GLOBAL MANUFACTURING – CHALLENGES AND SOLUTIONS

Hans-Peter Wiendahl
Institut für Fabrikanlagen und Logistik
Leibniz Universität Hannover, Germanyr
wiendahl@ifa.uni-hannover.de

The design and the operation of global supply chains has become a new challenge for many production enterprises, additional to the existing problems in everyday practice.
However, with increasing success followed up by growth the weak points often show up in the order execution process. This becomes apparent in a bad delivery performance, increasing inventories and frequent special actions.
The consequences are that the essential business processes, product design, process design, production and order fulfillment must be reviewed in a comprehensive cooperative process.
The classical single step order partially turns around due to the market priority of fulfilling customer wishes within short delivery times. Local optimization in a single enterprise can even be counterproductive.
The requirements for products, processes, production equipment and logistics in global supply chains require pliable solutions. These solutions have to take into account costs for material and added values at the respective production place, local conditions concerning knowledge and local content, currency relations between production locations and markets, commercial law terms, as well as protection from imitation.
The paper describes the challenge more from a scenario point of view, giving first solutions from industrial practice and formulating new fields of research in the production science.

1. PITFALLS IN GLOBAL SUPPLY CHAINS

The operation of global supply chains is a new challenge for many manufacturing companies. This does not only apply to the automobile industry and its suppliers but meanwhile also to medium-sized enterprises which serve international markets with high-quality special products.

With increasing success and the growth connected with it, weak points frequently appear in the order handling. Bad delivery performance and frequent special actions are typical. The main reasons are the wrong planning methods besides the bad customers and supplier connections, the use of insufficient control models, bad forecast quality, and missing logistic monitoring. In the operative phase too little attention is given on a consistent target system for punctuality, inventory, utilization, and delivery time. Also, regular checks of the planning parameters, such as plan lead time, lot sizes, and capacity are not being performed (Wiendahl et al. 2005).

Since global supply chains are naturally subject to quick changes, further weaknesses show up in the design of the products with regard to the variants. The manufacturing and assembly processes are inflexible at larger quantity changes.

In the past product development and order handling were regarded as primary processes whereas the order fulfilment and distribution were seen more as auxiliary functions. But nowadays the reliable delivery has a highest priority in globally distributing markets. This priority has to subordinate the development of the products, processes and production facilities to logistics.

The new requirements can be summarized in the following points:

- The arrangement of business processes and supply chains must be primarily carried out from the view of the market demand distributed globally.
- Instead of central factories with high production depth close to the market, adaptable and perhaps temporary production units are required.
- The production logistics must act in harmony with the purchasing and distribution logistics.
- Different order types in the same factory must be mastered with different planning and control procedures within the same planning system.
- Product structures must quickly adapt to the changing requirements of an internationally distributed production.
- Production and assembly methods must take into account local points of view with regard to know-how, labour costs and local-content regulations.

2. UNDERSTANDING THE SUPPLY CHAIN

The design of global supply chains follows a systematic procedure, the main rules of which are:

Supply Chain is a customer-oriented and value increasing design, planning and control of the global enterprise network for the processes “customer order to payment receipt” and “supply order to payment”. It follows the principles integral, process-oriented, simply, transparent and time-optimized based on standards, and summarizes the responsibility for all material, information and value streams for the fulfilment of the customer orders (Nyhuis, 2006).

As an example for the purchase process altogether 6 models were defined based on the SCOR model, figure 1.

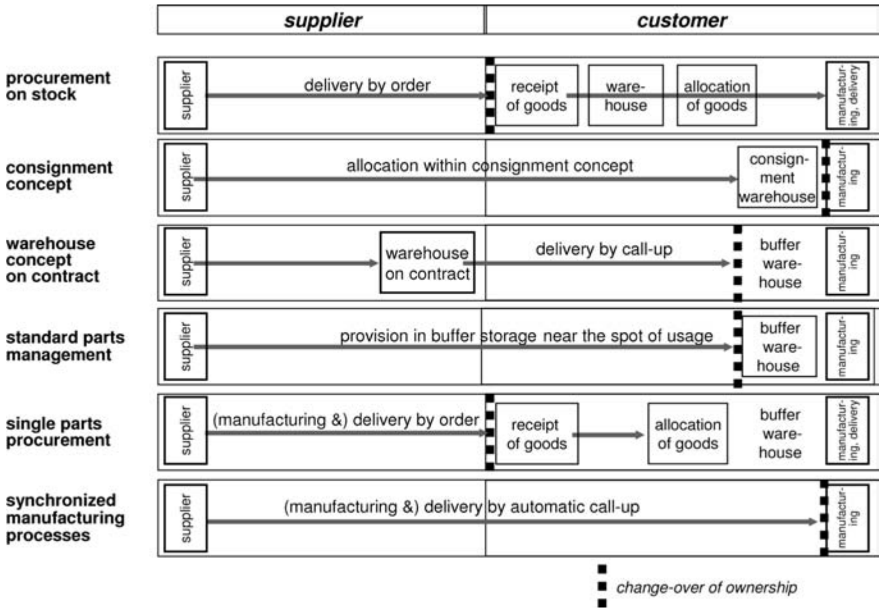

Figure 1 - Standard Procurement Models (SIEMENS AG).

Figure 1 starts with the classical individual procurement on stock, consumption near stocks such as the consignment concept and standard part management, then followed up by the automated call concept of the synchronous production. The aim is to minimize the inventory risk of the buyer at a maximum supply safety.

Models were also defined in the same way for the production process. The division defined originally by the company Philips has largely proved itself into three order types.

On the one hand it is distinguished, whether it is a series product or custom designed product and on the other hand whether a specific engineering effort is still required. The case "engineer to order" is typical of the machines and facility industry. A real supply chain in the classic meaning does not exist in the case of engineered orders because it is either a single or even a unique product. The two other cases "make to stock" and "make to order" are the standard cases in practice.

A producer would ideally like to manufacture and store (make to stock) finished products as little as possible because of the obsolescence risk and the capital binding. But if he makes the product only when an order arrives (make to order), the internal lead time is usually too long compared with the desired delivery time figure 2 illustrates such a case at the example of a multistage product on the left side. The overall lead time (here called replenishment time) is considerably longer than the usual market delivery time.

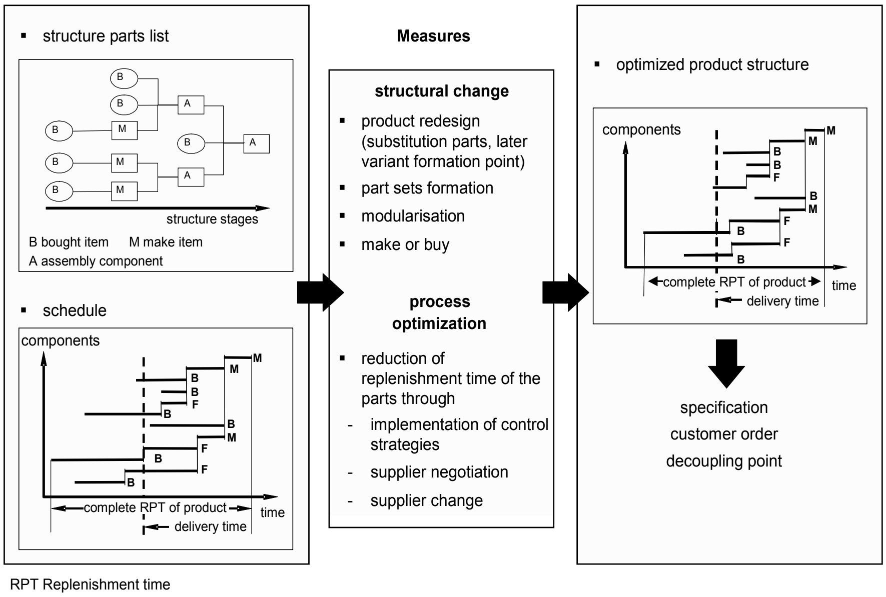

Figure 2 - Optimisation of a product structure (Nyhuis, 2006).

As a first step in order to solve that problem the number of stages of the product would be reduced and modules would be used. In the second step the transition time of the components would be lowered by optimization of the plan lead times and lot sizes or by negotiation with suppliers. These measures often do not suffice however, and a subdivision of the product must be carried out into order-neutral and order-specific components. This takes place at the so-called variant decoupling point.

In such a case far-reaching design considerations are required for the products in a global supply chain. One will often try to manufacture the order neutral components with a high automation level at the home place while the order-specific additions are configured as closely to the market as possible in short time to the desired end product.

An impressive example of such an approach is a module system developed by the company Sartorius in Göttingen for laboratory scales. The central component consists of the so-called monolith; it replaces the previous lever construction by one single work piece which is milled from an aluminium block. Figure 3 compares the old and the new design. It was possible to reduce the number of parts for the whole system by 27%. Based on this component manufactured in Göttingen and completed to a measuring cell it is possible to offer very different scales in the design and in the application.

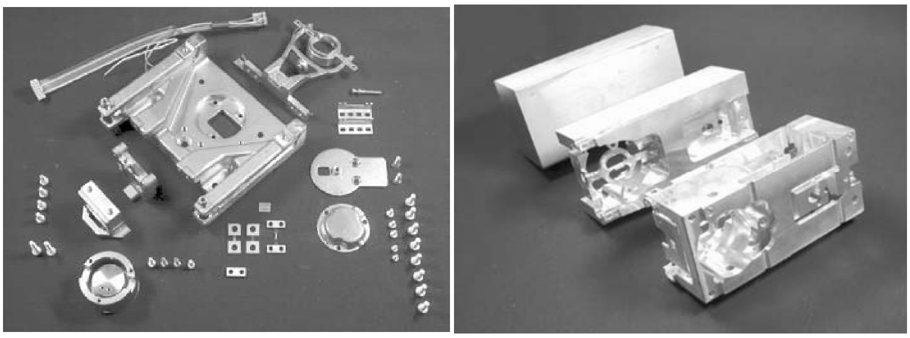

Figure 3 - Example of a product re-design (Sartorius AG).

The following logistics oriented design rules for products are suitable in global supply chains:

- Apply as few as possible product stages.
- Avoid long delivery times in low product stages.
- Create variants in product stages as high as possible.
- Separate the product into subcomponents with high and low wage share.
- Develop modules and platforms
- Consider technical copy protection

3. CHANGEABILITY ENABLERS OF SUPPLY CHAINS

As a next step after the redesign of the product it has to be looked at the manufacturing and assembly systems, and even at of the entire factory and its operative control. Because of the various influences from product design and market requirements, new technologies as well as currency and trade regulations it is no longer possible to fix a stable product range in the long run. The mandatory conclusion arises that the more unsafe the forecast is the more adaptable a production site must be. An exhibition hall in which heterogeneous events like a machine tool fair, a consumer goods fair, or a rock concert take place can be regarded as a vision of a highly adaptable factory.

The capital expenditure connected to such an approach can usually not be provided by a manufacturing company. However, it has been very successful to pay attention to the so called changeability enablers (Wiendahl 2002).

The outstanding enabler is modularity. A modular design allows a high rate of reuse for all objects of the supply chain and at all levels in different applications. The changeability quality of an object is further marked by its universality to accomplish different tasks. For example, the laser beam is universal for the production of metal parts unlike a form-bound punch die. Scalability permits extending or reducing the output of a resource economically, by e.g. a flexible working schedule. As the fourth enabler the mobility of a resource allows shifting quickly both within a site and between production sites. Mobility requires a self-supporting construction without foundations and a quick dismantling and refurbishing into standard transport units. Finally, the compatibility of machinery and also standardized interfaces of software secure the fast networking of facilities (Koren 2005).

These enabling features generally do require additional costs compared with conventional non-changeable solutions. However, these costs are frequently overestimated because also the manufacturers follow a similar strategy to be able to adapt their products to the special customer wishes. The additional costs contrast with the increased changeability in form of shorter downtimes. In any case it is rewarding at every new investment – is it production or logistics facilities, a building or software – these five enablers should be questioned systematically for every object (Wiendahl Heger 2004).

Some examples of adaptable facilities are introduced to production, assembly, and at factory level in the following which shall serve as a suggestion for projects of their own.

Manufacturing

In the production one has always tried to reuse production components as much as possible by a far-reaching application of modules. This reduces the design effort, decreases the functional risk and shortens the delivery time. In the context of the order handling in a supply chain, however, not only pure technical aspects have to be included. Figure 4 shows a systematic approach which starts out from the idea of a production module completely able to work autonomously (Drabow 2006).

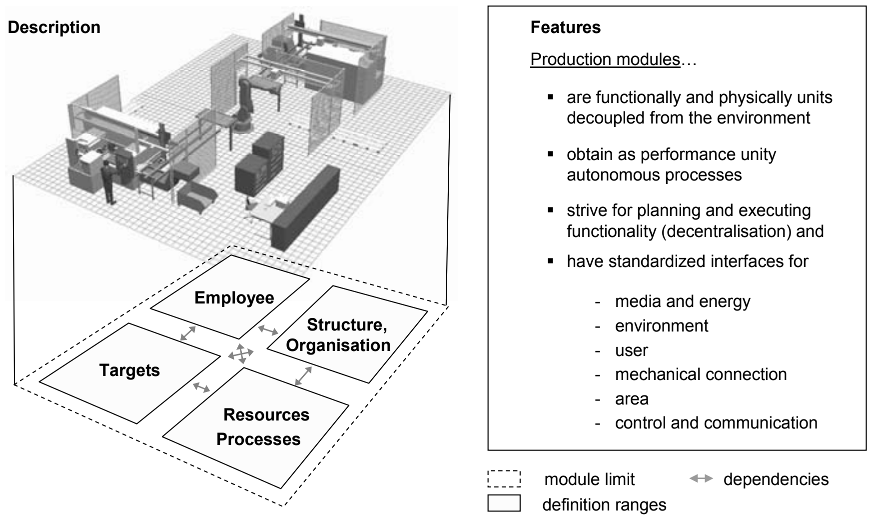

Figure 4 - Definition of production modules (Drabow, 2006).

Besides the real resources for the fulfilment of a process it is also looked at the targets, employees, as well as the inner module structure and the connection to the superior organization. The listed qualities of production modules in the figure make obvious, that the approach has great similarity to the concept of segments, holons or fractals. However, the depicted module aims at allowing a fast reconfiguration to whole production systems on the shop floor level.

An interface definition which permits a computer-aided design and quick reconfiguration of production systems is therefore included. Special interface types have been developed which include soluble interfaces for a quick reconfiguration besides the "classical" ones. Those soluble interfaces correspond with the changeability enabler "compatibility". Altogether, the approach is not unproblematic because the interfaces need a high precision and stiffness. This means noticeable additional expenses. And the manufacturer must guarantee a long-standing subsequent delivery of single modules.

Assembly

The mentioned problems of reconfigurable production systems are by far not as serious at assembly systems because the supplier industry offers modular scalable and mobile assembly systems for many years already.

For the application in global supply chains the changeability qualities of assembly systems still must be enlarged regarding the degree of automation. It is then possible, depending on the location of the assembly, to change the deployment of personnel. These so-called hybrid assembly systems combine automatic stations with manual stations. With respect to diversity of variants, productivity, and flexibility they are positioned between the manual assembly and automated assembly system (Lotter, 2006).

Figure 5 shows an example of such an assembly module with one assembly operator being employed. His activities are supplemented by three automatic stations for impressing, grease, and final test. The system is highly economic because the share of non value adding so-called secondary operations can be reduced to a minimum.

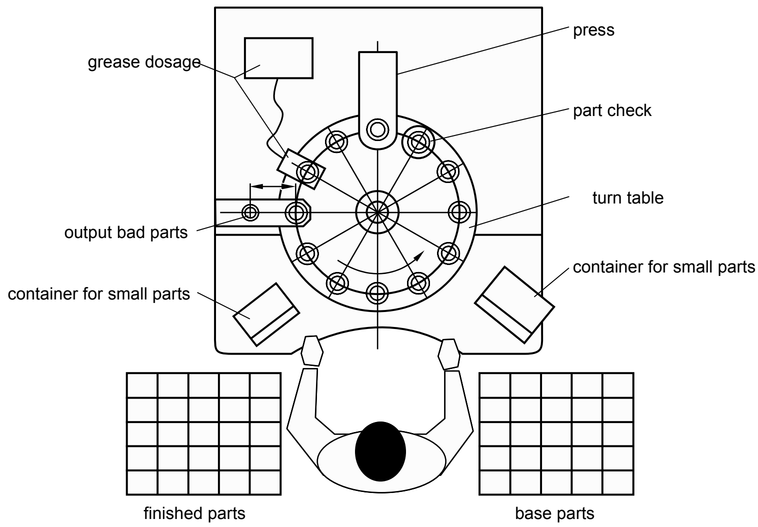

Figure 5 - Hybrid assembly system with turn table (Lotter, 2006).

A special advantage lies in the scalability of the system. This permits an expandable output in little steps which is achieved on the one hand by the automation of single operations and on the other hand by the combination of several modules to a system. Figure 6 shows the rough layout of the system. (Lotter, 2006).

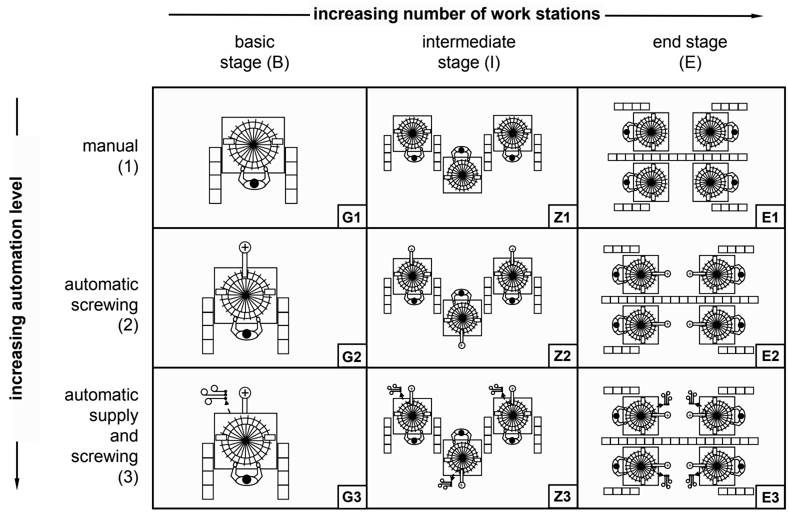

Figure 6 - Construction stages of an assembly system (Lotter, 2006).

In the basic stage B1 the complete pre and final assembly is carried out at an individual assembly table by hand. Automatic system stations are provided merely for the press fitting operation. In a first step, the screws are inserted automatically at the automated stages, see case B2. At the following construction stage G3 the supplying of the screws is automated with vibration bowl feeder's at all rotary work piece holders. The individual pre-assemblies and the final assembly spread out on three assembly tables in the intermediate construction stages I1 to I3. And the assembly spreads out with increasing volume to be produced on four individual assembly tables in the end stages E1 to E3.

The pure assembly costs of an automated system were compared with a modular hybrid assembly system in a specific example (Lotter, 2006). A quantity range had to be covered between 1,000 and 10,000 products per day. Target costs of EUR 0.21 per piece were predefined. Figure 7 shows the corresponding cost curves which reveal that the assembly automat reaches the target costs of the modular system only at a production rate of 6,000 to 9,500 pieces per day whereas considerable additional costs of the automatic system can be expected below these quantities.

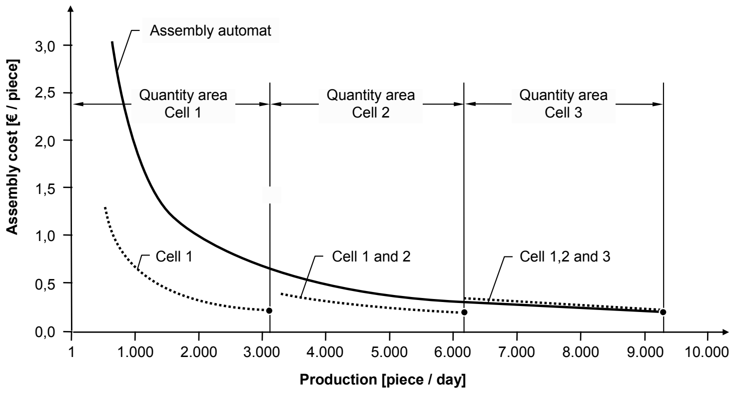

Figure 7 - Assembly cost comparison automated vs. hybrid cells.

In addition, a noticeable employment effect is connected with the cell solution, because 2 workers are employed per cell and shift.

Such concepts are therefore particularly suitable for quickly variable products and quantities because:

- the investment is considerably lower compared with an automated system designed for the final quantity,
- the risk of a bad investment is lower as well,
- the assembly unit costs are already in the target area of a final construction stage with use of the first construction stage,
- in the context of the actual development of the demand the development can gradually be carried out and
- single assembly cells can be used differently at decline in the demand.

4. PARADIGM OF THE GLOBAL PRODUCTION SYSTEM

The outlined problems and examples are far away from a closed system approach and do not lay the claim of a complete scientific penetration of the global production. The effect on the real operative control of such supply chains and the optimization connected to that was not treated. For example questions of an adequate training of the employees planning as well as the consideration of an adequate technical copy protection still have to be deepened.

A combined project called "global variant production system", short GVP, supported by the BMBF (German Ministry of Education and Research) therefore investigates the systematic penetration of these and broader problems with 6 companies and 2 research institutes being involved (GVP 2006). The goal is the development and proof testing of a highly flexible production system for high-quality mechatronic products which are producible manually or automated in variable quantities and in high a diversity of variants at different global locations. Figure 8 shows the project structure.

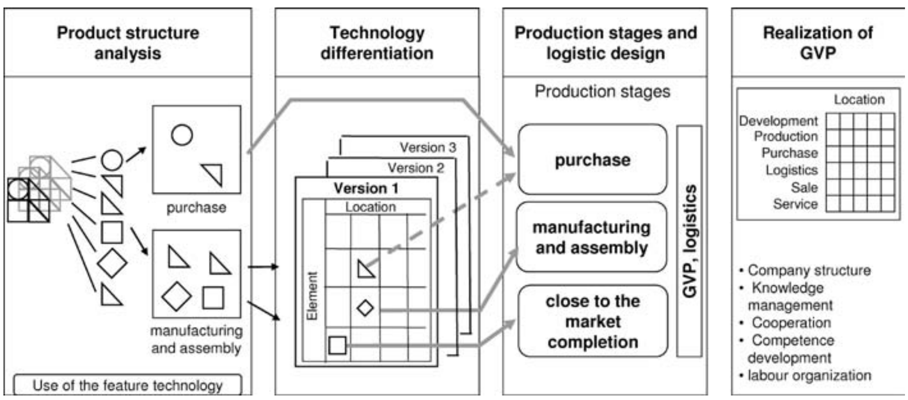

Figure 8 - The global variant production system GVP.

5. CONCLUSION

The explanations about the consequences of global supply chains have shown that for technical products the essential business processes product construction, process design, production and order fulfilment must be reviewed in a cooperative process starting with the customer order fulfilment at the highest priority. The requirements on products, processes, production facilities, and logistics in global supply chains require adaptable solutions under consideration of:

- costs for material and creation of value of the respective production place,
- local conditions with regard to know how and local content,
- currency relations between production locations and markets,
- boundary conditions referring to commercial law as well as
- technical copy protection.

Furthermore it is clear, that the quick and nevertheless economic change ability of all required resources is an important conducting principle.

6. REFERENCES

1. Drabow, G.: Modulare Gestaltung und ganzheitliche Bewertung wandlungsfähiger Fertigungssysteme.
2. Diss. Universität Hannover 2006
3. GVP Globales Varianten-Produktions-System: http://www.gvp-projekt.de/. Read out July 12, 2006
4. Koren, Y.: Reconfigurable Manufacturing and Beyond (Keynote Paper). In: Proceedings 3rd International CIRP Conference on Reconfigurable Manufacturing, University of Michigan, Ann Arbor, Michigan, 11.05.2005, p. 1-6
5. Lotter, E.: Hybride Montagesysteme. In: Lotter, B. u. Wiendahl H.-P. (Hrsg.) Montage in der industriellen Produktion. Ein Handbuch für die Praxis. Springer Verlag 2006
6. Nyhuis, P.: Gestaltung und Betrieb von Logistiksystemen. In: Executive MBA in Technologie-management und Logistik St. Gallen 09.01. – 13.01. 2006
7. Wiendahl, H.-H.; Cieminski G. von; Wiendahl, H.-P.: Stumbling blocks of PPC: Towards the holistic configuration of PPC-Systems. Production Planning & Control, Vol. 16, No. 7, October 2005, 634-651
8. Wiendahl, H.-P.; Heger, C.L.: Justifying Changeability – A Methodical Approach to Achieving Cost Effectiveness. In: The International Journal For Manufacturing Science & Production, Vol. 6, No. 1/2, 2004, p. 33-39
9. Wiendahl, H.-P.: Wandlungsfähigkeit – Schlüsselbegriff der zukunftsfähigen Fabrik. In: wt Werkstatttstechik online, Jahrg. 92, Nr. 4, 2002, S. 122-127

http://www.springer.com/978-0-387-49863-8

Digital Enterprise Technology
Perspectives and Future Challenges
Cunha, P.F.; Maropoulos, P.G. (Eds.)
2007, XVIII, 593 p. 325 illus., Hardcover
ISBN: 978-0-387-49863-8