SOME CASES IN APPLYING CONCEPT OF MC IN PRODUCTION SYSTEMS DESIGNING

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ABSTRACT

The paper presents three examples of production systems in order to make closer the MC Value Chain in real processes of production, suitable for MC implementation. The first case is in the area of electrical motor production, where products are customized by the producer in manufacturing process. The second example deals with customization of gear units and gear motors in the phase of logistic and distribution. The next case presents the customization of flexible, high-pressure hoses at the point of sail. The last example presents customization obtained by the customer who is equipped with assembly working unit, capable of adjusting flexible hoses to specific requirements for the own system.

KEYWORDS

Value Chain, Mass Customization, Production System Design, Group Technology

1. INTRODUCTION

First of all, it seems obvious to involve the value chain description. The value chain concept is helpful in understanding how value is created or lost. In the case where it starts from production it is important to look how we can increase the added value of the final product through different stadiums of production and sale. The value chain describes the activities within and around a production system, which together create a product or service. It is the cost of these value activities and the value that they deliver, that determines whether or not the best value product is delivered or not. Primary activities are directly concerned with the creation or delivery of a product and can be grouped into four main areas: production, outbound logistics, sales and usage services.

Once we begin to consider the world as a marketplace, then the individual differences become quite obvious. Cultural differences, compounded by individual differences, in a world where consumers are increasingly aware of options, place substantial pressure on firms to respond. The production process then needs to be flexible enough to cater to individual whims of consumers.

The Mass Customization process creates higher expectations on the part of customers. They expect the product they receive to match all their wants and needs completely. If it fails, they are likely to be much more discontented than they had bought a standard product. That is the reason why it is very important to be careful when and where to involve the customer in the creating of the value of product. As it was seen in the paper of Schenk&Seelmann (2003) presented at MCPC 2003 in Munich there can be four scenarios. A key challenge for mass customization to work effectively is that needs to be exchange of information and knowledge between the customer and the company. Involving the customer deeply in the processes of production seems to be very complicated unless it involves mass customization. Cases from different industries show that it can be done if there is a contact person who has all the adequate basic information to help the customer by giving certain direction. In other cases it is less complex, and the customer has the freedom of choosing options.

Group technology (GT), which is a tool for reaching the goal of mass customization, is the fundamental require for process planning. It provides a systematic way to review a family of components to see if an existing component might suffice on a new project. Activities and machines had to be grouped to minimize setups, routings and material handling. GT is background of the IIEM-approach, shortly introduced in the following chapter.

2. BASIS OF IIEM-APROACH

Basis of research and revitalization of production, organizing and control structures in IIEM (*Institute of Industrial Engineering and Management*) - approach makes the design of flows on the principles of ***group technology*** and applying of product approach in the designing of enterprise structures. It has been developed the basic unit of production structure – working unit enabled for the independent working process on the part of the production program.

An analysis of current methods and philosophies, and the industrial reality in which they should be applied, led to the following ideal vision (Cosic & Anisic, 2003):

- Lead-time from customer order to delivery = 0,
- Setup time/work/costs = 0,
- Capacity shortages = 0,
- Quality shortages/re-work = 0,
- Capital tied-up in goods = 0.

The vision points out that all of the production system features are of primary importance.

The IIEM-approach for development of effective production systems – companies, is based on a consideration of various conditions of existed influences of surroundings, objective conditioned conflict occurrences in working processes, and it is based on:

- classification of parts with similar characteristics,
- development of structure's segments on the basis of ability to exits independently, and
- applying of methods for rational integration of structure's segments in totality, using connections with necessary strength and direction, for insuring synergy's effects.

This, somewhat organic approach, relies of the following principles (Zelenovic et al., 1998):

- Principle of SIMILARITY,
- Principle of INDEPENDENT DURABILITY,
- Principle of MANAGING toward goals,
- Principle of ABILITY for effective work,
- Principle of EFFECTIVE MOTIVATION and CONDITION FOR WORK assurance.

3. DESIGN OF PRODUCTION STRUCTURES

3.1 Procedure of production structures design

Procedure for designing/revitalization of manufacturing structures, takes few steps as follows:

Step 1: **OPERATIONAL GROUP DESIGN**

Operational group is basic element in development of group flows and represents group of products/parts with similar characteristics, which determine possibility of production of these parts on the same machine or on the group of machines with the same characteristics.

Procedure of operational group design is consisted of the following phases:

- Classification of product families modules and parts,
- Design of clusters,
- Design of operational groups in assembly and machining.

Step 2: **DESIGN OF GROUP PROCESS PLANS**

The operational group is an essential unit in group flow design. This procedure means that we select real or design imaginary complex product/part representative, for which we create technology:

- Selection/design of product representative or/and complex parts for groups,
- Development of technological process plans for groups.

Complex part must include relevant characteristics of all products from operational group. For the selected real or designed imaginary complex product/part the group technology is created.

Step 3: **DESIGNING OF WORKING UNITS**

Groups of products / work pieces and flows it generated, satisfying necessary condition, separate in autonomous groups –**working units**–parts of system structure in which all projected operation for all work pieces are started and finished. There are two main types of working units (Anisic & Cosic 2002):

- Working units in assembly,
- Working units in machining.

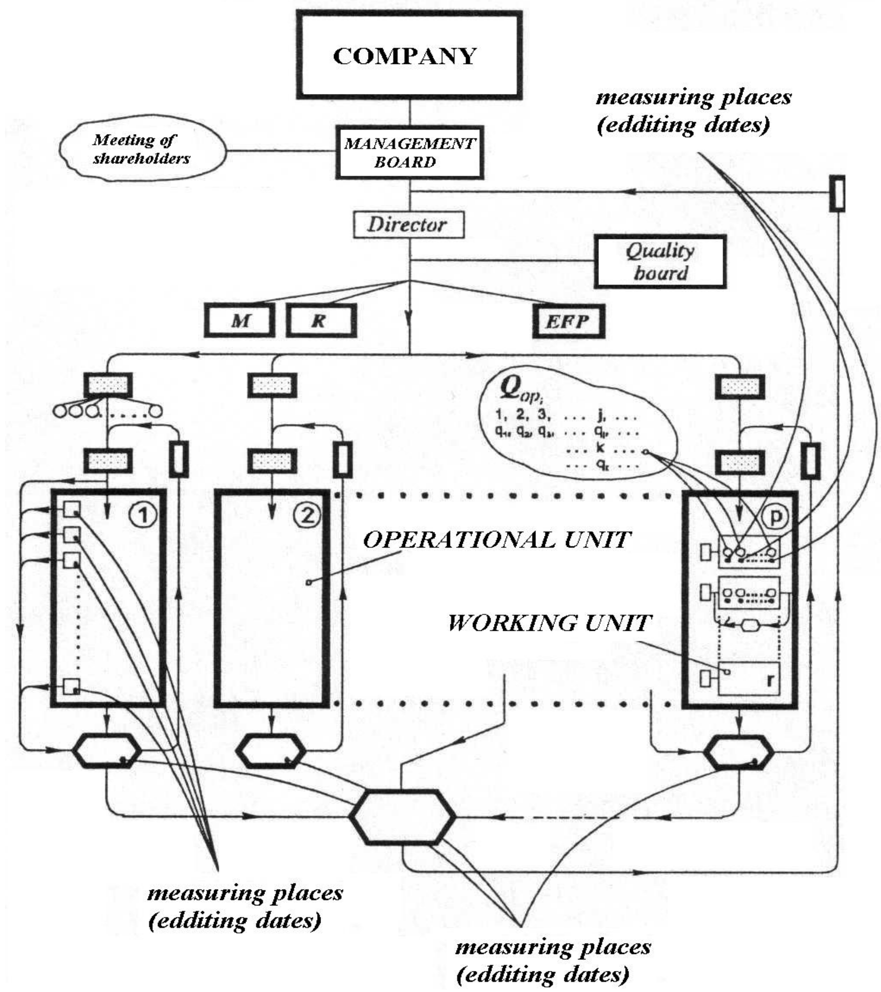


Fig. 1Operational unit

The main difference between IIEM and a ordinary system is what is done after the order entry point. In IIEM there are only the assembly of the product and the shipment that will make the lead time to customer. Many of the companies studied produce at least some of their products to customer order. That means that the total lead-time from customer order to delivery of the products will be the total time taken for ordering components and raw material, the manufacturing processes, administration, transportation etc. These lead-times will often be very long. A common solution is warehousing, which produces short lead-times to customer but will cause a relatively large amount of resources tied up in finished goods. IIEM will attempt to provide short lead-times with minimal resources tied up in goods and material.

3. DIFFERENT CASES OF PRODUCTION SYSTEMS, VALUE CHAINS AND CUSTOMIZATION

3.1 Electromotor production program

The first case presents the production of electrical motors (Fig. 2). This is the most frequent part of the complete range of motor production, starting from a shaft height of 63 mm to 132 mm and output power from 025 kW to 5.5 kW. Several decades of intensive production have led to the diversification of the production program and an enormous number of product variants. Table 1 shows the questionaire sheet for asynchronous electrical motors, giving buyers the possibility to customize orders according to a specific individual request. It is obvious that a combination of 48 given parameters due to fierce competition directly leads to low volume production fully oriented towards customers.

a) Single-phase motors of enclosed design

b) TEFC induction motors with wound rotor

c) TEFC induction motors with squirrel cage rotor - basic series

Fig. 2 Representatives of the electrical motor's production program SEVER®-Holding International, Serbia

Table 1. Questionnaire for asynchronous electrical motors

QUESTIONNAIRE FOR ASYNCHRONOUS ELECTRICAL MOTORS

CUSTOMER:

Company:	
Address:	
Person:	
Tel./Fax:	
Product:	
Num. of pcs.:	

A	MOTOR DATA
1	Motor type: three phase ☐ single phase ☐
2	Rotor type: cage ☐ slip-ring ☐
3	Load: output P_N= ___ kW
4	Voltage/Connection: U_N= ___ V /
5	Frequency: f_N= ___ Hz
6	Speed: n_N= ___ min^{-1}
7	Insulation class:
8	Duty type S1 ☐, S2 ☐, S3 ☐, S4 ☐, S5 ☐ IEC 60034-1: S6 ☐, S7 ☐, S8 ☐, S9 ☐, S10 ☐ min ___, % ___, start/h ___, FI ___
9	Standards: IEC or ___
10	Method of cooling: IC ___
11	Mounting arrangement: IM ___
12	Mechanical protection: motor IP ___ terminal box IP ___
13	Direction of speed*: left ☐ right ☐ both ☐
14	El. magnetic brake: Braking torque: ___ Nm Brake voltage: ___ V
15	Possibility of no load operation (only single phase motors):: yes ☐ no ☐
16	Rotor data (only slip-ring motors): U_{20}= ___ V , I_{2N}= ___ A

B	WORKING MACHINE DATA
1	Type of working machine:
2	Load: P_{RM}= ___ kW
3	Speed: n_{RM}= ___ min^{-1}
4	Load torque - speed ratio: constant ☐ square ☐ or: T ☐ ☐ ☐ ☐ ☐ Nm; n 0 25 50 75 100 %
5	Moment of inertia: J = ___ kgm^2
6	Other data:

C	AMBIENT CONDITIONS
1	Temperature: ___ °C
2	Relative humidity: ___ %
3	Altitude: ___ m
4	Specific conditions:

D	POWER TRANSMISSION AND STARTING CONDITIONS
1	Way of coupling:
2	Way of starting:
3	Number of consecutive starting from hot state: ___ start/h
4	Number of starting: ___ start/h

E	ADDITIONAL REQUIREMENTS
1	Overload: ___ %P_N, Duration: ___ min
2	Temperature rise limit: B ☐ or F ☐
3	Vibration level requirements: ___ mm/s
4	Terminal box position*: RHS ☐ TOP ☐ LHS ☐
5	Additional shaft load:
6	Converter fed motors: Converter type: Manufacturer: Speed range: ___ - ___ min^{-1}
7	Special flange: Attache the drawing
8	Second shaft extension: DA= ___ mm, EA= ___ mm
9	Special shaft extension: Attache the drawing
10	Colour: RAL ___
11	Other requirements:

F	ACCESSORIES, SPARE PARTS, DOCUMENTATION
1	Type of thermal protection:
2	Thermometers for bearings: yes ☐ no ☐
3	Heaters: yes ☐ no ☐
4	Spare parts: yes ☐ no ☐
5	Guarantee: yes ☐ no ☐
6	Manual in ___ language
7	Other requirements:

Analysis of the production program as a part of a research work conducted a few years ago [x], showed that there were more than 3500 different product identification numbers (BOM's) divided into three similar product groups (*Fig. 3*). Further, more than 50% of all orders were in quantity of 1 or 2 pcs (*Fig. 4*), so it is almost individual production where additional customization has been made setting out from a standard product type.

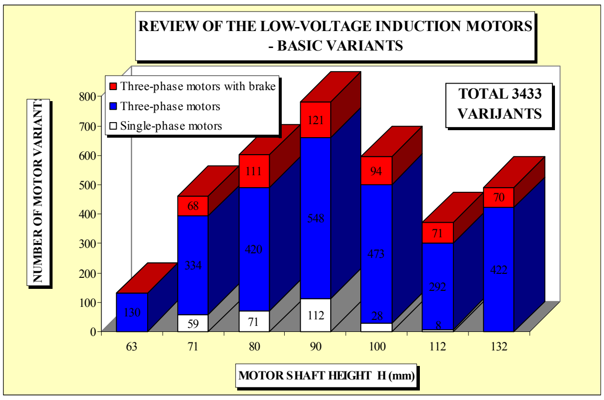


Fig. 3 Review of the low-voltage induction motors variants

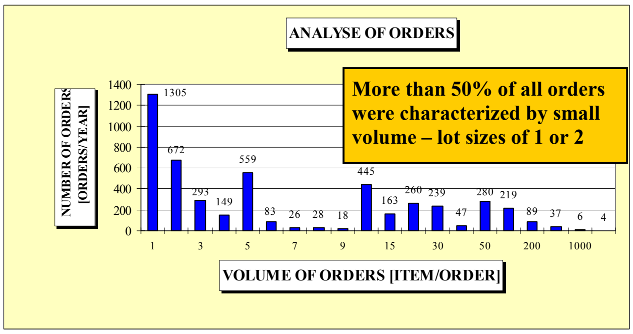


Fig. 4 Review of the customers orders

The main task was to design the production system and organize the process planning and control to meet individual customer needs with near mass production efficiency. The solution for such a type of production was flexible assembly system (Fig. 5), capable of accepting simultaneously several product variants with **minimum or zero changeover time** between variants. Customer orders were translated in so-called **commissioning departments**, were completes-kits of parts and components were formed, according to specific bills of materials and sent to assembly system. The main characteristics of the flexible assembly system is minimum labor division, with only two operations: pre-assembly and final assembly, resulting in a certain number of identical manual workplaces with the optimal level of automation. When the assembly complete/kit enters into the system it can be assembled in the first available workplace allowing almost continuous production of 30-40 different variants per shift.

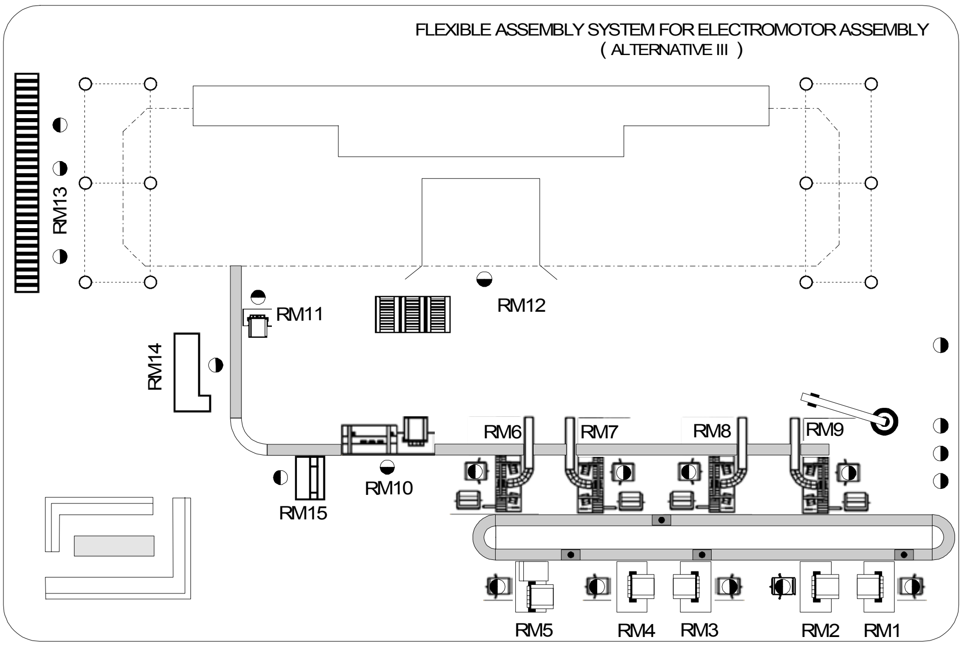


Fig. 5 Layout of the assembly system

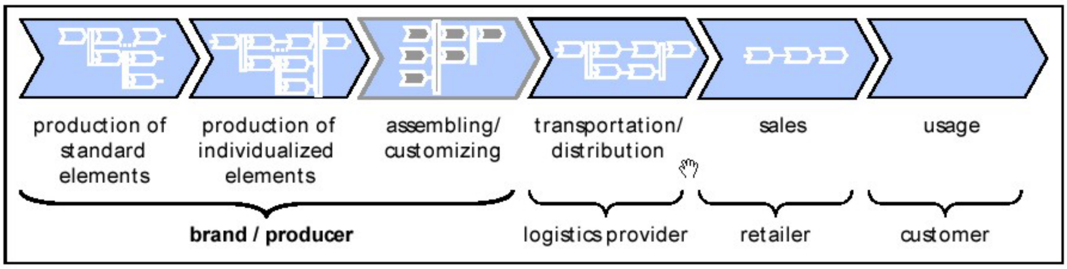


Fig. 6 Scenario I Customization responsibility shift towards producers [Schenk et.al.2003]

The presented scenario, given in the Fig. 6, might be the most difficult process to achieve the customer's needs. Involving the customer in a partnership in the production process planning in order to make a variation of the product requires a good knowledge about the process on the side of the customer. In industries, this is rarely the case, analyzing the results we can see that it might bring competitive advantage to the company, as a reward for opening the system to customers.

3.2 Gearbox production program

Universal gear units and gear motors are products manufactured (assembled) only for known customers (Fig. 7), with defined technical characteristics: max. torque, shaft height, gear ratio, mounting type and position or color. Gear motors are further defined with the following data: motor power, output speed, position of connecting box, level of IP protection, etc. (Table 2) The customer order sheet offers a large scale of customization that can be generated through the combination of parameters. Beside the mentioned technical characteristics, manufacturers are further pressed with prompt delivery requests, e.g. commonly in 72 hours, but it can be less, 48 hours or in extreme cases in 24 hours. Satisfying the specific customer requests in such a short time is a difficult task.

a) Helical geared motors

b) Helical shaft-mounted geared motors

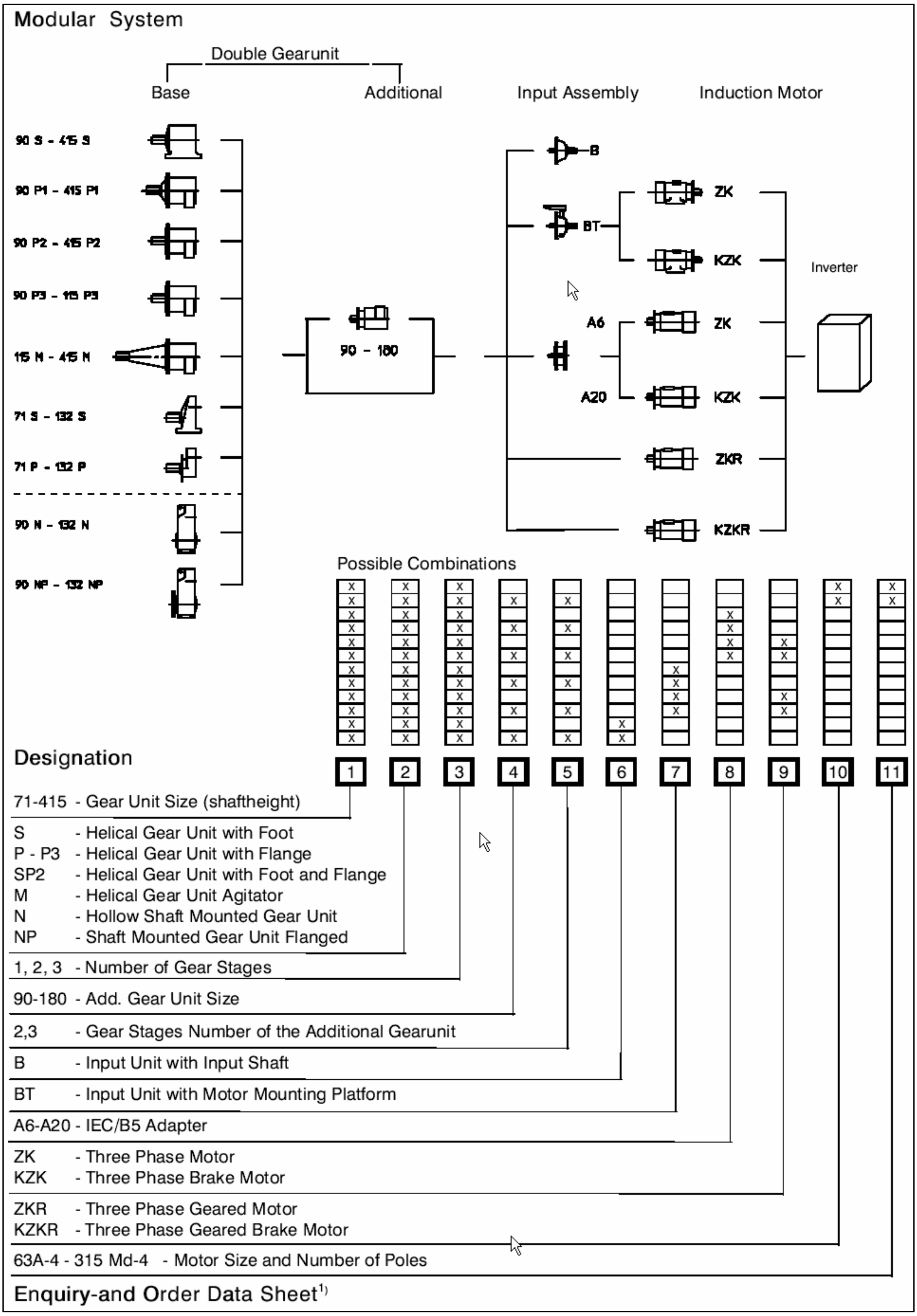
c) Helical worm geared motors

d) Worm geared motors

Fig. 7 Representatives of the gear motor's production program SEVER®-Holding International

Such situations implicate organizing **stock/assembly centers**, usually located near large consumer centers always keeping large supplies of subassemblies and components, prepared to be promptly assembled. All these considerations require careful analysis of the assembly technique of reducers, in order to choose the design which is at the same time, the most suitable for simple assembly and does not require a lot of parts or highly qualified workers. The reduction of delivery time inevitably generated new design concepts of gear units, their subassemblies and parts suited to be produced and assembled fast and easily.

Table 2 Review of the possible product variants



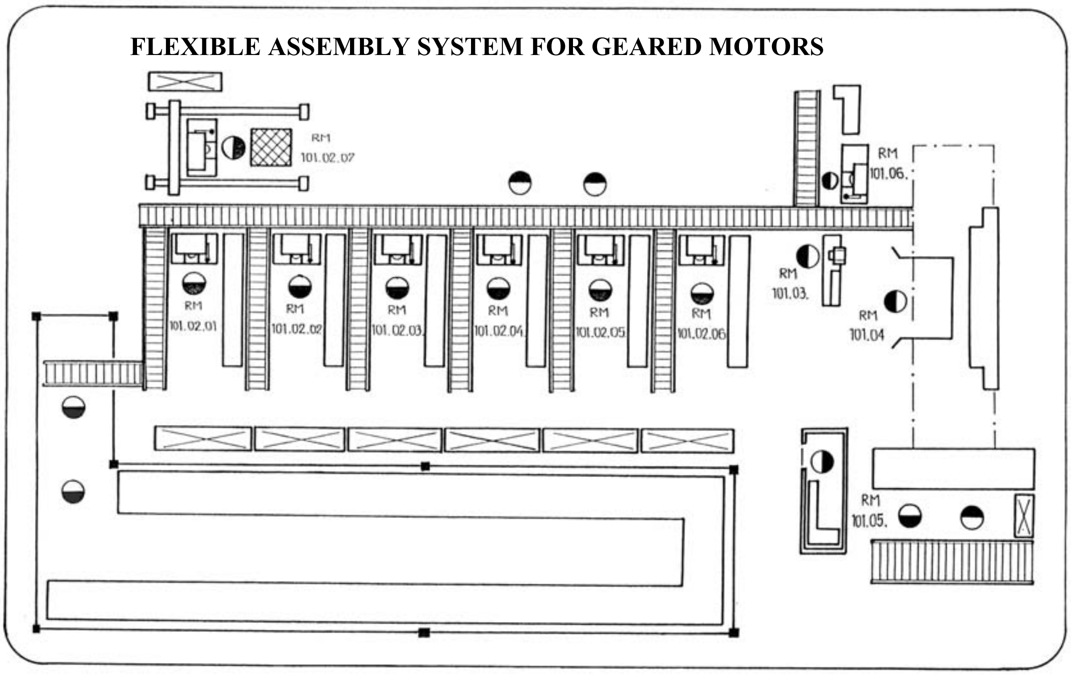


Fig. 8 Layout of the flexible assembly system for motor gear production

In order to decrease the time to respond to the customer order, there are dislocated stock/assembly centers designed. *Fig. 8* presents the layout of the assembly system, flexible enough to cope with different product variants. The most important moment seems to be the product design moment. A modular product assembled at the centers which are covering some regions might be a good way to quick respond to customer demand, but with a certain variety of possibilities. This is the second scenario of the value chain (Fig. 9).

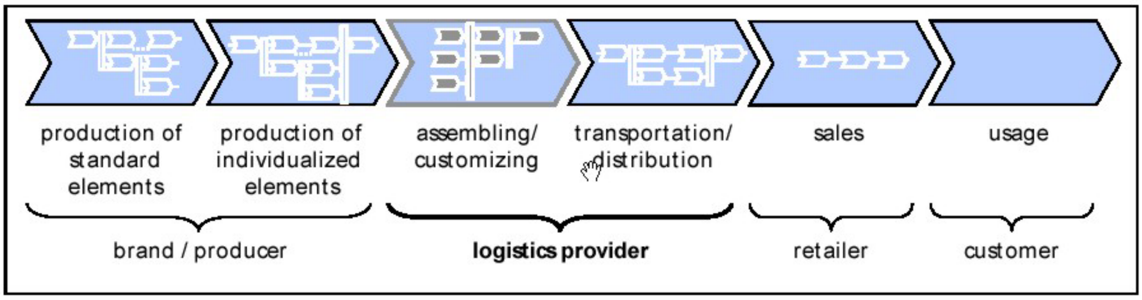


Fig. 9 Scenario II Customization responsibility shift towards logistics providers [Schenk et.al.2003]

3.3 Flexible hose production program

This example presents the production of flexible rubber hoses and fittings for rubber hoses (Fig. 10). Flexible hoses for conveyance of different fluids under low, medium and high pressure, used in hydraulics and pneumatics are made according to various international standards, such as EN DIN 853, EN DIN 857, EN DIN 856, SAE 100 R1, R2, R3, R5, R6, NCB 174, BS 3395, DIN 74310, UIC 830, JUS, etc, and also according to buyers' requests or specific technical conditions. For flexible hose production, FADIP-IFC® Serbia, uses technology obtained from British company DUNLOP. This technology has been in use for over 20 years and has been constantly improved to the present level, which is comparable to the finest technologies of this kind in the world. The second segment of our production program are fittings that provide connection of hoses to equipment for which they are designed. Fittings are made on highly productive and flexible machines in more than 6,000 different types.

The final product is a hose assembly made by connecting flexible hose and fittings, according to the buyers request. Hose assemblies are made in our assembly section, or in assembly units of smaller capacity. Total capacity of our assembly section is approx. 1,5 million assemblies and of each of assembly units min. 50.000 assemblies. Fig. 12 shows the point of sale and also customization of hose assemblies.

Besides these, we offer various new products, like portable irrigation systems, spare parts for irrigation systems and similar, that in various ways incorporate our basic program.

Fig. 10 Flexible hose production program FADIP-IFC® d.o.o.

Mass customization on the point of sale seems to be easiest case of making product variety, maybe there are less possibilities than in other presented cases, but it brings high level of popularity on the market. The problem of quick respond exists no longer because all parts are at the customization place. Also there is no information about the customer's demands before the moment of sale. This might influence the level of sale in a negative way.

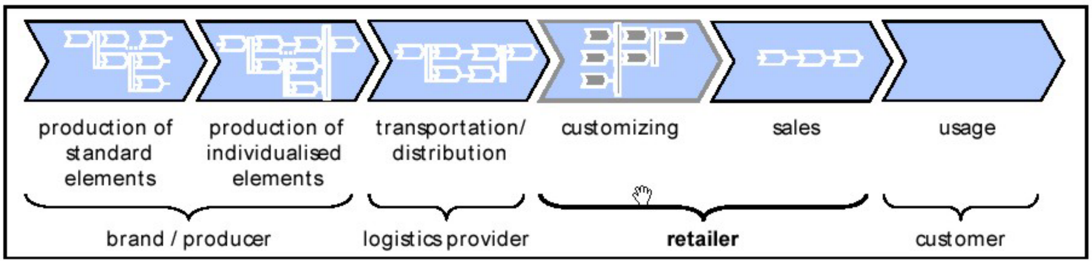


Fig. 11 Scenario III Customization responsibility shift towardspoint of sales [Schenk et.al.2003]

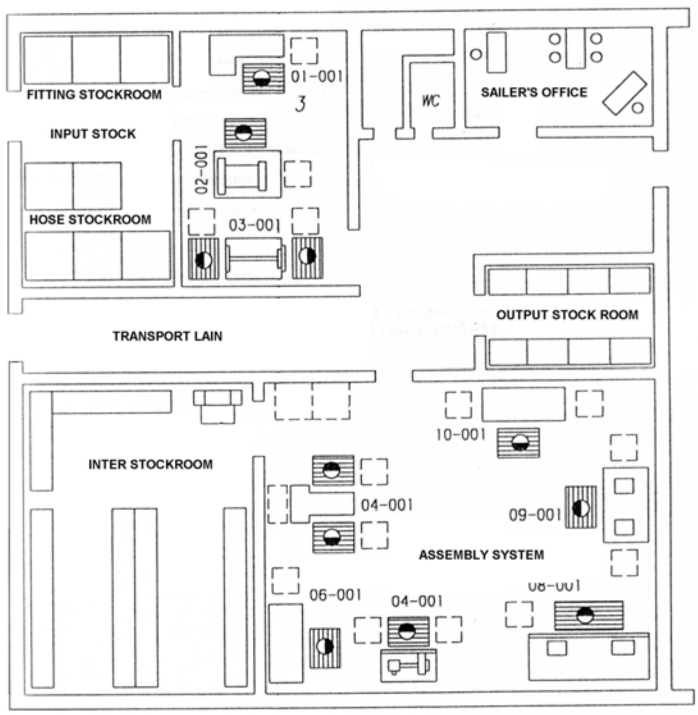


Fig. 12 Layout of the assembly system for flexible high-pressure hose production

5. CONCLUSIONS

In the conclusion it can be said, that the question of customization is very delicate and have to be very carefully considered, concerning the stage of involving customers in the process. Summering the three different cases it can be concluded that the assembly process is of a great importance with adequate product design and structure. IIEM – approach, based on group technology is a good way for achieving reliable and effective production system according to specific needs, primary concerning questions of the delivery time and customer's satisfaction.

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