GUIDELINES FOR ACHIEVING A PROPER MASS CUSTOMISATION SYSTEM

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ABSTRACT
The objective of this research was to identify guidelines for implementing mass customization in manufacturing enterprises, termed Mass Customisation Manufacturers (MCM). This was done by conducting two case studies in the Norwegian furniture industry. The study also wanted to explore if the actions necessary to transform an existing manufacturing system into one capable of performing mass customisation depended on the companies' outsets from mass production and handcraft respectively. Performance objectives like low cost and short delivery time was seen in relation to the degree of customisation. We argue that enterprises need to balance these performance objectives to become a true MCM. Successful actions towards the new strategy were analysed and generalised. The results contain a list of 8 general guidelines that proved useful for the case companies. The findings show that actions necessary to become a proper MCM are common and independent of the production concept tradition in the companies.

Keywords: Mass customisation, Production strategy, Operations management

INTRODUCTION
The aim of this paper is to present guidelines for implementing a mass customisation manufacturing strategy. The guidelines are derived from two case studies in the Norwegian furniture industry. The case companies have shifted their strategy to mass customisation from different outsets, one with background in mass production and the other in handcraft industry. The related activities in the respective projects are analysed and generalised to form guidelines. Differences and similarities in the approaches are highlighted.

Implementation of Mass Customisation is challenging and existing descriptions focus on success factors and enablers to achieve the concept (Silveira, 2001). However, many of the success histories explain just a narrow part of the actual complexity of implementing a relatively comprehensive and challenging business concept. This paper gives a brief review of theory concerning the concept, including the two different directions into Mass Customisation Manufacturing (MCM) represented by the case companies.

The case companies and the activities that formed their individual Mass Customisation (MC) solutions are presented. Based on these case studies, the findings are analysed and turned into guidelines for enterprises that want to take advantage of the challenging strategy of mass customisation. Eight generic guidelines for implementing mass customisation are proposed. One of the cases has previously been presented in the International Journal of Logistics (Alfnes & Strandhagen, 2000).

BRIEF REVIEW OF THE MASS CUSTOMISATION CONCEPT

Mass customisation (MC) implies rapid and non-expensive production of numerous artefacts or services, all according to customers' individual specification. An almost continuous flow of varied products, precisely described by each customer, is made without the corresponding cost found in craftsman type of production. The term Mass Customisation was introduced by Davis (1987) in the book "Future perfect". In it he referred to MC as a situation "*when the same large number of customers can be reached as in mass markets of the industrial economy and simultaneously they can be treated individually as in the customized markets of pre-industrial economies*".

The rise of this relatively new production strategy can be viewed as a response to changes in the market and an opportunity opened up by new technology. The development of new and flexible manufacturing technology and information systems has altered the situation for manufacturing companies in two ways. First, new information systems have increased communication possibilities and hence reduced the distance between manufacturers and customers, also on a global scale. The fact that anyone can order products from any producer has erased the traditional boundaries of markets. This of course has lead to increased competition and possibilities for customers to choose from a broader variety of products. Homogeneous mass markets have been replaced by segmented markets and the segments are continuously getting smaller, moving towards micro and individual markets (Kotler, 1989). This causes enterprises to strive to serve many different customers, in order to maintain the volume necessary for competitive production. Technology development is also providing companies with tools to make a variety of products easier than earlier. Today machines and software systems offer more flexibility in processes than just a few years ago. Reduced setup times and efficient handling systems have cleared the way for smaller batch sizes and more variation.

New information technology has increased the power in product development and this combined with market departments focusing on satisfying many individual customers has in some cases resulted in overreaction to customer demands for nuances (Pine et al., 1993). Hence, to be a successful mass customiser, a company needs to asses the demand for variety and to balance the integration with customers and the efficiency of production.

Pine (1993a) defines mass customisation to be; "the use of technology and management methods to offer product variety and customization through flexibility and quick responsiveness". This definition includes the core idea of providing customers with the specific product of their choice, but does however not explicitly mention cost and time issues. It rather leaves the reader to extract this from the information about "reaching many customers quickly". Hart (1994) operates with two definitions, the first being his visionary one; "the ability to provide your customer with anything they want profitably, anytime they want it, anywhere they want it, any way they want it". Since this is almost impossible to achieve, the other definition is more practical; "the use of flexible processes and organisational structures to produce varied and often individually customized products and services at the low cost of a standardized, mass-production system". In the latter definition the goal of low cost is explicitly addressed and the picture of what is desired from a mass customisation strategy is clear.

After the industrial revolution, manufacturers have divided into two main streams; those who chose to provide standardised low-cost products and those who continued to provide custom goods with higher price tags. Pine (1993a) introduced this new strategy as a suitable step forward for mass producers and Duray et. al. (2000) have argued that it is also applicable for handcraft producers in the strive for efficiency.

Zipkin (2001) defines three elements necessary in order to offer mass customisation. They include; *elicitation* (a mechanism for interaction with the customer and obtaining specific information), *process flexibility* (production technology that fabricates the product according to the information) and *logistics* (subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer). These elements need to be connected by powerful communications links (Zipkin, 2001). Zipkin argues that Mass

Customisation requires a high level of flexibility and responsiveness in all stages of the value chain. Therefore, very few companies have been able to realise the mass customisation strategy. Therefore there is a need for practical guidelines to assist companies in developing solutions specifically suited to their own situation with respect to market demands and own capabilities.

Leading proponents of mass customisation can give examples of mass customisation behaviour, but they are still developing the core principles of how to implement it (Kotha, 1994). Still in 2004, the lack of practical guidelines compared to the sum of available definitions makes McCarthy (2004) state; "*the problem is not about understanding what constitutes the strategy, but determining how to design and transform an organisational system from its current form (configuration) into one capable of achieving its new goals"*. This paper proposes some guidelines that are more concrete in their application.

MASS CUSTOMISATION MANUFACTURING STRATEGIES

The level of mass customisation is a topic discussed in literature in terms of level of customer integration. Silveira et.al (2001) has structured the levels as a continuum from pure standardisation to pure customisation based on proposals by other researchers (Gilmore and Pine, 1997, Lampel and Mintzberg, 1996, Pine, 1993b, Spira, 1996). The frameworks of Silveria et. al and Lampel and Mintzberg are listed in Table 1.

Table 1 - Generic levels of mass customisation (adapted from Silveira et.al 2001)

MC generic levels (Silveria et.al 2001)	MC strategies (Lampel & Mintzberg 1996)
8. Design	Pure Customisation
7. Fabrication	Tailored Customisation
6. Assembly	Customized standardisation
5. Additional custom work	
4. Additional services	
3. Package and distribution	Segmented standardisation
2. Usage	
1. Standardisation	Pure standardisation

Hence, the market interaction strategy can range from providing unique products, to providing standard products from a final stock. This categorisation in levels of customer interaction calls upon our attention for two reasons. First, customer integration is not the only performance objective for mass customisation. We suggest that the performance of the enterprise is simultaneously evaluated along three dimensions. The customer integration must be considered in balance with cost and delivery time issues (illustrated in Figure 1).

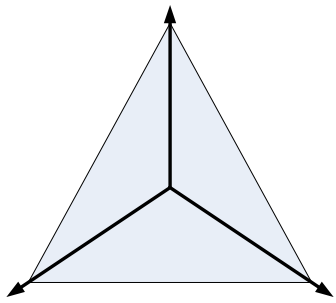

Figure 1. - MCM demands simultaneous benefits on cost, time and customization

The second reason to challenge the framework put forward by Silveira (2001) and Lampel and Mintzberg (1996) as levels of mass customisation is the extremes of their continuum of strategies.

The authors of this paper do not recognise the extremes of this classification as states of mass customisation manufacturing. By their nature, they do not satisfy the demand for a simultaneously high performance in cost efficiency, responsiveness and customisation (Figure 1). Only the market integration strategy corresponding to Lampel and Mintzberg's *tailored customisation* and *customised standardisation* are candidates for mass customisation manufacturing (Table 1). The *user phase* of Silveria (2001) and *segmented standardisation* of Lampel and Mintzberg (1996) might qualify as mass customisation, but are not true mass customisation manufacturing (Figure 2). This implies that cell phones that can be customised by the customer through use, but are made in batches with similar phones, are not true MCM-products.

Figure 2 illustrates why different market integration strategies do not automatically qualify for the notation mass customisation manufacturing and that the shift necessary to become one is directed towards the middle of the figure. The extremes of the scale do not sufficiently cover all aspect.

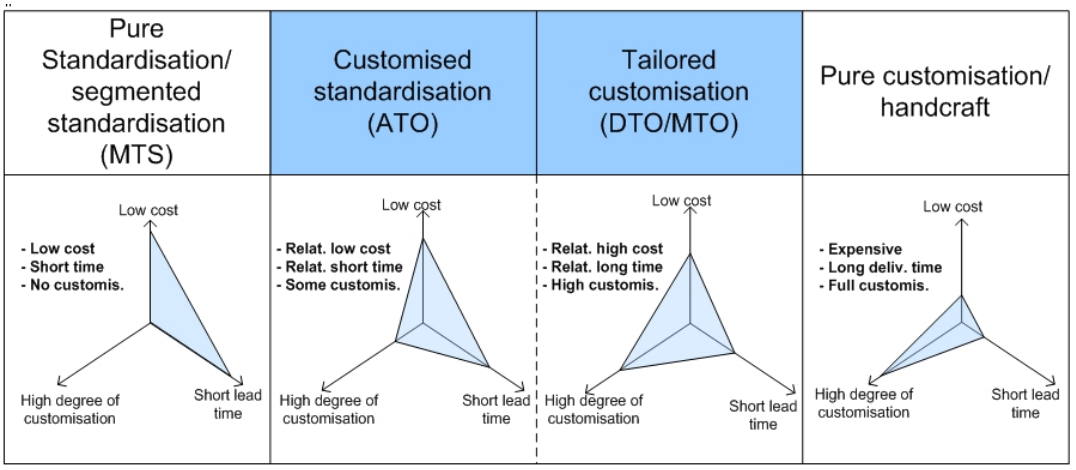

Figure 2. - MCM demands simultaneous benefits on cost, time and customization

Figure 2 also indicate that a shift of market interaction strategy to customised standardisation or tailored customisation is not sufficient to become a mass customisation manufacturer. In addition, actions have to be carried out in order to improve cost efficiency and responsiveness.

A transition from pure standardisation to MCM and transition from pure customisation to MCM are common in industry. This paper therefore studies the efforts of two case companies with their origins in these extremes positions of the customer integration continuum. The case studies are described in the two following sections.

CASE A: HÅG, A SWIVEL OFFICE CHAIR MANUFACTURER

HÅG is one of the leading manufacturers of office chairs in Scandinavia. The company produces approx. 1000 chairs a day with an average order quantity of two products, indicating the demand for variety. The delivery time from order reception to distributed products is 4-5 days. HÅG has been the market leader in Norway from the end of the 1970s with approx. 40 percent market share. Most of the customers are located in northern and central Europe and in the US and export constitutes 80 percent of total sales. The company has a product portfolio of 9 families with numerous options of customer choices in each. The products are highly modularised.

All operations are centralised at the factory in Røros, where assembly-to-order production and direct distribution to dealers are performed daily. Through successive development projects, HÅG is able to deliver customised chairs to the European markets with short delivery time, low cost and a

precision that outperforms the European competitors. This has confirmed HÅG's competitive position in the European furniture market. Success elements from HÅG's efforts to become an MCM enterprise are presented below

Customer interaction
HÅG used to mass produce office chairs to final stock and experienced an increasing problem in predicting customers' preferences. There was a need to start to assemble products according to actual customer orders in order to reduce uncertainty. This had to be done without a corresponding increase in delivery time. Final inventory was replaced with a final assembly area. Introducing an Assembly-to-Order (ATO) strategy (replacing their Make-to-Stock (MTS) strategy) was the first and most powerful change to become an MCM-enterprise. By moving the customer order decoupling point (CODP) *upstream* in the value creating chain, the customer influence was increased and uncertainty reduced.

Product structure
Office chairs have a modular structure, which was exploited in the new solution. The increased demand for variety was met with a corresponding expansion in the variants on the modules of highest interest for customers (textiles). Variants in modules less important to customers were reduced, allowing a more rational production. The assembly process was standardized through product modularity. When designing new products, HÅG now carefully plans the structure of the product and the number of variants of each module, in accordance with restrictions in technology and competence and market demands related to costs and delivery time.

Integration with key supplier
The supplier of textile covers located in the same region as HÅG was given a key role in the new solution. Textile covers are the most visible components and the module on which demand for variation is highest. The textile supplier was given a close JIT inspired connection to HÅG with respect to information exchange and physical material handling. Actual customer orders are now transferred electronically in real time and a new transport system is designed to carry textiles twice a day from the supplier directly into the assembly lines at HÅG.

Information system
Customer information (address etc.), order content (product specification) and delivery dates are entered into the ERP-system immediately after reception (can also be entered into the system electronically from retailers). The information is then made available to planners and operators in real time in order to start production without unnecessary delay. The textile supplier cuts textiles according to an electronically generated and communicated production plan (MTO). On each set of textile (including covers for seats, backs, arma and head rests) the supplier attaches a bar code. This bar code is used by operators at HÅG in the final assembly. It contains a link to the ERP-system and a complete list of components for the specific order is printed n the component pick zone. This constitutes the configuration system for the complete customer order.

Layout and material flow
The factory was divided into separate areas for component production, module assembly and final assembly. Machines and work in progress are placed more adequately to improve the spatial utilisation of the factory. Small buffers are established in each operations area in order to improve the flow of parts.

Control principles in operations
Production is controlled by three different control principles. Final assembly is based on customer orders, where the sequence is roughly generated in the order registration phase. The sub-assembly

processes are controlled by a kanban system. The task of operations in this area is to refill the component buffer in the order pick-zone and work is performed independently of customer orders. Hence, the customer order decoupling point is in the final assembly (ATO). Some of the early mechanical processes (cutting and stamping) as well as procurement of raw materials are still controlled by forecast.

Flexible operators
The mix of customer orders varies on a daily basis, both with respect to module volume and variety. Hence, the need for capacity in different production areas differs from day to day. The staff had to be cross-trained to be able to handle assembly of different types of chairs. Also, operators need to be multi skilled along the value chain to a certain degree in order to fill inn for each other and to job-rotate.

After implementation, HÅG has assessed its performance in terms of customer satisfaction and found areas for further improvement. The company will continue to adjust its solutions on continuous improvement basis according to the market trends.

CASE B: HAGEN, A WOODEN STAIRCASE MANUFACTURER

Hagen is one of the 10 largest manufacturers of staircases in Europe. They construct and produce approx. 30 customer-specific stairs each day to construction companies and personal customers. The market is mainly in Norway where Hagen is market leader with a market share of approx. 35-40 percent. Hagen is also exporting 9 percent of its volume to Germany and Denmark. The operations are performed on four plants in Norway and distributed directly to customers. The main factory is located at Stryn, which produces all components and completes the fabrication of "industrial" stairs. For stairs that require handcraft operations, components are distributed to the three other plants for completion.

The staircase industry has traditionally been characterised by full customisation, high level of craft-work and many manual operations. In such a way, enterprises were able to deliver stairs that were constructed and built to fit the particular measurements of each staircase room. However, this type of craftsman manufacturing was too expensive and cumbersome to be successful in the European market. Hagen therefore carried out a range of improvement activities in order to adopt a mass customisation strategy. Success elements noted from Hagen's effort to become a MC manufacturer are presented below.

Flexible manufacturing systems
Hagen invested in CNC (Computer Numerical Control) milling machines in order to produce customised steps and sidewalls efficiently and in high volumes. Later other CNC- machineries have been introduced for other components such as poles and handrails. In addition, they have invested in an automatic painting line that allows efficient and small series painting of components with different colours and types of paint.

Construction
Hagen adopted a CAD (Computer Aided Design) programme for construction of staircases and developed pre-defined design elements for all products. Shapes of the staircase modules are made according to standards and specifications, yet sizes of components can be customised exactly to individual needs in millimetre. The construction programme is modularised and divided into phases. This opens for customer interaction during construction, but also makes the construction job efficient.

Layout and material flow
The layout was flow-oriented. The traditional job shop layout that allowed components to take different process routes through the manufacturing was abandoned. The new layout was arranged

for an efficient line-flow from milling to packaging. There was also invested in some automatic material handling equipment to improve the flow.

Production control
A decentralised push-pull control system was developed in order to synchronise the production of different components of a customer order. Every component family are manufactured at a dedicated production line. The production schedule is therefore made specific for every component in the purpose of trying to fulfil the customer order in time. Since the products can have varying complexity, there are different criteria/rules to consider in the planning; fulfil a complete order to the delivery date, capacity utilisation (try to gather similar product families in a batch to avoid set up time) and control of the bottlenecks.

Order handling
The introduction of a web-based product configuration has improved communication with customers and made order commitment and construction easier and more rational. The CAD programme is able to communicate by an interactive 3D visualisation module. By giving the customer a "prototype" of the ordered product, this opens for greater understanding and elicitation for customers.

Hagen is now pursuing the mass customisation strategy through investments in ICT (Information Communication Technology), CNC machines and automatic material handling systems. This will make the staircase production even more efficient.

GUIDELINES FOR MASS CUSTOMISATION MANUFACTURING

We have extracted 8 general guidelines from the two cases. The guidelines are validated by the enterprises and found to be the most significant ones in their transition towards mass customisation;

1. Change the market interaction strategy to customised standardisation or tailored customisation
- offer high level of customisation on those components where customisation gives added value to customers
- postpone CODP in the value chain to improve responsiveness

2. Integrate with key partners
- establish partnerships with suppliers of customer-specific components
- integrate information systems to shorten delivery time, increase responsiveness and reduce costs

3. Establish modular products
- standardise neutral components that customers don't demand for customisation
- make a product programme based on similar design elements or components for all product families

4. Implement product configurators
- present customer options in a structured, illustrative and informative way
- lead customers to select product with esthetical design and that will be manufactured in a cost and time efficient way

5. Establish electronic order registration
- use information directly in construction and manufacturing
- achieve a streamlined order process and avoid unnecessary double work

6. Train operators to be multi- skilled
- educate operators in multiple tasks
- use the flexibility to allocate operators according to variations in product mix and volume

7. Introduce Flexible Manufacturing Systems (FMS)
- use appropriate technology to reduce time consumptions, produce high volumes and reduce costs

- strive for automation in manufacturing, but balance it towards the flexibility obtained by human resources

8. Establish a product oriented material flow

- design a layout that reduce non value added processes such as transporting, preliminary works and unnecessary inventories
- create short throughput time in order to enable quick response

CONCLUSION

This paper highlights that to achieve proper mass customisation, it is not sufficient to offer customised products. The performance objectives of interest for customers also include delivery time and costs. Hence a balanced improvement of customisation, cost-efficiency and responsiveness is the only appropriate approach to mass customisation manufacturing.

The research has aimed to support companies that want to transform their business to become a mass customisation manufacturer. Guidelines were developed by studying a former mass producer and a former craftsman producer. The challenges for these enterprises are to some extent common, independent of their outset. Common factors are identified and transformed into eight concrete guidelines for implementing mass customisation.

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