

Sheet metal material resources management in lean production

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Abstract. Industrial enterprises are responsible for increasing production waste. The purpose of the research is to develop tools of material resources management in lean production for sheet metal cutting at engineering enterprises with single or serial types of production. At the previous stages of the research, a situational analysis of the cutting process was conducted, a literature review was carried out, and the main provisions of the sorting method of sheet metal material resources after cutting were defined for dividing them into groups of business or non-business material resources. The main provisions of the proposed method are specified in this article. Further research tasks are also identified.

1 Introduction

The relevance of the research is determined by the fact that in an innovative market economy production efficiency is one of the main factors of competitiveness for industrial enterprises. The using of resource-saving technologies in production and the development of an accounting system for material resources allow to increase the economic efficiency of the current enterprise activity and ensure sustainable future development. In order to make strategic and operational management decisions, the enterprise management requires timely information: about operating cycle parameters of the manufacturing and technological system [1], about locations and causes of changes in planned enterprise indicators and about an external environment. These decisions affect optimization of cost structure, simple and expanded reproduction of fixed assets, making necessary consumer properties of products and competitive advantages in the market, obtaining net income and increasing business value [1-4].

In industrial enterprises, the management of material resources in the sheet metal rational cutting includes a lot of processes associated with lean production, which is aimed at eliminating losses in the value streams of products. Particularly, in organizing sheet metal cutting at an engineering enterprise, technologists, designers and managers have the task of increasing the sheet metal utilization rate in order to reduce technological costs, optimize the cost structure, and increase net income, which is part of the organization of lean production. Modern tools of managing material resources at an engineering enterprise are required in order to effectively solve such problems.

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In this study it was detected, that in scientific and practical literature about the organization of cutting sheet metal the issue of justified sorting of sheet metal material resources (MR) after cutting into business and non-business ones at engineering enterprises was not fully detailed. Prompt and reasonable sorting of sheet metal after cutting will reduce the costs of storing and transporting non-business MR from which products will not be produced, increase the sheet metal utilization rate, reduce unit sheet metal costs, optimize the structure of technological costs in manufacturing products from business MR. The solution of this problem differs at engineering enterprises with a single or serial production type, because the nomenclature and completeness of blanks and sheet metal MR after cutting are changed more often than in mass production.

Also, the relevance of the using sheet metal residues after cutting from the point of environmental ecology problems view and increasing the economic efficiency of an enterprise activity is confirmed by the studies that are given in the works [5, 6]. When using the rational cutting methods of sheet metal and using business MR in following technological processes, the sheet metal utilization rate is increased, and the load on the processing of industrial sheet metal waste is reduced. Thus, the enterprise takes into account the need for the rational use of nature resources, that is, it strives to be environmentally friendly, takes care of nature and ecology when organizing its activity, and seeks to reduce the environmental impact.

The object of the research is engineering enterprises with single and serial types of production. The subject of the research is the managerial relations arising in the material resources management in the process of functioning and developing lean production at engineering enterprises.

The purpose of the research is to develop tools of material resources management in lean production for sheet metal cutting at engineering enterprises with single or serial types of production.

In [7], the main provisions of the method for sorting sheet metal after cutting were determined. Also, approbation of certain aspects of the method was carried out using the example of sheet metal cutting cards. In this article the proposed method is specified taking into account the identified adjustments.

2 Materials and Methods

The theoretical basis of the study are the works of domestic and foreign researchers on the issues of lean production, material resources management and rational cutting of sheet metal. At this stage of the research, it has been revealed that rational cutting of sheet metal is carried out using rational cutting methods, which have been widely studied by researchers: L. V. Kantorovich, V. A. Zalgaller, E. A. Mukhacheva, I. V. Romanovsky, V. M. Kartak, Yu. G. Stoyan and others. The special group ESICUP (Euro Special Interest Group on Cutting and Packing) and a scientific school in Ufa work on the questions of rational cutting. It should also be noted that in 1990 H. Dyckhoff proposed a classification of cutting and packaging tasks, which was developed by G. Wascher, H. Haubner, H. Schumann. Thus, domestic and foreign researchers developed mathematical methods and approaches to organizing the rational cutting of industrial materials from the point of view of optimal location of blanks on a given material resource and optimal choice of a material resource for producing blanks from it. [8-14]

The empirical base of the work consists of production processes at engineering enterprises, analytical materials presented in the studied literature. A situational analysis of the sheet metal cutting process and sheet metal material resources management at the Vologda engineering enterprises made it possible to identify the bottlenecks of this process: the sheet metal utilization rate is about 0,8; there is scattered design of sheet metal cutting

maps; sheet metal cutting is based on the technologist's empirical perception; there is a lack of set of reasonable actions to sort sheet metal after cutting into business and non-business groups; there is a lack of marking of the business sheet metal material resources after cutting, which complicates their accounting and classification. As a result of the research, the main practical recommendations for the organization of sheet metal cutting were formulated.

As methodological basis of the research was selected the concept of lean production, which is focused on a continuous stream of value creation for the consumer, the continuous improvement of the organization's processes through the involvement of staff and elimination of all losses types. As part of the work, the issues of lean production are considered, associated with decreasing unit sheet metal costs due to using business MR, optimization of costs for storage and transportation of business or non-business MR, reduction of time costs for search and transportation of business sheet metal MR in production process.

General scientific research methods were used: analysis; synthesis; formalization.

3 Results

During the research, a sorting method of sheet metal MR into business or non-business material resources groups is developed under single or series production conditions. Prompt and reasonable sorting of sheet metal after cutting will reduce the cost of storing and transporting non-business MR which are not used in production process, increase the sheet metal utilization rate, reduce unit sheet metal costs, optimize the structure of technological costs in manufacturing products from business MR.

It should be noted that enterprise specifics of the production activity have a significantly influence on development of this method. The nomenclature of produced blanks and their completeness at mass production are not changed for a long time (operating cycle), so it is possible to definitely identify business and non-business sheet metal.

The nomenclature of produced blanks and their completeness at single and serial production are often changed, so the geometrical indicators of the sheet metal MR after cutting are also changed. Consequently, it is necessary to overestimate the material resources that were recognized as business resources, when production program is changed.

The main provisions of the sorting method are developed in the research.

1. Cutting Cards.

Since there are a lot of options for the location of blanks when designing a cutting card, so it is advisable to use software in order to reasonably and quickly select the optimal cutting card. The software market offers software for rational cutting of materials whose work is based on rational cutting methods proposed in the theory. These methods allow maximizing the packing density of blanks on a material resource (increase the material utilization rate). Modern developing enterprises use appropriate software package. That is, precisely the software used at the enterprise is responsible for the choice of a material resource, from which it is more expedient to make a products.

Since the analysis of the software market did not reveal those in which reasonable sorting is carried out into groups of business or non-business MR, so the further provisions of the method define aspects of making management decisions for dividing the MR in the appropriate groups.

2. Classes of MR. Evaluation of indicators, which characterize the MR after cutting, and identification of the MR with the appropriate class.

Since the MR after cutting can be interchangeable, it is advisable to determine the classes of MR that are proposed to be determined on the basis of the similarity of material resources according to the evaluated indicators in a certain range of values.

Interchangeability is related to the fact that, in terms of geometry, material resources may differ slightly, and the packing density may be the same in the production of certain blanks from them.

If there are classes in the process of designing cutting cards, taking into account the business MR, it will be sufficient to analyze the templates of the MR classes by software. Otherwise, it will be need to analyze all units of business sheet metal MR by the software, which will affect the greater volume of calculations, increasing the time of designing cutting card.

As indicators characterizing the sheet metal MR and the class of MR are proposed: steel grade, sheet metal thickness, area, length and width of a rectangle formed by the minimum addition of MR, the ratio of the MR area to the area of the rectangle formed by the minimum addition of MR. It should be noted that for many enterprises, the steel grade and the sheet metal thickness already uniquely determine the corresponding classes. Also, additional indicators can be used depending on the specifics of production, for example: MR coating, diameter of inscribed circle, diameter of described circle.

It is necessary to keep a quantitative account of sheet metal MR after cutting (in pieces) in the selected classes so that the cutting design program can determine the choice of MR taking into account its stock availability.

Thus, when the sheet metal MR is produced after cutting the indicator values characterizing it are evaluated. In the further, the MR is identified, that is, the MR is assigned to the appropriate class based on a comparison of the values of the MR indicators with the values of the class indicators. After that, sorting and quantitative accounting of MR is carried out.

It should be noted that minimum values of MR indicators should be expertly determined by managers of the enterprise from a technological point of view, in order not to carry out the evaluation and identification of MR, from which it is technologically impossible and inadvisable to produce blanks.

3. Evaluation of the potential demand volume for MR class.

It is proposed to evaluate the potential demand (Q_{sm} , piece / month) for MR classes, since it is not advisable to store material resources from which it is possible to produce blanks, but there is not a need for that. Therefore, after receiving the MR and defining it to the appropriate class, then it is necessary to sort it into the group of business or non-business MR based on a comparison of the potential demand with the amount of MR in the class (N_{sm} , pcs.) at the sorting time.

If $Q_{sm} > N_{sm}$, then sheet metal MR after cutting should be considered business, otherwise - non-business. In defining the material resources to the same class at identifying time, when $Q_{sm} = N_{sm} + 1$, priority should be given to MR with a larger area. It is also reasonable to recognize the MR as non-business if $Q_{sm} = 0$.

The key issue at the stage is correct evaluation of potential demand for MR classes (Q_{sm}). The relevance of the quantitative accounting of MR in classes is confirmed in order to evaluate the selected indicator, on the basis of which the actual average demand for class is determined.

4. Sorting MR into groups of business or non-business MR based on economic aspects.

It is necessary to make a sorting decision based on evaluation of the change in storage and transportation costs, when MR is defined to the group of business MR, in comparison with uncovered costs of sheet metal purchasing when non-business MR is sold at a reduced price.

5. Re-evaluation of business MR.

It is necessary to re-evaluate the stored business assets with a certain frequency, since the nomenclature of the produced blanks and the values of the indicators characterizing the sheet metal MR after cutting may be changed.

4 Discussion

The developed method of sheet metal MR sorting after cutting is one of the tools for managing material resources in lean production when cutting sheet metal at engineering enterprises with single or serial production types. The main provisions of the proposed method and the issues of material resources management arising from it require improving.

It is necessary to determine the method for evaluation the potential demand for classes of sheet metal MR. On the one hand, it is possible to consider the option of determining Qsm through the actual demand volume for corresponding class of MR. But then the distribution of the demand will not take into account lost demand. That is, it will not take into account the fact that at one of stages of designing cutting card the program of rational cutting proposes to use MR from a class that does not have the required number of MR, and in future the program is looking for a replacement class. Therefore, on the other hand, it may be more correct to evaluate the potential demand based on priority choices of appropriate classes by the cutting program. However, in this option, it is advisable to take into account the comparison of potential supply of MR class with potential demand. For example, if the second indicator is more than the first, then it is necessary to distribute the uncovered potential demand into other classes according to certain logic.

In further work, it is important to formulate proposals on organization of the storage and marking sheet metal MR after cutting in order to account and prompt search it in production process and to determine the method for evaluating storage and transportation costs of the MR. Therefore, it is relevant to study micro logistical processes associated with sheet metal after cutting. Also, when the production volume of potential business MR of certain class is more than the volume of potential demand on the class, then from the point of view of storage optimization it is necessary to decide at what production stage, in what quantity, with what frequency it is economically advisable to sort the sheet metal MR into the group of business MR. The relevance of these questions is confirmed by many studies, for example [15].

At part of the related issues of management accounting it is necessary to consider a system of quantitative and cost accounting of business and non-business sheet metal MR after cutting. At this stage of the study, it can be concluded that for cost evaluation purposes it is necessary to take into account the MR not only in pieces, as it was highlighted earlier, but also in kilograms, since this unit of measurement is reflected in documents of supplier, the price of sheet metal is also determined per kilogram or ton, movement of the material is accounted in kilograms at the researched enterprises. Since in proposed method it is important to take into account business MR, it is advisable to consider the MR after cutting as technological semi-finished products and the nomenclature of which will correspond to the MR classes. It will also ensure transparency of accounting at storage and in production process.

In the modern development of information technologies and the need for prompt and reasonable management decision making, it is advisable to develop a software package for sheet metal MR management. Previously, it was emphasized that the corresponding program belonged to CAD/CAM systems is responsible for rational cutting of sheet metal. Also, material resources accounting is organized in a certain ERP system. On the basis of the developed theoretical and practical proposals it is necessary to use ERP system with elements of a decision support system (DSS), which will sort the produced sheet metal MR after cutting into groups of business and non-business MR according to the proposed sorting method. The relevance of the DSS development, for example, is confirmed in [16, 17].

Since certain information about sheet metal material resources will be transferred from the CAD/CAM system to the ERP system (for example, nomenclature of sheet metal MR

after cutting, values of indicators characterizing the sheet metal material resources after cutting), and from the ERP system to the CAD/CAM system (for example, nomenclature of source sheet metal, which is bought from a supplier, results of sorting), it is necessary to ensure data synchronization between the systems. It should also be noted that in the ERP-system information about non-business sheet metal material resources after cutting should be stored on certain classes. The selling price of non-business sheet metal MR for organizations that buy it for further industrial processing depends on the steel grade. So, for example, it is advisable to classify the MR at least depending on the steel grade. As a unit of measurement for non-business MR, it is supposed that one will be sufficiently - kilogram.

A graphical representation of the interaction of software systems and users in the sorting of sheet metal MR after cutting is presented using the UML Activity diagram in Figure 1.

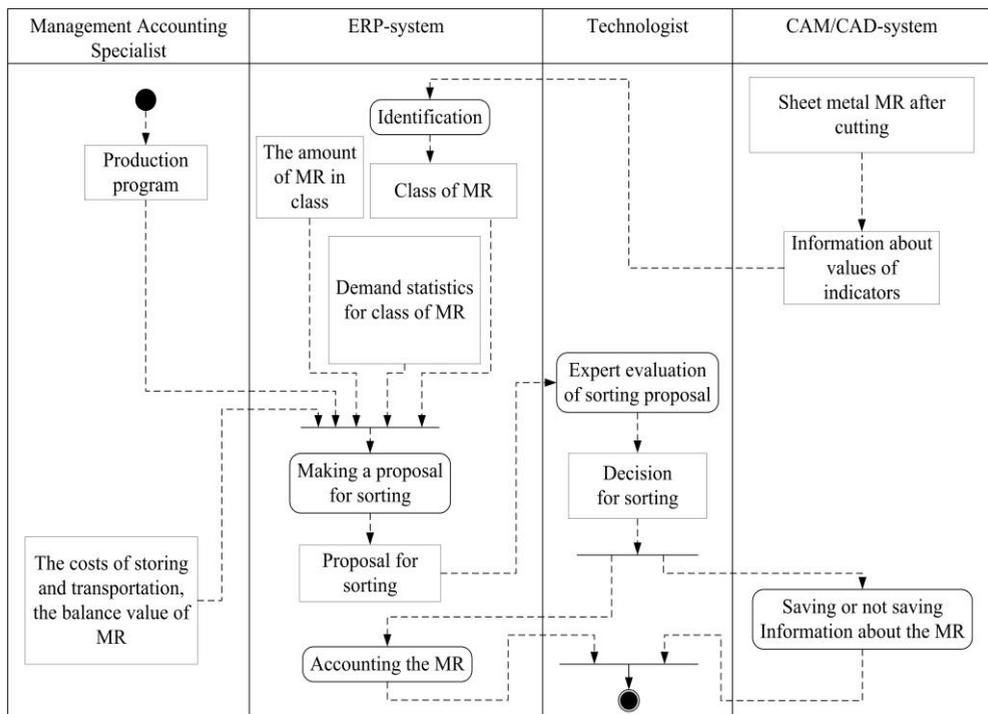


Fig. 1. Sorting of sheet metal MR after cutting.

The questions of developing a software package for sheet metal MR management are proposed to research together with colleagues from The Vologda State University.

5 Conclusions

Thus, the following research results obtained in this article:

1. The main provisions of the sorting method of sheet metal material resources after cutting in dividing into business or non-business MR groups have been detailed: the designing of cutting cards tacking in account of business material resources is carried out by software of rational cutting; for the purpose of evaluation and identification of sheet metal MR after cutting, it is necessary to determine classes of MR; quantitative account of MR should be kept in the classes; the decision of dividing the MR to business or non-business groups is made on the basis of evaluation of potential demand for the class of MR

and comparing it with the amount of MR in the class at the identification time; the final decision is made taking into account technological costs changes at the enterprise.

2. Research directions of developing tools for material resources management in lean production when sheet metal cutting at engineering enterprises are determined: it is necessary to determine the method for evaluation the potential demand for classes of sheet metal MR; it is important to formulate proposals on organization of the storage and marking sheet metal MR and to determine the method for evaluating storage and transportation costs of MR; it is advisable to develop provisions of management accounting for business and non-business MR in the ERP system.

The developed proposals for engineering enterprises will increase the sheet metal utilization rate, reduce unit technological costs and increase the net income of the enterprise. At the same time, increasing the sheet metal utilization rate reduces the load on the processing of industrial sheet metal waste, which brings the enterprise closer to the status of a green enterprise, which strives to be environmentally friendly, that is, to take care not only of economic efficiency but also of ecology and rational using of natural resources in organizing its activity.

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