

5 Customer Driven Manufacturing Versus Mass Customization

Comparing system design principles for mass customization and (traditional) customer driven manufacturing

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For the last years the concept of mass customization has gained broad attention within various branches of industry. Mass customization has been identified as a competitive strategy by an increasing number of companies. Accordingly theoretical, technical as well as managerial aspects have been studied aiming at a better understanding of this new paradigm. However, especially in Europe there is a long tradition of designing and manufacturing customer specific products such as machinery, ships and even cars. For this chapter we have analyzed various industrial cases, consultancy projects as well as research work in the broader field of customer driven manufacturing. We will identify a number of design principles for the appropriate design of customer driven manufacturing systems. Doing so, we will discuss concepts and principles for the design of manufacturing systems delivering a wide range of products and services that meet specific needs of individual customers. Synergies, similarities as well as limitations and potentials of both mass customization and (traditional) customer driven manufacturing will be evaluated.

5.1 Nothing new?

Mass customization (MC) relates to the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs. The concept has emerged in the late 1980s and early 1990s and may be viewed as a natural follow up to processes that have become increasingly flexible and optimized regarding quality and costs. In addition mass customization appears as an alternative to differentiate companies in a highly competitive and segmented market [1]. However, at the same time there is a long tradition especially in Europe in designing and manufacturing customer specific products such as machinery, ships and even cars [2, 3]. Whereas the concept of mass customization mainly addresses the customer in terms of a consumer the concept of customer driven manufacturing addresses mainly the customer in terms of a manufacturer and/or service provider, i.e. the capital goods industry. However, starting from

different perspectives both approaches are aiming at a cost efficient customization (and personalization) of products and services. The objective of this chapter is to present a rough systematic overview of both approaches. The main aim is to support a better understanding of the potentials and the synergies. Synergies, similarities as well as limitations and potentials of both approaches will be discussed.

5.2 Mass customization

Despite the increasing attention Mass customization has been receiving in practice as well as in literature, there is no common understanding about the term. Literature still provides a broad spectrum of definitions. Whereas some authors give a very broad and sometimes very general definition others provide more narrow and practical definitions. In a practical sense mass customization can be seen as an approach that uses information technology, flexible processes, and organizational structures to deliver a wide range of products and services that meet specific needs of individual customers (often defined by a series of options), at a cost near that of mass-produced items [4].

From an economic point of view, implementing mass customization concepts requests a careful determination of the range in which a product or service can be customized efficiently. The level or the levels of individualization of the offered items seem to be critical for an appropriate definition. Pine [5, 6] e.g. suggests five stages of modular production: customized services (standard products are tailored by people in marketing and delivery before they reach customers), embedded customization (standard products can be altered by customers during use), point-of-delivery customization (additional custom work can be done at the point of sale), providing quick response (short time delivery of products), and modular production (standard components can be configured in a wide variety of products and services).

Based on an analysis of existing frameworks to categorize the various levels of customization of a product, Da Silveira et al. [1] propose a set of eight generic levels of mass customization, ranging from pure customization (individually designed products) to pure standardization (see Table 1). Design as level 8 refers to collaborative product development, manufacturing and delivery of products according to individual customer preferences. The next level (Level 7: fabrication) refers to manufacturing of customer-tailored products based on predefined designs. Assembly as level 6 deals with the arranging of modular components into different configurations according to customer orders. On levels 5 and 4, mass customization is achieved by simply adding custom work (e.g. Ikea furniture) or services to standard products (often at the point of delivery). In level 3, MC is provided by alternative approaches for distributing or packaging of products (e.g. different labels and/or box sizes according to specific market segments). In level two, mass customization occurs only after delivery, through products that can be

adapted to different functions or situations. Level 1 refers to pure standardization, a strategy that according to Da Silveira et al. can still be useful in many industrial segments.

Table 1: Generic levels of mass customization [6]

<i>Generic Levels</i>	<i>Approaches by Gilmore/Pine [7]</i>	<i>Strategies by Lampel et al. [8]</i>	<i>Stages by Pine [5]</i>	<i>Types by Spira [9]</i>
(1) <i>Standardization</i>		pure standardization		
(2) <i>Usage</i>	adaptive		embedded customization	
(3) <i>Package & Distribution</i>	cosmetic	segmented standardization		customized packaging
(4) <i>Additional Services</i>			customized services; quick response	providing additional services
(5) <i>Additional Custom Work</i>			point of delivery customiz.	performing add. custom work
(6) <i>Assembly</i>		customized standardization	modular production	unique config. out of standard components
(7) <i>Fabrication</i>		tailored customization		
(8) <i>Design</i>	collaborative, transparent	pure customization		

5.3 Customer driven manufacturing

Apart from mass customization there is a long tradition especially in Europe in designing and manufacturing customer specific products such as machinery, ships, etc. In the following, these approaches of customer driven manufacturing will be evaluated and compared with mass customization in the next section.

5.3.1 Customer order decoupling point

In stable and evolving dynamic markets the product has been classified based on the way its demand, from the manufacturer's perspective, is generated. In other words, the point up to which a customer is involved in the final specification of the product. Based on the ratio between those parts of the manufacturing process which are driven by customer orders and those which are driven by forecasts

according to Wortmann [10] a manufacturing organization's operation can be classified by introducing the notion of the Customer Order Decoupling Point (CODP). The CODP refers to the point in the material flow from where customer-order-driven activities take place (see Figure 1). The customer's influence on the product can range from the definition of some delivery-related product specifications in advanced phases in the product life-cycle (e.g. packaging, transportation) to a modification of the ultimate functions of the product in the very early phases (e.g. customer-related product specifications).

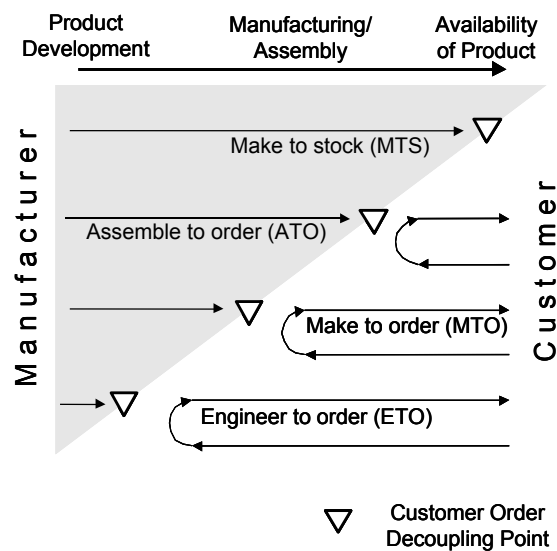


Figure 1: Typology of customer order decoupling point (CODP)

Make-to-stock (MTS): MTS typifies the manufacture of products based on a familiar and relatively predictable demand mix, where product life cycles are reasonably long and stable. In an MTS organization, a stock of finished products is maintained, from which customer orders are filled. Interaction with the customer is minimal and the production volume of each sales unit is high. Whilst an MTS system offers quick product delivery times, disadvantages of this system include high inventory costs and minimal customer interaction.

Assemble-to-order (ATO): ATO organizations maintain a stock of semi-finished products, so that following receipt of an order for a particular configuration, the relevant sub-assemblies can be assembled. In the ATO environment, the same core assemblies are generally used for the majority of products. Furthermore, whilst product routing is fixed, product delivery time is of relatively short length and is based on the availability of major subassemblies. A typical example of this type of manufacturing is that of personal computers.

Make-to-order (MTO): MTO organizations maintain a stock of standard components, so that following the receipt of an order for a particular design; the product is manufactured from these components. Whilst the product is not specified until a customer order is received, finished products from this system are partially one of a kind, but not pure one of a kind because the final product is not usually designed from a particular specification. Interaction with the customer is extensive and is based on sales and engineering. Product delivery times range from medium to long, whilst promises for completion of orders are based on the available capacity in manufacturing and engineering. The manufacture of machine tools and many capital goods are examples of this type of MTO manufacturing.

Engineer-to-order (ETO): ETO represents an extension of the MTO system, with the major difference being that the engineering design of the product is almost totally based on customer specifications. Customer interaction is greater and true one of a kind products are engineered to order. Figure 2 indicates potential customer driven activities in order processing in the capital goods industry.

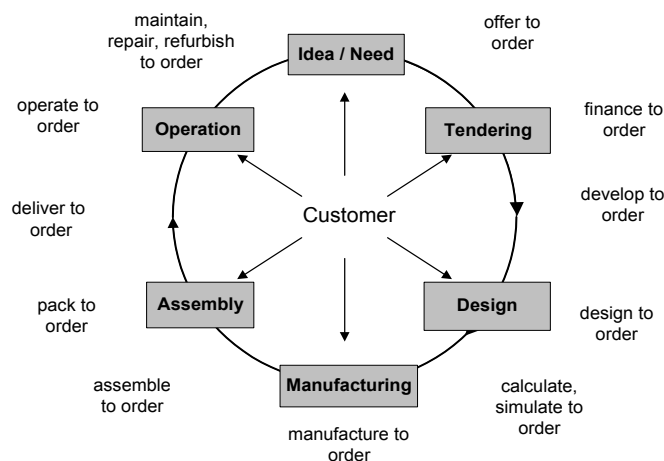


Figure 2: Potential customer driven activities in engineer-to-order (ETO) environments

5.3.2 Typology of production situations

Apart from the CODP, Wortmann proposes a second concept which is important in understanding customer-driven manufacturing. The second concept is concerned with the amount of investment made in developing products, production processes or specific resources independently of the customer order (see Table 2). According to this concept a company can be called *resource-oriented* or *capability-oriented* if it has invested substantially in resources (human, machinery, etc.) but not in specific processes or even products (independently of a particular customer order). A company is *product-oriented* if it has made substantial

investments in product development independently of any specific customer order. Quite often, a product-oriented company has also invested in resources.

In addition a company is *process-oriented* or *work-flow-oriented* if it has made substantial investments in production process development independently of customer orders. Quite often, a process-oriented company has also invested in resources. As there are also companies which are both product-oriented and process-oriented, the three concepts used in this dimension are not mutually exclusive.

Table 2: Typology of production situations [10]

	<i>Engineer-to-order</i>	<i>Make-to-order</i>	<i>Assemble-to-order</i>
<i>Product-oriented</i>	Packaging machines	Machine tools	Medical systems
<i>Process-oriented</i>	Printing	Fine paper	Service industries
<i>Resource-oriented</i>	Ship building	Repair shop	Construction company

A few examples are given in the following to illustrate the concepts. An aircraft-manufacturing company has invested billions of dollars in developing products without having a customer order. Nevertheless companies manufacturing aircrafts are able and usually have to add some customer driven engineering to each individual aircraft sold to a customer. Therefore, an aircraft company can be categorized as a *product-oriented engineer-to-order company*. The same is often true for companies producing packaging machines or other machinery systems. The production situation is different for most of the aerospace companies producing satellites. According to the requirements most of the satellites are built completely to a customer's order. However, satellites are built by companies being able to develop, manufacture and assemble customized satellites right the first time. Such companies can be categorized as *resource-oriented engineer-to-order* companies. The same holds as well for shipyards building ferries or cruise-liners.

Finally, consider a printing company specializing in weeklies. Suppose that this company subcontracts all the work to other companies, but that it standardizes and organizes the flow of work. Thus, the company has invested in quality control, logistics and in blanket contracts with other specialized companies. At least such a company might be able to subcontract not only the detailed layout and all related preparatory work, but also the printing and finishing and even the distribution of these weeklies. This company can be categorized as a process-oriented or work-flow-oriented engineer-to-order company.

5.4 Comparing mass customization and customer driven manufacturing

5.4.1 The origins

The concept of mass customization (MC) as well as the concept of customer driven manufacturing (CdM) originates from traditional manufacturing paradigms. Whereas the concept of mass customization originates from the mass production paradigm (MPP), the concept of customer driven manufacturing originates from the one-of-a-kind production (OKP) paradigm [2, 3]. However, today both underlying approaches i.e. MP as well as OKP are facing tremendous pressures: Customers are no more interested neither in buying standardized products nor in paying premium prices for customized products or even customized product features. Table 3 gives a first overview of the differences between MC and CdM.

Table 3: Mass customization vs. customer driven manufacturing

	<i>Mass Customization</i>	<i>Customer driven Manufacturing</i>
<i>Complexity of product</i>	low (usually commodities)	high (usually capital goods)
<i>Level of customization of product</i>	low to medium (often restricted to limited variety of configurations / product types)	high to very high (what the customer wants is what he get)
<i>Integration of customer into order processing</i>	usually low	usually high (often fully integrated)
<i>Type of customer addressed</i>	usually consumer	usually suppliers, service providers, etc.

Figure 3 depicts a diagram considering product variety on the one axis and process stability on the other axis can be used to classify the various approaches. Whereas MP can be characterized by a high process stability (i.e. no changes, no modifications are needed during order processing) and a low product variety (in extreme cases there are no variants), the potential of OKP can be characterized by high product variety and low process stability (product specifications as well as process specifications are changing from order to order), (see Figure 3a & b).

As the stability and the smooth operation of a production process is a prerequisite for cost efficiency the MC approach tries to keep the stability of the process but to increase the variety of products (see Figure 3c). To pursue these seemingly excluding goals has become possible, since modern manufacturing and information technologies offer the ability to companies to deliver a certain range of products and services that meet even the needs of individual customers at a cost near that of mass-produced items. Whereas MC mainly addresses the customer in terms of a consumer the concept of customer driven manufacturing addresses

mainly the customer in terms of a manufacturer and/or service provider, i.e. the capital goods industry. Originating from customized production approaches CdM is aiming at an increase in process stability without a decrease in the variety of the products to be offered to the customers.

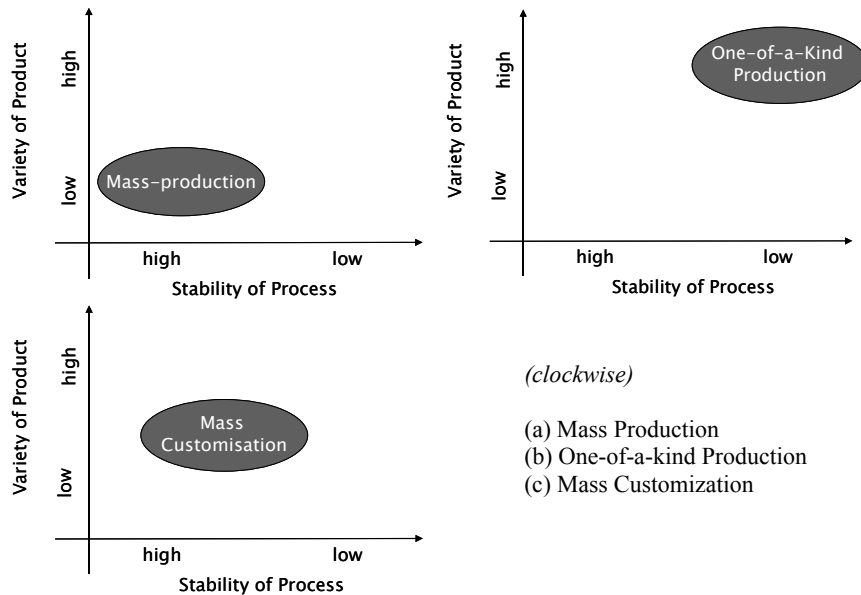


Figure 3: Product variety versus process stability

5.4.2 Common objectives

Starting from different perspectives both approaches do have a common objectives in cost efficient customization (and personalization) of products and services. Using the concept of the customer order decoupling point (CODP) the different starting points of both approaches become obvious (see Figure 4). As discussed above in Table 1 the main focus of MC so far is on ATO (Assemble-to-order) and MTO (Make-to-order). The Engineer-to-order (ETO) approach so far is not realized in practice or - if implemented - restricted to the customer driven variation of single and predefined product features.

Figure 5 depicts a set steps or even changes to undergo for a mass-producer as well as for a one-of-a-kind manufacturer to become a mass-customizing company. By increasing the customer focus through the implementation of the proposed changes a mass producer has to take care of his cost-advantages. Losing the cost-advantages and failing in achieving an increased customer focus leads to a critical situation for a company. By improving the cost focus a one-of-a-kind producer has to take care of his competitive advantages based on his customer focus. To lose the competitive advantage based on the customized offerings and to fail in achieving cost-advantages leads to a critical situation for this company as well.

However in both cases a careful change management process is crucial for a success development of the company.

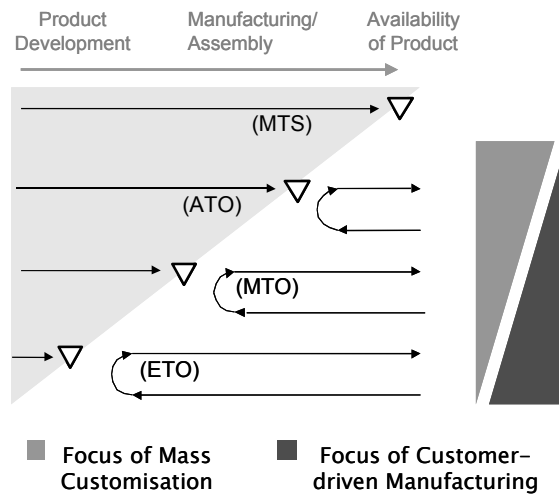


Figure 4: Classifying MC and CdM by using the customer order decoupling point (CODP)

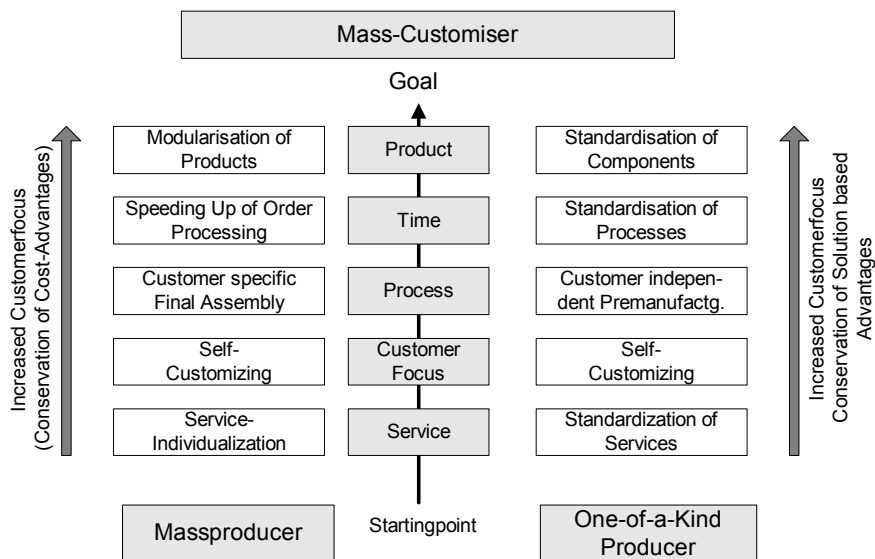


Figure 5: Two starting points, one ultimate goal: from mass production and one-of-a-kind production to mass customization (based on [11])

Da Silveira et al. have identified six success factors most commonly emphasized in literature when mass customization is applicable [1]:

- Customer demand for variety and customization must exist.
- Market conditions must be appropriate.
- Value chain should be ready.
- Manufacturing and information technology must be available.
- Products should be customizable (Products must be modularized, versatile and constantly renewed).
- Knowledge must be shared across the value chain.

As the successful implementation of MC relies on these success factors MC cannot be seen as every company's best strategy. To summarize, a successful implementation of MC involves major aspects of operations including product configuration, value chain network, process and information technology, and the development of a knowledge-based organizational structure.

5.4.3 System design principles

Both approaches, mass customization (MC) as well as customer driven manufacturing (CdM) theoretically intend to cover the various levels of individualization of products and processes. However, to achieve synergies similarities between both approaches have to be systematically analyzed and studied: What are the basic principles companies have to apply or to follow to come up with efficient manufacturing system that are able to design manufacturing systems optimized to realize lot-size one efficiently? What are the basic principles in designing manufacturing systems to deliver a wide range of products and services that meet even specific needs of individual customers?

System design principles for customer driven manufacturing systems are rules that show how customer driven-manufacturing might be put into practice. However, principles are general rules or guidelines that a company should try to obey in designing efficient customer driven manufacturing systems. In a study various industrial cases, industrial, consultancy as well as research projects in the broader field of customer driven manufacturing (including project management, software development, etc.) have been analyzed and a set of design principles for the appropriate design of customer driven manufacturing systems have been identified by the author [12, 16]. Table 4 shows a selection of principles identified.

Starting point for this analysis was the specification of the generic dimensions of a customer specific order. According to decision theory various strategies are applicable in dealing with the dimensions of such problems. Problems can be anticipated, avoided, ignored, outsourced, minimized, controlled, etc. From a problem oriented perspective order processing in customer driven manufacturing can be seen as a problem solving process conducted by a company. Analyzing the

various facets of this type of “problems” a set of so-called problem dimensions can be defined. Accordingly a customer order can be characterized by a number of dimensions such as its cost-criticality, time-criticality, novelty, uniqueness, complexity, in-transparency, momentum or uncertainty (about goal).

Table 4: Design principles in customer driven manufacturing

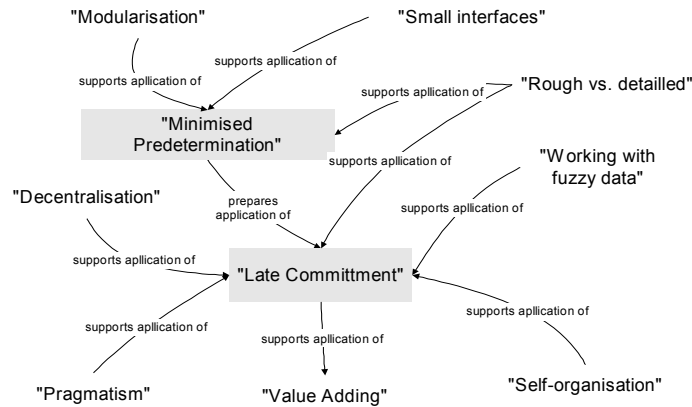
<i>Design principles in customer driven manufacturing</i>		
▪ Small Interfaces	▪ Repetition	▪ Co-operation
▪ Self organization	▪ Feedback	▪ Simulation
▪ Decentralization	▪ Rough vs. detailed	▪ Late Commitment
▪ Pragmatism	▪ Modularization	▪ Push vs. pull
▪ Prototyping	▪ Synchronization	▪ Integration
▪ Parallelism		

A template to characterize the concept as well as the potentials of the design principles in a standardized way has been developed. This template includes sections like “relationships with other principles”, “potential to solve a problem”, “potential for application” (i.e. application domain), etc. Figure 6 shows the template to systematically characterize the principle “late commitment”. Some of the principles identified in the study are of generic nature, whereas others are very specific. Generic principles might be applied to the different organizational levels (strategic, tactical and operational) within a company, whereas the field of other principles is limited.

First steps in analyzing industrial cases, literature and research projects related to MC have shown, that design principles are applied here as well. However, as MC and CdM originates from different manufacturing paradigms (see above), there are many differences as well. “Late differentiation” e.g. is used as one major principle in MC. Applying this principle allows companies to have standard processes until the point of differentiation, very often a prerequisite for cost efficient process design in MC. Apart from the principle “Late differentiation” (synonym in CdM is “Late individualization”) in CdM the principle “Late Commitment” is used quite frequently.

This principle again is well known in decision theory: „Make safe decisions first / dangerous decisions very late“. Even in product data modeling a similar principle is being applied: „Early Binding“ vs. „Late Binding“. De Vin proposed to apply the strategy called “Design by least commitment” in such cases where designers have to take decisions in very unstable environments [13]. Similar proposals have been made as well by Marri et al. and by Knackfuß for decision making in process planning [14, 15].

Relationships with other design principles



Potential to solve problem

		Dimension to be considered							
		Cost-criticality	Time-criticality	Novelty	Uniqueness	Complexity	In-transparency	Momentum	Uncertainty about goal
Strategy	To anticipate	-	-	-	X	-	-	-	-
	To eliminate	-	-	X	-	-	-	-	-
	To control	-	X	X	-	X	X	X	-

Potential for Application

Type of system to be considered		
Resource-related	Process-related	Object-related
-	X	-

Figure 6: Characterization of design principles in CdM (example) [12]

5.5 Conclusion

Both approaches, mass customization as well as customer driven manufacturing theoretically intend to cover the various levels of individualization of products. Whereas the mass customization concept originates from the mass production paradigm (MPP), the customer driven manufacturing concept originates from the one-of-a-kind production (OKP) paradigm. Accordingly the mass customization concept mainly addresses the customer in terms of a consumer and the customer

driven manufacturing concept addresses mainly the customer in terms of a manufacturer and/or service provider, i.e. the capital goods industry. However, it can be stated that the more complex the products, the higher the level of customization of the product and the more intensive the integration of the customer into the order processing the applications of mass customization seems to be limited. At the same time the CdM concept seems to be weak when the objective is to deliver customized products at a cost near that of mass-produced items. Both approaches, mass customization and customer driven manufacturing, do have strong as well as weak points. Identifying and applying generic design principles for manufacturing systems providing customized products seems to be a promising approach.

References

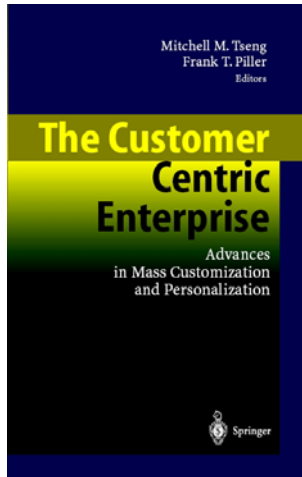
- [1] Da Silveira, G.; Borenstein, D.; Fogliatto, F. S.: Mass Customization: Literature review and research directions, in: *International Journal of Production Economics*, 72 (2001), pp. 1-13.
- [2] Wortmann, J.C.; Muntslag, D. R.; Timmermanns, P. J. M.: *Customer driven Manufacturing*, London et al. 1997.
- [3] Hirsch, B.E., Thoben, K.D.: *One of a Kind Production: New Approaches*, Amsterdam 1992.
- [4] Hart, C.: Mass customization: Conceptual underpinnings, opportunities and limits, in: *International Journal of Service Industry Management*, 6 (1995) 2, pp. 36-45.
- [5] Pine II, B.J.: Mass customizing products and services, in: *Planning Review*, 21 (1993) 4, pp. 6-13.
- [6] Pine II, B.J.; Victor, B.; Boyton, A.: Making mass customization work, in: *Harvard Business Review*, 71 (1993) 5, pp. 108-111.
- [7] Gilmore, J.; Pine II, B.J.: The four faces of mass customization, in: *Harvard Business Review*, 75 (1997) 1, pp. 91-101.
- [8] Lampel, J.; Mintzberg, H.: Customizing Customization, in: *Sloan Management Review*, 38 (1996) 1, pp. 21-30.
- [9] Spira, J.: Mass customization through training at Lutron Electronics, in: *Computers in Industry*, 30 (1996) 3, pp. 171-174.
- [10] Wortmann, J. C.: A typology of customer driven manufacturing, in: *International Journal of Service Industry Management*, 6 (1997) 2, pp. 59-73.
- [11] Reiß, M.; Beck, T. C.: Fertigung jenseits des Kosten-Flexibilitäts-Dilemmas – Mass Customization als Strategiekonzept für Massenfertiger und Einzelfertiger, in: *VDI-Z*, 136 (1994) 11/12, pp. 28-30.
- [12] Thoben, K.D.: *Kundenspezifische Produktion – Anforderungen, Prinzipien, Methoden und Werkzeuge*, Habilitation, University of Bremen, Bremen 2001.
- [13] De Vin, L. J.: Co-operation between Manufacturing Functions in Sheet Metal Part Manufacturing, in: Martensson, N; Mackay, R.; Björgvinsson, S. (Eds.): *Changing the Ways We Work – Advances in Design and Manufacturing*, 8 (1998), pp. 425-431.
- [14] Marri, H. B.; Gunasekaran, A.; Grieve, R. J.: Computer Aided Process Planning: A State of the Art, in: *International Journal of Advanced Manufacturing Technology*, 14 (1998), pp 261-268.

- [15] Knackfuß, P.: 1992, Ein Konzept zur merkmalsgestützten Konstruktion – Arbeitsvorbereitung und Fertigungssteuerung bei der Herstellung von Blechteilen, Dissertation, Universität Bremen, Bremen 1992.
- [16] Hirsch, B.E.; Thoben, K.D.: Why Customer driven Manufacturing, in: International Journal of Service Industry Management, 6 (1997) 2, pp. 33-44.

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Companies are being forced to react to the growing individualization of demand. At the same time, cost management remains of paramount importance due to the competitive pressure in global markets. Thus, making enterprises more customer centric efficiently is a top management priority in most industries. Mass customization and personalization are key strategies to meet this challenge. Companies like Procter&Gamble, Lego, Nike, Adidas, Land's End, BMW, or Levi Strauss, among others, have started large-scale mass customization programs. This book provides insight into the different aspects of building a customer centric enterprise. Following an interdisciplinary approach, leading scientists and practitioners share their findings, concepts, and strategies from the perspective of design, production engineering, logistics, technology and innovation management, customer behavior, as well as marketing.

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