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LEAN PRODUCTION AND EFFICIENCY OF MODULAR ARCHITECTURE IN SUSTAINABLE ENTERPRISE DEVELOPMENT

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ABSTRACT

The significance of Lean production and modular architecture in sustainable enterprise development is presented in this paper. The implementation of Lean production in realization of modular design enables a development of an appropriate production programme in which design costs are lower and reduction of waste during processing is becoming an imperative. On the example of intelligent transmitters production it was shown that modular architecture enables the production of independent entities, realizes modules according to precisely defined technical documentation and makes possible easy servicing, improvements and fixing. The implementation of Lean concept algorithm in a repeated use of materials in a sustainable enterprise development is presented as well.

Key words: Lean manufacturing, sustainable development, product, modular architecture, reuse, transmitter.

INTRODUCTION

Current trends show that customers have become demanding so producers have to offer more quality, functional and ergonomical products at increasingly shorter terms of delivery. In regard to this, Bouchereau and Rowlands (2000), wrote that a lot of time is needed to estimate the relation between customers' requirements and characteristics of products or services. In other words, customers are often ambiguous and they have different perception regarding certain issues so there is a real problem in translating their codes into some measurable characteristics of products or services, (Chen et al., 2004).

According to Rainey (2005), increasing perfrormances and costs (waste) reduction within an existing product are seen as two most important reasons for continuing the changes of these products. Moreover, Ottosson (2004) showed that most redisigned products are incorporated into new technology so as the enterprise can stay on the market. Modular design of a product therefore has a strategic role for sustainable enterprise development. On one side, design costs will be lower if an existing module is used but on the other side, they can be even higher if new modules and the environment are designed. A selection of the current modules can save money that would be spent on testing and correcting the faults.

The aim of this work is to present a created algorithm for re-use of the materials in an enterprise sustainable development along with included Lean concept elements through modular architecture of a product.

LEAN CONCEPT AND LEAN PRODUCTION

LEAN concept (LC) represents a system characterized by optimisation of a production process and making a cheap product in time with the best quality. The main principles of LC are (Inmam and Mehra, 1990): 1) loss recognition; 2) process standardization; 3) continuity; 4) pull system; 5) quality at input; 6) permanent improvement.

According to Wolmack and Jones (1994) LEAN manufacturing (LM) can be defined as an alternative integrated model of production which combines recognisible tools, methods and strategies of product development and manages supply and operations in an enterprise. LM assumes less work at workplace, less work space, less investment, less time and stock as well as smaller number of tools. It has been proved in practice that methods and instruments of LM are not equally applicable in small and big enterprises (Matt & Rauch, 2013). There are also differences in relation to a type of production, where significant possibilities have been observed in large-scale and mass production and, some partial and under certain conditions, in small-scale and individual production, (Vorkapić et al., 2017). Also, LM has better usage in the enterprises which have accepted and implemented quality system (Zhou, 2012).

MODULAR ARCHITECTURE OF PRODUCTS

Modular architecture (MA) is an engineering methodology which takes into consideration both physical and functional relations between the components within a product life cycle (Kreng & Lee 2004). MA divides a product in modules which are changeable and where it is possible to change geometric size or functions so as different product variances can be got (Erens & Verhulst, 1997). Gu et al. (1997) point at the importance of MA in a functional interaction between the components during the exchange of materials, energy and signals as well as in spatial and geometric coordination (positioning, linking, bending, hermetic quality).

MA implies design of components and their packing in modules. In relation to this, according to Gu and Sosale (1999), modular design of a product has the following advantages: (1) divides design in a parallel product development, (2) improves the production and assembly, (3) improves standardization, (4) enables unhindered product servicing, (5) enables product improvement, (6) enables recombination of elements within a product, (7) enables recycling, (8) enables re-use and product waste, (9) adjusts a product to customers' needs.

Since the modules are physically connected, a designer is given a chance to realize different module's combinations in the form of a new product (Umeda et al., 2008). Also, MA enables connecting components or forbids mixing and convergence of components (Sa'ed and Kamrani, 1999). Changes in modular design represent another form of continual improvement. In this regard, the advantages of modular products are reflected in the following: 1) economical scope of components, 2) easy finishing, 3)increased diversity of products, 4) reduced time of ordering and 5) simplified design and testing (Ulrich, 1995).

Modules should be adjustible enough in order to have general significance for many current and future products. According to Anderson (2004), the principles of modular design include: (1) total costs, (2) re-use, (3) connections and protocols, (4) standardization, (5) clear connection for faster connecting, (6) documentation, (7) faults removing and (8) consistence.

During standardization it is necessary to take into account that too many different parts and types of material are not used because it is not possible, in this situation, to organize a permanent flow owing to diverse and uncertain demand. It is a real problem because, on one side, engineers do not understand or appreciate the significance of a supply chain and the flow of operation while, on the other side, there is a pressure put on engineers to analyse similarities or compatibility as well as the independence of elements within MA (Gershenson et al., 2003).

CLOSED MATERIAL FLOW IN SUSTAINABLE DEVELOPMENT

In closed supply chains a customer can become a supplier, in other words, a customer can be a seller of used products (Thierry et al., 1995). In this situation, used products "behave" like starting resources in sustainable development of an enterprise. For making a closed material flow block of diagram by implementing LEAN production in sustainable development of an enterprise, presented in Figure1, several studies were used (Fleischmann et al., 1997; Spengler et al., 1997; King et al., 2006). The purpose of the closed loop of material flow is to save material, total energy input and reduction of waste and harmful gas emission (Nasr & Thurston 2006).

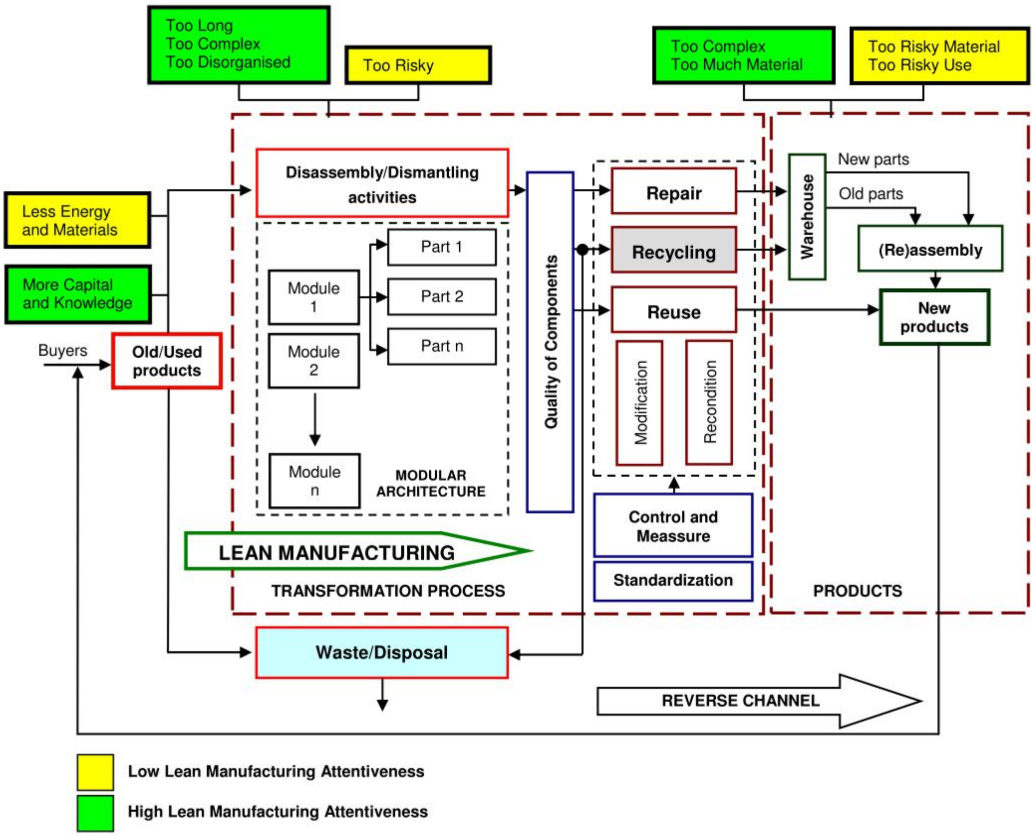

Figure 1: Closed material flow by implementation of Lean production in sustainable development of the enterprise

The received product is disassembled after inspection and disposed in waste. Correct parts are then disassembled in integral modules in reverse order from the way they were assembled. Disassembled modules are then separated. Each part of the module is then inspected and controlled. Further activities are related to measuring and control. All activities are independent and they are carried out based on factual situation and the insight in correctness/incorrectness of the device.

The first activity means fixing or refreshing modules or parts. A repaired or later contolled part goes to warehouse of finished parts. These repaired or fixed parts combined with new parts participate in the realization of new products. The second activity implies recycling. Recycling represents a procedure which strives to return the product into original state by applying the operations of disassembling, restoring and exchanging certain parts or joints. Recycling of used material can be divided into the following techniques: 1) for processing in-built parts and 2) re-use of processed material. At this point, classification of a module's functional parts is carried out while disfunctional parts are disposed in waste. Correct parts are also stored in warehouse of finished parts. If some modules satisfy the basic functions and purpose, the third activity which means re-use is applied. Re-use includes: modification (changing one or more characteristics of a product) or processing the existing parts.

SUSTAINABLE DEVELOPMENT ON THE EXAMPLE OF IHTM TRANSMITTER

A new product, realized through MA, iz based on the family of different products in which a basic component can participate in diverse variants of a product by means of module division. Product design has an important role in fast and easy disassembly of components. It is exactly the level where important designer's decisions related to further product realization can be made in regards to technical and economical feasibility, overall functionality and structural product compactness (Desai & Mital, 2003).

On the example of intelligent transmitters of pressure, level and temperature from the production programme of IHTM-CMT, here will be explained the significance of modules in sustainable development of an enterprise. Previous experience has shown that the mentioned products were only serviced in or out the warranty period. Purchase of damaged or scrapped product both by customers or distributors was not taken into consideration. In the following section of this paper we have analysed, by implementing LC, the modules characteristic for recycling and re-use with the aim of achieving considerable savings of material and energy.

Figure 2 shows a transmitter with marked modules. Common names of all three modules are given in the following order: 1) module 1 – electronic box, 2) module 2 - joint, 3) module 3 – measuring chamber. All modules are consisted of parts which make a final product when joined together.

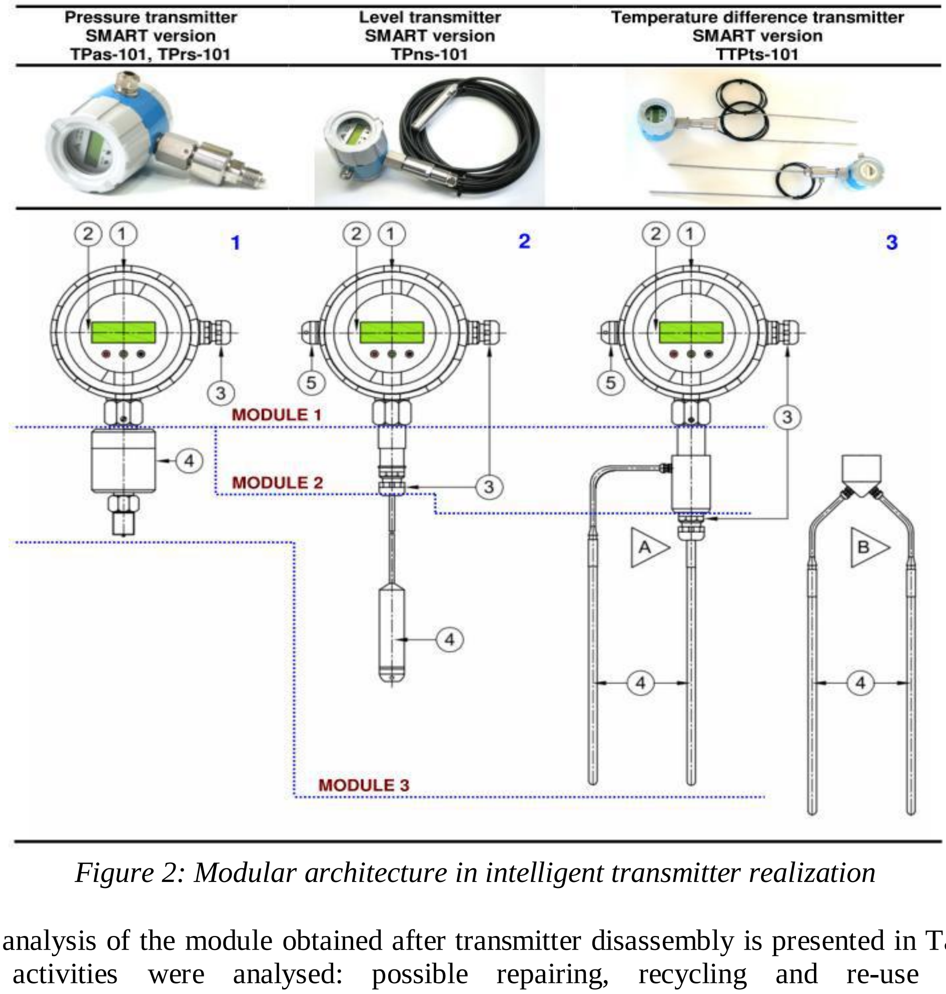

Figure 2: Modular architecture in intelligent transmitter realization

A detailed analysis of the module obtained after transmitter disassembly is presented in Table 1. The following activities were analysed: possible repairing, recycling and re-use of certain modules/elements. As can be seen, on most parts there haven't been any repairs so far but all parts can be recycled or re-used. A great number of parts cannot be repaired due to the selection of material or design solution (the exceptions are a printed board and Pt-100 sensors). In addition, the materials used in the transmitter realization are too expensive. The following materials are most used: 1.) stainless steel (most used, body: X6CrNiMo17-12-2, membrane: X2CrNiMo17-12-2/ X5CrNi18-10); 2) aluminium alloy (Al.Cu5.Mg1.55); 3) electrical components (printed board and waterproof cable), 4) brass (CuZn39Pb3), 5) glass and rubber. Protection from corrosion requires hazardous chemical treatment or colours. Aluminium and its alloys are therefore frequently used as corrosion resistant metals.

Table 1: Module analysis of IHTM-CMT product disassembly

Product	Module	Part	Repair	Recycling	Reuse
Pressure transmitter SMART version TPas-101, TPrs-101 **1**	1	1.1 Metal enclosure	-	+	+
		1.2 Electronics package	+	+	+
		1.3 Cable connection (PG)	-	+	-
	2	2.1 Connection (M)	-	+	+
	3	3.1 Pressure sensor	-	+	+
		3.2 Process connesction	-	+	+
Level transmitter SMART version TPns-101 **2**	1	1.1 Metal enclosure	-	+	+
		1.2 Electronics package	+	+	+
		1.3 Cable connection (PG)	-	+	-
		1.4 Relative pressure sensor	-	+	+
	2	2.1 Connection (M)	-	+	+
		2.2 Distancer	-	+	+
	3	3.1 Absolute pressure sensor	-	+	-
		3.2 Wet probe	-	+	+
		3.3 Cable	-	+	+
Temperature diff. transmitter SMART version TTPts-101 **3**	1	1.1 Metal enclosure	-	+	+
		1.2 Electronics package	+	+	+
		1.3 Cable connection (PG)	-	+	-
	2	2.1 Connection (Var. A) Fixed and dislocated probes	-	+	+
		2.1 Connection (Var. B) Two dislocates probes	-	+	+
	3	3.1 Temperature sensors (Pt-100 sensors)	+	+	+

CONCLUSION

Modern business concept of an enterprise recognizes a customer as central figure along with maximun saving of its resources. Identification and elimination of unnecessary activities enable the achievement of production processes' maximum quality. Every activity which spends resources complicates the production process and increases the time of production which, on the other hand, increases the price of products.

The implementation of LM and MA on the example of IHTM-CMT product realization showed the influence which this concept could have on sustainable development of an enterprise. General conclusions point at the following:

1. MA divides a product design in several independent entities (modules) together with enabling development of the enterprise;
2. Product realization through modules improves production and assembly. It has been shown that most modules of a transmitter can be assembled even at some inaccessible places which reduces time and costs of assembly;
3. All mentioned modules are standardized and produced according to precisely defined technical documentation;
4. Servicing represents a very important segment (for more complex modules and preventive maintenance). Incorrect module can be exchanged by a new or repaired one.
5. Product improvement is permanently carried out. One of them is a module recombination. Each of all mentioned modules can be connected to a semimodule but different modifications of existing modules are possible as well.
6. Modules' components can be disassembled, repaired, separated, recycled and re-used.
7. Product adjustement based on diversity of modules is necessary in order to satisfy customer's individual requirements and desires. In this way an enterprises is trying to bridge a gap between customers and designers.

Implementation of modular design on the concrete example of IHTM-CMT transmitter realization enables development of a production programme based on the enterprise’s own results and contributes to a high rate of flexibility. It is important to stress here a re-use of the transmitter which contributes to reduction of electronic waste. The concept of collecting outdated electronic equipment represents a new platform and a topic for serious thinking.

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REFERENCES

Anderson, D. M. (2004). Design for manufacturability & concurrent engineering: how to design for low cost, design in high quality, design for lean manufacture, and design quickly for fast production. CIM press.

Bouchereau, V., & Rowlands, H. (2000). Methods and techniques to help quality function deployment (QFD). *Benchmarking: An International Journal*, *7*(1), 8-20.

Chen, C. Y., Chen, L. C., & Lin, L. (2004). Methods for processing and prioritizing customer demands in variant product design. *IIE Transactions*, *36*(3), 203-219.

Desai, A., & Mital, A. (2003). Evaluation of disassemblability to enable design for disassembly in mass production. *International Journal of Industrial Ergonomics*, *32*(4), 265-281.

Erens, F., & Verhulst, K. (1997). Architectures for product families. *Computers in industry*, *33*(2-3), 165-178.

Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., Van der Laan, E., Van Nunen, J. A., & Van Wassenhove, L. N. (1997). Quantitative models for reverse logistics: A review. *European journal of operational research*, *103*(1), 1-17.

Gershenson, J. K., Prasad, G. J., & Zhang, Y. (2003). Product modularity: definitions and benefits. *Journal of Engineering design*, *14*(3), 295-313.

Gu, P., Hashemian, M., Sosale, S., & Rivin, E. (1997). An integrated modular design methodology for life-cycle engineering. *CIRP Annals-Manufacturing Technology*, *46*(1), 71-74.

Inman, R. A., & Mehra, S. (1990). The transferability of just-in-time concepts to American small businesses. *Interfaces*, *20*(2), 30-37.

King, A. M., Burgess, S. C., Ijomah, W., & McMahon, C. A. (2006). Reducing waste: repair, recondition, remanufacture or recycle?. *Sustainable Development*, *14*(4), 257-267.

Kreng, V. B., & Lee, T. P. (2004). QFD-based modular product design with linear integer programming—a case study. *Journal of Engineering Design*, *15*(3), 261-284.

Matt, D. T., & Rauch, E. (2013). Implementation of lean production in small sized enterprises. *Procedia CIRP*, *12*, 420-425.

Nasr, N., & Thurston, M. (2006). Remanufacturing: A key enabler to sustainable product systems. *Rochester Institute of Technology*, 15-18.

Ottosson, S. (2004). Dealing with innovation push and market need. *Technovation*, *24*(4), 279-285.

Rainey, D. L. (2008). Product innovation: leading change through integrated product development. Cambridge University Press.

Sa'ed, M. S., & Kamrani, A. K. (1999). Macro level product development using design for modularity. *Robotics and Computer-Integrated Manufacturing*, *15*(4), 319-329.

Spengler, T., Püchert, H., Penkuhn, T., & Rentz, O. (1997). Environmental integrated production and recycling management. *European Journal of Operational Research*, *97*(2), 308-326.

Thierry, M., Salomon, M., Van Nunen, J., & Van Wassenhove, L. (1995). Strategie issues in product recovery management. *California management review*, *37*(2), 114-135.

Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research policy*, *24*(3), 419-440.

Umeda, Y., Fukushige, S., Tonoike, K., & Kondoh, S. (2008). Product modularity for life cycle design. *CIRP Annals-Manufacturing Technology*, *57*(1), 13-16.

Vorkapić, M., Radovanović, F., Ćoćkalo, D., & Đorđević, D. (2017). Applicability of the LEAN concept to the management of small-scale manufacturing enterprises in Serbia. *Tehnicki Vjesnik = Technical Gazette*, *24*(6), 1929-1934.

Womack, J. P., & Jones, D. T. (1994). From lean production to the lean enterprise. *Harvard business review*, *72*(2), 93-103.

Zhou, B. (2012). Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs). *Annals of Operations Research*, 1-18.