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Management of parts and components for units and assemblies in mechanical engineering industry and its impact on the environment

V. Mitrofanovs*, I. Boiko and Ē. Geriņš

Riga Technical University, Institute of Mechanical Engineering, Viskalu 36A, LV-1006 Riga, Latvia
*Correspondence: v.mitrofanovs@meistars.lv

Abstract. Most of the service centers operating in the repair and maintenance of machines and mechanisms apply warehouse management systems based on event prediction, which ensures inventory replenishment based on the initial diagnosis of the units. Such methodology is enforced measure, since the components and assemblies, even from the same manufacturer, having similar functions, design and connecting components have their own engineering numbers and part numbers for ordering. Unfortunately, this method is relevant only with perfect logistics and minimal time factor. If these criteria cannot be fulfilled, the maintenance and repair time increases, especially at a distance from logistic centers.
By reducing lost sales and quick customer satisfaction, own warehouse stocks based on statistical data increases. Unfortunately, none of the modern methods gives a 100% result and eventually leads to overstocking and formation of deadstock. On the other hands more and more components are made from composite materials, complex alloys, permanent joints are being used. But due to ineffective management the significant part of expensive components is became needless. The aim of this research is to develop an algorithm allowing to optimise the logistics chain and reduce the inventory and deadstock, reduce disposal of used and obsolete units and assemblies, resulting in significantly lower consumption of natural resources, energy and reduced negative impact of waste on the environment. Our research shows that in various fields of science there are being developed methodologies, which would solve the described tasks by combining those methodologies in a single algorithm.

Key words: management of parts and components, impact on the environment, parts algorithm.

INTRODUCTION

In general, in the repair and maintenance of machines and mechanisms there are being applied event prediction-based warehouse management systems, which ensures inventory replenishment based on the initial diagnosis of the units. Unfortunately, this method is relevant only with perfect logistics and minimal time factor. If these criteria cannot be fulfilled, the maintenance and repair time increases, especially at a distance from logistic centers. On the other hand, none of the modern methods gives a 100% result and eventually leads to overstocking and formation of deadstock.

There are known some research in the field of spare parts management with the goal to minimize the downtime of the capital assets needs, because the capital assets are essential to the operational processes of the companies involved. Thus in (Driessen et al., 2014) the focus of the research is on the responsibility of a Maintenance Logistics Organization (MLO) to minimize maintenance delay due to unavailability of required spare parts. This framework can be used to increase the efficiency, consistency and sustainability of decisions on how to plan and control the spare parts supply chain. Nevertheless, authors point out, that the proposed framework in which the connection between these decisions is outlined, will need refinement and alterations for every particular organization.

In other research (Geertjes, 2014) focus is on the process of replenishing spare parts inventories and on the study the ordering decisions made by planners. During the study author finds 31 potential factors causing interventions in spare parts planning, which were categorized to five different processes concerning spare part planning and control, in order to allocate the factors to concrete process owners. After analysis of the empirical data achieved from 3 companies author concludes, that the planning systems should be modified in such a way that interventions and reason for interventions are stored. In this way, the efficiency of the implemented improvements can be determined and ordering decisions can be easier monitored in the future. Additionally, author proposes to develop a feedback mechanism to learn from own past decisions (take into account human factor) and to study the exact impact of intervening. Thus, the ready methodology has not yet elaborated.

A system approach to repairable stocking and expediting in a fluctuating demand environment is used in (Arts, 2013). As a result, a general framework for maintenance spare parts planning and control of spare part supply chain have elaborated, which outlines the decision functions at strategic, tactical, and operational level and also describes the interactions and (hierarchical) relations between these decisions and provides an outline of how these decisions can be decomposed. But proposed framework still needs to be elaborated in details for using in industry.

It is clear that the impact of the management of parts and components in industry have strong influence on the environmental issues. Companies around the world are challenged to manage the opportunities and risks of developing successful products in increasingly competitive and regulated markets (HIS, 2011): in today’s stressed economic climate, technology continues to advance at an increasing pace and supply chains are expanding globally, while regulations and consumers drive demand for green products. So, industry needs simple and reliable methodology as a simple algorithm for management of parts and components for units and assemblies.

Nowadays, writing an algorithm to be executed by modern computers and setting multitasking between them is a reality. However, unfortunately, today ‘Artificial Intelligence’ is not capable of inventing and developing an algorithm for itself. Hence it is possible and necessary to set milestones to create a route to the desired goal. Knowledge, education and regular improvement of both complemented with modern tools and technologies allow to come up with solutions to extraordinary tasks.

The aim of this research is to develop an algorithm allowing to optimise the logistics chain and reduce the inventory and deadstock, reduce disposal of used and obsolete units and assemblies, resulting in significantly lower consumption of natural resources, energy and reduced negative impact of waste on the environment. Our research shows that in various fields of science there are being developed methodologies, which would solve the described tasks by combining those methodologies in a single algorithm.

Let us review the path of components from the task of design to their disposal step by step.

METHODS

Any component manufacturer aims to provide consumers with necessary volume of products that meet technical requirements during operation in a timely manner (Fig. 1).

The parameter of the required production volume of a component is obtained considering several main factors:

1. production volume of assembly units in which the component is used;
2. operation period of the component and operation period of the assembly unit;
3. correction factor, which is based on unforeseen replacement of the component ($k_{fm} > 1$);
4. correction factor, which is based on the probability of the component being produced by a competitor ($k_{ks} \leq 1$).

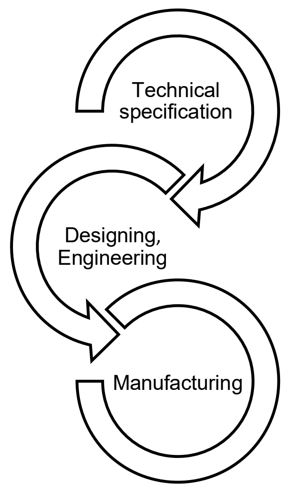

Figure 1. PLC from manufacturer.

It is a kind of puzzle, which analysts of the manufacturers strive to put together. In our opinion, the most effective is **RCM Methodology** (Fig. 2) (SKF, 2008), which is widely spread among manufacturers.

Unconditional requirements for components are environmentally friendly production process and eco-friendly operation. Most of the service centers operating in the repair and maintenance of machines and mechanisms apply warehouse management systems based on event prediction, which ensures inventory replenishment based on the initial diagnosis of the units (Fig. 3).

Reason					
A	**C**	**B**	**A**	**A**	**A**
B	**D**	**C**	**B**	**A**	**A**
C	**D**	**C**	**C**	**B**	**A**
D	**D**	**D**	**C**	**C**	**B**
E	**D**	**D**	**D**	**D**	**C**
	5	4	3	2	1
Probability					

Figure 2. RCM Methodology.

Such methodology is enforced measure, since the components and assemblies, even from the same manufacturer, having similar functions, design and connecting components have their own engineering numbers and part numbers for ordering. Unfortunately, this method is relevant only with perfect logistics and minimal time factor. If these criteria cannot be fulfilled, the maintenance and repair time increases, especially at a distance from logistic centers (Serov, 2005).

At the heart of stock planning of most distribution centers are:

- ABC analysis (method that allows to classify resources according to the level of their importance)
- XYZ analysis (allows to classify resources of the company depending on the character of their consumption and accuracy of predicting changes in their consumption within specific timeframe)
- VEN analysis (Vital Essential Non-essential) – direct segmentation of the 'need' of the product range
- RFM analysis (Fastest Medium Rare) – product range analysis based on the frequency of hits/taking)
- SWOT analysis (strategical planning method, which consists of identifying the factors of the internal and external environment of the organization and dividing them into four categories):
  - ➢ Strengths,
  - ➢ Weaknesses,
  - ➢ Opportunities,
  - ➢ Threats.

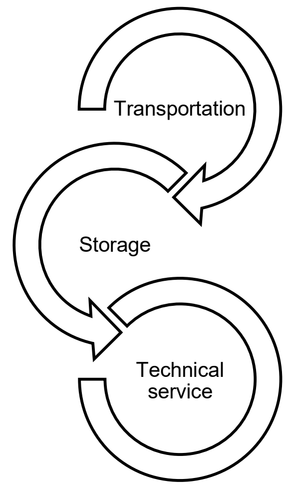

Figure 3. PLC from distributer.

Currently, telematics systems are being developed and implemented, which are able to inform about the need to replace one or another component in a specific period of time. This is certainly a positive factor for reducing the extent of error when storing spare parts (Driessen, 2014).

Reliability Centered Maintenance (Fig. 4) allows to anticipate equipment failures based on the data on previously consumed spare parts and the readings of telematics systems (Defense Acquisition University, 2018). The diagram shows the methodology proposed by the world's largest component manufacturer ZF.

Using unique spare parts for assembly units of the same type leads to a general increase in the volume of undemanded or damaged before the moment of operation homogenous spare parts.

More and more components are being made from composite materials, complex alloys and permanent joints are being used more often. Scientific centers and universities in different countries are developing disposal methods for used components (Fig. 5) (Bakran, 2000).

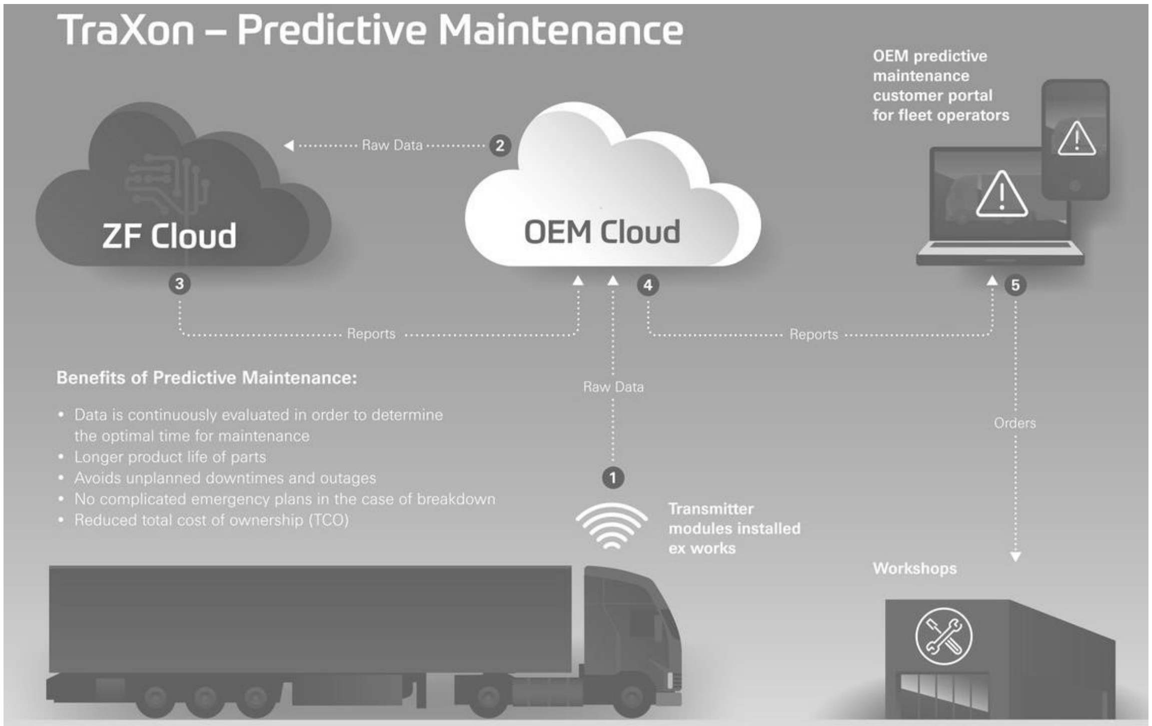

Figure 4. ZF Reliability Centered Maintenance.

Below are graphs of our research on Fast Moving Parts of filtering group products.

In addition to that we should understand that **Pareto Principle** 80%, 15% and 5% is used as a basis. Nevertheless, any inaccuracy or unpredictable event leads to lost sales or to overstocking and the formation of deadstock.

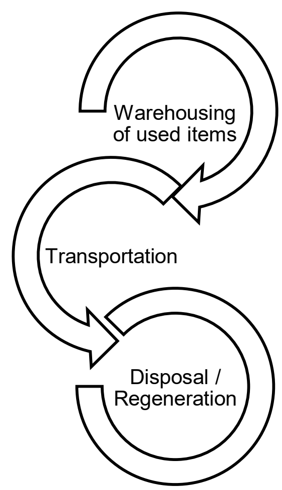

Figure 5. PLC from recycler.

Creating the models of the supply chain and applying the maximum number of methods allow to approach more accurate rate of the possible consumption (Defense Acquisition University, 2018). Unfortunately, none of the modern methods ensures a 100% result (Fig. 6). Based on the data collected we have calculated and created graphs using various event processing methods. As can be seen on the graphs all of the methods have certain error.

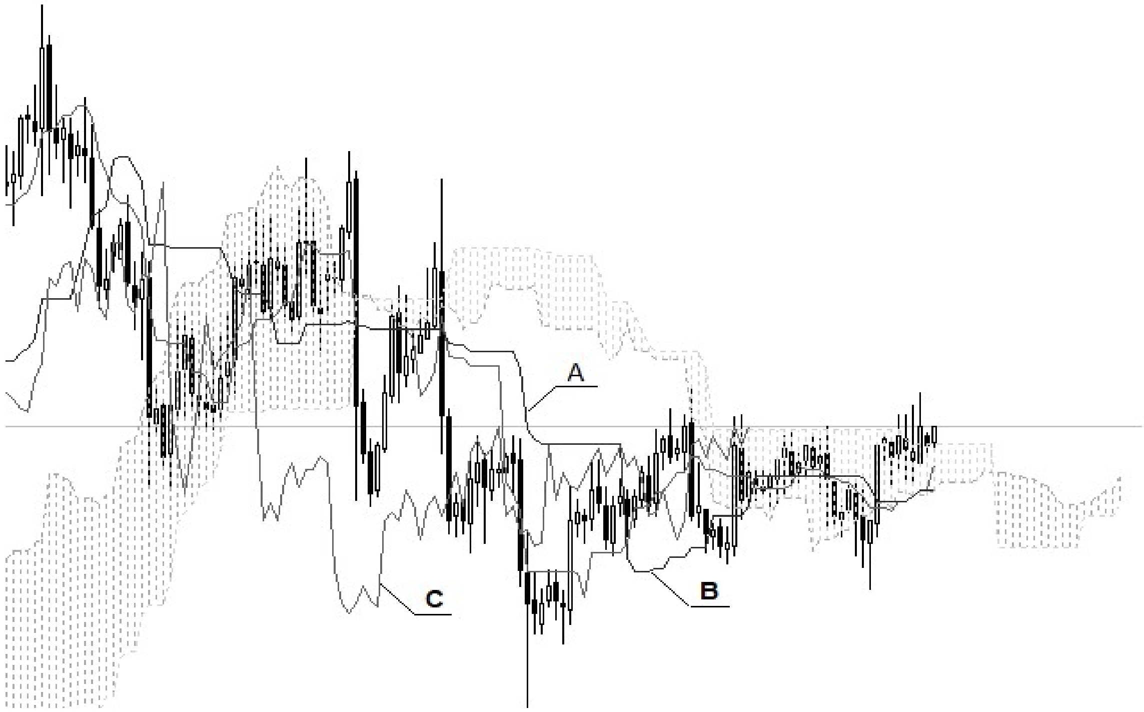

Figure 6. Combined graph of the required storage volume with the use of various methods: A) Curve of the real state of the warehouse; B) Curve of the average expected consumption amount; C) Curve of the real consumption.

Figure 7. Steel housing (a), plastic housing (b) and steel housing with aluminum valve (c).

We have carried out the study of various types of filtering elements (Fig. 7) and in addition to that we have obtained technical specifications from a number of manufacturers based on which was found that at least half of the materials do not perform the function of the main working component directly, but serve only as a unique constructive element (Fig. 8 and Fig. 9).

Our research reveals the gap in the supply chain for setting up the design task of components and assemblies in the full life cycle of materials.

Please note that currently there are tasks:

- for manufacturer to develop a product that meets technical requirements of the life cycle during operation period;

- for distributor to provide information to manufacturer about the predicted volume of the required products;
- for recycling organizations to develop a methodology for the disposal of products in the post-operational period (Bakran, 2000).

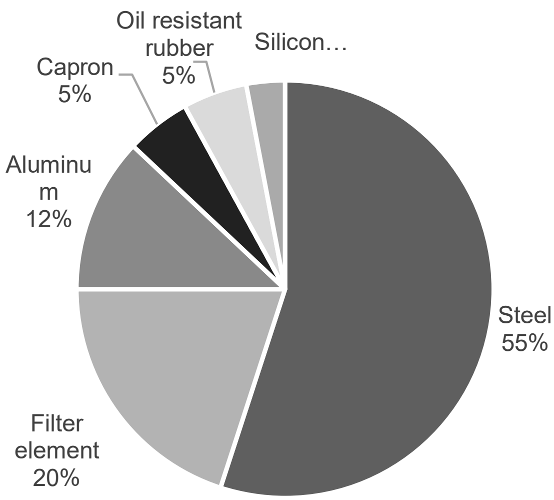

Figure 8. Steel housing.

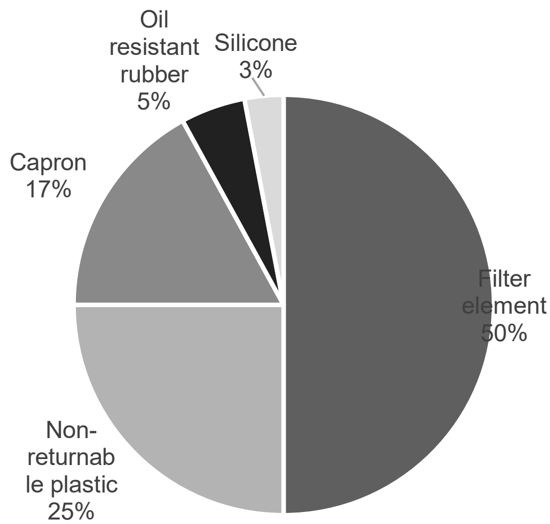

Figure 9. Plastic housing.

RESULTS AND DISCUSSION

We believe that the task in the design of products should be set more comprehensively: from the very beginning of production to the methodology of recycling and disposal of products, as well as methods of applying or dismantling the components that were not included in operation.

We are exploring the possibilities of patent law on the opportunities of applying the standards and unification to already existing assemblies.

Standardization and unification of a number of products will allow to significantly reduce the disposal of undemanded spare parts.

Rules for using the materials for spare parts, particularly for frequent wear and tear items, should be further elaborated in more detail.

Within further research we consider possible scenarios for solving the tasks describe above and possibilities of introducing these solutions into production, which would save logistics time, reduce inventory, deadstock, disposal of used and obsolete assembly units and components. The solution of each task will significantly reduce the consumption of natural resources, energy and negative impact of disposal on the environment.

CONCLUSIONS

A key thesis in our work is to introduce changes into the product life cycle by taking into account the influence of all factors on setting up the technical specifications for product design and implementing the ECO solutions being developed by us (Fig. 10).

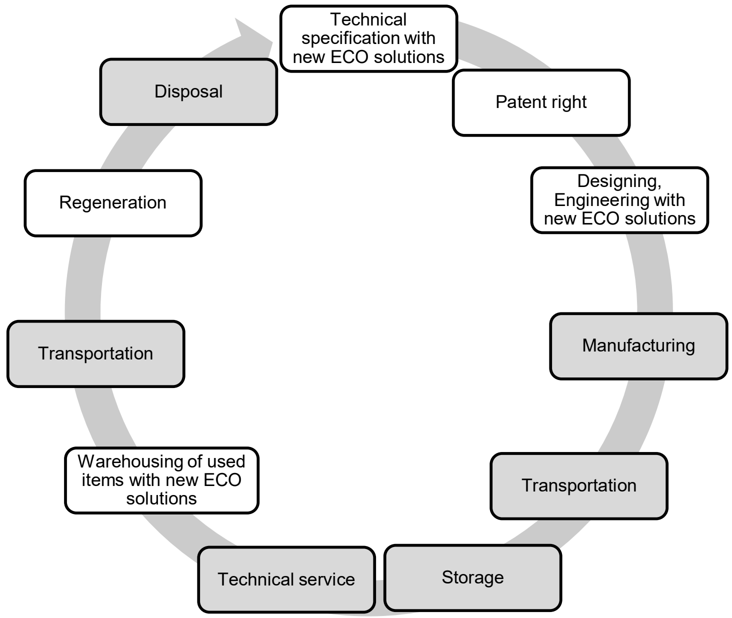

Figure 10. New vision of Product life-cycle.

REFERENCES

Arts, J.J. 2013. Spare Parts Planning and Control for Maintenance Operations, 217 pp.

Bakran, M.-M. 2000. Maschinenbau Energie und Umwelt, Universität Bayreuth, 75 pp.

Defense Acquisition University Reliability Centered Maintenance (RCM), 2005-2018.

Driessen, M.A., Arts, J.J., van Houtum, G.J., Rustenberg, W.D. & Huisman. B. 2014. *Maintenance Spare Parts Planning and Control: A framework for control and agenda for future research*, 30 pp.

Geertjes, F. 2014. *A first step towards fully automated spare parts planning systems An empirical study on ordering behaviour*, 74 pp.

IHS Parts Management Solutions: Information Resources and Tools for the Life of Your Products, 2011.

Serov, I.A. 2005. *Stochastic simulation of a logistics chain 'production - storage-distribution'*, 438 pp. (in Russian)

SKF GmbH Optimierung des Instandhaltungsaufwands mit Methode: Reliability Centered Maintenance (RCM), 2008.