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SPARE PARTS CATEGORIZATION IN STOCK MANAGEMENT

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Abstract. Spare parts management is a complex process which is full of challenges. Spares characteristic features such as random demand, long lead times, risk of obsolescence and long periods of their provision on the market make the process complex. A crucial issue in the spare parts management is the knowledge about the internal features of them as well as of the whole environment of this industry. The objective of this paper is presentation of a chosen method of spare parts management which is parts categorization and its influence on stocks created by the presented approach. The aim is the emphasis that spare parts need to be analyzed and treated individually due to different parameters which are more complex than the components planned and managed for the production processes. The article includes the data presentation, data study and results of the analysis as well as further possible ways which can enrich the research on spare parts management.

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1. INTRODUCTION

A choice of a correct spare parts management method is a challenge for the companies dealing with these processes. As spare parts forecasting and inventory management is one of the most challenging problems in the whole logistic support process (Kumar, 2000, p. 281) crucial is a complex analysis of the stocks, forecasts and the environment of spare parts. During the product life cycle spare parts are needed to fix breakdowns as well as replace damaged components in accidents and other reliability problems. Even without considering crashes and other damages during its life, machines need maintenance parts and products, e.g. vehicles require lubricants, brake pads, different filters, etc., to be replaced or changed (Manzini et al., 2010, p. 409). Since companies are frequently required to reduce costs and increase asset utilization, misguided decisions may lead to undesirable results in the company and its environment.

There are different approaches of stock replenishment. One of the most frequently used ordering systems is a MIN-MAX system. It is based on periodical review, but decision whether to order or not depends on the current level of inventory position. If it is smaller or equal to established inventory decision level s an order is placed as equal to the difference between level S and current inventory position. Otherwise the order is not placed (Fechner & Krzyżaniak, 2013, p. 127). It is rather applicable for production purposes and may not be efficient for spare parts management due to characteristic features of spares.

The purpose of this paper is a presentation of parts categorization as one of spare parts management methods and verification of this method on a group of parts due to their characteristic features which influence the spares forecasts approaches. As a tool supporting parts categorization a tailor-made matrix is recommended. Different conditions which shall be taken into consideration are described in this paper.

2. LITERATURE OVERVIEW

In the literature different approaches are given to manage the problem of spare parts inventory. Some of them are new approaches using the newest tools such as simulation software and some of them are early approaches of spare parts management which show that this research field is nothing new however it is constantly causing challenges for the researchers. Plenty of described methods focus on designing and testing models or algorithms to improve the management of existing systems.

A method described in the sixties of the twentieth century is a multi-echelon technique for recoverable item control (METRIC). It is a mathematical model of a base-depot supply system where a particular line item may be demanded at several bases and the bases are supported by one central depot (Sherbrook, 1968,

p. 122). Another approach is the use of multi-objective simulation-based evolutionary algorithm for spare parts allocation problem in the aircraft industry (Lee et al., 2007, p. 489). Dudeja (2014, p. 27) describes grouping of parts as a support for an efficient supply planning process. The parts are grouped on the basis of parts succession, value and criticality. Another approach focusing on parts grouping is parts categorization (Jouni, Huiskonen & Pirttila, 2011, p. 167). The authors divide parts into three groups: key parts, industry specific parts and commercial parts. The key parts have only a few possible suppliers and are in most cases made-to-order parts with long lead times. The industry specific parts have similar characteristics as key parts. They are usually manufactured according to the company specific drawings, but their lead times are considerably shorter. Commercial parts are commonly used. They are usually stocked at suppliers' warehouses.

A spare parts forecasting approach using Croston based models and artificial neural networks is the next presented method on spare parts management (Sahin, Kizilaslan & Demirel, 2013, pp. 1–21). The authors present four Croston based methods – original Croston's method, Syntetos & Boylan approach, Vinh's approach and Leven-Serstredt method. The authors develop traditional neural networks which, according to their research, suffer from the problem of low accuracy of forecasting unseen examples.

The next approach in the spare parts management is parts classification defined with respect to multiple attributes such as inventory constraints, costs of lost production. To solve various multi-attribute decision problems a decision diagram is created and integrated with a set of analytic hierarchy process models (Braglia, Grassi & Montanari, 2004, p. 55). Another approach on spare parts management is the use of enhanced fuzzy neural networks (EFNN) for managing automobile spare parts inventory in a central warehouse (Li & Kuo, 2008, p. 1144). The next complex method of spare parts management is the use of genetic algorithms and Monte Carlo simulation described in the literature (Marseguerra, Zio & Podofillini, 2005, p. 326). The authors propose an approach which couples the Monte Carlo simulation method for achieving a more realistic system modeling, and the genetic algorithms for determining the optimal spares allocation with respect to different objectives. There are also studies which focus on the failure problems in the systems where spare parts are required. One of them is the investigation of multiple failures problems in a continuous, infinite horizon, order-for-order spares replenishment inventory model (Cheung & Hausmann, 1995, p. 171). The second example of studies on machine repair or down time affecting cycle times was presented by Schulz (Schulz, 2004, p. 759). The author presented a methodology for base stock parameters selection, taking into consideration the influence of cycle time reduction as well as inventory investment.

Different environmental features of the industry where spare parts are used are one of the reasons of a wide range of spare parts management approaches prepared for individual conditions of the analyzed area. The presented methods of spare parts management are subjectively chosen examples which show the variety of different possible solutions described in the literature of the subject.

3. SPARE PARTS CATEGORIZATION APPROACH

The demand of spare parts is characterized by fluctuations and volatility. It is affected by stochastic factors, such as intensity of product use, wear behavior, failure rates, or type of maintenance. To achieve a competitive advantage in a company the spare parts strategy shall be aligned with the specific situation of the firm. The strategy logistics planning is required because of different factors. These are:

- Changes in the primary product markets,
- Rising cost awareness;
- Unutilized potentials;
- Intensive competition in the spares markets;
- Rising customers expectations (Wagner, Jönke & Eisingerich, 2012, p. 70).

This is the reason why classical method of stock replenishment may not be sufficient for spare parts management.

During the spares replenishment process creation factors which are important for the company need to be taken into consideration. To identify the factors several issues need to be clarified. First of all a question occurs if each spare part shall be kept on stock. This is especially important for spares with low demand. If a decision has been taken whether parts shall be kept on stock the next step is to determine an optimal order quantity. The third decision is to be taken how many pieces shall be kept on stock. The last issue is the decision when a new order shall be released (re-order point). If all the issues are clear and there are no doubts related to spare parts management in the company (Bosnjakovic, 2010, p. 499).

The importance of particular spare parts is not the same. They have different functions and play different roles. Some of them do not take part in the insurance of system functioning without downtimes. Therefore, it is not a good solution to manage all the parts in the same way using the same replenishment policy. To take a decision when and in which quantity particular components shall be reordered parts grouping into several groups is recommended. Each item in stock shall be taken into consideration due to several criteria. These can be following:

- spare parts price;
- rotation in particular period of time;
- criticality;
- lead time.

The four given criteria are crucial for spare parts management however more other can be implemented to the research according to the specific company conditions.

4. PARTS CATEGORIZATION TWO-STEP-MATRIX

As a tool supporting spare parts management a categorization two-step-matrix is recommended. It is created due to parameters which are taken into consideration. In the research, there are three parameters verified: price, rotation and lead time, as all the parts are treated as critical for the functioning of the system. In the matrix, the analyzed criteria are divided according to their characteristic features. Price of the parts can be low (L), average (A) and high (H). Rotation of the parts in particular period of time can is divided into following groups: high rotation (H), average rotation (A), low rotation (L). The last proposed criterion in the matrix is lead time which is considered in three dimensions: long (L), average (A) and short (S). In the first step price and rotation of the parts are analyzed (Fig. 1).

		Rotation		
		H	A	L
	L	LH	LA	LL
Price	A	AH	AA	AL
	H	HH	HA	HL

Fig. 1. Price-Rotation matrix, self study

The second step of the approach is addition of the third parameter which is lead time. The result of this connection is presented in Figure 2.

		Price/Rotation								
		LH	LA	LL	AH	AA	AL	HH	HA	HL
	S	SLH	SLA	SLL	SAH	SAA	SAL	SHH	SHA	SHL
Lead time	A	ALH	ALA	ALL	AAH	AAA	AAL	AHH	AHA	AHL
	L	LLH	LLA	LLL	LAH	LAA	LAL	LHH	LHA	LHL

Fig. 2. Price-Rotation-Lead-time matrix, self study

By creation of the Price-Rotation-Lead-time matrix (PRL) twenty-seven groups of parts are created. The abbreviation of each group name comes from first letters of parameters in following order: lead-time – price – rotation of the part. Depending on the affiliation to particular groups another spare parts management approach is suggested depending on the environmental characteristics and individual features of the company and agreements with the customers as well as suppliers. The recommendation of spare parts treatment is presented in Figure 3.

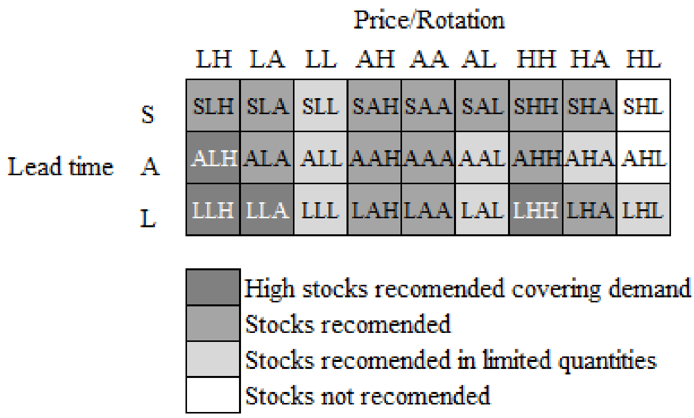

Fig. 3. Spare parts groups treatment, self study

The first group for which spare parts stocks are recommended consists of cheap and middle-prized high-rotating parts, and average-rotating parts with long lead-times as well as expensive, high-rotating parts with long lead-times. The second group of parts consists of high- and average-rotating parts of different prices with different lead-times. This is the largest group where fourteen subgroups belong to. The third group consists of low-rotating parts of different prices and lead-times. The smallest group consists of expensive, low-rotating parts with short or average lead-times which can be delivered fast if the demand occurs.

The spare parts categorization can be either the stock replenishment method in itself (after parts grouping correct reorder points are established) or the first step before a particular spare parts management method will be chosen due to the available support in form of software etc. Thanks to the division of parts according to specific parameters it is easier to establish a satisfactory stocks level which results by achievement of the assumed availability of parts at the lowest possible stock levels.

5. PARTS CATEGORIZATION – CASE STUDY

To present the impact of parts categorization on stock levels a case study is has been prepared.

5.1. Data characteristics

As the range of spare parts mounted in different devices is counted in some cases in hundreds of thousands the analysis data have been narrowed down to the two most rotating groups which create 25 per cent of turnover in the analyzed period of time. This group consists of over six thousand items. The data have been collected within four years. The data characteristics presented in the Table 1 is created due to the Pareto principle which suggests that most effects come from relatively few causes; that is, 80 per cent of the effects come from 20 per cent of the possible causes (Cox, Blackstone Jr. & Spencer, 1995, p. 59).

Table 1. Characteristics of parts groups in the analysis

Group	Percentage of parts	Turnover in each group
A	7%	80%
B	19%	15%
C	74%	5%
Sum	100%	100%

The first group (A) is represented by 7% of all analyzed parts. This group represents 80 per cent of the whole spares turnover. The second group (B) includes 19 per cent of all the analyzed parts which represents 15 per cent of the achieved turnover. The last group (C) includes 74 per cent of all the analyzed parts. This shows that spare parts management does not follow traditional Pareto principle. To divide the groups in more detailed way parts categorization is implemented.

5.2. Analysis description

The spare parts have been analyzed according to the categorization approach presented in this paper. The parts have been divided into groups according to their price, rotation and lead-time, creating twenty-seven groups. For the analysis the parameters have been chosen on the basis of the characteristics of the whole group of parts. Expensive parts cost more than one thousand euro. The cheapest ones cost a few cents. High rotation is represented by the rotation higher than two pieces of a particular part a day. A rare rotation is characterized by demand lower than one piece in every three months. Lead time ranges are counted in weeks – a short lead time lasts less than one week. Average lead-time lasts between one and four weeks. If a part shall be delivered after more than four weeks from the order, the lead time is called long. These values can change according to particular conditions in the analyzed environment.

The percentage division of all the groups of the analyzed data is presented in the Figure 4.

		Price/Rotation								
		LH	LA	LL	AH	AA	AL	HH	HA	HL
Lead time	S	<1%	<1%	5%	<1%	<1%	1%	SHH	SHA	<1%
	A	2%	5%	47%	<1%	<1%	12%	AHH	<1%	1%
	L	1%	3%	15%	<1%	<1%	5%	LHH	<1%	1%

Fig. 4. Spare parts groups share, self study

Over six thousand parts have been analyzed during the study. From the twenty-seven groups to four no parts belong. Less than one per cent of parts belong to eleven groups. Four groups include parts at the level of one per cent each. Four groups include parts in the amount of two to five per cent. Two groups include over sixty per cent of the analyzed data base. One group consists of forty-seven per cent and the second one of fifteen percent items.

The parts share in the groups creates a particular possible savings. Only circa one per cent of analyzed parts belong to groups SHL/AHL for which no stocks are recommended. The second group, for which stocks reduction is suggested consists of eighty-six per cent of the analyzed parts. A decrease by a half of stocks on these parts allows reducing stocks for this parts group by three per cent of the whole stock value. As the stocks are counted in millions of euro, three per cent create a significant value to be released. In the analyzed data some groups have not been recognized. A reason for this is that data have been narrowed down as described in the data characteristics.

6. CONCLUSION

Spare parts management is a challenging process because of the characteristic features of parts and the environment in which they occur. Stochastic demand, long provisioning requirements as well as long lead times and high parts prices cause that the process is even more complex and requires unconventional treatment. To plan stocks of spare parts it is not enough to analyze parts rotation but more factors need to be taken into consideration which cause the process starts to be multidimensional. The proposed approach supporting spare parts management is one of the easiest methods which can be implemented to achieve more precise results in spares stock management. The analysis shall help to take decision how to manage particular groups of parts representing similar features. The decision is not only how many pieces shall be kept on stock but if they shall be kept on stock at all. When the time requirements for spares provisioning are counted in years it is crucial to order and keep on stock only necessary parts because with every year the chance to meet demand for older parts is lower and lower until the parts go out of date. To avoid the situation when the parts are analyzed according to the same criteria or only one criterion which is rotation and basing on historical data it is possible to manage different groups created in the process of parts categorization according to different spare parts management methods.

The objective of this paper was presentation of one of available methods of spare parts management and its application on a chosen group of parts to show that spares cannot be treated like production parts. Parts categorization has been proved by the analysis of a limited group of parts showing relative possible savings.

Further works may include an analysis of larger group of parts or of another time period chosen. It is also recommended to develop the research by the choice of different more complex methods of spare parts management due to the parts categorization and presentation of possible savings to be achieved due to the analysis.

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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 field is spare parts management including stock inventory, logistics processes and the environmental conditions occurring in the spare parts management. Characteristic features of spare parts and their influence on the whole industry are the area of her interests. Her professional work is connected with the research field.