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RECONFIGURING PRODUCTION AND ORGANIZATIONAL STRUCTURES FOR MASS CUSTOMIZATION

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Abstract: *Mass customization is a concept which can be accessed from different points. In this paper we will view the concept from production angle. Having in mind the concept of effective production systems developed on Faculty of Technical Sciences in Novi Sad, the model of production system oriented on mass customization market will be presented. Further more the four steps model for implementing mass customization concept into the production system is discussed. The last segment of the paper brings the analizys of real production system from furniture industry as well as the reconfiguration of the system according to the given implementation model. Concluding the paper advanteges and effects of implementing the mass customization according to principles of effective production systems are discussed.*

Key Words: ***Mass Customization, Effective Production Systems, Production and Organizational Structures, Group Technology, Work Units***

1. INTRODUCTION

Mass customization markets are developing every day in every segment of industry. First steps have already been made in bicycle, motorbike, house appliances, computer, audio and video equipment, clothes, food, drink and drugs industry. And it is a question if there will be any industry in the future that will not be affected.

"The emergence of global markets has fundamentally altered competition as many firms have known it"[1] leading to “mass customized markets” [2]. Parallel overview of mass production and mass customization can bee seen in Table 1.

Mass customization relies on several principles of management [3]:

- Just-in time delivery – this processing of materials and components eliminates process flaws and reduces inventory-carrying costs.
- Reducing set-up and changeover times. – these reductions directly lower run size and cost variety.
- Compressing cycle times – this eliminates waste and increases flexibility and responsiveness while simultaneously decreasing cost throughout all processes along the value chain.
- Production to order – production is based upon receipt of an order instead of forecasts. This lowers inventory costs, eliminates fire sales and write-offs, and provides the information necessary for individual customization

Table 1 *Parallel overview of mass production and mass customization*

Mass production	Key characteristics	Mass customization
Built to stock	Business model	Built to order
Predefined	Product	Configured to order
Long	Life cycle	Short
Acceptable	Quality	Superior
Low	Price	Concurrent

From four levels of mass customization (Figure 1), first three levels (differentiation, cost and relationship level) have a customer centric perspective. A fourth level takes an internal view and relates to the fulfillment system of mass customizing company: Mass customization operations are performed in a fixed solution space that represents “the pre-existing capability and degrees of freedom built into a given manufacturer’s production system”[4].

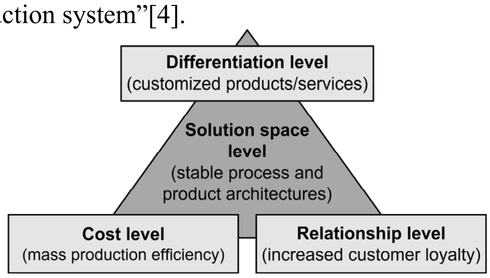

Fig. 1 *The four levels of mass customization* [5]

So we can say that the degrees of freedom, mainly the flexibility of the system, are defining the capability for producing the customized products. If that is the case, we must adapt our production system in purpose of producing the customized goods (Figure 2).

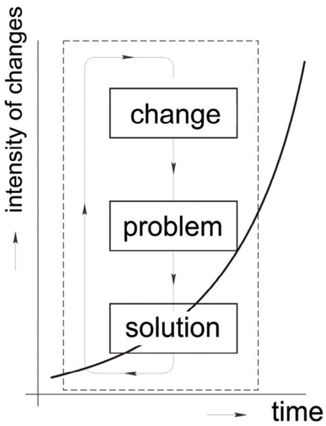

Fig. 2 *Change-problem-solution diagram* [6]

In our case the change is in the way of customers thinking, the problem is in the market development [2] and the solution is in reconfiguration of the production system for mass customization.

2. RECONFIGURING THE PRODUCTION SYSTEMS

2.1. Effective production systems – IIEM approach

Analysis of work processes in real systems, conducted over a long period of time at Institute for Industrial Engineering and Management (IIEM) on Faculty of Technical Sciences in Novi Sad, consistently showed a lack of effectiveness with respect to quality, lead time and costs, in a time of rapid technology development, fast growth of competition, unstable markets, economic uncertainty and increasing social demands [7]. The analysis highlighted the need for reengineering material flows first, followed by other functions in companies. Basic conclusions were that most of inadequacies resulted from complex – process type of flow (Figure 3).

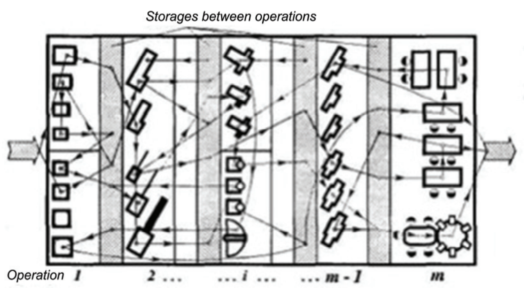

Fig. 3 *Process type of flow* [7]

In basis, the philosophy of effective production systems (EPS) developed during the years of research are following principles [7]:

- *Principle of similarity*: part characteristics and manufacturing methods which allow simplicity and minimum complexity in system flows;
- *Principle of independent durability*: based on a natural law of separating (like living organisms) and creating a full individuality and conditions for autonomous operation. The term autonomous operation requires sufficient connections with environment and supporting systems, because we are talking about open systems;
- *Principle of managing toward goals*: based on the need for keeping process parameters within design limits in real time and given environmental constraints; the basic challenge is the capability for resisting environmental impacts and disorders in working processes;
- *Principle of ability for effective work*: the basic characteristic of high quality systems, based on the principle of independent durability, is the ability for accomplishing programmed effects/investment rate. It is possible by development of flexible structures with minimum complexity, development of real-time control procedures, for turning system from breakdown operating stage in planed time;
- *Principle of effective motivation* and conditions for work assurance: based on a thorough investigation of relation between various participants, hierarchy of position, work place integrity, and accomplishing a pleasant and productive atmosphere.

In result reconfigured systems were based on group technology (Figure 4) and work units organization (Figure 5). The resulting material flows were of a product type (Figure 6).

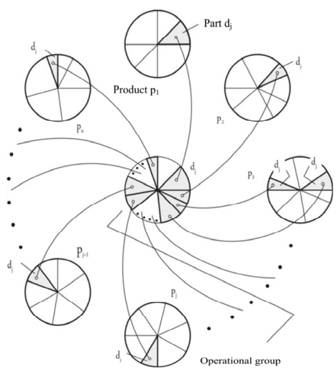

Fig. 4 *Grouping of parts* [7]

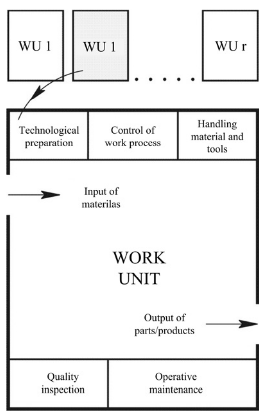

Fig. 5 *Work unit*

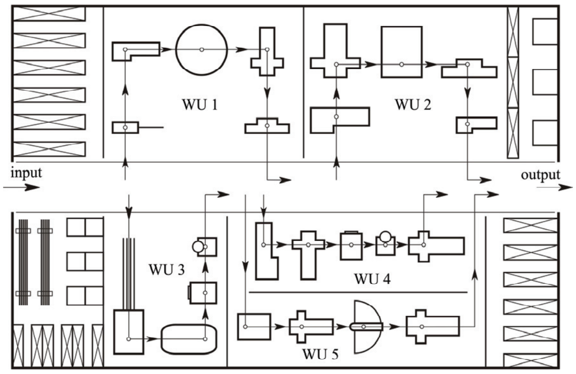

Fig. 6 *Product type flows*

Table 2 *Effects of implementing of EPS in industry*[7]

Fact.	Product.cycle. T_{cp}		RATIO $T_{cp}/\Sigma t_{ij}$		Turnover coefficient		Input variety (for N orders N!)	
	Prev.	After	Prev	After	Prev	After	Prev	After
Fac. 1	1123	14	75020	25	2,46	8,54	250!	5!
Fac. 2	520	22	110	12	4,52	15,12	210!	7!
Fac. 3	235	18	9300	45	0,51	2,65	1350!	30!
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Fac. 25	95	4	155.250	250	2,47	12,05	450!	8!

Effective production systems approach has proven itself in practice (Table 2) decreasing unfinished production 4 to 15 times, increasing turnover ratios 10 to 12 times, reducing manufacturing lead times by 8 to 25 times, enabling better operating plan execution up to 95 - 100% and higher suitability for automation towards flexible automated cells.

2.2. Model of production system for mass customization

Taking into consideration advantages of effective production systems and the demands that mass customization puts in front of modern production companies the model of production system built on basis of effective production systems and oriented on mass customization market was developed (Figure 7).

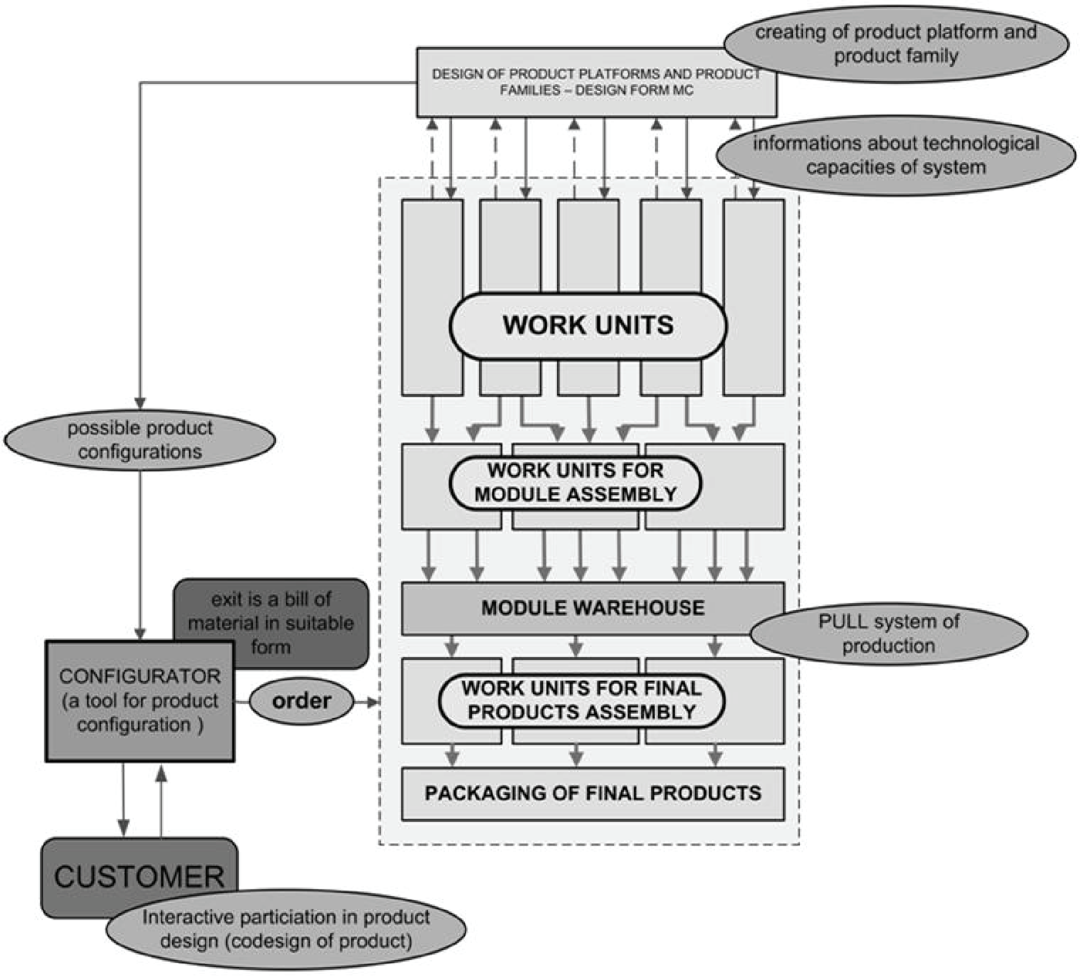

Fig. 7 *Model of production system built on basis of effective production systems and oriented on mass customization market*[8]

This is a system built on:

- standardization of products and technology processes (embedded in design for group technology)
- elimination of unnecessary duplication in product design, construction and production
- group approach in engineering of material flows in system
- product approach in design of production structures
- creating of product platforms as basis for product families design and implementing the principle of designing products only on basis of existing platforms or designing new ones
- design of work and assembly units as basic building elements of production function which allow greater flexibility of production system
- modularization of products and increase of interchangeability of modules in product family, and if possible inside whole product palette of company
- pull system of production in which we do not “push” but “pull” production trough the system depending on market needs and gained orders
- minimization or complete elimination of “just in case” stocks in production system and warehouses of final products
- shortening of production lead time (T_{cp})
- maximal increase of coefficient of turnover (K_{ob})
- decreasing the $T_{cp}/\Sigma t_{ii}$ ratio (where T_{cp} is real lead time in system, and Σt_{ii} is a sum of operational times)
- decreasing number of variants of orders entering as result of grouping the parts in production
- decreasing set-up times in production to minimum and decreasing of number of changes of dies to minimum
- applying configurator tools for easier access to (new) customers and efficient acquisition of orders
- completely using synergy potentials of pull system, configutator tools and data base of designed product families

Production system in Figure 7 is based on group technology and organizing production in production and assembly work units. This system configuration is suitable for pull system which is built into basis of effective production systems.

3. IMPLEMENTING THE CONCEPT OF MASS CUSTOMIZATION INTO PRODUCTION SYSTEM

Taking into consideration all previously mentioned, procedure of implementing mass customization into production company can be presented in four steps (Figure 8).

STEP 1 Analyzing the system

First step of implementing mass customization on the basis of effective production systems is the analysis of the system (Figure 8) which includes:

- material flows
- ratio $T_{cp}/\Sigma t_{ii}$
- coefficient of turnover K_{ob}
- unproductive times
- size of unfinished production
- degree of plan completion
- degree of process automation
- psycho-sociological conditions of work

Special attention during the system analysis should be addressed to all sorts of built in limitations in sense of acknowledging them and eliminating them in some of upcoming steps.

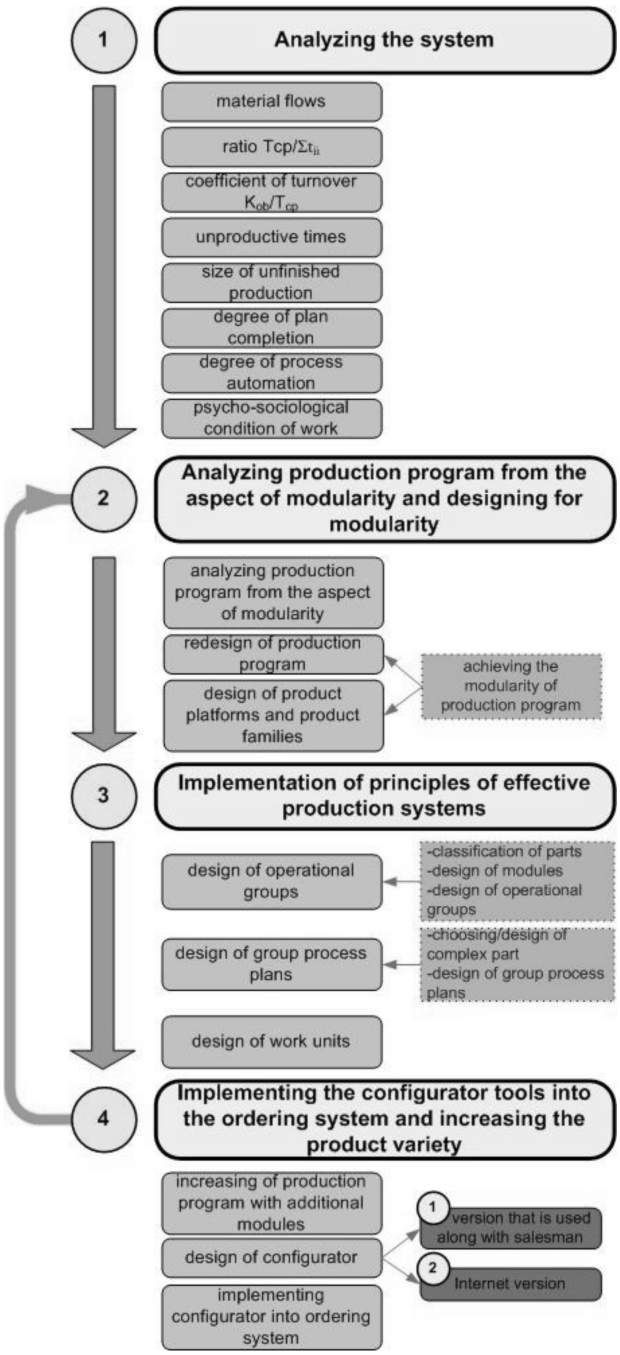

Fig. 8 *Model for implementing mass customization into production system* [8]

STEP 2 Analyzing production program from the aspect of modularity and designing for modularity

In this step we should analyze the production program from the aspect of modularity. In other word the possibility of translating whole program to modular production is analyzed. Similarities in design, functionality, material and all other properties relevant for production of parts, subassemblies and assemblies should be considered. This way we can significantly reduce the number of part, subassembly and assembly variants. At the same time this analysis should provide good foundation for increasing the variety of final products.

For the purposes of translating production program to modular production in this step we need to redesign the program and eliminate unnecessary duplication in design, construction and production (Figure 8). This part of the step is essential for creating a base for platform and family design with modules creating the backbone of whole design process.

The designing of product platforms and families after the analyzing of production program from the aspect of modularity is decisive for implementation of mass customization into the company. Number of designed platforms depends on size and diversity of production program, technological systems present in production and the market presented in customers needs, wishes and expectations. Every platform can then be developed into a product family or families.

Step 2 presents the core of implementation of mass customization concept into the company. It is the preparation for production and it affects it in great deal.

The forming of product families can be done in several ways, which depend on complexity of products and technological capacities of production. In some cases a need for creation of completely new product platform will arise which will be the basis for a new product family. In other cases we will adopt some of our existing products or its components and subassemblies for a product platform. None of these ways of creating product platforms does not mean excluding the other one. Product designers must choose the best way for creating platforms, but in most cases both approaches will be used at the same time.

Nothing of modularity created in this step is visible to the customer. That means that the goal is the translation of system to new production type of already existing or in some ways redesigned products. Redesigning is done trough change of dimensions, colors, way of assembling and producing assemblies and sub assemblies, standardization of repeating components etc.

This step gives basis for the next one in which we translate the production system to effective production system.

STEP 3 Implementation of principles of effective production systems

In this step the reconfiguration of production system is done. Reconfiguration is done using the IIEM approach (effective production system) with elimination of built-in restrictions found in analyses (step 1). Implementing the principles of effective production systems is done in three steps (Figure 8):

1 design of operational groups
2 design of group process plans
3 design of work units

The basic five principles on which concept of effective production systems is based were mentioned in second part of the paper[7].

STEP 4 Implementing the configurator tools into the ordering system and increasing the product variety

This step represents final and full implementation of concept of mass customization into production system.

After design of adequate product platforms and product families it is necessary to link all future products to these platforms and families or design new platforms but never to design individual (detached) products. Product program can be expanded in this step simply by adding new modules which will be compatible with some product family or even exchangeable and usable in multiple product families.

We need to complete the system based on customers order and configurator tools used for their acquisition. This is the moment in which configurator has to be designed. The configurator tool is based on product platforms and families and must be able to present all available product variants to the customer. In ideal case the product configurator should be able to generate an order which would be forwarded to production, assembly or other part of company depending of organization. The configurator can be used with or without (Internet version) help of sales person (Figure 8).

The type of products and type of industry will determine the way of using the configurator. In some industries like computer sector (Dell company) Internet configurators have proven themselves. The properties of a car for example, are not so easy to represent. Further more there is a question of ability of specific customer (user) to imagine their product and maybe satisfying their need for checking the quality of material and other features of product. The truth is that universal solution does not exist. In some cases the sales person which would guide the customization process will be the best solution, in others the Internet version will be perfect. The cases of combination of these two concepts will also bee seen. The success of configurator, and for that matter the whole implementation process, will depend on customers thrust in quality of products. If the quality of products, delivery deadlines, price and treating of customers is satisfying, there is a great possibility that company will keep the customer and build a loyal relationship with him in longer time period. The bigger offer of product variants the satisfaction of customer will be greater, knowing that he bought the product that completely or close to completely satisfies his needs.

The last step in implementation can be but does not have to be taken. This depends of target market, but also technical and technological capacities of production company to embrace this kind of production. For some companies modularization will present just right level of implementation. The only thing is that then mass customization would not be visible to the customer who will, not knowing, order customized products.

The task of companies management is to find the right moment and scale for implementing of mass customization. That will be essential for successful implementation of the concept.

4. IMPLEMENTING THE MODEL OF RECONFIGURATION IN REAL CONDITIONS IN FURNITURE INDUSTRY

For the purposes of research a furniture production company was chosen. The first goal was to analyze the production company that is producing panel furniture, its production program, production capacities, material flows and technological capabilities. The analysis of company went in direction of making the general picture about the company, its market orientation, organization and production capacities, but the main goal was to analyze the production function and her elements.

Part of the companies wide production program can be seen on Figure 9. At the time of the research the program had approximately 440 products and expanding.

Fig. 9 *Part of companies production program*

Number of product variants and the type of production made this company a suitable candidate for reconfiguration towards mass customized production.

The production program is divided in six types of furniture: closets, shelves, bedrooms, separate furniture program, children rooms and kitchens. All of the products belong to panel furniture.

The goal was to determine if there is a possibility for implementation of mass customization concept in production company and transforming the system to model shown on Figure 7. In order to achieve this we must go trough all four mentioned steps (Figure 8):

1. Analyzing the system
2. Analyzing production program from the aspect of modularity and designing for modularity
3. Implementation of principles of effective production systems
4. Implementing concept of mass customization in production system

4.1. Analyzing the system

During the analysis of the system first conclusion was that the products were designed individually, although the furniture was designed as a part of certain recognizable and complementary styles. This way of design affects the material flows in production.

The technological systems are arranged according to process approach (Figure 10). The arrangement is according to operations:

1) Cutting
2) Edge finishing
3) Drilling
4) Machining on CNC centers
5) Control
6) Final control
7) Special machining
8) Packaging

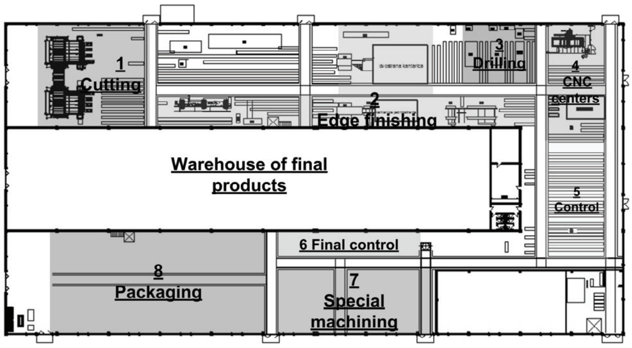

Fig. 10 *Technological systems arranged according to process approach*

All operations are not done on all of the parts, but the sequence of operations always remains the same. CNC centers are capable of doing all of operations needed on parts except of cutting. The operation of special machining can be attaching of ornaments of some sort or other non standard operation.

The interesting characteristic of the company is that there is no assembly process. In fact that is the characteristic of panel furniture industry. The assembling of furniture is done at home by a company employee or customer himself. The assembly operation is here replaced by packaging.

Material flows are not too complex despite of process arrangement (Figure 11), although the production control is difficult having in mind the large quantity of product variants and the similarity between them.

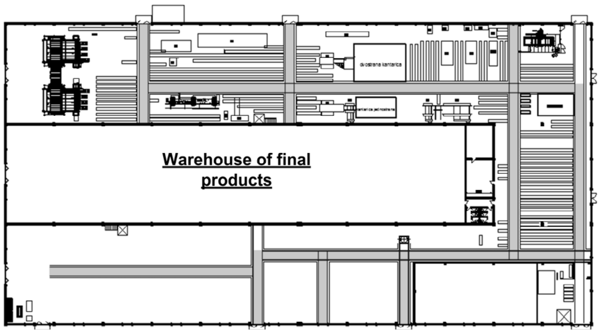

Fig. 11 *Transport ways in production*

The transport ways are longer than they could be if the production was organized in work units and technological systems arranged in product approach. The existing transport ways are a potential for capital improvement. The fact is that no matter how many operations part has it must go trough whole production system to reach the warehouse.

The ratio $T_{cp}/\Sigma t_{ii}$ (where T_{cp} is real lead time in system, and Σt_{ii} is a sum of operational times) is not suitable. The biggest quilt for this is the system of production where big batches of products leave the production at the same time because the system of final control. Having the sample of 100 parts in mind the ratio is 3870 to 94300 depending on complexity of the part (ratio is better for complex parts). If we take in consideration the ratio for whole series of parts ($T_{cp}/n\Sigma t_{ii}$) the result is similar, from 24,5 for complex up to 628 for simple parts. Unproductive times are in correlation to this ratio, and although they were not measured the conclusion is that the situation with these times could not be any better.

The way of launching the orders in production is in direct link with the size of unfinished production. Optimizing the batch size and implementing of work units could significantly reduce the stocks appearing in production. Implementation of work units into the system will be discussed later in the paper.

The degree of operating plan execution is in range between 97 to 98%. The main part of non realized production goes on waste, mainly because of the type of material used. Further upgrades are possible in this segment also with implementation of effective production systems.

4.2. Analyzing production program from the aspect of modularity and designing for modularity

In this phase of implementation we need to do modularization of the complete production program. In this case we have existing production program, so the products had to be compared with each other. The similarities that we are looking for are in material, quality and above all compatibility and interchangeability of parts shared between the products.

When the level of similarity is established and when the groups are made on basis of possibility of combining of product segments (future modules) we should take the steps for redesigning the existing production program and designing of product platforms and product families. Each of new products should than be based on existing or at the same time created platform based on modules.

Dividing the products in modules would at the same time resolve the problem of high products stocks, because the level of stocks of individual parts would fall. In the future stocks would be only kept in modules and not in final products. To show the plastic example four future product families were chosen and analyzed (Figure 12).

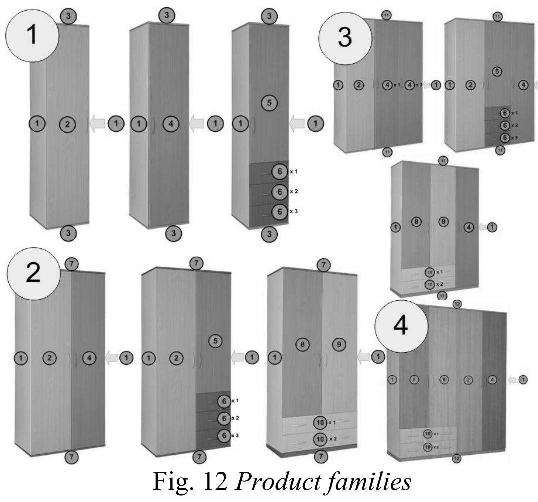

Fig. 12 *Product families*

First of all it is necessary to say that under the module we imply one or more parts depending on functionality of the parts. For example the module could be a door or upper and lower panel of the closet although they are not attached to each other.

Analysis of products showed that some of the modules were appearing more frequent than the others. The ratios were in some cases 10:3. Keeping in mind the size of the sample (only 10 products) the question is what would the result be if we would analyze the whole production program (440 products).

The families of closets mentioned above were divided into modules. Only the outer parts of the closets, the doors, vertical sides, upper and lower panels and drawers were taken into consideration. Number of modules found this way was only 12, and the number of combinations was getting higher with every module. The number of variants gained this way suits the implementation of mass customization concept.

With decrease of stocks in warehouses modularization of production would decrease the time that parts spend in production (the lead times). The parts would be waiting only for the module members and not for the whole product to be finished. The most complex module in mentioned example is a drawer consisted of 6 parts. In this way the storing of parts would be simplified since the number of together stored parts would fall from hundred in some cases, to average of few parts stored together.

Metal parts, handles, ornaments and hinges, would be easily packed when the order comes. These parts can play a great part in customization of products since in many cases only the changing of handle would be enough for making the sale.

So the effects gained by modularization would be:

- decreasing of warehouse stocks
- decreasing of unfinished production
- better control of production
- better scheduling of production
- greater agility of the system
- shorter lead times
- enabled mass customized production

With modularization of production program we have all prerequisites for transfer to mass customization.

4.3. Implementation of principles of effective production systems

In order to implement the principles of EPS into the system the material flow analysis was conducted. Every product was disassembled to his parts (Figure 13) and technology processes of parts were compared.

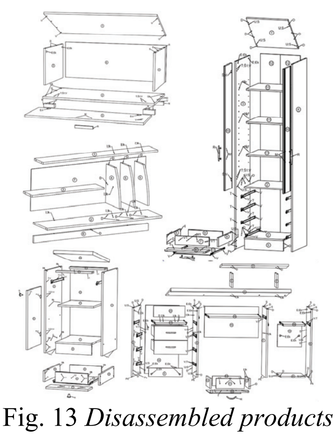

Fig. 13 *Disassembled products*

Analyzing material flows for complete production program and operations done on parts we concluded that the whole production program can be presented with one complex part (Figure 14). That means that complete production program presents one operational group due to specific production of panel furniture and raw materials used, the wooden panels.

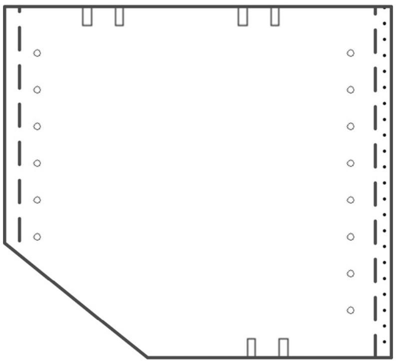

Fig. 14 *Complex part presenting the whole production program*

Since one complex part could not be used for reconfiguration the analysis had to go to the next level, the level of type grouping, so the material flows could be observed. The parts were grouped according to technology processes (Burbidge). The final result was 16 typical groups of parts (Figure 15).

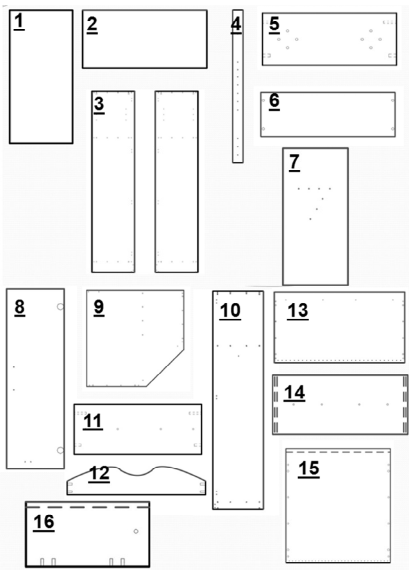

Fig. 15 *The typical groups of parts according to technology processes*

After the grouping of parts the material flows for every group had to be generated. The resulting flow diagram can be seen in Figure 16.

Further analysis showed that it is possible to separate one existing flow to two autonomous ones. Creating of two separate flows (Figure 17) decreases the complexity of the material flows and relieves the existing flows.

Reconfiguration made possible by new material flows shortens the transport ways significantly, speeding the transport of parts trough the system.

Flow 1 is flow of complex (complicated) parts, and Flow 2 is the flow of simpler parts. Separating the less complex parts into the Flow 2 those parts can be presented by a different complex part (Figure 18).

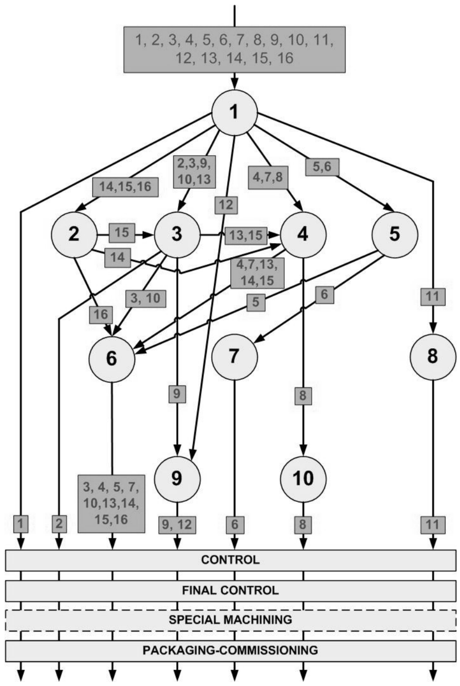

Fig. 16 *Flow diagram for typical groups*

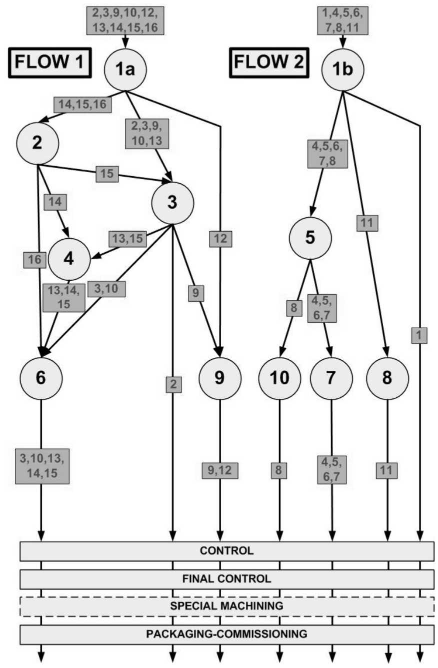

Fig. 17 *Two flow diagrams created with analyzing of typical group flows*

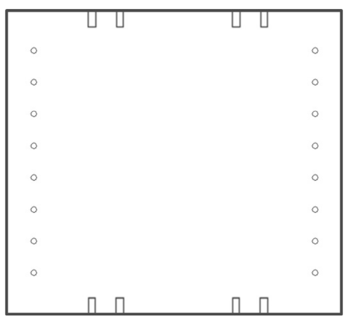

Fig. 18 *Complex part presenting the parts in Flow 2*

Using the results and the information obtained in this step we can do the reconfiguration of the production system. Reconfiguring the production system means arranging the technological system in new way (reengineering of production structures) having in mind the material flows created for typical groups and principles of EPS, with goals of:

- simplifying the material flows,
- increasing the suitability for managing of production,
- shortening the lead times,
- decreasing of queues between operations and
- increasing the efficiency.

Implementation of EPS principles led to a new layout of production structures in the system (Figure 19). Production system has been divided into three work units:

- Work unit 1 – for production of complex parts
- Work unit 2 – for production of simple parts
- Work unit 3 – for packaging-commissioning of modules

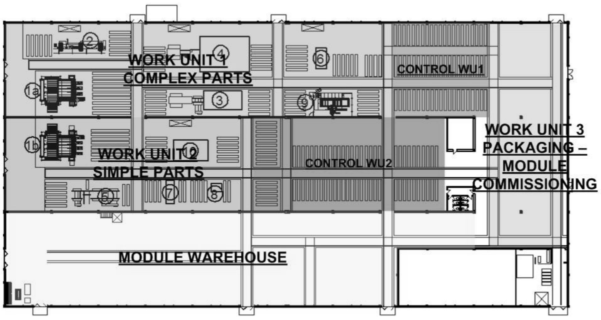

Fig. 19 *The layout of reconfigured production system*

Technology systems are divided in three work units according to product approach and based on material flows for typical groups. So the old placement based on the process approach is changed. Visual control is divided in two parts, one for every production work unit.

New layout brings the need for changes in planning and scheduling of production. Scheduling of production should be done in shorter periods – for the moment it is done monthly. The periods should be weeks or days. Complete system should be leaning to agility and faster responses to market needs. Scheduling should be adjustable and able to take even the individual orders. This could be done inside the typical group which would be released periodically during the week. The goal is to make the system indifferent to the size of the order. Implementing the principles of EPS it is possible to achieve such production.

As a result of implementing the principles of effective production systems into the company (with group technology and work units as the basis of the concept), done in this step we have the following effects:

- simplifying the material flows
- shortening the length of transport ways for every part in production
- decreasing of set-up times as a result of group technology implementation
- creating the conditions for shortening the schedule intervals and accepting the individual orders typical for mass customization as well as setting the base for automated scheduling
- shortening the lead times in combination with product modularization
- decreasing the $T_{cp}/\Sigma t_{ii}$ ratio in combination with product modularization
- decreasing of queues due to smaller batches launched in production

Only when first three steps are successfully done we should proceed to step four. In step three we have been eliminating the built-in limitations. With step three behind us the only thing that remains is to present our products to the customer. Product configurators have proven themselves as a good way to accomplish this step.

4.4. Implementing the configurator tools into the ordering system and increasing the product variety

The fourth step is yet to be done in practice. Importance of this step is essential for full implementation of mass customization concept into the system. Because of that the company must be certain what is customers solution space in creating his own product. Is it all predestined modules offered in configurator or can the designing of parts also be done. Further more the adaptation of products for customized production as well as (re)constructing parts will have a great impact on success of the whole implementation process. If the previous three steps are done in proper way, the configurator will be just a tool which will enable customization and bring our products to the customers.

5. CONCLUSIONS AND FUTURE RESEARCH

The research done in this paper, theoretical as well as those done in the industry, brings us to conclusion that implementation of principles of the effective production systems into the system oriented towards the mass customization markets, lead to increased effects in the sense of:

- decreasing of set-up times,
- simplifying the material flows in system,
- simplifying the launching of orders into the system,
- shortening the lead times in system,
- shortening the transport ways and with it the transport times in the system,
- decreasing the size of unfinished production,
- decreasing of queues between the operations,
- increasing of coefficient of turnover, with decreasing of stocks in production and
- creating of conditions for a better operating plan execution.

The future research could be:

- implementing the bar code system in production control,
- implementing the RFID tags in production control,
- the development of commercial configurator for furniture industry,
- development of software solution for scheduling of customized production based on EPS,
- development of automated classification tool for purposes of panel furniture industry,

- implementing the model in other industries and
- implementing product lifecycle management into the system.

6. REFERENCES

[1]Sanderson, S.W., Uzumeri, M.; „*Managing Product Families*“, Irwin, Chicago, 1997

[2]Davis, S.M.; „Future Perfect“, Addison-Wesley Publishing Company, New York, USA, 1987

[3]Pine, J.B.; *„Mass Customization: The New Frontier in Business Competition“*, Harvard Business School Press, Boston, 1993

[4]Von Hippel, E.; *“Perspective: User Toolkits for Innovation“*, The Journal of Product Innovation Management, 247-257, 2001

[5]Piller, F.T., Tseng, M.; *„The Customer Centric Enterprise: Advances in Mass Customization and Personalization“*, Springer, 2003

[6]Zelenovic, D.; *„The Technology of Organization of Industrial Systems – Enterprises“*, FTN Izdavastvo, Novi Sad, 2005 (in serbian)

[7] Zelenovic, D., Cosic, I., Maksimovic, R.; *“IIEM – approach in development of effective manufacturing systems – companies, group technology & cellular management – A state of-The-Art Synthesis of Research & Practice”*, Cluwer Press, Buffalo – New York, 1998.

[8]Suzic, N.; *„Researching the possibilities of applying concept of mass customization in effective production systems environment“*, magister's thesis, Faculty of Technical Sciences, Novi Sad, 2010 (in serbian)

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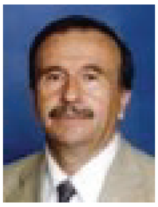

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