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PRIMARY PRODUCT STANDARDIZATION IN SPARE PARTS MANAGEMENT

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Abstract: Spare parts forecasting and inventory management is a complex process which is often underestimated by the primary product producers. It differs from the production parts management. Although these two processes do not follow the same guidelines both are connected and exert impact on each other. A crucial issue by the spare parts management is to understand the differences between the two types of parts. The objective of the paper is to present main assumptions of the impact of the primary product standardization on spare parts management, showing its characteristic features and internal conditions influencing the further life of the product. The article describes the analysis of specific factors created during the product design and production processes which can negatively influence spare parts management as well suggested solutions which can help to avoid negative occurrences during the product use.

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1. INTRODUCTION

Spare parts (service parts or repair parts) are those modules, components and elements which are planned to be used without modification to replace an original part (Cox, Blackstone Jr. & Spencer, 1995, p. 77). Spare parts forecasting and inventory management is one of the most challenging problems in the whole logistic support process (Kumar, 2000, p. 281). To provide product's reliability a range number of parts are kept on stock for just in case. Many of them may never be needed and become obsolete. The issue is visible in the automotive industry by commercial vehicles where companies cannot allow their products to be out of operation for a long time. To keep their products functioning different approaches of spare parts management are implemented. New studies are being held to improve spare parts management processes within different companies. One issue which cannot be forgotten is that the spare parts depend on the primary product of the production process and they should help keep this product in a good condition as long it is possible or planned. The proposed hypothesis of this paper is the impact of the primary product standardization on the spare parts availability. One of the elements which help to standardize the produced product is the bill of materials.

2. PRIMARY PARTS – PARTS IN THE PRODUCTION

In a highly competitive business environment, companies must diversify their offers to meet customers' demands. Following questions occur: how to offer a wide variety of products which meet customers' needs, at the same time controlling production, inventory and logistic costs (Baud-Lavigne, Agard & Penz, 2012, p. 50). One of the ways to achieve the goal is the standardization of the product. It is the possibility to replace a component or a sub-assembly by another with either more functions or including components with higher quality in order to decrease the number of parts. Product standardization can reduce the number of parts which have to be managed to save the fixed costs. Product standardization shall start during the product design phase. When the decision of production is taken, a very important role plays the bill of materials. It is a listing of all the subassemblies, intermediates, parts and raw materials which go into a parent assembly showing the quantity of each required to make an assembly. It is used in conjunction with the master production schedule to determine the items for which purchase requisitions and production orders must be released (Cox, Blackstone Jr. & Spencer, 1995, p. 9). A significant issue is to think globally about the whole product life cycle and not only to focus on production and sales. In conventional Material Requirements Planning (MRP), a Bill-of-Materials (BOM) for products is fixed (Ram, Naghshineh-Pour & Yu, 2006, p. 399). In the literature of the subject a flexible bill-of-material is described as a tool to compensate the inflexibility in the Master Produc-

tion Schedule (MPS) when time or quantity for the final product is not flexible. It should provide the opportunity to deal with planning production in the face of unforeseen shortages at the item level.

A wide range of parts sellers offer them on the aftermarket because of the potential demand for them from the market. The problem occurs for the companies which produce their vehicles on a relatively small scale. In 2015 sales of cars and light trucks in Poland reached the level of 400 000 sold vehicles (http://motofocus.pl/wiadomosci-rynkowe/14747/sprzedaz-nowych-samochodow-wnbsppolsce-wnbsp2015nbspr-rekordowy-grudzien) whereas the sales of commercial vehicles was at the level of 22 000 sold vehicles (http://www.log24.pl/-news/2016/1/1-2/rekordowa-sprzedaz-ciezarowek-w-2015,6184). For large production series where the vehicles are bought by thousands of customers the probability of parts demand is relatively high. The primary product diversification may be high so the customers may get personalized vehicles. For commercial vehicles produced in relative small series it is not always viable to keep the parts on stock and wait for the demand for them, particularly when the demand is random. Because of the demand uncertainty as well the product variants it is not viable to keep in stock parts which do not rotate regularly and the probability of their demand is not certain. On the other hand, when the demand occurs the customers wish to get them as soon as possible, very often the contracts include notations regarding vehicle reliability and penalties for vehicles off road. It causes the commercial vehicles should be much more standardized products and the number of offered variants to the customers' needs to be well balanced to be able to provide aftersales service.

3. SPARE PARTS PROVISIONING

The demand of spare parts is characterized by fluctuations and volatility. Several researches have been conducted in the area of spare parts management. However according to Wagner (Wagner, Jönke & Eisingerich, 2012, p. 70) no strategic framework has been developed for spare parts logistics so far. Manufacturers can achieve a competitive advantage if their spare parts strategy is aligned with the specific situation of the company. In the literature following reasons for a strategic planning and alignment of spare parts logistics are presented:

- Changes in the primary product markets – technical equalization of products, global pressure of competitive environment (Wagner, 2012, p. 70);
- Rising cost awareness - improvements in stock management, transport and logistics in the supply chain (Wagner, 2012, p. 70);
- Rising customer expectations in form of short lead times and a long-term availability of spares (Legnani, Cavalieri, Ierace, 2009, 113).

In the literature of the subject different approaches have been described. They present different levels of complexity and capital spending. As examples of different spare parts management approaches following methods are presented:

- Parts grouping;
- Mathematical models of spares provisioning;
- Complex methods demanding wide range of input data.

The first group of methods in the field of spare parts management is parts grouping. Different scientists have prepared solutions which base on parts division using different criteria. Jouni P., Huiskonen J., Pirttila T. present a categorization matrix dividing spare parts into three main groups: key parts, industry specific parts and commercial parts (2011, p. 167). Key parts have only a few possible suppliers and are in most cases made-to-order parts. Their lead times are long and the suppliers request demand forecasts to be able to plan their production to avoid the risk of lack of the availability. The industry specific parts have similar characteristics as key parts but are easier to be manufactured which causes the decrease of unavailability of them. They are usually manufactured according to the company specific drawings, but are more generic in nature (e.g. machined mechanical parts). Additionally, the supplier lead times are considerably shorter. Commercial parts are commonly used. These are e.g. bulbs, nuts, screws etc. There are lots of supply sources for them and they are stored in the suppliers' warehouses.

Another example of spares grouping is VED classification, where the parts criticality plays the crucial role (Manzini, Regattrieri, Pham & Ferrari, 2010, p. 423). Spare parts are divided into three groups V – vital, E – essential and D – desirable and the provisioning method depends on the classification group of the particular part. One more example in this group of methods is a multi-attribute classification of spare parts by spares tree. The method of spare parts management is chosen for different group of parts, which are divided according to their criticality (Braglia, Grassi & Montanari, 2004, p. 55).

Another approach in spare parts management is implementation of mathematical models. Examples for this method are given by Manzini (Manzini, Regattrieri, Pham & Ferrari, 2010, p. 412). The authors present the Croston model, basing on exponential smoothing. This approach according to the authors considers series with zero value of demand occurring many times – forecasting of low and intermittent demand. Second mathematical model presented by the authors is the Poisson model based on Poisson distribution. This method forecasts the probability of rare events. There are other approaches presented in the literature of the subject, the presented ones are only an abstract of the literature overview.

The most complex approaches of spare parts management include implementation of artificial neural networks ANN (Sahin, Kizilastan & Demirel, 2013, p. 1) or different simulation approaches e.g. Monte Carlo simulation (Marseguerra, Zio & Podofillini, 2005, p. 325). This method is generally used to mathematical modeling of complex processes. It bases on the assumption, if a large number of observations is available, probability distribution of different situations occurring, calculat-

ed for a particular number of observations, is the same for the whole environment. According to this method observation results can be predicted.

In some companies easier methods are enough to provide efficient spare parts management. In other companies parts grouping is not enough and more advanced solutions need to be implemented. However, there is no universal approach for spare parts provisioning and the chosen method is only the individually chosen solution and not a golden mean.

4. PRODUCTION PARTS VS. SPARE PARTS

A very important issue by the spare parts provisioning is to understand the difference between the production parts and spare parts (Kumar, 2005, p. 9). The main differences are following:

- the demand on production parts is predictable, depending on the production plan whereas the demand on spare parts depends partially on maintenance and service action and partially on unpredictable events;
- the demand on production parts depends on the demand on the final product it is used for whereas the demand on the spare parts depends on failures of the part, and often on the product life cycle.
- during the production process alternative parts can be taken into consideration by bill-of-material creation which causes the spare parts management a complex process.

Purchasing of production parts is connected to the production process of a particular number of final products which gives the possibility to negotiate the cooperation conditions with the supplier whereas the demand on spare parts is very often related to single parts which are often unavailable by the supplier and need to be produced for the particular order.

The unit demand on spare parts causes the difficulties in the proper spares provisioning. The company needs to deal on the one hand with the customer wishes and demands on the other with the long lead times and minimal order quantities offered by the supplier. As the golden mean has not been found yet, different approaches in spare parts provisioning need to be implemented to deal with the difficulties presented.

If all the parts mounted on the vehicle are taken into consideration the whole process of spare parts provisioning starts to be more complicated as it used to be. The main components mounted on the vehicles can be divided into following four groups: body, engine (including equipment), chassis and electrical system.

The body of the vehicle includes both external and internal parts. To the external parts following examples can be given: bumpers, doors, glasses, and wipers. Examples of inside elements are following: seats, a dashboard, a steering wheel etc. The chassis includes among other things a powertrain, driving system, steering

system and brake system. To the electrical system belong e.g. wire harnesses, alternators etc. The parts mounted on the vehicle which do not change shall be standardized during the product production. If the same aggregate is mounted on the vehicle, no other solutions shall be implemented, unless it is required by the construction changes. Sometimes the solutions are changed because of the designer's ideas at the places where they are not needed – a chosen example are windshield variants mounted in the vehicles.

The exchange of this part is needed in particular situations when:

- A production failure occurs;
- It breaks (e.g. because of an accident, act of vandalism etc.);
- On the vehicle owner's wish.

Different types of a windshield can be mounted in one vehicle according to the final product design, market features, customer wishes etc. In the Table 1 subjective combination of different windshield types is given:

Table 1. Windshields combination, self study

Parameter	Types of windshields
Material	Laminated glass
	Tempered glass
Heating	Heated
	Not heated
Upper shade	Without shade
	Green shade
	Blue shade
	Grey shade
	Bronze shade
Complexity	One-piece
	Divided

Different solutions for windshield types can be added to the given examples depending on customer wishes, technological development etc. Using the parameters given in the table 1 a matrix of 40 possible combinations is created. It means if a company offers in one model of its vehicle all the variations of a windshield, all of them should be available in the aftermarket.

If one additional parameter is added to all the 40 presented combinations – screen printing, next dozens of possibilities are created.

The decision which of them should be kept on stock should be taken after a careful study of stock replenishment. Costs of vehicle off road should be taken into consideration including penalties when the vehicle is off road.

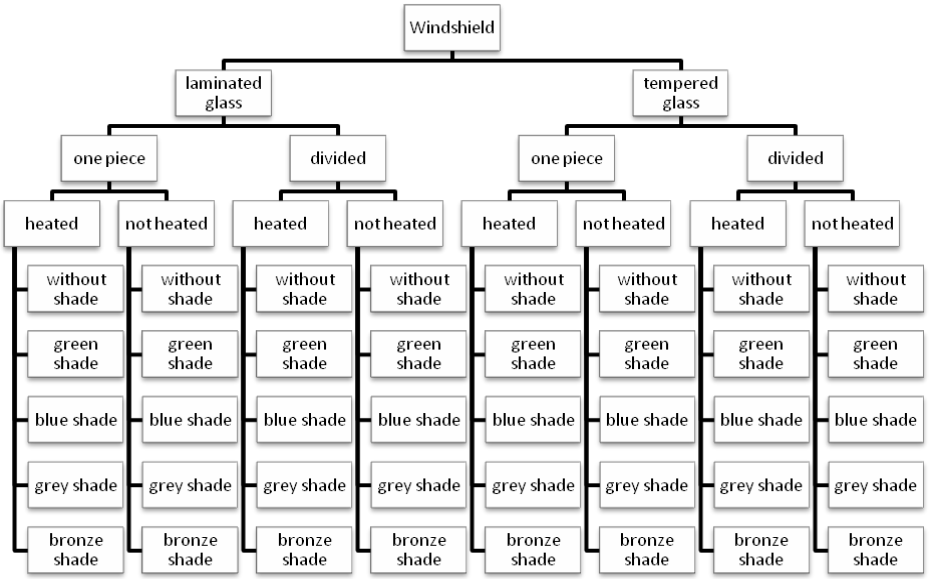

Fig. 1. Windshield's variants, self study

5. PRODUCT STANDARDIZATION FOR SPARE PARTS PROVISIONING

How important for the company is the well-balanced spare parts management show Wagner and Lindemann (2008, p. 401). According to the data presented in their paper the profit margins of spare parts sales in the automotive industry are three to four times higher than the margins in car sales. To provide spare parts for the customers and not to freeze the capital in stocks form the very beginning of product design the standardization of it needs to be implemented. As supporting actions which can help to improve the process of spares provisioning after the reduction of primary solutions are creation of spare stocks management tools supporting the stock replenishment processes, precise analysis of suppliers' changes in their products and coherent documentation management.

During the product design process the complex product life needs to be considered. In the automotive industry in the area of commercial vehicles the issue is visible because the access to spares is required in a long period of time – in the assumed vehicle life period. Short lead times are also required from the customers, very often counted in hours. By the spare parts provisioning the company faces also the constraints on the side of the suppliers. The quantities ordered for the primary product are connected with the production plan. For the aftersales minimal order quantity (MOQ) by the supplier is very often higher than demanded. To epit-

omize it a windshield is used as an example. Providing the windshield to the production of commercial vehicles by decreasing the types of windshield shades from four to two the number of combinations decreases by 40 per cent. If for one vehicle type all the windshield variants are offered and the customers can choose them according to their pleasure, appropriate quantities of it will be delivered to the assembly line. In the time of vehicle's use the parts replacements are required and all the windshield's variants need to be in offer. The parts provider (the producer of the vehicle) needs to face the stochastic demand, high costs of stock-keeping, high stock levels and transportation costs (Simchi-Levy & Zhao, 2012, p. 1). By stochastic demand it is not easy to plan what shall be kept on stock. For parts with long delivery dates to which also windshields are counted it is necessary to keep them on stock. A simple calculation is presented: by a glass break only one piece is needed. The MOQ equals five pieces. 40 types of a windshield have been presented in the Fig. 1. To provide all the possible parts to the customers which have been presented in this paper equation is used:

$$Nw = MOQ \times Wt$$

Where:

Nw – number of windshields;
MOQ – minimal order quantity by the supplier;
Wt – number of windshield types.

By the given example of the windshield to provide all the spare parts mounted on the vehicles 200 glasses need to be kept on stock. If the number of windshield types decreased by 40 per cent by excluding two glass shades the number of glasses on stock would decrease to 24 types which gives 120 pieces of glasses on stock. The equation used to all the parts kept on stock which occur in a wide range of variants shows how big is the impact of new solutions mounted on the primary product according to spares stocks values.

The analysis support element which shall improve the process of spare parts stock management is choice of proper spares provisioning methods. Examples of them have been characterized in the chapter three of this paper and need to be chosen according to individual features of the company. The second action which should support the product standardization for stock optimization is a proper analysis of suppliers' products changes. Those changes are implemented because of different reasons. One of them is the technical development which forces companies to improve used solutions. Second reason of this process is that product's development can be a tool to exclude competitive solutions in the market and gain more profit. The more often a part is changed the shorter is the time period to develop, produce and bring to the market a competitive and/or copied solution. If such changes are not immediately marked in the ERP system as cross-references, in the future it can be one of the reasons of stocks increase. A proper master data

management shall be a good solution for both primary product standardization and spare parts management.

6. CONCLUSION

The described analysis presents how the reduction of available product variants influences the spare parts management by keeping the assumed customer service level and decreasing capital frozen in stocks in the automotive industry. The primary product standardization is not the golden mean leading the company to savings. It is the first step to reduce the spares stocks and to help the company to manage keeping the vehicles in active service despite accidents and unplanned faults. The result of the standardization is smaller amount of parts which need to be managed. However as it has been shown in this paper, the supporting actions are required to achieve the goal completely. At this point is it needed to mention that the presented standardization analysis justifies the need of industry and science integration. Without the theoretical background in the form of spares management solutions the industry can base only on own estimations which can result from methods presented in the literature of production management but not fitting to the environment of spare parts. Different spares provisioning methods presented in the literature overview show the possible ways of future actions supporting the product standardization. It is crucial to keep in mind main differences between spares and production parts. If updated suppliers' cross-references are taken into consideration as well the master data management is tailor-made to the company's environment and requirements, following goals can be achieved. First of all overstocks can be minimized. The next advantage of it is the support of long term spares provisioning by the limitation of possible solutions available for the customer. Finally significant savings can be provided by the company keeping the same customer service level. The final product standardization shall prevent the unlimited amount of vehicles' variants which can lead to overstocks and capital blockage in stocks for a lot of years of primary product use.

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BIOGRAPHICAL NOTES

Natalia Pawłowska-Kalinowska is a PhD student of the Faculty of Engineering Management at the Poznan University of Technology. Her research as well interests area is spare parts management including stock inventory, logistics processes and environmental inpact on spares. Her professional work is conneted with the research field, the author takes part in processes of spare parts management in one of the companies in Poland.