ANALYSIS OF SPARE PARTS IN TERMS OF THEIR AVAILABILITY MANAGEMENT FOR THE PRODUCTION PROCESSES NEEDS

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Abstract

Customer service is perceived as the ability to satisfy the requirements and expectations of customers, mainly as to the time and place of the ordered supplies, using all available forms of logistics activities. The specificity of the production process indicates that one of the main factors affecting the production continuity is the availability of spare parts for machines and equipment. The aim of the research was to develop a method of analysis of spare parts in terms of their availability management for the production processes needs, which can be used by logistics and maintenance managers. This article presents an analysis of spare parts availability management in terms of ensuring continuity of production resources. The proposed method supports the management of the availability of spare parts and is composed of two parts, ie. Spare parts classifications by two aspect: frequency of use and criticality criterion (for effective maintenance). Spare parts classifications by aspect of frequency of use divided items into three classes based on their history of consumption. Spare parts classifications by aspect of criterion for effective maintenance based on knowledge and experience of employees of the Maintenance Department and applying the AHP (Analytic Hierarchy Process) method. Based on the results of analyses and adopted criteria, among others such as: logistics costs of deliveries, time of waiting for delivery, place of storage of parts, time of preparation of machines for repair, etc. a decision algorithm has been developed for the selection of variants ensuring availability of a spare part.

This paper takes into account both literature analysis and business practice research on the basis of research projects (national and international) carried out at the Institute of Logistics and Warehousing and Poznan School of Logistics in Poland.

Keywords: spare parts management, maintenance, production process efficiency

1. INTRODUCTION

In the era of globalisation and dynamically-changing market conditions, focus on customer service is a key factor improving the competitive position of a company and its products. Order execution time is an extremely important factor determining product value and customer satisfaction. One of the key economic processes affecting order execution time and shaping product value for a customer is the process of production.

Constantly-changing market situation brings more and more complex challenges in terms of contemporary production management (Wyrwicka, Mrugalska, 2017). While conducting a multidimensional analysis of production process continuity, a number of factors directly and indirectly influencing its maintenance should be taken into account. Authors of reference books concerning production process continuity mostly concentrate their research and analyses around product flow processes as the object of production and management of inventories of finished products, semi-finished products and raw materials. Issues concerning the subject of securing uninterrupted work of production resources with particular emphasis on the availability of spare parts are rarely discussed. The results of studies[1] show that the process of operation maintenance and the availability of spare parts is, particularly in production processes characterized by extensive use of machinery, robotics and automation, one of the most significant factors ensuring its continuity, efficiency of servicing and inspections, failure removal rate and smooth renovations.

It may therefore be stated that managing the availability of spare parts is the element influencing the efficiency of actions carried out by the Maintenance Department and, in a broader extent, the efficiency of a production process.

2. MANAGING THE AVAILABILITY OF SPARE PARTS

An analysis of spare parts' availability should commence with the identification of internal customer's needs resulting from the maintenance of production process continuity.

Integration and reliability of logistic processes in spare parts' supply chain is the crucial indicator in a comprehensive analysis of spare parts' availability in a production process. The term "reliability of a logistic process" includes, in particular (Nowakowski, 2015):

[1] On the basis of project carried out in the area of materials management as part of the operations of the Institute of Logistics and Warehousing.

– reliability of delivery – defined as the probability of keeping all deadlines and delivery's compliance with the order,
– reliability of transport – defined as the probability of providing the order on time and undamaged,
– reliability of logistic infrastructure – includes parameters defining the work of staff and supporting equipment (devices, tools, measurement and control equipment).

The article focuses on presenting the method of spare parts' availability management focusing on the fulfilment of needs.

The purpose of the methods of spare parts' availability management focusing on the fulfilment of needs is to maintain the continuity of the production process. There are two further goals: failure-free operation of machines and devices and, consequently, ensuring the availability of spare parts:

– for the purpose of performing planned works, i.e. renovation, investment and diagnostic works, inspections, servicing,
– for the purpose of performing planned works, i.e. removal of failures.

The method of managing the availability of spare parts in the aspect of the fulfilment of needs consists of three parts, the completion of which will allow meeting the assumed objective:

– classification of spare parts according to consumption frequency,
– classification of spare parts according to criticality,
– variants of securing the availability of spare parts (location of spare parts inventory).

3. CLASSIFICATION OF SPARE PARTS ACCORDING TO CONSUMPTION FREQUENCY

Classifying spare parts according to consumption frequency requires taking the following actions:

1. Defining the scope of resource items subject to the analysis (according to objects of maintenance, groups/classes of spare parts, groups/categories of maintenance operations etc.) and collecting data concerning the consumption of individual resource items.
   The first stage consists in collecting the company's data concerning the volume of resource items' consumption in a selected period (e.g. data from logs, the IT system, record sheets, service records and shift logs of the Maintenance Department).
   Conducting the data collection process requires adopting the following assumptions concerning the scope of resource items and concerning consumption:

– the list of spare parts should include all resource materials from the adopted period of analysis which were consumed, accepted to the warehouse and/or stored in the analysed period,
– the scope of data concerning consumption, including:

- the quantity consumed in measurement units - collected data should be expressed in measurement units relevant for individual spare parts,
- the period for which the data on historical consumption volume should be collected should refer to a renovation cycle[2] applied by the Maintenance Department, which is mostly 3 years (year n, n-1, n-2, where year n is the year closest to the current year),
- places of consumption – a machine or a device in which a specific spare part was used,
- category of consumption needs – definition of the type of works: planned (e.g. servicing, inspection, renovation, upgrade, refurbishment) and unplanned (failure).

2. Division of spare parts into groups according to consumption frequency: On the basis of collected data concerning released spare parts consumption volume in individual months of the analysed period (the last year), particular resource items are assigned to appropriate groups according to the following criteria:

– group 0 – indexes which are not released,
– group 1 – indexes released once a month or more frequently,
– group 2 – indexes released more frequently than once every 6 months, but less frequently than once a month,
– group 3 – indexes released less frequently than once every 6 months.

4. CLASSIFICATION OF SPARE PARTS TO CRITICALITY

Another classification is based on the criticality of spare parts. The starting point for assessing the criticality[3] of spare parts is determining which spare parts should be included in this classification, thus dividing all spare parts covered by the analysis into usable and non-usable ones. The first step should therefore consist in dividing spare parts into:

– rotating spare parts - spare parts which have been used for the needs of the Maintenance Department in the analysed period,
– non-rotating spare parts – spare parts which have not been used in the analysed period despite they were in stock and/or were accepted to the warehouse.

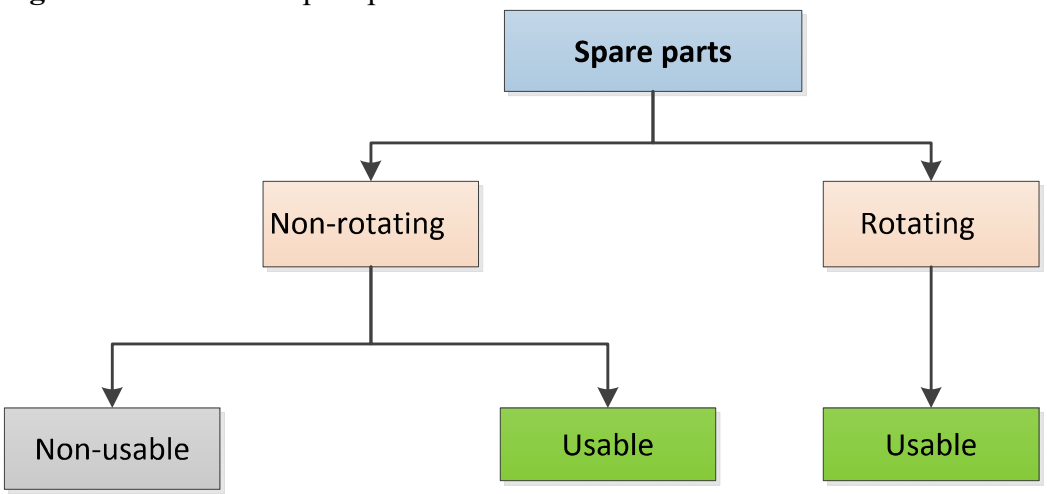
Non-rotating spare parts should be further divided into:

[2] A renovation cycle consists of: short cycles (current repairs), medium cycles (medium repairs) and long cycles (major overhauls).
[3] Criticality assessment should be interpreted as indicating those parts in the set of all spare parts which are essential to maintain the production process and the absence of which may cause production discontinuity (Nowakowski, Werbińska-Wojciechowska, 2010, p. 47, Kolińska, Doliński, 2013).

– usable spare parts – the ones that, despite being unreleased in the analysed period, may be used in the future due to the presence of machine facilities using these parts,
– non-usable spare parts – the ones that, due to the lack of machines and devices that use a specific part or due to the loss of their features, may be used in the consumption process (they are subject to scrapping).

The division has been presented in Figure 1.

Figure 1. Division of spare parts



Source: own study based on projects concerning the optimisation of resource management in production companies, carried out at the Institute of Logistics and Warehousing, Poznań 2009-2013

Critical spare parts should be therefore considered parts which are essential from the perspective of production process continuity maintenance, and the absence of which causes process discontinuity and contributes to significant (from a company's perspective) losses for a company.

The process of determining the criticality of usable spare parts may assume one of the two forms (Kolińska, Doliński, 2013, p.245):

– making a decision on the criticality of a specific spare part by Maintenance employees, on the basis of their knowledge and experience,
– making a decision on the criticality of a specific spare part with the use of a multi-criteria method of hierarchy-based analysis of decisive problems in the decision-making process, such as AHP (Analytic Hierarchy Process).

The first variant is characterised by a high degree of subjectivity due to the lack of the methodology of proceedings during the determination of a specific spare part's criticality.

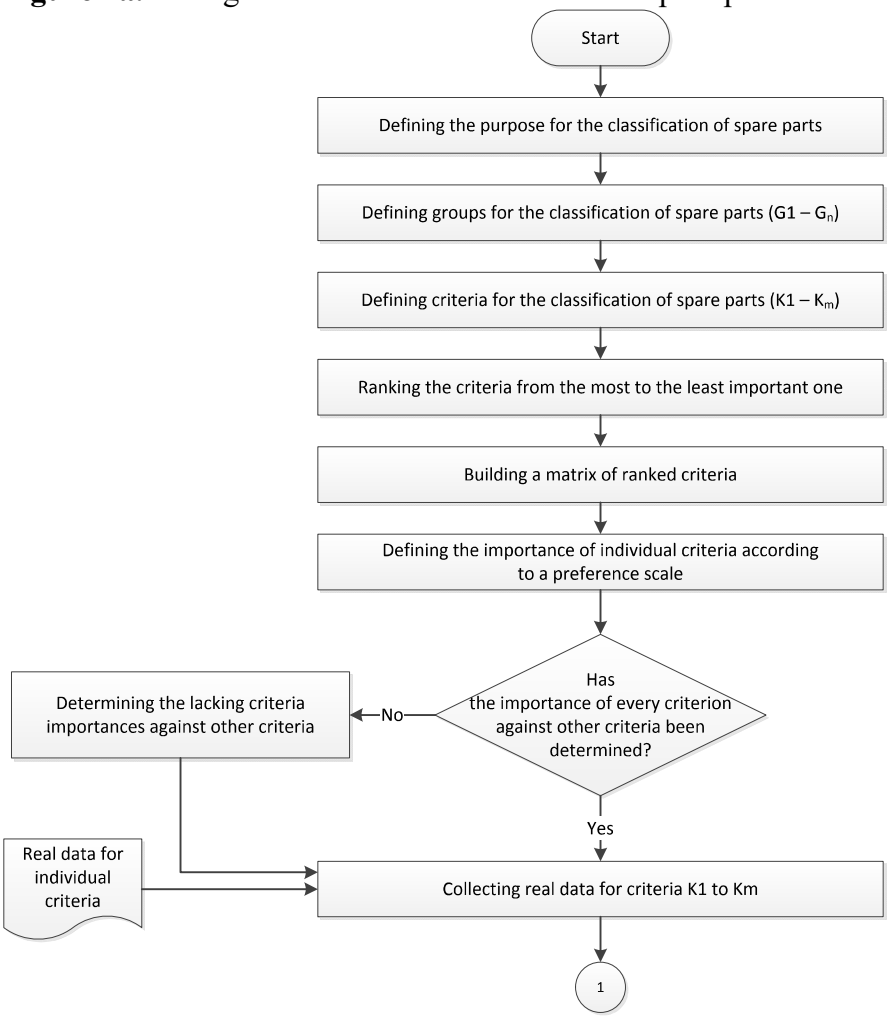
The second variant, on the other hand, is characterised by a specific methodology of proceedings, which contributes to a clear method of classifying spare parts.

Considering the above criteria, it is justified to assume the AHP method in the classification of spare parts as the right one.

The process of classifying spare parts (Figure 2) to determine their criticality is carried out in 12 stages according to the following assumptions:

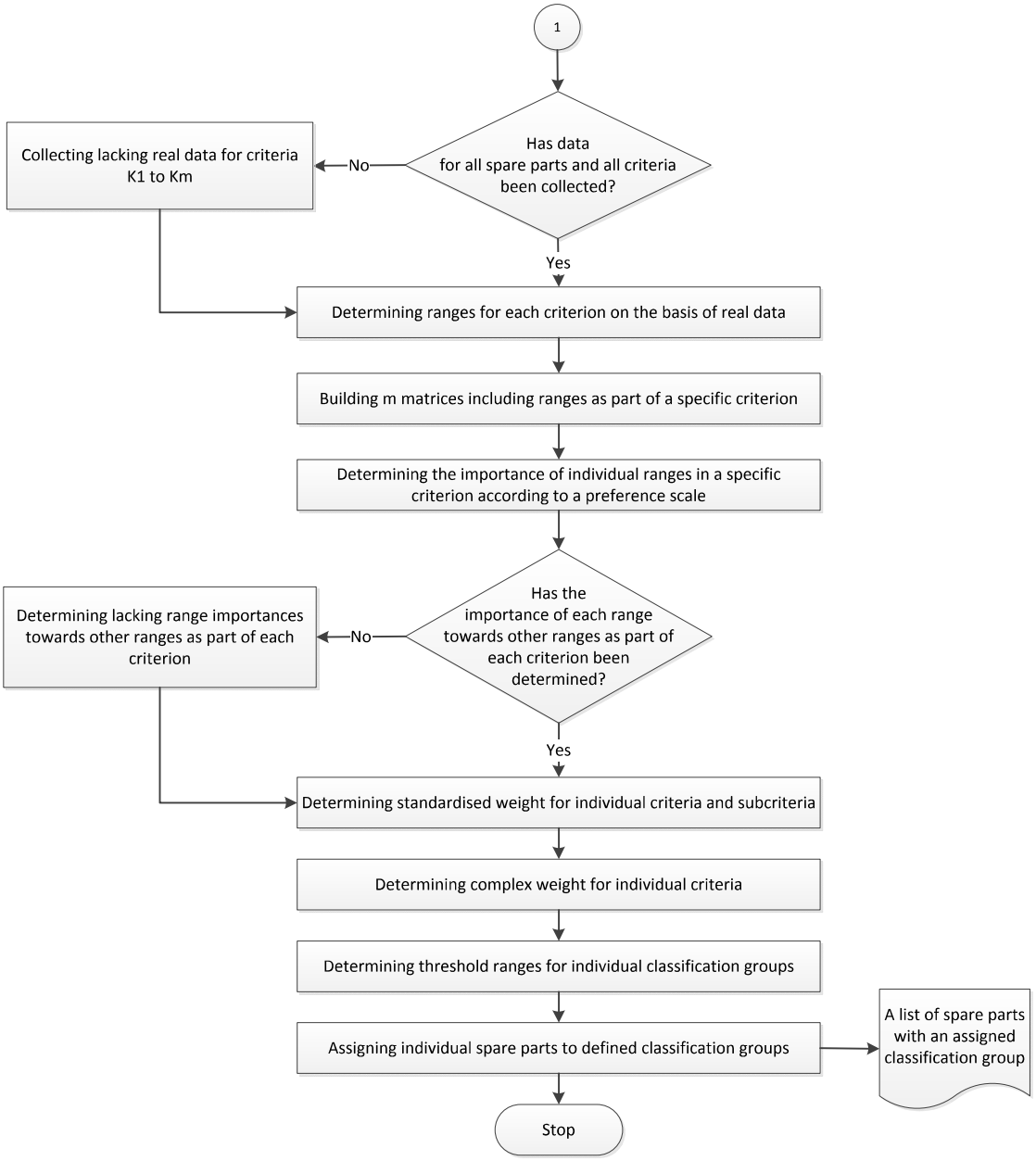
- stages related to the forming of groups, determining classification criteria and their prioritisation are conducted jointly by the Maintenance Department and the Purchase Department,
- employees of the Maintenance Department and the Purchase Department determine the responsibility of individual departments/persons for collecting appropriate data,
- coordination and supervision over the process of defining the criticality of spare parts is required,
- the spare parts classification process includes resource items defined as usable (rotating and non-rotating).

Figure 2a. An algorithm for the classification of spare parts



Source: own study based on (Kolińska & Doliński, 2013)

Figure 2b. An algorithm for the classification of spare parts



Source: own study based on (Kolińska & Doliński, 2013)

5. AN ALGORITHM FOR SECURING THE AVAILABILITY OF SPARE PARTS

Selection of the right variant ensuring the availability of spare parts is determined by a number of factors related both to production environment and to the supply chain of spare parts. On the basis of conducted research, a series of decisive criteria for the selection of variants ensuring the availability of spare parts for

individual resource items have been identified. Considering the above-mentioned factors, decisive criteria of selecting variants of ensuring the availability of spare parts for individual resource items have been defined. Table 1 lists the criteria and their possible values, which will allow determining variants of ensuring the availability of spare parts.

Table 1. Criteria for selecting the variants of ensuring the availability of spare parts

Criterion	**Possible values according to a specific criterion**		
Type of work	Planned works	Unplanned works	
Criticality of spare parts	Critical	Significant	Other
Spare parts consumption frequency	Very frequently	Frequently	Rarely
Maintenance Department's authorisation	Yes	No	
Cost of deliveries	on the company's part	on the supplier's part	
Is equipment needed to transport the spare part?	Yes	No	
Does the company have such equipment?	Yes	No	
Who is responsible for organising transport?	Company	Supplier	
Is the time of preparing the device for repair longer than the time of delivery?	Yes	No	
Object of purchase	Material	Service and material	Service without material
Place of storage of spare parts	Enterprise	Supplier	
Owner of a spare part	Enterprise	Supplier	
The party responsible for making a decision regarding the moment of ordering a spare part and regarding order volume	Enterprise	Supplier	

Source: own study based on actions carried out as part of projects concerning the optimisation of resource management in production companies, conducted at the Institute of Logistics and Warehousing, Poznań 2009-2013

Table 2 additionally presents the link between the classification of spare parts, carried out in two stages according to criticality assessment and to spare parts' consumption frequency. Selection criteria have been defined for decisive processes - according to a spare part's storage place, owner and party responsible for making a decision regarding the volume and time of ordering a spare part.

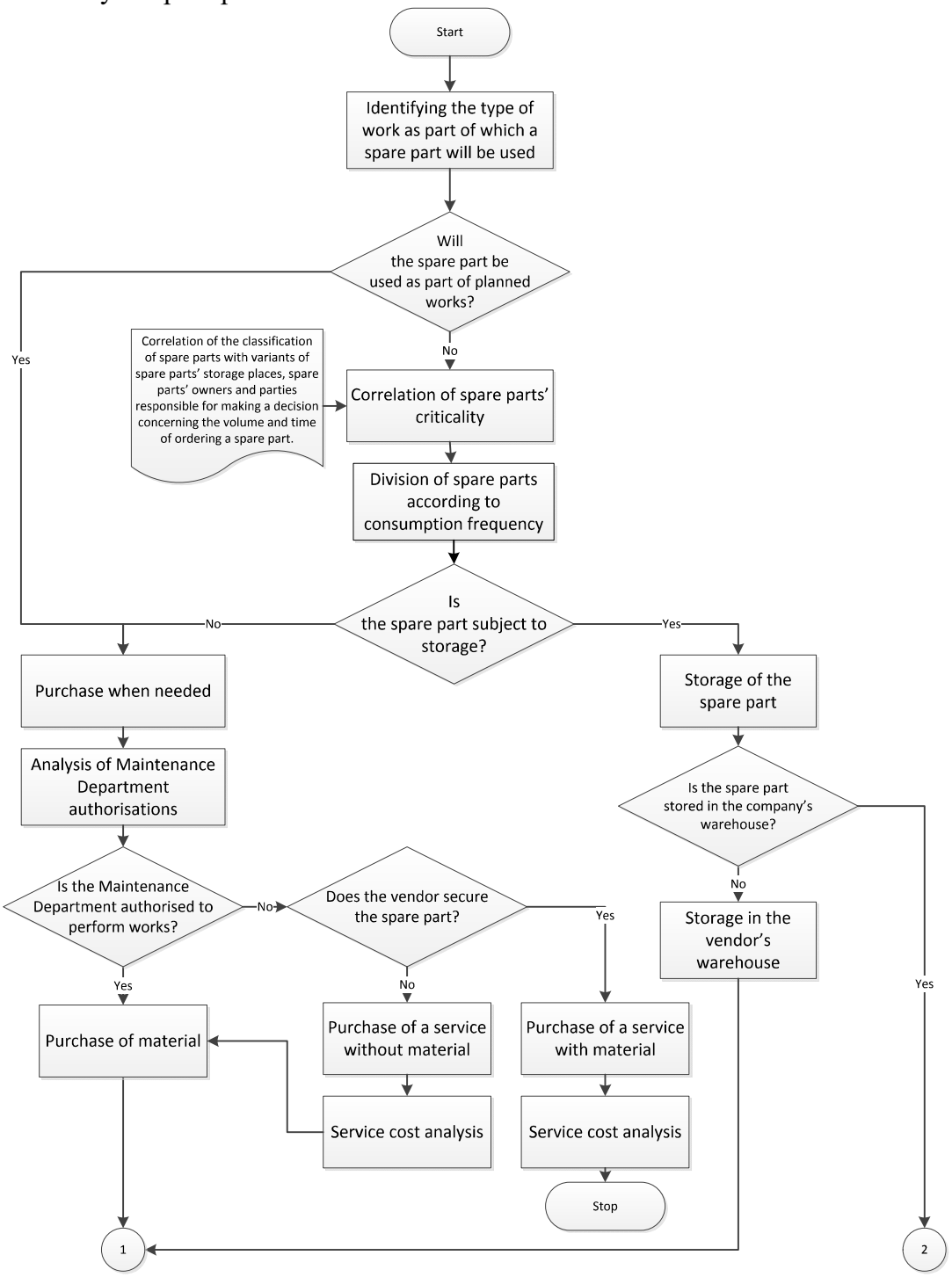
Table 2. Correlation of the classification of spare parts according to criticality with variants of spare parts' storage places, spare parts' owners and parties responsible for making a decision regarding the volume and time of ordering a spare part

Groups		Place of storage of a spare part							
		Company				Supplier			
		Owner of a spare part				Owner of a spare part			
		Company		Supplier		Company		Supplier	
		The party responsible for making a decision regarding the moment of ordering a spare part and regarding order volume		The party responsible for making a decision regarding the moment of ordering a spare part and regarding order volume		The party responsible for making a decision regarding the moment of ordering a spare part and regarding order volume		The party responsible for making a decision regarding the moment of ordering a spare part and regarding order volume	
		Company	Supplier	Company	Supplier	Company	Supplier	Company	Supplier
Critical	Very often	X		X					
	Often	X		X					
	Rarely	X		X		X		X	
Significant	Very often	X		X					
	Often	X		X					
	Rarely					X		X	
Other	Very often	X	X	X	X				
	Often		X		X		X		X
	Rarely					X	X	X	X

Source: own study based on actions carried out as part of projects concerning the optimisation of resource management in production companies, conducted at the Institute of Logistics and Warehousing, Poznań 2009-2013

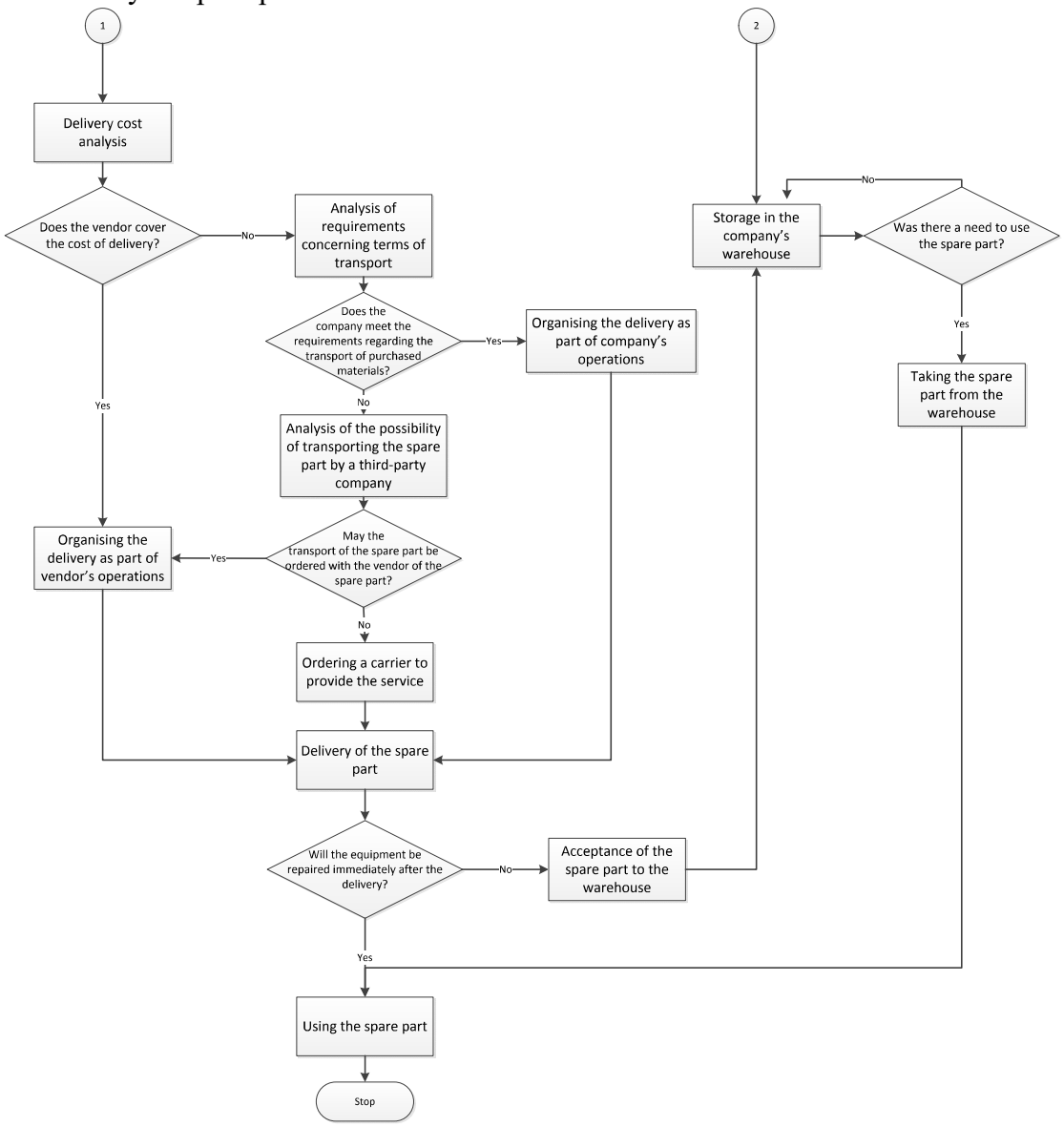
Considering the above criteria, an algorithm facilitating the selection of variants and operational actions ensuring the availability of spare parts (Figure 3) has been developed.

Figure 3a. An algorithm facilitating the selection of variants ensuring the availability of spare parts



Source: own study

Figure 3b. An algorithm facilitating the selection of variants ensuring the availability of spare parts



Source: own study

The method of ensuring the availability of spare parts allows a comprehensive analysis of spare parts, taking into account such elements as the degree of criticality (critical, significant, other), planning of renovation works or the frequency of consumption of specific parts. Both the algorithm (Figure 3) and examples of variant options show that the availability of spare parts for the purposes of maintenance is not merely a problem of determining specific parts' inventory volume.

More and more frequently attention is drawn to availability in a broader scope, i.e. to ensuring the continuity of material flow starting from the vendor of a spare part. Thus, it is justified to use and ensure the availability of spare parts in the aspect of stock management in a supply chain by a vendor (VMI - Vendor Managed Inventory) as part of joint planning, forecasting and replenishment of inventory (CPFR -

Collaborative Planning, Forecasting & Replenishment), as well as controlling and steering related process in a supply chain.

When conducting an analysis of reference books and carrying out studies as part of a research project[4], the following variants of procurement of materials in a supply chain should be identified[5], taking the specific nature of spare parts' availability into account:

- vendor's management and responsibility for the process of procurement (VMI option), inventory is kept at the vendor's site and it is the vendor's property (lack of inventory and delivery in the JiT system from the vendor's production process to the recipient's production process may be an option),
- vendor's management and responsibility for the process of procurement (VMI option), inventory is kept at the vendor's site and it is the recipient's property,
- vendor's management and responsibility for the process of procurement (VMI option), inventory is kept at the recipient's site and it is the vendor's property,
- vendor's responsibility for the process of procurement (VMI option) inventory is managed by a logistics operator, kept at the logistics operator's site and it is the vendor's property,
- recipient's management and responsibility for its own procurement process, inventory is kept at the vendor's site and it is the vendor's property (consignment stock option),
- recipient's management and responsibility for its own procurement process, inventory is kept at the vendor's site and it is the recipient's property,
- recipient's management and responsibility for its own procurement process, inventory is kept at the recipient's site and it is the recipient's property (classic form of procurement).

Using the variants of procurement management in a supply chain requires the integration of information between the vendor of spare parts and the production company, ultimately the Maintenance Department. It requires the integration of indicators assessing the process of ensuring availability, process execution benchmarking and assessment methods. It is important both from the point of view of production process efficiency in a supply chain (Kolińska, Cudziło, 2014), and of the comprehensive character of the presented model of spare parts' availability management in the aspect of production process service level.

[4] Simulation of a company's material flow management as a tool of a multi-variant analysis of the efficiency of transport processes, No. Z509 549940, Poznań School of Logistics, Poznań 2011-2013.
[5] detailed analysis focusing on the variants of procurement of materials and inventory management in a supply chain has been presented in the following publications: (Sliwczynski & Kolinski, 2016, Cyplik, Hadaś, Domański, 2009).

6. CONCLUSION

The developed method has been created as a response to the need to comprehensively manage the availability of spare parts, taking the aspect of production process continuity maintenance into account. The developed method is a tool of analysis which will be verified in subsequent stages of research work. In the Authors' opinion, the issue regarding the availability of spare parts is an important element of efficient management in a production company, which requires more profound analyses and scientific research. Current scientific literature does not provide a clear solution regarding the scope and method of conducting an analysis of spare parts' availability in the aspect of maintaining the continuity of a production process. The absence of a defined method of a comprehensive analysis of factors affecting the process of managing the availability of spare parts makes it difficult to make right decisions in this scope.

The paper presents merely one of the elements influencing the availability of spare parts, focusing on satisfying needs resulting from planned and unplanned repairs of production machines and devices. Another element of this model is to conduct a controlling analysis of the impact of the spare parts availability on the production process efficiency, which was presented in a publication (Kolinska, et al. 2017). However, due to the complexity and detail of the discussed issues, the presentation of the whole model requires prior presentation of its components.

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