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THEORY OF SPARE PARTS INVENTORY MANAGEMENT FOR PRODUCTION EQUIPMENT

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Abstract: This article presents theoretical basis of spare parts inventory management in manufacturing company. Basis definitions, allocation and differences in spare parts inventory management were compared with other manufacturing inventories. The issue of spare parts inventory management is emphasized in aspect of maintaining continuity of production and generated costs of maintaining inventory.
Keywords: material stocks, spare parts, requirement planning.

1. Introduction to spare parts inventory management

In medium and large manufacturing companies, effectiveness of production orders is dictated largely efficient technical maintenance of machinery and devices. Disposing adequate places of spare parts storage allows ensuring a proper conservation and repair of damaged equipment. It should be noted that storage may operate correctly only when technical documentation is available [4]. Due to complexity and dependence of particular machines and equipment, its lack may result in large financial losses.

Storage of production inventory plays an important role in realization of fundamental production processes in a company. The purpose of maintenance a high level of resources of raw materials ensures consistent production flow and protection from unexpected events, while reducing an uncertainty connected with quality and term of realized deliveries [11]. Accumulated stock may also satisfied customers demand and ensure company a competitive market position. Although, a major problem in financing company activities connected with inventory storage are costs of creating, maintenance and stock-out.

In aspect of company management, spare parts inventory are defined by Z. Sarjusz-Wolski as a type of material stocks, used in production process, which are not a final product sold to final customer [14, 16].

K. Ficoń also analyses logistics of supply and characterizes spare parts inventory and components as material stock, also distinguishes raw materials and semi-finished products. Author emphasizes that some machines components can be produced by a mother company in order to fulfil their own needs [6].

Generally, spare parts requirements may be results of following elements [1]:

- "exchange of object, which reached technical or guarantee service life,
- exchange due to reaching the limit of technical condition e.g. aggregate does not fulfil parameters during technical inspection,
- damage of object during application (*damage discovered during operating, during scheduled services*),
- damage during storage, (*loss of quality*)

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– exchange of parts recommended by producer or authorized body in bulletin or Airworthiness Directive".

Figure 1. presents creating process of production inventory, including spare parts inventories and storage connected with it.

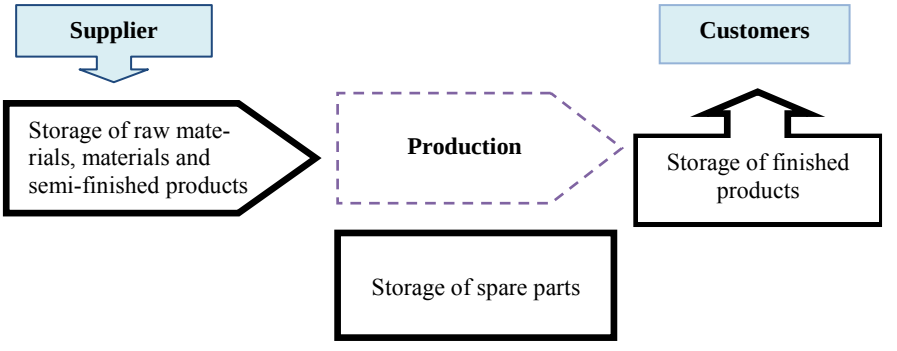

Figure 1. Stages of stocks formation in company
Source: Author's elaboration based on: A. Becht, Zarządzanie operacyjne, Towary i usługi, Wydaw. PWN, Warszawa 2012, p. 546.

In general structure of inventories, within the framework of its function, spare parts inventory is accumulated mainly by manufacturing companies and entities responsible for supply of spare parts.

2. Spare parts allocation

In demand planning for spare parts, it can be distinguished [3]:

1. Maintenance parts (high level of unreliability). These are spare parts, which possession is required "at short notice", because of their failures. They belong to regularly storage products. In their case, the same policy as for other material stocks is applied.
2. Parts of buffer stock. The purpose of these parts is to ensure security or protect against threat of continuity of production (possible component failure or damage). The likelihood, that time of storage of this part exceeds maximum lifetime of device, is quite high. Their sustainability ranges from 95% to 99 during machine lifecycle, so their maintenance is often unnecessary. Necessity of their storage is connected with huge losses, which company can suffer due to lack of particular part. An additional problem of maintaining such items is their cost. Besides, parts must be available at short notice, so their value is usually quite high. In this way, a significant part of capital invested in inventory maintenance is frozen. Their high price is dictated by the passage of time, after which they are used from the beginning of machine use (average about 15 years). After several years it is usually hard to obtain the same part from any supplier. This is the reason of frequent decisions to purchase these items at the time of acquisition of equipment. Generally, company has a choice to purchase part much earlier than it is needed and store it at least a few

years. Is can also try to buy it just before the moment of preventive replacement or at the time of a failure.

3. Capital spare parts. These are parts of a medium level of reliability, located between the high reliability of buffer stock and low reliability of inventory maintenance. These parts generate higher purchase costs than parts of low reliability. Decisions relating to the storage of such items are usually taken at the stage of purchasing equipment and can be purchased in different amounts. Applied management strategy for capital parts differs from buffer stock strategy.
4. Reuse spare parts. These are reusable parts that can be repaired and re-installed on the machine or device after being damaged. Planning policy for the management of these elements should consider more than one of their lifecycle.

Another classification of spare parts inventories divides them according to their availability in the market and the volume of purchase, on [8]:

- key parts, which are delivered by few suppliers and made against order, what causes long lead time of order. Therefore production and repairs should be planned in advance, because there is a high probability of lack of parts in required time;
- industrial parts, which have similar features as key parts, differ in production process, which greatly simplifies causes of lower risk of lack of parts and larger number of suppliers of these items. They are made in accordance with customers technical drawings, but have more universal character and order lead time of industrial parts is considerably shorter than for key parts;
- commercial parts have universal character because of their application in all industries. These include small items such as: light bulbs, screws, bolts, gaskets, etc., which are easily available, but their lead time of order is the shortest.

In turn, considering type of production, maintenance requirements can be divided into [15]:

1. individual parts such as gaskets, bolts, filters, etc.
2. components ready to be installed, compound by supplier from different parts, mainly systems feeding a machine operations (complementation of product). This is a special type of component, because as contrasted with other means of production, is not converted but only included to a technical object [12].

Considering criterion of spare parts specification, they can have standard (widely available) or specific (adjusted to the need of final customer) character. Parts with high level of specifications usually are made to order (MTO), so lead time of their delivery is quite long, prices relatively high and demand is sporadic. These parts can be obtained from different suppliers or only from a manufacturer of a machine. Their order is always associated with a longer waiting period than in case of other parts. Taking into account reasons of spare parts demand and analysing types of elements, it is possible to formulate an inventory management strategy. A problem connected with specification of parts, mainly affects individual production or short run production of untypical machines and devices.

3. Differences in management

Management of spare parts storage, due to specific features of this stock, requires taking into account many additional factors of demand, which in case of regular stock are not. Differences can be observed during the procurement process, while buying a much smaller number of highly differentiated products, due to current needs of maintenance schedule.

In a sphere of production, stocks of maintenance parts significantly differ from inventory of production in progress and finished products. Firstly, these stocks differ in role in production process. Inventories of production in progress are maintained in order to reduce irregularities that may occur during production. These variations may result from changes that have occurred in the structure of the product, equipment failures or price differences for transport services, energy supply, etc. Secondly, inventory of finished product are a direct source of supply to final customers, and they are storage in order to protect from anomalies occurring on market. The role of spare parts inventories in manufacturing process is to ensure assistance and maintain full readiness of equipment to work. Spare parts inventories are not intermediates and final products sold to the customer on the final market [10].

In addition, planning the level of parts stock differ from planning a regular material stocks, in requirements of service level (that are higher because of potential financial costs resulting from problems with machines), demand for spare parts (because it has a heterogeneous and stochastic nature) and value of parts purchase (because prices of their parts can be very high) [7].

Current activities of supply chain are focused on minimizing a material stock and time of manufacturing, which results in a greater emphasis on improvement of the system of spare parts flow. A different nature of these inventories requires use of management strategy, other than in case of regular materials [5], which also requires to take into account following, special conditions of a storage operation [10]:

- Lead time of requirement is associated with planned maintenance and failure. In the second case the event is difficult to predict, especially when there is no information about previous failures, for example due to the absence of regular inspection or in case of acceleration of new devices. The only way to avoid unexpected downtime is a continuously monitoring status of devices and planning of repairs and replacements, before there is a dysfunction of the system.
- Maintenance strategy determines demand for spare parts inventories. One of methods to restore standby equipment is to repair or exchange of a faulty item. Decision, which method is to be chosen significantly influences on a level of maintenance inventories. Selection an available amount of parts of the same type „at short notice" is also very important. A larger number of SKU (Stock Keeping Unit) allows to use them at any time, when there is a sudden demand. In turn lower number of SKU influences on greater likelihood of sudden supply.
- Costs of parts deficit are costs of downtime and production losses, which are difficult to estimate.
- Acquisition of individual part is more probable than finished components. It is connected with the fact that purchase and repair costs of components are typically higher than costs of parts exchange.

- Faults of parts are usually dependent on each other, what means that failure of one element may be the result of dysfunction of the second one. This is a serious problem, especially when relation of particular components is unidentified.
- Often, demand for particular parts is satisfied by cannibalism of other parts of components.
- In case of outdated machines, for which parts are designed and occurred their expiration, the problem is to find spare parts for them. First, it is difficult to identify the necessary number of specialized parts, which is sufficient for the whole machine lifecycle and it also is the source of excessive freezing of capital. Secondly, it is difficult to replace item that is no longer manufactured.

These restrictions refer mainly to maintenance managers, who have to take into account these events when planning supply of spare parts.

In addition, a significant problem in spare parts inventory management which usually does not affect other material stocks, is associated with the appropriate selection of management strategies for slow-moving parts, which demand is irregular and random. Statements of historical data about demand for parts, it is possible to find those with zero demand as well as these with frequent use of a particular part. It caused that estimation of lead time of delivery, which is necessary to determine parameters of control system is very limited.

4. Conclusion

According to definition spare parts belong to material stocks, but management of them differs from management of regular stock. In order to effective control of parts flow a technical documentation of machines and devices is required, which indicates the type of parts and depending on it way of their ordering and storage in a warehouse. Regular following of changes in production area and knowledge of life cycle of individual components ensure an availability of necessary parts, which minimizes the risk of losses resulting from downtime and costs of maintenance unnecessary inventory in the storage.

Establishing the level of inventories which fulfils needs of maintenance by balancing costs of parts storage, becomes very important. In case of spare parts inventory management and any other activities main objective is to minimize the total of direct and indirect costs.

Effective spare parts inventory management is a challenge for many industrial companies aspiring to high efficiency of machines and devices pay a special attention to availability of parts.

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