

Remanufacturing and 4R Strategy in Analysis of Advancing the Production of Level Transmitter Type: The Case of Serbia

Miloš Vorkapić

University of Belgrade, ICTM-CMT, Belgrade, Serbia
Email: worcky@nanosys.ihtm.bg.ac.rs

Siniša Minić

University of Priština, Teacher Education Faculty, Serbia
Email: sinisaminic@yahoo.com

Abstract – This paper presents the algorithm incorporating implemented strategies: remanufacturing and 4R. As an example, level transmitter has been analyzed at the end of its lifetime. Reusing the transmitter is realized through: verification, disassembly and reassembly, replacement of parts, cleaning, and testing. The paper gives an example how to save on materials and energy appearing as a large losses during the manufacturing process. Just from this standpoint, mentioned strategies are of great significance for sustainable development of production companies in Serbia. The algorithm represents how domestic companies should ensure and improve the production process but as well to improve communication with customers and a better business environment. Customer appears as a supplier of used products, thereby changing the business philosophy in designing products for more life cycles.

Keywords – Algorithm, 4R, Remanufacturing, Sustainable Production.

I. INTRODUCTION

Production and sale in small batch production is mainly carried out according to order of buyer. So, small batch production process is analyzed in the field of sustainable development and functioning of small enterprise.

Customers must sent detailed specifications, so that the manufacturer can design and make product that will meet customers' real needs [1]. The same process holds true for engineering changes to existing products, as well as new products. Many manufacturers prefer the customer to specify the desired functionality or result from the product, plus other critical environmental attributes, (size, electrical constraints, vibrations, etc...).

The production process is concerned with transforming a range of inputs and outputs. Many authors, [2]-[5], define three basic types of input values: material, energy, and other factors (water, tools, supplies, information). Output values in the transformation process are mostly: finished product, material losses, energy (or energy dissipation) and time losses.

Modern enterprises are facing ever increasing challenges of shorter product lifecycles and more products' complexity. Nowadays, the term of product lifecycles includes: faster product development through purchase of components for manufacturing, fitting and service; disassembly of product, repair and re-use of parts and components, as well as avoiding the use of toxic substances [6]-[11].

More and more attention is being paid to the realization of new products; more attention is being paid to ecologically pure products [12]. Therefore, it comes to the changes of production process during product lifecycles, in order to reduce waste and emissions. Such projects of cleaner production have contributed to savings in companies; while on the other hand motivate managers and employees to move in that direction. [13]

II. FLOWCHART

Diagram of material flow is given in manufacturing process, in figure 1, [14]-[15]. The word is about sustainable manufacturing in the field of sound and sustainable development of small and medium-sized enterprises with an emphasis on environmental protection [16]-[19]. Flowchart, in Small-Scale Enterprises implies active participation of management, from reducing costs of input values, up to monitoring, measuring and control of input, intermediate and output elements.

The manufacturing process consists of three sub-processes: production preparation (preparatory stages), production process and ending of production process [20].

Managing of production elements is done through quality control, which in itself includes: 1) analysis, measurement and correction of output parameters, 2) improvement of input parameters (see figure 1) [14]. In this regard, in the manufacturing process and sustainable development, attention should be given to the organization of the manufacturing process through [21]: reducing consumption of energy and resources, reducing the use of toxic materials; using material of good-quality and characteristics, possibility of upgrading, repairs and recycling of products.

In standard or traditional Flow chart, material is bought from supplier, then takes place input control of material and finally stored in a warehouse. Follows manufacturing process or transformation process of material in finished product. The output control of a new product is taking place, and realized/new product is being stored in a warehouse of finished products, after controlling.

Rectilinear Flow chart/diagram described in this way indicates that material is losing permanently. Communication in a seller-buyer relationship has been reduced to pure/true sale, so the producer does not have feedback what is going on with the product in exploitation or what is going on with the product at the end of its lifecycle.

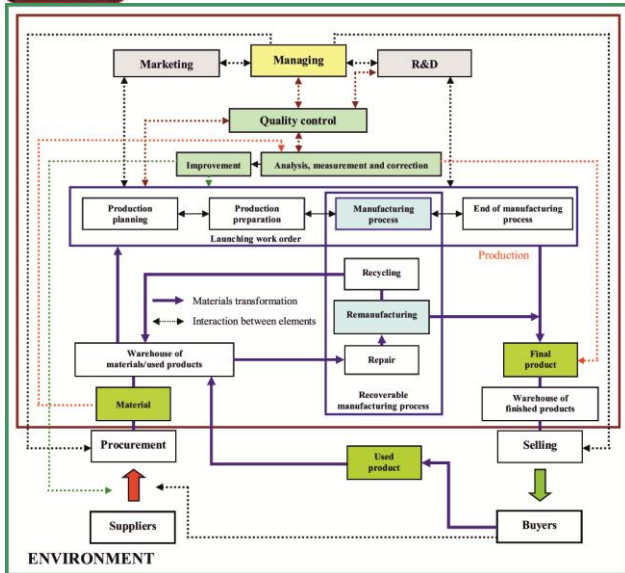


Fig.1. Flow chart of material in processing/manufacturing process

Two strategies are implemented in the Flow chart: remanufacturing and 4R. This was formed Flow chart of material in manufacturing process represents the backbone of the efficient business enterprises with emphasis on environmental protection [22]. Feedback has been provided by customer, namely customers appear as suppliers of worn-out/old products or raw material for reprocessing. Such a flow diagram allows: reducing waste, recycling old parts and reuse of products end-of-life.

III. REMANUFACTURING

Manufacturing system is considered satisfactory if there is a demand for production and remanufacturing (see figure 1) [23]. Such system can include purchasing of products from customers, then storing them and using in remanufacturing process later.

Remanufacturing includes disassembly and cleaning parts, measuring and testing of parts [24]. Finally, the usable parts are placed into a warehouse. It means that product can be made up of old and new components.

The authors pointed out that it can be saved up to 85% of the weight of the product, and takes 80% less energy for the realization of the product manufacturing, by application of remanufacturing in research.

Remanufacturing should provide following operations [25]:

1. Gathering components;
2. Inspection and verification of subassemblies;
3. Sorting out of elements;
4. disassembly;
5. testing of elements;
6. recovery, repair and replacement the parts;
7. assembling the parts;
8. testing and adjusting of operating parameters;
9. delivery and
10. warranty.

Many companies have become successful by applying remanufacturing. The following advantages are pointed

out in literature [26]-[27]: 1) enterprises using recycled products reduce its expenses, 2) application of remanufacturing itself in marketing purposes represents a strategy to increasing profit or profitable, 3) specialized equipment/fittings is used in remanufacturing process, 4) the tools are being optimized due to assembly and disassembly, 5) remanufacturing provides provide stability in investments and in the economic operation of an enterprise and 6) There is independence from suppliers. Remanufacturing process, in case of SAD, relates most to managing of materials (25,6%), production (28,2%), while only 12.8% related to management [28]. Also, the manufacturing cost is increasing for a short time if the percentage of returned products is increasing [29]. On the other side, with increasing percentage of used products whilst maintaining the quality, remanufacturing process becomes more complex and expensive.

IV. 4R STRATEGY

Small enterprises should introduce 4R strategy in its business policy. This strategy includes in itself: 1.) Reducing material waste to a minimum (**Reduction**); 2.) Reuse of waste materials (**Reuse**); 3.) collecting material waste in order to preserve environment (**Recycling**), 4.) regeneration of raw materials and energy from waste materials that can not be reduced, reusable or recyclable (**Recovery**) [30]. The purpose of recycling is to reuse materials or elements from the used products. [31]. In this regard, aim of this paper is to show the willingness of enterprises to accept this strategy in sustainable development.

V. ALGORITHM FOR IMPROVING THE PRODUCTION PROCESS

There are mainly open supply chains involving the entire process from initial raw materials all the way to the final product in domestic enterprises.

In the production process, next to the finished product on the output occur losses which may be in the form of: shaving, badly made items, a broken tool due to improper handling, etc...

In open supply chains, buyers and sellers act as independent entities. Regarding it, enterprises possess large stocks of raw materials and provide additional capacity for the defense of changing market. [32]. However, such an approach is a major risk.

This paper presents a new algorithm for introducing mentioned strategies in the product realization process (see figure 2). As a starting point, studies were of great help for designing algorithm [31], [33].

In the algorithm is given feedback between buyer-seller. The buyer appears as a supplier or appears in the role of seller of used products, [31]. In that way, customer helps enterprise to reduce accumulation of raw materials and losses in realization of new products.

As a solution for the algorithm appears reuse of old products or product parts (see figure 2). In this case, it is possible to reuse of some parts without any previous

electrical and electronic waste are proposed through: 1) disassembling (dangerous or valuable components are being separated) and 2) upgrading (the desired content of material is being upgraded).

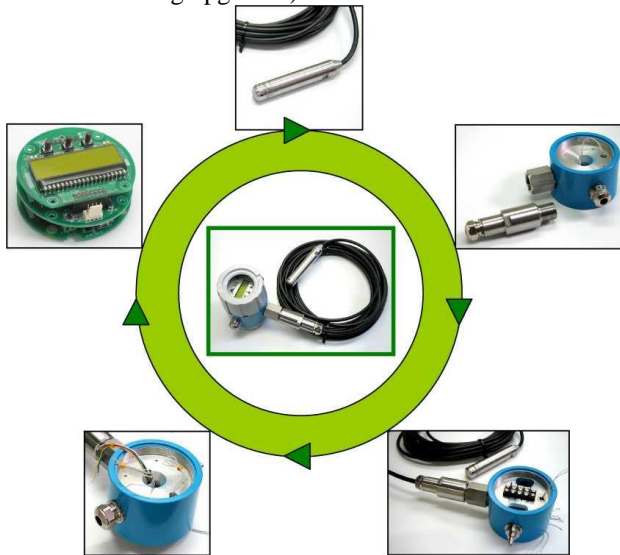


Fig.4. Elements of level transmitter

On figure 4, is shown the sequence of technological operations in the process of assembling level transmitter. Implementation and verification/control of assembling level transmitter is carried out in the following steps:

1. Connecting transducer with a cable and box electronics.
2. Connecting electrical block with cable on which level transducer is attached. Installing the electronics on spacers attached on the box.
3. Installing an electrical connection on electronics. Connecting and checking of all components.
4. Formation of the finished product by setting a cover with a glass on the box electronics.

Disassembly Procedure is conducted according to the following procedure:

1. The cover of the box electronics is removed and visually checking circuit: box, glass and Seeger ring, or are there mechanical damages, or whether some of these elements are missing (see figure 5).

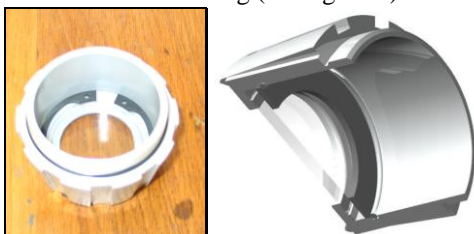


Fig.5. Cover assembly of electronic box

2. Circuit electronics is removed from electronic box. If the circuit works, is separated in a box for storage, if not, than the circuit is separated in a separate box for waste. The algorithm now provides environmental concerns, and gives the possibility of implementing the application of EU directives (Directive of management of electrical and electronic waste - The WEEE

Directive, Waste from Elektrical and Electronic Equipment, 2006. adopted).

3. Separation of cable with level transducer and visual checking whether there are mechanical damages. If there is no damage, correctness of circuit transducer is checked. The correct circuit goes to the warehouse, while defective one in waste.
4. Electronic box with electrical connection also checks that there are no mechanical damages (see figure 6). Connection is separated if it is damaged. Further steps are described.

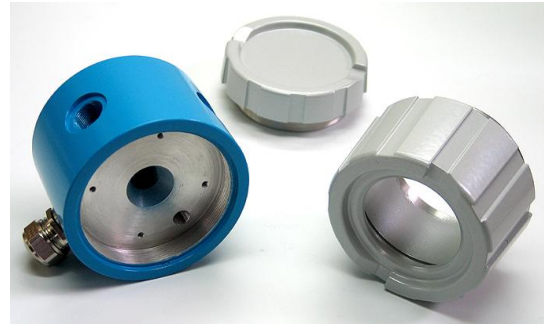


Fig.6. Circuit of electronic box

Unfortunately, designers are becoming more and more cautious regarding the issue of recycled components, since such components may have variable characteristics in terms of quality. [41].

In this respect, in literature [42]-[43], „design for remanufacturing“ was discussed, or it is about a technology that is focused on the detailed design products through: disassembling and reuse for more lifecycles. This in our case indicates that the product must be reliable, durable, replaceable, repairable and available again, or to keep the identity and functionality.

VII. CONCLUSION

The paper gives an example of how to save materials and energy appearing as huge losses in manufacturing process. We have tried in the paper to explain how it is important introducing remanufacturing and 4R strategy in companies/enterprises of small-batch type of production in Serbia. Implementation of remanufacturing and 4R strategy in the field of reparations, replacement of parts and assemblies, consumption of materials and energy is minimized [44].

The algorithm that has been set, represents a procedure for domestic enterprises how to improve the production process, improving communication with customers and provide better business operations on the market.

The waste is considered as an essential resource in the algorithm. Unfortunately, in making mentioned strategic decisions, reuse of waste is not considered in domestic companies. By introducing customers as suppliers of used products, transformational process gets feedback. In this way introduces a new business philosophy in designing of products for more lifecycles.

However, in spite of these advantages, some manufacturers perceive repaired/old products as an

obstacle in: 1) research and development activities of companies and 2) creation of new products.

Through detailed analysis and implementation of algorithm, companies will be able to:

- to produce new or repaired / modified products with as little losses of energy and materials and with less waste generation harmful to the environment;
- to analyze the lifecycle products better, or to incorporate environmental protection as a strategic decision in the sustainable development of enterprises.

At the example of the electronic level transmitter, reuse of products is important from the standpoint of reducing the amount of electronic waste. The concept of collection of obsolete electronic equipment represents a new platform on which the companies in Serbia should think.

Further investigations/researches should focus on quality control. In order to overcome the problems of remanufacturing (material flow, available space and supplies), it is necessary to introduce a better control in designing and in elements of production cycle of products. Related to, the algorithm opens the possibility for the use of standardized management system, such as ISO 9001 and ISO 14001, etc., or integration into a unique management system. ISO 14001 deals with environmental management including the protection, restoration and improvement of the environment and represents upgrading the standards of ISO 9001.

ACKNOWLEDGMENT

This work arose, in part, within the framework of the project TR-32008 by Ministry of Education, Science and Technological Development of Republic of Serbia.

REFERENCES

[1] Schmitz, H., 2004. Local enterprises in the global economy: Issues of governance and upgrading. Edward Elgar Publishing.

[2] Rosenblatt, M.J., Lee, H.L., Economic production cycles with imperfect production processes, IIE transactions, 18,1, pp. 48-55, 1986.

[3] Anderson, C.L., The production process: Inputs and wastes, Journal of Environmental Economics and Management, 14,1, pp. 1-12, 1987.

[4] Mallidi, K., Paraskevopoulos, A.T., Paganelli, P., Process modelling in small-medium enterprise networks, Computers in industry, 38,2, pp. 149-158, 1999.

[5] Morroni, M., 2009. Production process and technical change. Cambridge Books.

[6] Jeffrey, K.R., Hunt, D., Design in small manufacturing companies in Scotland, Design Studies, 6,1, pp. 18-24, 1985.

[7] Ali, A., Krapfel, R., LaBahn, D., Product innovativeness and entry strategy: impact on cycle time and break-even time, Journal of product innovation management, 12,1, pp. 54-69, 1995.

[8] Griffin, A., Modeling and measuring product development cycle time across industries, Journal of engineering and technology management, 14,1, pp. 1-24, 1997.

[9] Borland, N., Wallace, D., Environmentally Conscious Product Design: A Collaborative Internet-based Modeling Approach, Journal of Industrial Ecology, 3,2-3, pp. 33-46, 1999.

[10] Westkämper, E., Feldmann, K., Reinhart, G., Seliger, G., Integrated development of assembly and disassembly, CIRP Annals-Manufacturing Technology, 48,2, pp. 557-565, 1999.

[11] Guide, V.D.R., Jayaraman, V., Srivastava, R., Production planning and control for remanufacturing: a state-of-the-art

survey, Robotics and Computer-Integrated Manufacturing, 15,3, pp. 221-230, 1999.

[12] Fresner, J., Engelhardt, G., Experiences with integrated management systems for two small companies in Austria, Journal of Cleaner Production, 12,6, pp. 623-631, 2004.

[13] Achanga, P., Shehab, E., Roy, R., Nelder, G., Critical success factors for lean implementation within SMEs, Journal of Manufacturing Technology Management, 17,4, pp. 460-471, 2006.

[14] Sladić, B., 2008. Menadžment kvaliteta isporučilaca (in Serbian). Studio MS. Belgrade.

[15] Maxwell, D., Van der Vorst, R., Developing sustainable products and services, Journal of Cleaner Production, 11,8, pp. 883-895, 2003.

[16] Schmitz, H., Collective efficiency: Growth path for small - scale industry, The journal of development studies, 31,4, pp. 529-566, 1995.

[17] Frijns, J., Van Vliet, B., Small-scale industry and cleaner production strategies, World Development, 27,6, pp. 967-983, 1999.

[18] Hallberg, K., 2000. A market-oriented strategy for small and medium scale enterprises (Vol. 63). World Bank Publications.

[19] Desai, D.A., Cost of quality in small-and medium-sized enterprises: case of an Indian engineering company, Production planning and control, 19,1, pp. 25-34, 2008.

[20] Buffa, E., 1980. Modern Production and Operations Management. Wiley. New York.

[21] Hauschild, M.Z., Jeswiet, J., Alting, L., Design for environment-do we get the focus right?, CIRP Annals-Manufacturing Technology, 53,1, pp. 1-4, 2004.

[22] Ward, P.T., Bickford, D.J., Leong, G.K., Configurations of manufacturing strategy, business strategy, environment and structure, Journal of management, 22,4, pp. 597-626, 1996.

[23] Konstantaras, I., Skouri, K., Lot sizing for a single product recovery system with variable setup numbers, European Journal of Operational Research, 203,2, pp. 326-335, 2010.

[24] Sarkis, J., Manufacturing's role in corporate environmental sustainability-Concerns for the new millennium, International Journal of Operations & Production Management, 21,5/6, pp. 666-686, 2001.

[25] Kivanc, H., Gupta, M.S., 2000. "Effect of Reusable Rate Variation on the Performance of Remanufacturing Systems", in Sample papers from the Environmentally Conscious Manufacturing Conf., Boston, Massachusetts, USA.

[26] Giutini, R., Gaudette, K., Remanufacturing: The next great opportunity for boosting US productivity, Business Horizons, 46,6, pp. 41-48, 2003.

[27] Gehin, A., Zwolinski, P., Brissaud, D., A tool to implement sustainable end-of-life strategies in the product development phase, Journal of Cleaner Production, 16,5, pp. 566-576, 2008.

[28] Guide, V.D.R., Production planning and control for remanufacturing: industry practice and research needs, Journal of Operations Management, 18,4, pp. 467-483, 2000.

[29] Rubio, S., Corominas, A., Optimal manufacturing-remanufacturing policies in a lean production environment, Computers & Industrial Engineering, 55,1, pp. 234-242, 2008.

[30] Ayres, R.U., Metals recycling: economic and environmental implications, Resources, conservation and recycling, 21,3, pp. 145-173, 1997.

[31] Chopra, S., Meindl, P., 2001. Supply Chain Management: Strategy, Planning and Operation. Prentice-Hall, Inc.

[32] Dobos, I., Richter, K., A production/recycling model with quality consideration, International Journal of Production Economics, 104,2, pp. 571-579, 2006.

[33] Thierry, M., Salomon, M., Van Nunen, J., Van Wassenhove, L., Strategic issues in product recovery management, California management review, 37,2, pp. 114-135, 1995.

[34] Boothroyd, G., Dewhurst, E., Knight, W., 1994. Product Design for Manufacture and Assembly. New York: Marcel Dekker.

[35] Gungor, A., Gupta, S.M., Disassembly sequence planning for products with defective parts in product recovery, Computers & Industrial Engineering, 35,1, pp. 161-164, 1998.

[36] Kimura, F., Kato, S., Hata, T., Masuda, T., Product modularization for parts reuse in inverse manufacturing, CIRP Annals-Manufacturing Technology, 50,1, pp. 89-92, 2001.

- [37] Simon, M., 1988. Design for Dismantlin. Professional Engineering.
- [38] Gu, P., Hashemian, M., Sosale, S., Rivin, E., An integrated modular design methodology for life-cycle engineering, CIRP Annals-Manufacturing Technology, 46,1, pp. 71-74, 1997.
- [39] Ulrich, K., Tung, K., 1991. "Fundamentals of Product Modularity", in Proc. of the ASME Design Technical Conf., Miami, Florida.
- [40] Loch, C., Kavadias, S., 2007. Handbook of new product development management. Routledge.
- [41] Barker, S.G., King, A.M., 2006. "The development of a Remanufacturing Design Platform Model (RDPM): applying design platform principles to extend remanufacturing practice into new industrial sectors", in Proc. of Life Cycle Environmental Conf., Leuven, Belgium, May 30th-June 2nd, pp. 399-404.
- [42] Nasr, N., Thurston, M., 2006. Remanufacturing: A key enabler to sustainable product systems. Rochester Institute of Technology.
- [43] Umeda, Y., Fukushige, S., Tonoike, K., Kondoh, S., Product modularity for life cycle design, CIRP Annals-Manufacturing Technology, 57,1, pp. 13-16, 2008.
- [44] Sarkis, J., A strategic decision framework for green supply chain management, Journal of cleaner production, 11,4, pp. 397-409, 2003.

AUTHOR'S PROFILE



Miloš Vorkapić

was born in 1974 in Kosovska Mitrovica. He received his dipl.-ing. in Mechanical engineering from the Faculty of Mechanical Engineering, Belgrade, Serbia and his Mag. Sci. from the same faculty.

He works in the field of pressure, level and flow transducers and transmitters. Mag. Sci. Vorkapić is an associate researcher with the ICTM-CMT and the quality manager of the Centre.



Siniša Minić

was born in Gulija, Leposavic Serbia, in 1970. He received the B. Sc and M. Sc. degrees in electrical engineering from the Faculty of Electronic Engineering, in 1996 and 2001, respectively and Ph. D. degree from Technical Faculty in Čačak, Serbia, in 2004.

He is assistant professor at Teachers College in Prizren – Leposavic where he lectures: Computers in education, Information Technology, Educational technology, Informatics in pedagogy, Information technology in teaching.