*II International Conference on Industrial Engineering and Industrial Management*
*XII Congreso de Ingeniería de Organización*
*September 3-5, 2008, Burgos, Spain*

# A Management Approach to Lean Production System Implementation in Small and Medium-sized Enterprises – Results of a Research Project

**Uwe Dombrowski[1], Isabel Crespo[1]**

[1] Institute of Production Management and Operations Research. University of Braunschweig, Langer Kamp 19, 38106 Braunschweig, Germany, i.crespo@tu-bs.de

## Abstract

*Small and Medium-sized Enterprises (SMEs) are facing everyday new challenges and permanently changing conditions of today's business environment, which is characterized by a constantly rising product variety, an increasing customer demand for lower prices, higher product quality and shorter lead times. SMEs just like large enterprises are forced to adapt and improve their strategies, structures, and activities continuously. Therefore, in recent years numerous approaches and management frameworks have been developed and implemented in order to improve enterprises' competitiveness and to support the adaptation to new conditions. One of the successful frameworks is the implementation of a Lean Production System (LPS). LPS do not only help to reduce waste in the production process but also allow the company to focus on customer value. This paper presents a holistic management approach to Lean Production System implementation in SMEs which has been developed in a publicly financed research project and successfully implemented in six SMEs. The experiences gained from the research project are presented to facilitate the hands-on application of this management approach in other interested SMEs.*

**Keywords:** Lean Production System, Implementation, Small and Medium-sized Enterprises

## 1. Introduction

### 1.1. Current situation of SMEs

Changes in the business environment as shorter life cycles, higher product variety, fluctuations of the production volume, rapidly changing technologies, as well as the customers' demand for low prices, and short lead times, force SMEs to improve their processes and organization, Herrmann *et al* (2006). In addition to the general business conditions, large enterprises expect from SMEs to be able to cope with their requests on flexibility and high product quality permanently, Schneider (2000, pages 20-25). In spite of these facts, SMEs build the backbone of the European economy and employment market, representing 99.8 % of all enterprises in the European Union, providing around 74 million jobs and contributing to entrepreneurship, innovation and growth. Two thirds of all jobs in Europe (66.1 %) are in SMEs, while only one third of all jobs are provided by large enterprises, European Commission (2005, pages 7-8). In addition to this, the economic growth of Europe is positively associated with an increased role of the SMEs. They serve as driver for spreading knowledge, increasing the amount of competition in the global market and its diversity, Observatory of European SMEs (2003, page 15). In this regard SMEs have to use not only recent developments in production, information and communication technology but also have to apply current organizational concepts, Zahn *et al* (1995). Therefore SMEs have to face

these new challenges and the permanently changing conditions mentioned above, but in contrast with large enterprises they are subject to specific requirements and limitations – especially in the use of their resources, Behringer (2004, pages 22-28). SMEs need to find ways to tackle these challenges, since the challenges are likely to persist and even to increase in the future.

### 1.2. Lean Production Systems in SMEs

One of the successful strategies to deal with the changes and requirements of today's business environments is the implementation of a Lean Production System. This term, coined in *The Machine That Changed the World*, emblematises the efforts of many American and European production enterprises to copy and adapt the well-known and successful Toyota Production System which had been developed from the founder of Toyota, Sakichi Toyoda and the engineer Taiichi Ohno, Ohno (1998, pages 27-43). "Lean Production" is widely considered the next big step in the evolution of manufacturing beyond Ford's mass production, Liker (2006, pages 4-14).

LPS do not only help to reduce waste in the production process but also allow the enterprise to focus on customer value, Spath (2003, pages 41-44), Womack and Jones (2003, pages 41-50). A Lean Production System can be defined as an enterprise-specific compilation of rules, standards, methods and tools, as well as the appropriate underlying philosophy and culture for the comprehensive and sustainable design of production. A LPS enables an enterprise to meet the requirements of today´s business environment, taking into account technological, organizational, workforce-related and economical aspects, Dombrowski *et al* (2006). This definition supports a system approach to Lean Production, in which LPS are described by hierarchical connections of different elements, Cochran (1999), Korge (2005). The system is structured in four levels as shown in Figure 1. First of all, the main objectives of the enterprise that directly address the customers´ demands are formulated on the first level of the system (e.g. increase quality). These objectives are then broken down into sub-goals (e.g. increase product quality with better failure detection) which allow the deduction of operative measures. In order to achieve the sub-goals, methods (e.g. statistical process control) and tools (e.g. quality control charts) are applied. Methods and tools of similar content are bundled in fields of activities (e.g. total quality management). Altogether, 14 common fields of activities could be identified: visual management, workplace organization, 5S-housekeeping, teamwork, total quality management, continuous improvement, process standardization, total productive maintenance, leveling and mixed production, just-in-time concepts and kanban, technology and manufacturing process, human resource management, process-orientation and product design, and environment protection, Dombrowski et al. (2006). Within these fields of activities the LPS addresses technological and organizational issues, as well as workforce-related aspects. In addition to these tangible elements, a common vision of the ideal state as well as a philosophy and corporate culture that also reflects the lean ideas are crucial parts of the LPS, Liker (2006, pages 18-25), Spear and Bowen (1999). It is important to mention that the implementation of a LPS is not just a regular rationalization project, but a fundamental change in the organization and culture of an enterprise, Dombrowski et al. (2007a).

In recent days many large enterprises have developed and successfully implemented a LPS. While large enterprises are able to provide necessary resources like budget, manpower, and time, as well as experts' know-how to configure and implement a LPS, SMEs lack these essential resources, Dombrowski *et al* (2007b). Moreover, many approaches to LPS implementation can not applied by SMEs for different reasons: specific needs and

expectations of SMEs are not adequately considered, size restrictions and flat hierarchies are neglected, the link to the strategy of the SME is deficient and, referring to one of the most important drivers in SMEs, the entrepreneurs and employees cannot cope with the new challenges without widespread support, Behringer (2004, pages 22-28). In addition, the implementation of a LPS in SME needs the continuous support of a well-structured qualification background.

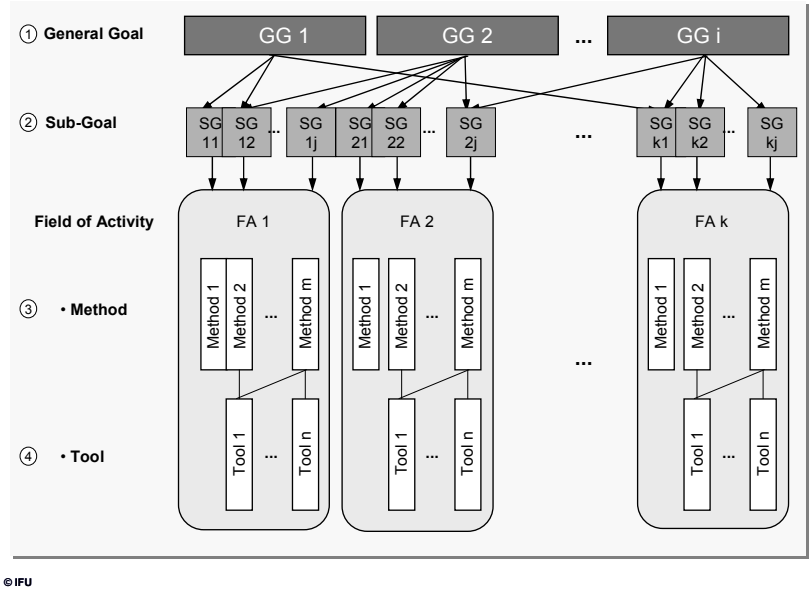


**Figure 1**. Structure of a Lean Production System

The specific characteristics of SMEs affect the size and structure of the implementation teams (e.g. project teams), the time horizon and scope of planning and also the whole sequence of the implementation process of a LPS. For the development and design of a management approach to LPS implementation the following aspects have to be taken into account for SMEs:

- The SME's entrepreneur has difficulties and limited ability to effectively diagnose the strategic opportunities, to derive strategic goals and to translate these into general goals in the LPS structure. Furthermore external support might be helpful here.

- The entrepreneur of the SME is in charge of the project management and acts as driver and motivator of the whole process.

- Most SMEs lack experts' know-how to realize the implementation but also financial resources to afford external support.

- Missing performance indicators will complicate an analysis of the current state of the organization and the monitoring of the implementation and future benefits of a LPS.

- Often it is only possible to configure small project teams whose project work partly takes place during off-time.

- Pilot projects as performed in large enterprises can hardly be carried out in SMEs. Instead of realizing an overall project, urgent and easy-to-integrate project modules need to be defined and realized. Moreover methods and tools should be adapted for the use in SMEs.

- The communication of aims and project schedules to the employees as well as the integration of them in the implementation process should occur at an early stage.

Taking into account the specific characteristics of SME the implementation of a LPS has to be considered in a holistic way. With this aim and in order to achieve long-term success as well as to assure their existence, it is necessary to develop a holistic management approach to Lean Production System implementation in SMEs. By using this management approach SMEs will be able to adapt and improve their strategies, structures, and manufacturing systems to new conditions and market requirements continuously within manageable time and effort.

## 2. Management Approach to Lean Production System Implementation in SMEs

The management approach suggested here is addressed in the joint research project[1] "ProfiL-Production and Organization Flexibility in Life Cycle". The core elements and the structure of well known management frameworks (e.g. St. Gallen management model, McKinsey 7-S model, Porter's models) have been analyzed and integrated in our concept to meet the SMEs' requirements. The holistic approach suggested here consists of five cross-linked modules: *Developing Strategy, Configuration, Implementation, Qualification and Control and Evaluation*.

### 2.1. Developing and linking strategy for the LPS implementation

In practice, SMEs often lack proper strategic planning. Strategy development in SMEs is often only a pragmatic and spontaneous reaction to changes in external conditions, Welter (2003, pages 33-38). This originates from the entrepreneur's limited ability to effectively diagnose the strategic opportunities, as well as from a focus on short-term planning and from the demand for quick and concrete results, Observatory of European SMEs (2003, page 8). The actual implementation of the strategy is sometimes hindered by the intense involvement of the entrepreneur in day-to-day business. Otherwise, SMEs show potentials that facilitate the development and implementation of the developed strategies such as an organizational culture based on the proximity between the entrepreneur and the employees does not only accelerate the decision-making process but also supports the implementation, Schneider (2000, pages 20-25). Taking these factors into account, the methodic proposed in this first module will support the SME's entrepreneur to develop the future vision and philosophy of his company and to deduct the general goals of the LPS structure. For these purpose, an approach to determinate and formulate the strategy of the SME has been developed.

---

[1] This work stems from the participation of the authors in a research project funded by the German Federal Ministry of Education and Research (BMBF) within the Framework Concept "Research for Tomorrow's Production" and managed by the Project Management Agency Forschungszentrum Karlsruhe, Production and Manufacturing Technologies Division (PTKA-PFT), reference: 02PI2075, title: Production and Organization Flexibility in Life Cycle (ProfiL).

As a first step should be considered what the SME is trying to accomplish both internally and externally. What is the SME trying to build for its internal stakeholders (employees)? How is the SME trying to help them to contribute, and what will they get in return? What impact is the SME trying to have on the outside world? Why do they exist as an enterprise? In order to answer all these questions a PESTL analysis (the term PESTL describes the Political, Economic, Sociological, Technical and Legal environment) and an in-depth analysis of the SME should be carried out. Based on these external and internal analyses, the current strategical state of the SME will be derived by dint of portfolio methods (e.g. SWOT-analysis). Next the entrepreneur of the SME should be able to define its vision and mission statement (if is not already existing) or to reconsider and assess it. Afterwards the adequate strategy for the enterprise should be formulated. A SME cannot be a profitable, financially healthy business with out a well-developed strategy, Liker (2006, page 24). In this process of developing strategy for the implementation of a LPS the focus on customer value is essential. Furthermore the following aspects should be considered by developing a strategy that supports the LPS implementation, Liker (2006, page 26):

- Commitment to long-term contributions to society and to the economic performance and growth of the company.
- Commitment to lean methods for waste elimination, to value stream perspective (the term value stream describes all activities which are necessary to build a product) and to development of excellent processes supported by thoroughly tested technology.
- Commitment to develop leaders and employees who live the philosophy for the long term.
- Commitment to thorough consideration in decision making, to understand processes in detail and to build a learning organization.

Once the strategy of the SME is defined, a thorough analysis allows the entrepreneur to derive strategic goals, which directly lead to the general goals in the LPS structure. As an example the entrepreneur of the SME might decide to reduce costs in order to stay competitive. This can lead to the minimization of manufacturing costs for a specific production area as a general goal of the LPS. By these means the alignment of the strategy of the SME with the general goals of the LPS is guaranteed.

## 2.2. Configuration of the LPS

The structure of the LPS will be configured in the second module. Once the general goals for the LPS have been described, sub-goals can be deduced. These sub-goals specify the general goals and indicate which methods and tools might be applied. Next, methods and tools are selected, whereby similar elements are bundled in fields of activities, which are described in chapter 1.2. Continuing with the previous example a sub-goal to support the general goal - minimization of manufacturing costs - would be the reduction of downtime at the bottleneck machine. In order to detect major problems, an analysis of reasons for machine failure is conducted using a failure list as a tool.

Two aspects should be taken into account during the configuration of a LPS for SMEs. On the one hand, entrepreneurs need support for the selection of adequate methods and tools. The selection should not only reflect the specific goals of SMEs, but also consider their capabilities and resources, Kuhn *et al* (2006). This is especially true since, normally, SMEs

cannot afford to use trial-and-error-procedures without endangering their existence, Herrmann *et al* (2006). In order to overcome problems caused by a lack of knowledge of methods and tools, the use of external expertise might again be reasonable. On the other hand, there is a need to adjust methods and tools to requirements of SMEs, Lay *et al* (2008). Basic methods such as teamwork, work standards, methods of 5S housekeeping, and methods of TPM can be successfully applied in SMEs as shown in the research project "ProfiL". These basic methods require minor amount of time and specialized knowledge, support the processes of the enterprise and can be successfully applied in SMEs. Other methods such as kaizen or total quality management require knowledge and experience about the processes of the SMEs and are difficult to implement without excessive effort. On this account methods and tools were evaluated according to criteria of three different categories, i.e. effort for implementation, characteristics of SMEs/ boundary conditions and strategic goals of SMEs. These categories include criteria such as man power effort, knowledge demand, financial resources, qualification and motivation of employees, target position, and minimization of manufacturing costs. This evaluation tool supports the SME entrepreneur by the configuration of its LPS.

### 2.3. Implementation process of the LPS

Based on the implementation process of LPS suggested by Dombrowski et al. (2007a) (similar descriptions of LPS implementation with a different level of detail are given in Spath (2003, 104-109) , Wildemann *et al* (2006) and taking into account the special characteristics of SMEs an implementation process of a LPS for SMEs has been developed in the third module. This process contains seven different phases that are executed consecutively and have sometimes also to be repeated. Figure 2 visualizes this process.

The implementation process typically starts with the awareness (phase 1), when the entrepreneur of the SME learns about success stories of existing LPS. The entrepreneur's frequent contact with entrepreneurs of other SMEs (e.g. in SME networks) provides access to this knowledge. If the entrepreneur decides to pursue the idea of a LPS, the achievable benefits have to be analyzed in detail. Moreover, the integration of the lean principles into the existing strategy is necessary and objectives for the LPS have to be formulated, Dombrowski *et al* (2007b). In this regard, the entrepreneur often has to consult external experts. Simultaneously, all employees of the SME need to be informed about these issues at a very early stage. At the end of this assessment and strategic planning (phase 2) the entrepreneur decides whether to commit to the LPS or to abandon this idea. Next, a central LPS planning and steering team is installed. Generally the team is comprised of the entrepreneur, employees with lead positions (e.g. executive producer) and possibly external experts. This team is responsible for the conceptual design of the LPS and determines the sub-goals, fields of activities of the LPS and also the methods and tools to be used. Since many SMEs lack LPS knowledge, the central planning and steering team is, if possible, supported by external experts. At the end of this phase the LPS design is adopted. Once the conceptual design has been agreed on (phase 3), the central planning team also devises a master and detail plan for the implementation and plans necessary organizational changes. The master and detail plan provides milestones, comprises workshops and training courses, specifies the implementation on a local scale, and plans the utilization of resources. These activities are part of the LPS implementation planning (phase 4). In this phase implementation teams are installed. Employees with lead positions and shop-floor employees constitute the implementation teams that account for the implementation of the tangible measures (methods and tools). The decision on the tangible measures marks the end of this phase. Following these basic planning and set-up activities, which are centralized, the decentralized roll-out starts with a pilot

project phase (phase 5). During the pilot phase the implementation teams are testing new methods and tools in selected sectors of the SME. With the experiences gained in these project modules the implementation in the whole SME is less risky. The success of the implementation of the new methods and tools will only be possible once the entrepreneur gets all involved employees on board, Dombrowski et al. (2007c). Newly implemented methods can only develop their full potential if the employees accept the processes and utilize the implemented methods. Once a method or tool is successfully implemented, the rollout (phase 6) for this element has been completed.

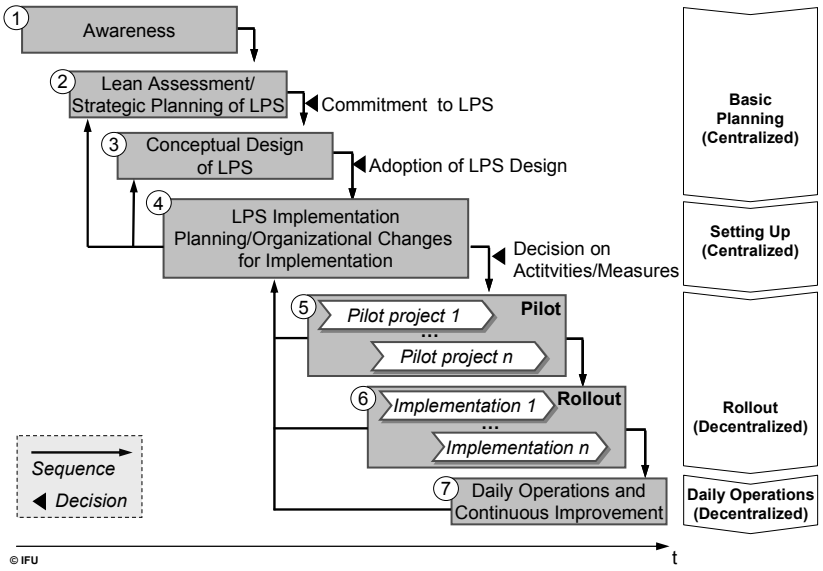


**Figure 2**. Phases in the Implementation Process of a Lean Production System in SMEs

After the transition to the daily operations phase (phase 7) the implemented elements have to be continuously applied and developed in order to ensure continuous improvement. Therefore, during pilot projects, rollout or daily operations, a leap back to the LPS implementation planning phase may occur. Furthermore, if substantial changes in the LPS become necessary changes in the conceptual design might be necessary. This can lead to the repetition of the conceptual design or even the lean assessment phase. Under normal circumstances these iterations also occur, since once in a while it is necessary to review the implementation process and realign the LPS with the strategy of the SME (Module 1) and with the elements of the LPS structure (Module 2). An implementation can take 5-10 years, not taking into consideration the continuous enhancement that persists for decades, Oeltjenbruns (2000, pages 213-237).

## 2.4. Qualification Framework

During the different phases of the LPS implementation process, knowledge is handled and qualification activities are necessary by all means, Dombrowski (2007a). The qualification framework presented here contains three different phases. Phase 1 contains two steps. First of all, the existing specialized knowledge about lean methods and tools currently available in the SME will be examined by using a standardized questionnaire and conducting interviews with the entrepreneur and employees of the SME. Additionally, the state of implementation that has been reached regarding already known methods will be analyzed. Secondly a qualification matrix will be utilized as an effective tool to evaluate and track the progress and qualification level of each employee. In this matrix each employee's capabilities are represented and

placed. The result of the first phase of this qualification concept is an effective and well-founded description of the qualification level of the entire enterprise.

The aforementioned qualification level is a requirement for the next phase in which a knowledge profile of the SME will be developed. The need for specific knowledge regarding different methods constitutes the knowledge requirements for a LPS implementation and therefore gives a hint on the knowledge that has to be available in the enterprise, i.e. the entrepreneur and employees. The knowledge profile contains the previously developed qualification level, the knowledge requirements for specific methods, as well as a strategic commitment which links the qualification concept and the strategic planning of the SME. In case of the research project "ProfiL" the knowledge profile had been developed with the support of external experts. In general SMEs need to be assisted with the creation of its knowledge profile.

The first element of the third phase is a "workshop-house" that contains a catalogue of workshops of Lean Production methods. This "workshop-house" should support the transfer of basic knowledge about methods to employees, specialized knowledge to the entrepreneur during the basic planning phase as well as essential knowledge for the operative implementation of these methods to the implementing teams during the rollout phase. The second element of the third phase presents various ways to impart the required knowledge (e.g. frontal experts-training, cascade-training, and method-adoption by the worker). Experts in the field of Lean Production impart knowledge about LPS implementation, methods and tools in several workshops directly to the employees and the entrepreneur. This approach represents the so-called frontal experts-training and can be used at the beginning of the LPS implementation process during the basic planning and setting up phases to start the process right. The cascade-training (cascade means in this context that the information transfer and the impartment of knowledge happens in a top down way) consists firstly of a frontal experts-training for the entrepreneur and employees with lead positions (e.g. the central LPS planning and steering team by the LPS implementation). Secondly, the entrepreneur and the employees are responsible for the transfer of this acquired knowledge to other employees later on. This approach should be particularly used during the rollout phase of the LPS implementation. The willingness and will of the employees to support the LPS implementation can also be increased by using the "method-adoption by a worker" approach. By implementing this approach entrepreneurs or employees will be qualified as experts in specific subject areas (in this case methods and tools of Lean Production), Dombrowski *et al* (2003). They will be named as "mentor" of the method or tool and are also primarily responsible for the implementation in the SME. Furthermore, they should constantly analize the application of the method during the rollout and daily operation phase, looking for ways to improve the use of materials, machines and manpower and encouraging the employees to develop continuous improvement in thinking and action.

### 2.5. Control and Evaluation

The fifth module comprises a concept which supports the SME's entrepreneur to control, evaluate and manage the operational and strategical development of the SME by the implementation of a LPS. A SME specific balanced scorecard for the evaluation of the benefits based on key performance indicators (KPIs) has been developed. It is essential to choose a sensible set of KPI that shows direct linkage to the production process, can be influenced by the LPS implementation process and is easy to quantify on a daily basis. These KPI measure the achievement of the strategic goals of the SME that have been defined in the four typically "perspectives" of a BSC that are labeled "Financial", "Customer", "Internal

Business Processes", and "Learning & Growth". Designing the specific balanced scorecard (BSC) for the SME requires selecting three or four good KPI for each perspective. The BSC identifies and visualizes deviations of the acutal state from the planned stated. If deviations occur the execution of adaptive actions needs to be ensured by escalation management, which should be defined before the implementation process is started, Dombrowski et. al (2008). Adaptive actions include the adaptation of implementation plans. While for the design of a SME specific balanced scorecard a methodology has been developed in the research project "ProfiL", further research need to be conducted to develop and enhance a method for the evaluation.

## 3. Summary

This paper has addressed the need for a holistic approach to implement a LPS in SMEs. The first module presents the development of the future state vision of the company, its philosophy, its production strategy and the deduction of the strategic goals as well as the process of linking these strategic goals with the general goals in the LPS structure. The structure of the LPS will be configured in the second module. Here, sub-goals, methods and tools will be defined and selected. The third module comprises the actual LPS implementation. For the development and design of a LPS implementation process the special characteristics of the SME must be taken into consideration. This process contains seven different phases that are executed consecutively. In addition a well-structured qualification framework to support the LPS implementation in SMEs is essential part of module four. This framework considers the need for specialized knowledge about the lean philosophy and methods as well as the current qualification level of the entrepreneur and employees of the SME. Finally the fifth module supports the entrepreneur to control, evaluate and manage the operational and strategical development of the SME by the implementation of a LPS. As a result, SMEs, too, might utilize the advantages and potencials holistics approaches offer. Furthermore, the experience gained by using these approach in the research project "ProfiL" is extremly positive.

## References


Behringer, S. (2004). *Unternehmensbewertung der Mittel- und Kleinbetriebe*. Erich Schmidt.

Cochran, D.S. (1999). "The Production System Design and Deployment Framework". *SAE Technical*, pp 1-9.

Commission of the European Communities (2005). *European Commission Staff Working Paper, concerning the activities of the European Union for small and medium-sized enterprises (SMEs)*. SEC 170.

Dombrowski, U.; Crespo, I.; Schmidt, S. (2007b). "A Holistic Approach to Production Optimization as an Integral Part of Strategy Development and Implementation in SMEs". *Proceedings of the 40th CIRP International Manufacturing Systems Seminar*, pp 253-259.

Dombrowski, U.; Palluck, M.; Schmidt, S. (2006). "Strukturelle Analyse Ganzheitlicher Produktionssysteme". *ZWF*, 101:113-118.

Dombrowski, U.; Quack, S. (2007c). "Erfolgreiche Restrukturierungsprojekte durch Mitarbeiterpartizipation". *ZWF*, 102:568-571.

Dombrowski, U.; Schmidt S. (2008). “Planung und Steuerung der Implementierung Ganzheitlicher Produktionssysteme“. *Wt Werkstattstechnik online*, 98(4):236-241.

Dombrowski, U.; Schmidt, S.; Crespo, I. (2007a). “Knowledge Management as a Supporting Function Lean Production System Implementation”. *Proceedings of the 2nd International Conference on Changeable, Agile, Reconfigurable and Virtual Production*, pp 453-462.

Dombrowski, U.; Tiedemann, H.; Bothe, T. (2003). “Mitarbeiterbildung als strategischer Wettbewerbsfaktor, Further education and training employees as a strategic competitive factor”. *BFT Betonwerk und Fertigteil-Technik*, 4:6-14.

Herrmann, C.; Bergmann, L.; Crespo, I. (2006). “Developing of an Integrated Modernization Concept for SMEs”. *Proceedings of the 39th CIRP International Seminar on Manufacturing Systems*, pp 457-463.

Korge, A. (2005). „Lean Management mit System“. *wt Werkstattstechnik online*, 95:29-34.

Kuhn, S.; Elzenheimer, J. (2006). “Gezielter Methodeneinsatz im Mittelstand*“. VDI-Zeitschrift*, 6:86-89.

Lay, G.; Zanker, C. (2008). “Planungsinstrumente zur Verwirklichung Ganzheitlicher Produktionssysteme in KMU“. *wt Werkstattstechnik online*, 98:242-248.

Liker, J.K.; Meier, D. (2006). *The Toyota Way Fieldbook: A Practical Guide for Implementing, Toyota´s 4Ps*. McGraw-Hill.

Observatory of European SMEs 2003 (2003). *Report No.8: Highlights from the 2003 Observatory*. Enterprise publications.

Oeltjenbruns H. (2000). *Organisation der Produktion nach dem Vorbild Toyotas*. Shaker.

Ohno, T. (1998). *Toyota Production System: Beyond large scale production*. Productivity Press.

Schneider, H. (2000). *Produktionsmanagement in kleinen und mittleren Unternehmen*. Schäffer-Poeschel.

Spath, D. (2003). *Ganzheitlich produzieren: Innovative Organisation und Führung*. Log_X.

Spear, S.; Bowen, H.K. (1999). “Decoding the DNA of the Toyota Production System”. *Harvard Business Review*, 97:97-106.

Welter, F., (2003). *Strategien, KMU und Umfeld*. Duncker & Humblot.

Wildemann H.; Baumgärtner G. (2006). “Suche nach dem eigenen Weg: Individuelle Einführungskonzepte für schlanke Produktionssysteme”. *Zeitschrift für wirtschaftlichen Fabrikbetrieb*, 101(10):546-552.

Womack, J.P., Jones, D.T. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Simon & Schuster.

Zahn, E., Huber-Hoffmann, M. (1995). *Die Produktion als Wettbewerbskraft: Produktion als Wettbewerbsfaktor*. Beiträge zur Wettbewerbs- und Produktionsstrategie, pp 134-155. Gabler.