Mass customized production and design processes for the parquet flooring industry

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ABSTRACT

We propose new ideas of applying mass customization concepts in the production of wooden floorings, especially for the parquet industry. Due to market requirements this industry is obliged to observe special quality standards during production. The current grading system of hardwood does not meet the specific demands for the appearance of the wood in the final products. The standards are aimed at reducing the number of characteristics which define the various grading classes regarding the appearance of the boards. Mass customizing parquet flooring could open new business opportunities for the industry. In order to offer customers the possibility of individually composed floors, several types of customized modules instead of the currently produced floor boards can be manufactured. The transfer of natural patterns of wood into the final product by involving the customer in the design process was one goal of our research. Natural patterns and features, which would not be used in a standard driven production process, could be allowed. The target and advantage of the system is the higher added value of a low grade material and probably fewer complaints about defects of the final product by the customer.

Our research explores these new production concepts in a case study approach with an Austrian manufacturer of parquet flooring, using simulation as a method. We analyze several possible product-variety/customer-order mixes and their distinctive production outcomes when producing different customized modules of floorboards. We also present new ideas how an individualized supply chain process in the production of parquet flooring could look like.

INTRODUCTION

The term Mass Customization has been coined in the late 1980ies and has become subject to research concerning operations management since Pine (1993). McCarthy (2004) defines Mass Customization as the capability of companies to produce a relatively high volume of product options for a relatively large market, which is demanding customized products without tradeoffs in cost, delivery and quality.

Implications of mass customization on the supply chain, concerning information and material flows and the connection between product types and the decoupling point, have been researched for example by Yang and Burns (2003). Mass Customisation strategies, such as postponement, can also have effects on customer satisfaction. Reiner (2005) shows for a supplier of the telecommunication industry, that postponement strategies such as labeling imply a substantial potential for customer-oriented improvements.

Sigg & Jonas (2003) report on applications of mass customization and use of postponement strategies as well as customized product configuration in furniture production. According to a Delphi-study of the wood-working-industry undertook by the Fraunhofer Institute for Manufacturing Engineering and Automation over 25% of furniture shall be produced in lot size 1 on industrial scale (ProWood 2004). Working solutions for customized furniture design, production and ordering processes, like the famous IKEA kitchen configurator, are well known solution within the wood-working-industry. What concerns production processes of parquet flooring, in the last 30 years innovations have mainly taken place on the technical equipment side. State-of-the-art descriptions of production processes from the 1970ies (Kisseloff 1974) do not differ very much from analyses in the 1990ies (Hamberger 1995) or our observations of production processes in a case study in 2005.

Mass customizing parquet flooring could open new business opportunities for this industry. In order to offer customers the possibility of individually composed floors, several types of customized modules instead of the currently produced floor boards can be manufactured. During the production process several possibilities to modularize floorboards arise. We present and evaluate these possibilities on their implications on the current production process. These results are then compared to the status quo of parquet manufacturing at a case study company. We show how reconfigured production processes affect storage levels of semi finished products, service rates and thus customer satisfaction.

CURRENT PRODUCTION PROCESSES

Analyzing the relevant business and production processes we identify the parameters currently faced in the manufacturing of parquet flooring. The case study company produces floorboards in 5 different qualities, 19 different wood sorts and allows for several different finishing possibilities, like lacquering or oiling, from which the customers can choose freely. The production of floorboards is split in two stages: First, the (visible) upper layer is produced in a make-to-stock environment, followed by a buffer in which conditioning processes of the floorboards (according to the wood sort) take place. This buffer is also functioning as Customer Order Decoupling Point (CODP). In the second step of the production, a make-to-order environment can be stated. Floorboards are retrieved from the conditioning chamber and then finished according to customer orders. Customers can order their desired boards only in the distinctive qualities. Due to its character as a natural resource, wood is subject to several anomalies and different quality patterns. The company is faced with uncertainties and cannot be sure to produce the quality desired by the customer with the raw material it uses as input to the process. Thus a lot of work-in-progress of different product variants has to be kept in stock at the conditioning chamber, which is one of the major bottlenecks of the production process. A multi layer 3-strip parquet production process in general can be divided into four sub-sections (Kruse et al. 2003):

- Manufacturing of the upper layer (the one visible to the customer) and storing in a conditioning chamber,
- Manufacturing of the middle layer or support layer and undercoating (a process not considered and described here, as this is a standardized semi finished product),
- Press sizing of upper layer and support layer to a floorboard and finishing operations of the surface of the floorboard, and
- Finishing Processes like milling of tongue and groove, quality end control and packaging.

After the storing of the upper layers in a conditioning chamber for a defined time, they are retrieved according to customer orders and as a next step, press-sized with the middle layer. The retrieval process marks the decoupling point of the process. It is here where each floorboard is assigned to a specific customer requirement. One of the main difficulties in developing mass customization concepts for the parquet industry lies within the discrepancy of the point in time, when a product becomes unique and distinguishable from other products, and the point, where an order is assigned to it. The former is called the Product Differentiation Point (PPD), the latter is the Customer Order Decoupling Point. Figure 1 shows the current production processes of parquet and where the two points mentioned above differ from each other.

SIMULATION STUDIES

In order to conduct simulation experiments for testing modularization strategies, we implemented real-life production data from more than 13 months using the simulation software Arena®. The real-life data are available for a production line which produces floorboards in 19 different types of wood and up to five different qualities. Customer orders for the same time frame were implemented in the simulation as well. Floorboards are produced according to our specifications and customers are able to order also according to these specifications. The results of the simulation runs of the current production processes were used as references to compare the performance of two new modularization concepts. Table 1 shows the input-percentages of the different wood types, Table 2 shows the matrix of the originally known quality outputs per wood type. It gives also an idea of the difficulties caused by inconstant quality of the raw material and its different quality output per wood type.

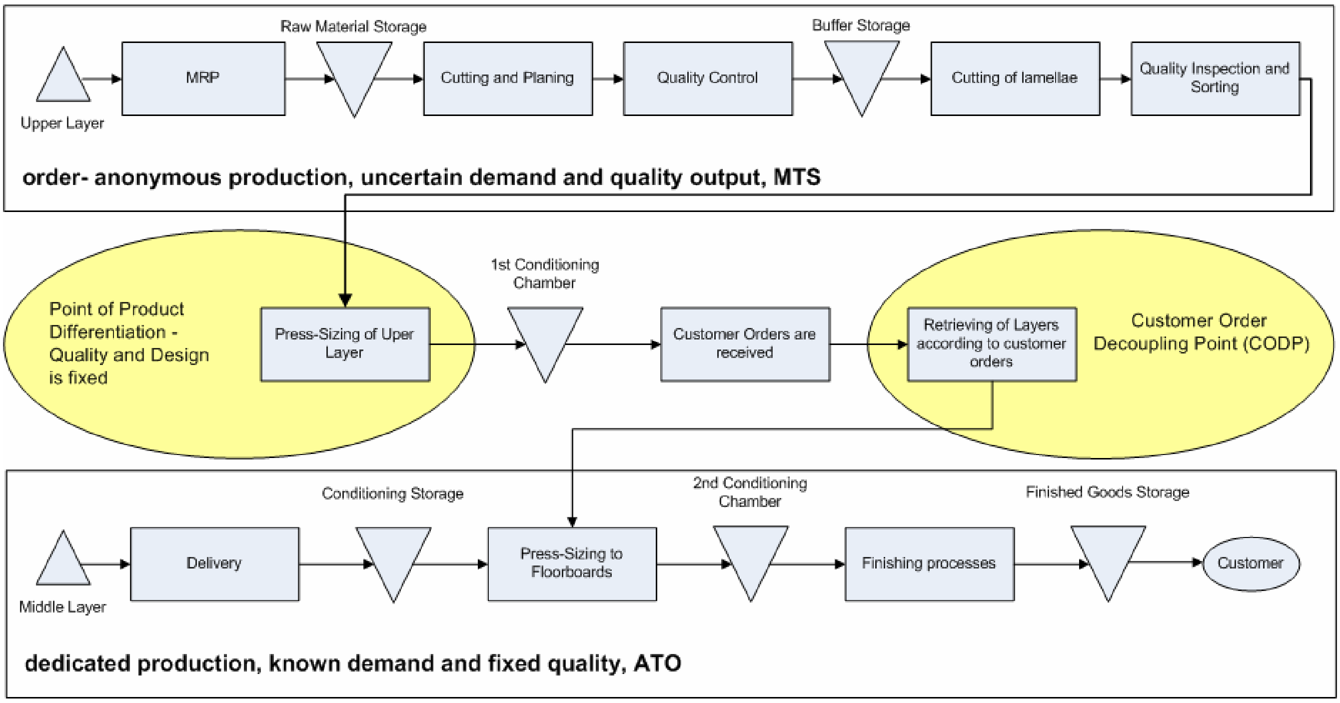

Figure 1. Production Processes including PPD and CODP

Table 1. Wood Types

Wood Type	Input Percent
6	19,84%
9	19,35%
1	14,21%
7	11,04%
5	6,97%
2	6,02%
16	4,31%
13	3,03%
12	2,64%
4	2,64%
11	2,38%
8	2,36%
15	1,81%
14	1,40%
17	0,70%
10	0,54%
3	0,44%
19	0,25%
18	0,07%

Table 1.Quality Output per Wood Type

Wood Type	qA	qB	qC	qD	qE
1	4,47%	61,56%	24,61%	8,15%	1,21%
2	7,72%	52,36%	30,50%	2,39%	7,04%
3	0,00%	100,00%	0,00%	0,00%	0,00%
4	0,06%	93,21%	0,06%	6,66%	0,01%
5	0,00%	64,62%	0,06%	35,29%	0,03%
6	6,83%	67,25%	10,77%	14,97%	0,19%
7	5,15%	57,88%	27,07%	4,63%	5,26%
8	0,00%	96,84%	0,00%	3,16%	0,00%
9	5,70%	54,79%	25,16%	14,22%	0,13%
10	0,00%	100,00%	0,00%	0,00%	0,00%
11	9,72%	72,38%	16,06%	1,83%	0,00%
12	0,00%	79,76%	0,24%	20,00%	0,00%
13	0,00%	56,07%	0,00%	43,93%	0,00%
14	0,00%	80,26%	0,00%	19,74%	0,00%
15	0,00%	98,70%	0,00%	1,30%	0,00%
16	0,00%	90,66%	0,00%	9,34%	0,00%
17	0,00%	100,00%	0,00%	0,00%	0,00%
18	0,00%	100,00%	0,00%	0,00%	0,00%
19	0,00%	100,00%	0,00%	0,00%	0,00%

Three different scenarios were evaluated further, where scenario Status Quo is the core model of all tested production environments and used as a reference to compare the new modularization concepts. One product line of floorboards is produced in the mentioned 19 different wood types in 5 different qualities. Customers can place their orders in the same distinctive categories. The CODP is located at the retrieving process of the upper layers from the conditioning chamber. 18 lamellae of the same quality and wood type are glued together to form one floorboard, the mixing of qualities is forbidden, thus five different so-called M-boards per wood sort can be produced. Customer orders in this scenario correspond exactly to the observed real-life data, the demand for M-Boards d(M) corresponds exactly to the demand for the five qualities qA, qB, qC, qD and qE for every single wood sort.

Scenario Concept 1.0 does not allow for a mix of different qualities on a single M-Board, thus an M-Board MA consists only of lamellae of the quality qA while MB can either be composed of quality qB or quality qC and MC can either be composed of quality qD or quality qE. Customer orders are modeled analogously, thus for example demand for floorboards MB equals the sum of the current part demands for qB and qC.

Scenario Concept 1.1 differs again in the combination possibilities of M-Boards. Now a mix of different qualities of lamellae on single floorboards is allowed. This does not cause any difference in composing MA, but for MB, which now can be composed of any combination of the qualities qB and qC, as long as the restriction of 18 lamellae per M-Boards is satisfied. The same is true for the composition of MC. Customer orders are analogous to the former model. Of course these modularization metrics can and should be adapted over time and from every producer, in order to reflect his actual input quality distribution.

DISCUSSION

All relevant simulation scenarios resulted in different, but robust outputs, both in produced variants and parameters such as throughput time or customer satisfaction. This allows for a comparison between the models. Robustness was tested in several simulation runs of the same model subject to a by-chance variation of time and quantity in both raw material input and customer demand. To compare the output of each model, its order fulfillment results were set into relation to the distinctive customer orders. Also benchmarks of the storing process at the CODP have been measured. Table 3 gives an overview of the results. All benchmarks are presented in both the median and the mean, as the results of the (up to 95 different) product variants differ on a broad scale.

Table 3. Output of the tested simulation environments

mean	Status Quo	Concept 1.0	Concept 1.1
Order Fulfilment Rate	80,02%	84,11%	84,42%
Rate of Number of Fulfilled Orders	85,53%	89,62%	89,67%
CODP Stock Level / Orders	138,46%	168,31%	156,22%
CODP Stock Output / CODP Stock Input	81,42%	82,63%	80,32%
CODP Stock End-Level / CODP Stock Start-Level	34,57%	25,63%	26,72%

median	Status Quo	Concept 1.0	Concept 1.1
Order Fulfilment Rate	93,72%	92,45%	94,69%
Rate of Number of Fulfilled Orders	98,01%	97,42%	98,22%
CODP Stock Level / Orders	98,55%	94,86%	98,07%
CODP Stock Output / CODP Stock Input	92,94%	96,29%	93,16%
CODP Stock End-Level / CODP Stock Start-Level	11,85%	7,30%	10,08%

RECONFIGURING SUPPLY CHAINS

The above described possibilities of individualization via the use of product-configurators also imply a variety of new to be developed or restructured supply chains for the parquet industry. Before describing new ways of ordering for customers and supply processes for the companies we have to describe shortly the current last-mile-processes in the parquet industry. Figure 2 shows current and possible future supply chains in the parquet industry.

Today, customers can buy parquet floorings either as a finished product in Do-It-Yourself-markets or they can visit a specialised retailer who sells wooden floorings using conventional samples. The floor boards are then delivered to the customer who can either lay the floor himself or has a professional do the work. Another "high end" possibility would be inlays developed by designers and produced in piece production.

The modularization concepts combined with a product configurator allow for more flexible supply chains and order fulfilment processes in the parquet industry. Borders and competences valid in the supply chains of today are dissolving, helping customers in becoming co-designers or co-producers. Toffler coined the term of the so-called prosumer (cf. Toffler 1970, cited in Piller and Moeslein 2002). The producer of today, who supplies wholesale and retail, can become a direct seller to customers via internet configuration processes. A shift of market power and new cooperation concepts and other pricing strategies will be the result of this process. For supply chains in the parquet industry one can develop a number of scenarios.

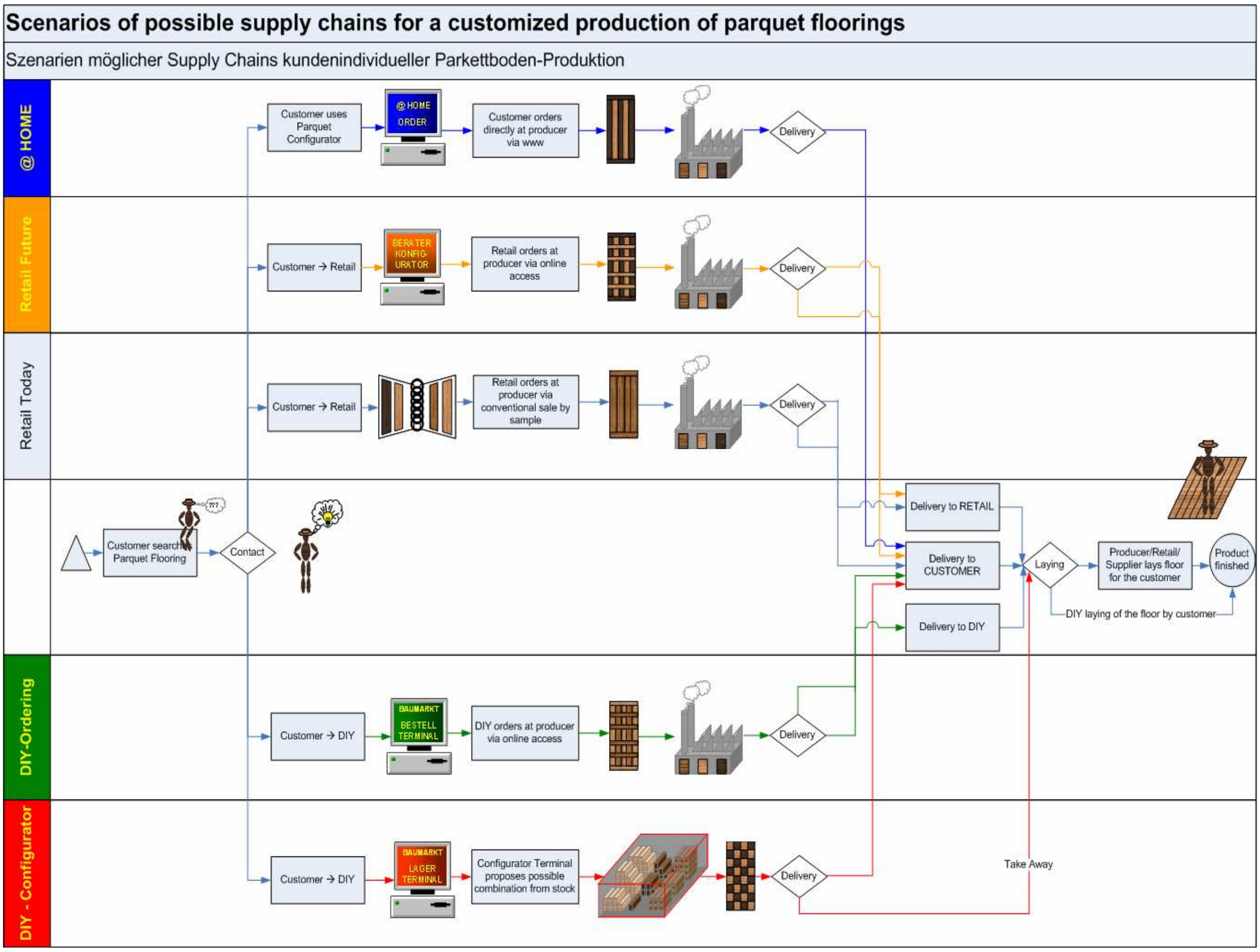

Figure 2. Current and Future Supply Chains in the Parquet Industry

The first scenario completely leaves out the retail or wholesale processes. The customer directly orders his individually created floor from the producer via a configurator and the internet. The producer delivers directly to the customer, including a detailed laying plan for his individual floor. Another possibility for the producer would be to offer the service of laying the floor at the customers home himself. Another possibility for the customer would be to continue ordering via a specialised retailer. With the help of the trained professional, the customer can then create and order his individual flooring online. This concept has the advantage that customers who are not technically interested can also create and buy an individualized wooden floor.

The next possible supply chain scenario implies the use of configuration terminals in DIY-markets. Customers who don't have the possibility of using internet applications at home or at work could then also order online. Another possibility of using a configuration terminal in a DIY-Market or at a retailer could be a function of the software, which creates automatically proposals of ready-to-take-home floors. This concept would need a direct communication between the configurator and the inventory management system. The customer can state his preferences and the configurator then presents solutions and examples of individual floorings which can be created with the products the DIY-market has on stock.

This concept could be extended to a vendor managed inventory application, which allows for a direct filling of the DIY-markets inventory by the producer. Thus the software could offer the customer valid due dates and more examples of individual floorings as a function of waiting times. It is possible that customers face more possibilities when they wait for the next production batches finished. Creating communication links between the production management system of the producer, the inventory management system of the retailer or DIY-market and the product configurator could result in committed and held due dates and higher customer satisfaction, combined with better use of raw material output and lower stock levels.

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