CONTROL OF SPARE PARTS INVENTORY IN ORGANISATIONS

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Probably every organisation focuses on obtaining very significant market positions in their field of business. The production for customers is overriding for it. However, meeting this goal is preceded by its production. Now the preparation of production is sometimes on the edge of the interests of its staff, although it is now scientifically strengthened, e.g. in the field of maintenance or materials. The maintenance needs for operation of every device simple materials and spare parts.

This article describes a pilot project of authors, carried out in the Czech Republic on a sample of selected organisations. The project deals with the control of materials and of spare parts inventory in organisations. It describes the current state of the problem and nonconformities occurring in this material field. Results of the survey are compared with findings from a brief literature research. The preparation of the device is a key part of material savings in terms of spare parts, but also from the perspective of a subsequent production. Therefore the article proposes a solution in the area of control of materials and of spare parts inventory for strengthening the competitiveness of these organisations.

KEYWORDS

spare part, material, organisation, maintenance, supply, management system, store

1 INTRODUCTION

Given the unpredictable environment in which organisations operate the management of materials and spare parts supply in organisations is of increasing importance. It ensures the timely delivery of the final product to the customer. The following paper deals with some aspects of this issue in greater detail.

2 LITERATURE REVIEW ON THE MANAGEMENT OF MATERIALS AND SPARE PARTS SUPPLY

According to [Legat 2013] stock items in organisations are mostly either overstocked or under stocked. The auxiliary relationship of stock items, i.e. materials and spare parts, to organisations' actual production is described in [Tomek 1999]. In the long term, [Huiskonen 2001] considers it necessary primarily to reduce, in maintenance terms, the criticality and uniqueness of the various items of material. [Hautala 2010] highlights the fact that the supply chain of materials and spare parts for organisations is only as strong as its bottleneck or weakest link. Legislative obligations of suppliers are to be applied. However, in the pilot example mentioned, suppliers create much nonconformity in the supply of materials for the organisation. [Lucca 2015] lists human, service, equipment and environmental nonconformities as well as nonconformities in production design. [Rustenburg 2001] highlights the reparability of parts and the use of consumables. Some parts must be replaced after a certain period of time regardless of wear and tear. The following factors are a part of the reality: changes due to a technological development and previously performed maintenance tasks, the organisation's decreasing budget for materials and spare parts during the year, the current situation in terms of availability of supplies, which are not considered within current inventory models. The application of stock item management tools, such as in text of [Molenaers 2012], results in bill of material optimisation. However, the text points out the frequent inaccuracy of stock information in organisations. According to [Pintelon 2006], the growing complexity of equipment that is intended for maintenance is also problematic. All the more so that maintenance management requires a long-term maintenance strategy to be set out. [Huiskonen 2001] argues that the inaccuracies of materials and spare parts inventory models lead to distortions in the software that is intended for this area. [Vavra 2014] points out that the issues of equipment maintenance support has not been fully addressed in organisations, giving rise to (not only) material nonconformities.

According to [Huiskonen 2001] and others, it is mainly the coordination and communication between organisations and suppliers of materials and spare parts that is problematic. In response, this author stresses the need to implement cooperation within the supply chain of items of material for organisations. [Rustenburg 2001] highlights the following features: criticality, redundancy, normative consistency and various restrictions on the items supplied. [Molenaers 2012] considers the following to be essential: criticality, the probability of failure, supply time, the number of suppliers, technical specifications as well as maintenance type. The general study [Tsang 2002] highlights the need to consider the human factor and information flow for maintenance support. According to [Cavalieri 2008], the following factors are important: stock of spare items, forecasts for their use, identification and checks of the situation. By contrast, [Huiskonen 2001] describes spare parts based on their: criticality, technical specifications, value and demand, as well as location, responsibility and checks that are carried out. According to [Legat 2013] the following factors are important for items of material: name, identification, supplier, delivery time, technical specifications, drawings, tests, location, criticality and characteristics of the supply cycle.

Each publication suggests a different methodological solution to managing the supply chain of materials and spare parts and dealing with their nonconformities, as seen e.g. in [Cavalieri 2008]. The general study [Tsang 2002] considers the method of spare parts supply management to be crucial, alongside organisational structure and supply options. However, [Pintelon 2006] points out that while there are a number of existing management tools for spare parts and related issues, these are not applied to maintenance. In the thesis, the 5W tool is used to search for a solution to the issue of spare parts supply[Hautala 2010]. [Lucca 2015] uses the Ishikawa diagram and the 5M tool to specify and it subsequently addresses the causes of given nonconformities for deliveries of components in the automotive industry (e.g. diesel system assemblies). The article [Rustenburg 2001] analyses the use of complex tools, such as the Vari-metric model, for spare parts management in the marine sector. [Molenaers 2012] proposes a method for classifying the criticality of supplied materials into levels, based on decision diagrams and pair wise comparisons in the petrochemical industry. According to [Legat 2013]], the Bootstrapping method is best suited for stock items inventory management in order to minimise stock levels. The integrated

approach to spare parts stock management as shown in Figure 1. is originally based on [Bacchetti 2012].

In addition, [Mirghani 2003] presents a case study for using a framework for stock items calculation in maintenance planning. By contrast, [Giakatis 2001] draws attention to hidden costs in connection with production and secondary processes, which are, to a large degree, tied to the materials used in organisations.

[Rustenburg 2001]proposes that the following issues should be explored: irreparable items and items to be disposed of, costs of technical equipment during the service life, and ensuring the supply of spare parts for complex technical systems. [Molenaers 2012] proposes that a general multidisciplinary decision-making tool should be created to determine the criticality of stock items. [Huiskonen 2001] recommends that a distinction should continue to be made in the management of various types of spare parts, while [Legat 2013] already presents a certain solution. [Vavra 2014] recommends paying greater attention to long-term support for operating equipment. In connection with the building up of New Industrial Production, e.g. according to [Bartosik 2014], there is a need for new features or essentially functions to be added to spare parts, so that the parts can communicate and cooperated with the rest of the technical system.
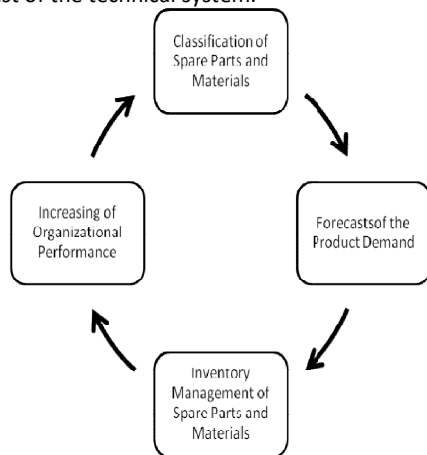

Figure 1.An integrated approach to spare parts stock management, originally based on Bacchetti, N. Saccani

3   DISCUSSION ON THE TOPIC

There are quite a lot of publications on materials and spare parts supply management in organisations that differ in terms of the orientation of their production. However, these publications usually do not directly specify the different parts and types of materials. Rather they refer to: the industry, the complexity of the technical system or equipment, the use of an assembly or functional subsystem, and the items under review and the management tools used. Given the brief literature review that has been carried out, it is possible to say that this issue is faced, to one degree or another, by all organisations and there is ongoing development in this area.

Instead of the 5M tool, which is used e.g. in [Lucca 2015], it would be more suitable to use the 6M tool that also includes the measurement of items. This specifies the values of the features of the given items of material which, in turn, makes the management of the organisation as a whole more accurate.

In terms of characterising materials and spare parts, a large number of features are mentioned. However, safety features, environmental features, determined substitutes and item cost are omitted. For both spare parts and consumables, the service life should also be determined but, in many cases, it is not (e.g. some plastic parts may begin to break apart all of a sudden

which may catch users by surprise and cause additional work for them).

The issue of a bottleneck in the supply of materials and spare parts for (not only) maintenance is often overlooked in organisations.

The literature review that has been conducted provides a broad overview of the issue of materials and spare parts supply management in organisations. However, it also points to a number of unresolved nonconformities, which also gives room for the research described in this paper.

The problem in this area lies in the fact that there is a lack of knowledge about the status quo and about the method of warehouse management and, in particular information how the distribution of specific types of materials is used in organisations in connection with the storage and following maintenance.

4   PILOT PROJECT

Therefore pilot project uses data from 10 randomly selected organisations only. This type of the research was done at the first time in the workplace of authors. The project was launched in 2014 and it continued in 2015. The organisations are based all over the Czech Republic. Of the above number, there are 3 small and medium-sized organisations (up to 250 employees) and 7 large organisations. Various branches of the national economy are represented. The organisations carry out piece (40%), serial (40%) and even mass production (20%) of products. Manufacturing organisations account for 80% and organisations that provide services account for 20%.

The issue of materials and spare parts supply management in organisations has been derived from much more comprehensive research into maintenance management and maintenance stock management in those organisations, which is also carried out by the authors of this paper. The paper aims to describe the actual situation of materials and spare parts supply management in Czech organisations and to propose appropriate recommendations for strengthening these organisations' competitiveness.

In terms of methodology, mainly observations of the operation of organisations were made and the data was subsequently analysed, simple statistics was used and recommendations were derived from the individual nonconformities identified. The recommendations achieved in the article have not been implemented in the surveyed companies yet, but it is expected to be implemented in further research of the authors.

5   THE CURRENT SITUATION IN STOCK MANAGEMENT IN ORGANISATIONS

The survey shows that organisations prefer to simply refer to spare parts rather than to indicate the relevant material used. In this respect, consumables are an exception.

It is common for there to be thousands or more types of items of materials and/or spare parts in organisations. Overall, the price of materials and spare parts in organisations' warehouses in the Czech Republic is in the thousands or even millions of CZK. Due to difficult supplier relationships, organisations in the Czech Republic tend to overstock. This is because under stocked items often lead to loss of production and, in turn, lower profits and sometimes even loss of customers.

It is interesting to see the kinds of materials and spare parts that are used specifically in Czech organisations. Of course, given the small number of organisations examined, this list (and the percentages indicated) is only indicative. However, it is an adequate source of initial information. Given their administrative tasks, all service and manufacturing

organisations (i.e. in 100% of cases) require office consumables. It consists from a paper and plastics. The paper is often a photosensitive last time. Documents from it bring problems for the archives from this reason. Plastics office consumables are produced mainly from worse recycled materials and have a pure quality. Besides that, fasteners (e.g. bolts, nuts, washers, pins etc.) are most often used in manufacturing organisations (approximately 80% of cases). There are produced from metals (as better steel and light metals). Fasteners have on themselves technical oil or an emulsion to better assembly. They need a high precision manufacturing. They are much more durable.

Also, mechanical and electrical materials (e.g. wires, sheets, fittings etc. made of steel and light metals) are used, depending on a production type. A kind of material of these parts can be a less precision manufactured. The recycling of these types of materials is easy. They service life is a long but these parts are often changed from due to the expiration hours of service life during the functioning. In addition, mechanical parts (e.g. bearings) and electrical components (e.g. capacitors) are used, depending on production type. These are mainly composite materials with a harder manufacturing and also a harder recycling. Plastics are currently used quite often in both manufacturing and nonmanufacturing organisations, because former metal components of cheaper functional units are often replaced with plastic parts. There is a lot of kind of plastics. Some parts of these plastic are a health dangerous and also danger for the environment. Plastic materials are suitable for the mass production of organisations. They service life is a short. Plastics are a photosensitive and a bit fragile. A portion of organisations (approximately 20%) choose to purchase entire functional units (i.e. machine, electrical, pneumatic or hydraulic systems). Several kinds of materials are used here. This fact influences a service life and a functionality of the object. Every kind of material in the functional unit presents its properties in the whole. While that simplifies and speeds up maintenance and reduces requirements for employees' knowledge and skills, it also suppresses their creativity. Furthermore, organisation cannot improvise much, especially in emergency situations. This survey also shows that approximately 30% of organisations use unique spare parts or materials. That places increased demands on the supply chain. The situation about used materials in organisations and their degree of the stocking brings Figure 2.

Based on the survey conducted, it can be concluded that Czech organisations' approach to the methodology of materials and spare parts stock management is as follows.

Most organisations are trying to develop their own universal method for determining the minimum stock level of spare parts and materials. The optimal stock level of spare parts and materials tends to be derived from the current scale of production (i.e. both manufacturing and services), the utilisation of the given equipment or the turnover of individual stocked spare parts and materials, or possibly a combination of all of the above. Forecasts of future consumption are made based on the organisation's employees' experience from previous periods, which are based on a representative history of consumption.

When determining spare parts and materials stock levels, organisations mostly follow the criterion of a minimum weekly lead time. The minimum reserve amount is determined by the nature of the product and the consumption frequency, but also the delivery deadlines of the third-party supplier organisation of a specific spare part or a material. Cost-intensive parts and materials are usually purchased at the time of consumption, while taking account of a planned production. That assumes a reliable supplier with timely supplies, which is a problem in the Czech Republic.

Determining the optimal ordering level for a spare part or material is based on the cooperation between several parts of the organisation. The first part of the organisation (e.g. the Controlling Department) provides a certain financial framework for the spare parts and materials stock level. The second part is maintenance. Based on various reports that are usually generated from an ERP system etc., maintenance employees identify and document, for financial management purposes, which spare parts and materials have the highest turnover, which are expensive and yet the organisation must 'keep' them in stock as there is no other way of ensuring their availability (e.g. as consignment stock, servicing by the manufacturer etc.). The third part of the organisation carries out the technical preparation of production. In the case of planned major repairs and modernisations to production lines or the purchase of new equipment, it reports in advance which spare parts and materials will need to be in stock in the near future. This is a starting point for determining storage space and necessary logistical equipment (if any) for handling the relevant stock
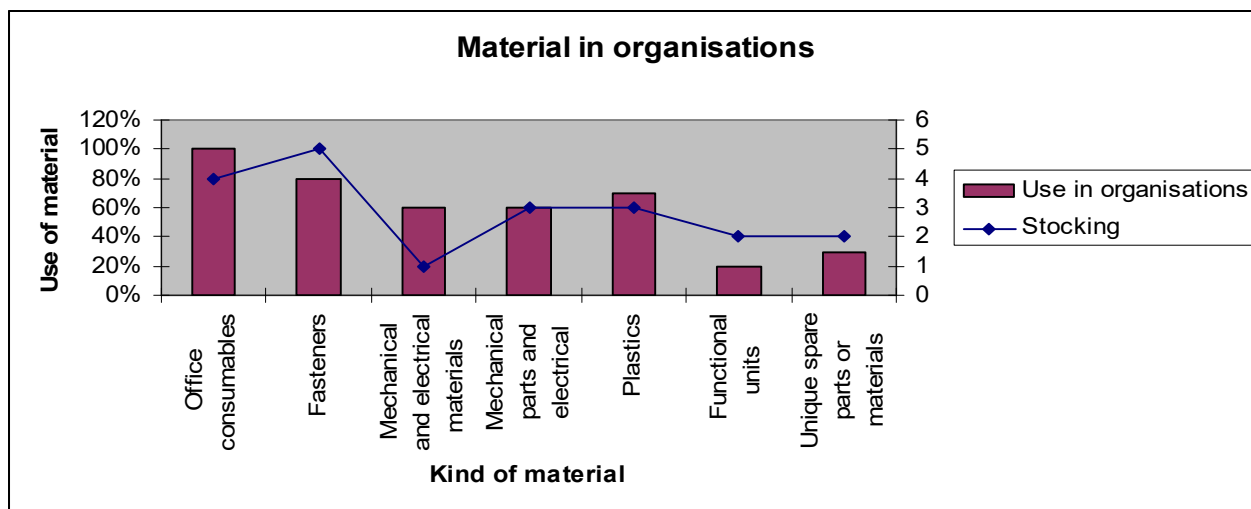

Figure 2. Materials used in organisations and their degree of the stocking.

items. In this respect, the process of determining the optimal

levels of materials and spare parts is a constant controlled negotiation between these three parts of the organisation as mentioned above. The organisational structure used is quite important to the process. The optimal levels of stocked materials and spare parts are constantly sought in connection with technical changes and modernisation of the given equipment. As part of the annual cycle, the final agreement that has been reached by these parts of the organisation is incorporated into the annual budget. This materials plan is then used for monthly reporting as a benchmark for comparing whether or not the budget amount has been successfully met.

The majority (approximately 80%) of the organisations surveyed use some maintenance system software (a special database or ERP system). As a general rule, these systems keep records of all stocked spare parts and materials and their flows into and from stock. They are usually able to determine the turnover of each stock item. Depending on the needs of the given organisation, a report can be generated (e.g. once in a quarter) that lists items with the lowest and highest turnover. The most frequent items can be analysed in terms of why they are so frequently replaced. For lowest-turnover spare parts and materials, it is usually analysed whether they need to be kept in stock. However, a third of the organisations surveyed have no determined minimum stock levels. Due to the absence of stock management, it is not possible to determine the appropriate optimal level for stock items. Therefore, stocks of less-expensive materials and spare parts are continuously purchased and kept in amounts that are estimated by the employees based on their experience with maintenance in previous years, the behaviour of their suppliers and the overall availability of parts in the market. However, that leads to unnecessary overstocking. Sometimes, this situation is also caused by agreed framework contracts with customers who require them as a necessary guarantee for a good business relationship. In these organisations, more cost-intensive parts and materials are not purchased until the moment they are needed, with an expected consequence in the form of an outage of planned production.

Approximately 40% of the organisations surveyed said they carried out TPM. All records of the preventative equipment maintenance and repairs that have been carried out are evaluated once a year. On this basis, the frequency and focus of maintenance checks is determined. In addition, these outputs are used for planning the number of necessary spare parts and materials. Also, these outputs are beginning to be used for updates to organisations' emergency plans that are used in the risk management.

Approximately 60% of the organisations surveyed carry out spare parts and materials categorisation according to their importance (according to the criteria of turnover, price etc.). In this respect, the ABC analysis seems to be the most commonly used tool.

In an optimal situation, each item of equipment should have technical documentation from the manufacturer, including a list of the various parts (e.g. a bill of material). This is supposed to make it easier for the organisation to divide parts into several groups according to the priority of their function for the organisation's production. However, the issue of the manufacturer's technical documentation for equipment is addressed by one of the authors of this paper in a different research. Therefore, it can only be concluded that the completeness of equipment documentation is currently not adequate for maintenance.

In the survey that has been carried out, 60% of organisations reported information about the management of unused stocks of spare parts and materials. Of that number, 30% of organisations sell stock items in the internal market (e.g. within the concern) or the external specialised market. An additional 30% of organisations only depreciate stock items and keep them in stock. It should be noted that even though the collection of used parts by the original manufacturer was mentioned in one case, this does not necessarily mean environmentally friendly disposal.

6 NONCONFORMITIES

Based on an analysis of the data relating to the area that was surveyed in organisations, relatively frequent mistakes in stock record keeping were found. The reasons included irregular depreciation, late entry of item values into the software, and incorrect transcription of item values between physical and electronic stock documentation and so on.

Very often organisations are faced with long delivery times for spare parts and materials from their suppliers, despite the fact that timely delivery has been agreed with or even offered by the supplier.

The purchase price is particularly high for spare parts. Looking at the market, it is obvious that prices of stock items for maintenance are growing relatively fast.

Almost every organisation owns a rather large number of stock items. As a result, large storage areas are needed. Employees find these warehouses difficult to navigate. In addition, managing relationships with so many entities is demanding in terms of communication and coordination.

The equipment wear and tear is not always regularly monitored and a regular maintenance is not always established and adhered to. This may lead to the sudden occurrence of a failure, which sometimes even requires an unknown spare item. Furthermore, there is an outage of a normal production.

No precise consumption of stock items over a certain period is specified.

It was discovered that there were efforts to use a supplier and leave all of the above concerns relating to spare parts and materials supply to that supplier.

Recently, organisations have also faced declining quality of many materials and spare parts supplied.

7 A COMPARISON WITH THE LITERATURE REVIEW CONDUCTED

As opposed to the findings of the literature review on this topic, the following findings have been made. Organisations in the Czech Republic are rather overstocked with spare parts and materials in warehouses. The criticality of organisations' stock items could not be assessed due to the internal nature of this feature. The uniqueness of stock items in organisations is relatively low. The respective manufacturers are often the bottleneck in the supply chain of spare parts and materials. In the Czech Republic, the problematic areas seem to mainly include regular care for spare parts and materials in organisations' warehouses, which is associated with a human error. Data on stock items are often distorted and outdated. Stock item inventory management is closely related to the financial management of Czech organisations. The communication with suppliers requires increased effort from organisations and is often tied to signed contracts. Czech organisations use rather general spare parts and materials stock management methodologies that are based on classical models of inventory management. Modern methods are only slowly implemented. While organisations also state that they use the TPM method, other findings about the organisations suggest that this is more about using the modern term and less about applying the actual concept. Given the number of

organisations that were surveyed in this pilot project, there is no visible difference between small and medium-sized organisations on the one hand and large organisations on the other hand. Only small and medium-sized organisations use so called small software systems.

8 PROPOSED SOLUTION

Based on the survey conducted, the consequences of the lack of standardisation in spare parts and materials stock management in organisations can be determined. These include the following issues:

− Wrong stock keeping has a negative impact on logistics operations, from ordering an item to the delivery of the organisation's products to customers.
− High prices of individual stock items, high storage costs, long delivery times and the risk of unavailability of parts etc. often lead to overstocking in the organisation.
− In the Czech Republic, the average delivery time for a spare part or a material ranges from 48 hours up to a week, depending on how much the organisation may be willing to pay for express delivery.
− Sometimes, failure due to a lack of spare parts or materials means that the organisation will experience an outage of several days and, in turn, incur a loss of tens of thousands of CZK as well as the actual cost of repair to the equipment.

Regular care for stock items is necessary both in the stock-keeping system and in the actual warehouse and all types of transcriptions of their data need to be minimised.

The following factors play a role in determining the optimal stock level for a spare part or material for equipment maintenance:

− The number and type of the items of equipment (with respect to the frequency and severity of failures).
− Equipment supplier or manufacturer (flexibility to respond to unexpected demand for a spare part or material, delivery deadlines for spare parts and materials).
− The age or period of operation of the equipment.
− The price of the spare part or the material (it is essential for the financial management of the organisation).
− The quantity ordered.

Given the frequent nonconformities in this area, the following features can be added to the characteristics of stock items, i.e. materials and spare parts: environmental features (service life, safe disposal), safety features (with respect to protection of the health of persons) and determining substitutes for the given item (in case of failure of supply).

The attention should mainly be paid to the selection of the stock item supplier. Subsequently, a long-term relationship needs to be built with the supplier. In this regard, reliability is essential. This somewhat reduces the cost of stock items while also optimising their quantity and, above all, reducing their delivery times. Furthermore, it is possible to rely on a higher quality of the necessary stock items supplied.

Internally, an organisation must carefully monitor an internal material flows into the maintenance and the associated consumption of spare parts and materials for a certain period. This information also subsequently helps optimise stock items in terms of both quantity and range.

Unused stock of spare parts gradually loses its value and, after a certain amount of time, is fully depreciated by the organisation. If there is unused stock of spare parts, it is necessary to carry out a review of whether it is appropriate for

the spare part or material to be used for maintenance or repair of other equipment. If no such option is available, it is useful to offer these items for sale in order to reduce stock levels. Since these may be parts that are already obsolete, the selling price needs to be considered. Items, that have no further uses, need to be disposed of in an environmentally sound manner as a part of waste management.

9 CONCLUSION

In this paper we have introduced a pilot project exploring the stock management of spare parts and materials. The disadvantage of the survey carried out is the small number of organisations surveyed. Only 10 organisations were included in this pilot study. That being said, the number is sufficient for an initial outline of the issue as it includes organisations from all over the Czech Republic and from various branches of the economy. Findings are verified on next examples of organisations in this time.

Generally, organisations should aim to reduce the stock levels of spare parts and materials and possibly seek alternative solutions in the form of:

− Consignment stocks of suppliers.
− Selected spare parts must be delivered by the supplier within a specified time limit.
− Standardizing stock items in order to reduce the number of different items, which can also be facilitated by equipment design.
− Educating the organisation's employees with respect to materials and spare parts stock management.

Currently, consumables and fasteners are the most common types of material used in organisations. That means that there are up to hundreds of stock items. From the perspective of improving stock management, the most pressing is the need to standardise parts (not only) for equipment maintenance. This may be facilitated by an appropriate design of the equipment. In addition, mechanical and electrical materials and mechanical and electrical components are also often used.

It can be recommended that the following be added to the characteristics of stock items: safety features, environmental features, determined substitutes and item cost.

The manufacturer of spare parts and materials can be singled out as the bottleneck in the supply chain. Here, given the increasing risks, the distance between the manufacturer and the customer requesting a stock item will also play a role in the future. In addition, there is room for improvement in the accurate record-keeping of the use of stock items for equipment maintenance.

This article provides a list of the types of stock items of materials that are used in organisations in the Czech Republic. It also outlines the current situation and methodology in spare parts and materials stock management.

The article presents simple principles of spare parts and materials stock management that may support the organisation in its holistic management, regardless of its size and line of business. The above principles of stock management are also in line with an orientation towards a process-based approach. As a result, financial, spatial and time savings can be achieved.

Organisations are faced with the challenges of inventory management of spare parts and materials in relation to the minimum amount.

Theproposed recommendations in this paper are: simple, cheap, saving the spatial and temporal arrangement.

An effort was made to implement the recommendations in other organisations. The solution was greeted by the

employees at the lower levels of management. The problem of this implementation shows in disinterest by the leaders of organisations that are not willing to release finance and especially to release staff for the actual implementation of the measures.

Overall, this approach to stock management reflects the reality of the current market and strengthens the competitiveness of the given organisation.

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