglomeration of leisure boat manufacturer. The supplier has many characteristics of being a craft manufacturer. It develops and manufactures customized products or products in small volumes to a large number of boat manufacturers, but is aiming for more standardization and larger volumes to reduce costs. However, the manufacturing processes are mainly manual, but with the support of some machine tools. The other company is a leading global craft manufacturing OEM[4], with a turnover of approximately €80 million. The OEM is an important customer of the supplier.

In general, the supplier is decoupled from their customers in the manufacturing phase. Intercompany contact in this phase is generally limited to order receiving and issues relating to quality or delivery problems. The relationship could be characterized as "communicators" with low levels of information systems- and business process integration (Muckstadt, Murray, Rappold and Collins, 2001).

Automotive Industry

The reference case is a fast growing global supplier in the automotive industry. With a turnover of €905 million in 2008, it is among the 100 biggest suppliers to the automotive industry. A diversified product range implies different strategies for the business areas, which are relatively autonomous. The basic strategy expressed by the top management is "*to produce what the customers demand"*. The customer and supply chain focus has been interpreted into an overall lean manufacturing strategy with elements of both mass manufacturing and mass customization.

The supplier is aiming for, and has reached, the status as first-tier supplier in most of its business areas. The customers (OEM) have adapted major lean principles, such as waste reduction, pull, and Just-In-Time manufacturing.

The relationship between the supplier its main customers (OEMs) could be characterized as "collaborators" where strategic and tactical decisions are made jointly. They execute collaboratively to achieve the maximum system effectiveness, where information systems and business processes are highly integrated (Muckstadt *et al*. 2001).

4 Quality Improvement in Craft Manufacturing

Quality Improvement in the Leisure Boat Industry

The leisure boat case companies have been quality focused and build and retain a craftsmen-tradition with a strong ownership to their products. Quality issues are dealt

[4] OEM=Original Equipment Manufacturer, normally the same as "final assembler"

with on an ad-hoc basis. Practical problem solving is a basic capability for both companies. Quality and improvements have not been well defined or documented. This holds true also at the supply chain level, partly as a consequence of the lack of integration of processes and information systems between the two companies. Knowledge transfer is often informal and based on personal relations. The “red books” used by the supplier in the leisure boat case sum up much of the challenges in their work for quality improvements. Operators make their own personal notes in these books about manufacturing processes they are involved in. The books have been an important tool for quality improvement, but the developed knowledge remains in the books and in the heads of each worker.

Referring to the PDCA improvement cycle, quality improvement in the leisure boat cases have traditionally been described as follows:

- *Plan*: There are quality systems, product descriptions and manuals, but few process descriptions at shop floor-level and between companies. Performance measurement systems are absent or not capable of indicating the need for improvements. Changes are often based on discussions and more on personal experiences than on facts. The “red books” used by the operators is an important tool for quality improvements. Notes and improvements are not communicated or registered anywhere else.
- *Do:* The planned changes will often be easy to implement in a small scale situation. The people behind the proposed changes are often also testing them in their daily operations. Even though the rationale for a change is not formally and explicitly described, involved actors have knowledge about why and how changes are to be made. However, the overall effects of changes carried out are often not fully understood by the people carrying out the changes and therefore sub-optimal improvements may occur.
- *Check:* The processes are not described in details and the performance measurement systems are poorly developed. When the effect of the changes are evaluated and decisions about full implementation are made they are often based on experiences and discussions among the people involved in the processes
- *Act:* Implementation is difficult due to the lack of standardized and described processes and that changes often are linked to the operators that were originally part of the first steps of PDCA. When operators rotate, knowledge about any changes made is often low and may be lost. Involving colleagues in changes could make implementation easier.

An important challenge for the leisure boat supply chain is to find ways to improve quality and introduce industrial principles aiming for standardization and improved productivity and quality, but without loosing the flexibility, personal involvement, and problem solving capabilities of craft manufacturing.

Quality Improvement in the Automotive Industry
Lean principles and improvement tools are typical in quality improvement in the automotive industry. Continuous learning and incremental development are basic elements of lean manufacturing (Liker, 2004). This is to some extent similar to what we see in the craft manufacturing in the leisure boat industry. However, there some

fundamental difference, especially the more structured and fact-oriented approach in lean manufacturing. In our case from the automotive industry, quality improvement is more based on explicit than tacit knowledge. Highly integrated processes require quality improvements and changes based on facts, and the integrated information systems enable the manufacturer to do so. This is reflected in the PDCA- cycle:

- Plan: There are normally two sources for quality improvement: (1) the OEM identifies potentials for improvement when launching a new vehicle, from field quality faults and from supplier quality results such as PPM[5] and JIT; (2) the supplier takes initiatives e.g. through quality teams. Standardized tools are used to plan for changes, in particular cause-effect diagrams, and often as a part of A3 techniques.

- Do: The supplier has to take the cost of a trial in a small-scale production. This is often done at the mother plant. Even if the OEM normally does not accepts a 0-series they might evaluate a "batch" of products or processes. The processes are well described and linked to integrated common quality systems which enable the company to see if changes are working out and to investigate the selected processes.

- Check: Quality requirements, normally quantitative, are well defined by the OEM. Change of suppliers processes are often checked towards how the Net working Capital is influenced. Quality requirements, normally quantitative, are well defined by the OEM. Change of suppliers processes are often checked towards how the Net working Capital is influenced.

- Act: The integrated processes require that the changes have to be documented. The processes have to be mapped and standardized. Depending on the character of the changes, the operators and people involved will go through training and a learning process to implement the change.

Influenced by lean principles described by Womack *et al*. (1991), Kennedy (2003) and others, the case in the automotive industry has developed a knowledge-based model for improvement and R&D projects:

- *Robust learning:* A3 techniques (Sobek, 1997), visualization techniques and root cause analysis etc, enabling a common understanding of the problems, knowledge gaps and possible solutions and different.
- *Knowledge standards:* bringing the right knowledge into the context of the project. Knowledge relation maps is an important tool that converting the issue, for example a product, into different knowledge fields and establishing relations between the fields.
- *Optimized project organization:* with phase gates that ensures that the right decisions are made and that they are made as much as possible on facts.

Research and development are emphasized by the supplier, but there is also a general understanding of the importance of knowledge created through continuous

[5] Parts Per Million: Quality measure for defects per million

improvement and incremental development. The tacit knowledge created through operations is basic elements of the strategy for developing the process-oriented capabilities.

5 How we Approached the Challenges in the Leisure Boat Industry

Transferring Knowledge - Inherent Quality

Even if there is much repetitive work, and there are product documentations, there is little system support for standardization. Without good process descriptions the boat builder (OEM) also had difficulties to define process measures. This is supported by Andersen and Fagerhaug (2002) that process descriptions are needed in order to define measures. Further, the boat builder (OEM) had difficulties describing the quality of their work and productivity since no good process descriptions were available. However, even if the documentation of product quality, processes and measures were limited, the building processes is characterized by an inherent understanding of how things are and should be. This is also a typical aspect of tacit knowledge (Polyany, 1966). A big challenge occurs when this tacit knowledge is to be shared with people in another working context, for example a supplier.

The above description of the OEM was also reflected in the situation for the supplier studied in this research. These challenges was approached similarly and coordinated for the supplier and the OEM in our research project which the case study is derived from.

To be able to work structured on quality improvement according to the PDCA cycle the first issue was to build a common reference for improvement. This was done by involving craftsmen and engineers in work sessions aiming to:

- describe the manufacturing process, using simple mapping, photos and visualization techniques (Figure 2);
- measuring man- and machine hours according to the process map;
- define quality according to processes in the process map.

This was done to make the knowledge more explicit (Polyany, 1966) and enabling knowledge transfer and a common platform for discussions, and improvement.

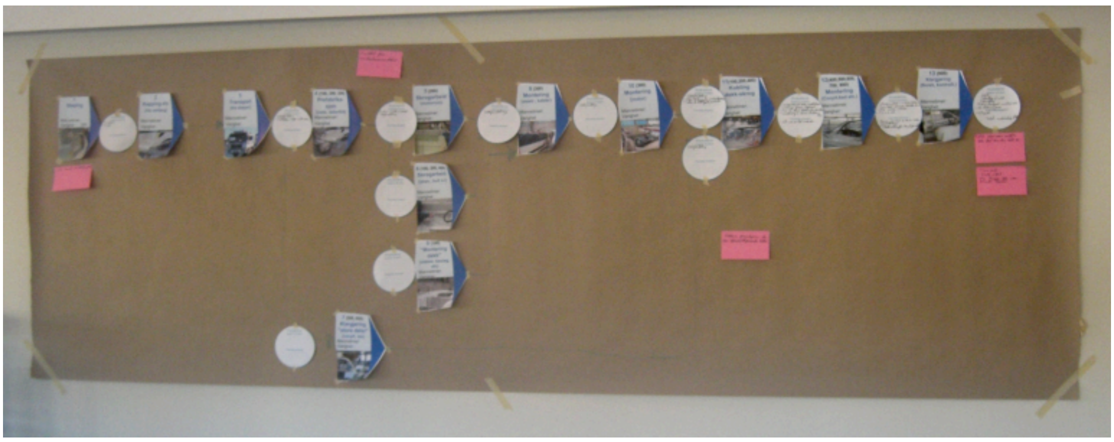

Figure 2 Prosess mapping – making knowledge explicit[6]

In this phase it was essential to include the people at shop floor level since they were the containers of knowledge. It was also important because they are playing a key role in the quality improvement and need to have ownership to the improvement processes, and will also be the primary users of the documentation.

Adapting Lean Principles into Craft Manufacturing

One of the overall objectives in the project for establishing an infrastructure (Hill, 2000) or organizational system (Anderson et al., 1994) for quality improvement was to adapt lean manufacturing principles, focusing on waste reduction, quality and continuous improvement into craft manufacturing operations. This also included focus on a tighter supply chain relationship and a more Just-In-time oriented manufacturing. A common denominator for the project was in addition to make a more fact-based improvement process, to create meeting points and channels for knowledge transfer and decisions.

The project has worked considerably to establish an "improvement culture", which means that people at different levels should focus on improvement. However, the focus has been on the shop floor level, where craftsmen have been motivated to share experiences and learn from each other in a structured way. This means that several workshops were organized for craftsmen and engineers aiming to introduce tools and principles for problem solving and improvement. This included root-cause analysis and other A3 techniques used in the automotive case.

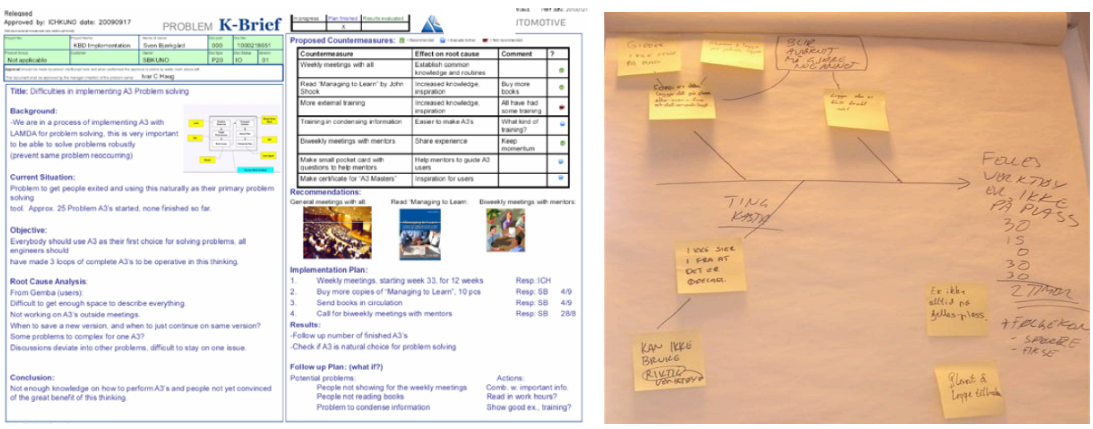

Figure 3 A3 template from the automotive case and Root-cause analysis in the leisure boat case[5]**.**

The A3 process has been described as a powerful method that systematically guides problem-solvers through a rigorous process, document the key outcomes, and propose improvements (Sobek, 1997). The root-cause analyses were used to improve quality, reduce defects, but mainly to reduce waste in manufacturing. The tools are illustrated in Figure 3. An important part of establishing a structured improvement culture was to train improvement agents. These people, normally team leaders (engineers) at shop floor level got a special responsibility to implement tools and follow up improvement

[6] Pictures are diffuse to protect company sensitive information

activities. This represented a decentralized approach to improvement, necessary to involve the craftsmen and their tacit knowledge and to obtain employees fulfilment.

The manufacturing in both the leisure boat OEM and the supplier were organized in teams. “Daily kick-off meetings” were implemented, with a 10 minutes, fixed agenda related to plans for the day but also for problem solving and discussion of improvement issues. This was a new forum for opening the “red books” and where craftsmen and engineers could launch and discuss their suggestions and experiences each day. The settings resemble the “obeya” (Womack *et al.* 1991) we found in the automotive case. Some issues where resolved at these meetings while others had to be addressed to other forums. Addressing these issues required standardized forms (less than one page), based on a maximum of facts. However, to succeed in this kind of decentralized improvement there need to be an organizational system capturing the initiatives from the “daily kick-off meetings”. In the leisure boat cases this included weekly development meetings for engineers (team leaders) and managers from manufacturing and other departments. In these meetings issues addressed from the “daily kick-off meetings” was a fixed topic on the agenda, and feedback to addressee was obligatory.

The integration level is much higher in the case from the automotive industry than in the leisure boat case, and is enabled by information systems for example related to quality and product development. The supplier in the leisure boat industry has also taken steps towards new and much more integrated information systems. A new product database is one such example. The object for this database is to presents facts to the OEMs, particularly on geometry, quality and assembly issues, to be used in both quality improvement and product development.

6 Conclusion

Visionary leadership is necessary to implement structured improvement and approaches as we see in lean manufacturing. The top management of the studied companies were deeply involvement in the change project. Handing over responsibility, and empowering craftsmen and engineers in quality improvement could be challenging for both those handing over and those receiving new responsibilities. The case companies in the leisure boat industry now approach continuous quality improvement in a much more structured way than previously. The PDCA cycle is fact-oriented, and is based on commitment from the shop-floor level. This is reflected in a focus on waste reduction and visual manufacturing systems.

However, the companies are still in an early phase of implementing these approaches to quality improvement. We believe that the fact-based, decentralized and incremental approach to improvement and development in lean manufacturing is powerful and useful also in craft manufacturing. Nevertheless, there are genuine differences between the leisure boat industry and the automotive industry that limit the applicability of lean approaches in the prior. For instance, the comparatively lower volume of the leisure boat manufacturer limits investments in information systems and supply chain integration. This gives rise to challenges in quality improvement from a supply chain perspective. We believe that also in a supply chain perspective, involvement by the shop-floor level and capturing of the tacit knowledge of the craftsmen is important for quality improvement.

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