System analysis of the procurement warehouse for the achievement of its effectiveness

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Abstract. The work shows the features of applying system analysis to the problems of increasing the efficiency of the procurement section of a large machine-building work. The purpose of the work is to eliminate obstacles to achieving the efficiency of the work of the procurement site with the help of system analysis. Specific solutions are presented for a comprehensive increase in the interaction of subsystems of the procurement site, redevelopment, and the use of more advanced devices to increase efficiency. To solve the problems, the main tools of system analysis are applied - suprasystem-system-subsystem analysis, structural analysis, functional analysis, and site-specific calculations - such as analysis of norms and time of operations, analysis of layouts and compliance with the organizational structure, as well as analysis of equipment operation and finding optimal solutions for its equipment. Discussed the results of the system analyses and limitation of it's implementation in real workshop.

1 Introduction

The tasks of improving labor organization and increasing the efficiency of certain production facilities often fall to middle managers, who, as a rule, do not have experience in conducting extensive analytical work and developing system solutions in the field of production management. In addition to the turnover that prevents you from simply starting to solve the problem, it is often not possible to identify all the key problem areas and put them into a holistic picture to improve production.

The problem can be solved using methods of system analysis of management problems. It is known that the founder of applied systems analysis, I. Ackoff, managed to help over 400 companies find the best organizational and management solutions and take their companies to a new level [1]. The approach was implemented to solve the problem of improving the production of the procurement section, which is present in almost all significant reinforcing enterprises, which will be discussed in this article. To solve the problem, materials were used [2-13].

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2 Initial data

A large machine-building enterprise was experiencing significant problems with the operation of the procurement site. It was considered the weakest point among other workshops and was not able to fulfill the plan in a timely manner. The situation worsened significantly after the decision was made to unite all the procurement sites of the enterprise, transferring the existing procurement site from another site. As a result, the situation began to deteriorate further, despite the efforts of staff and the provision of additional transporter staff. The initial layout of the enterprise site with the locations of the procurement workshop sections is shown in Figure 1.

Fig. 1. Layout of the enterprise site with the location of sections of the procurement workshop.

The main location of the main equipment is the procurement area of cutting machines and guillotines. The layout of the main equipment is shown in Figure 2.
Fig. 2. Scheme of the procurement area with main transport flows. 1 - grinding machine; 2 - cutting machine; 3 - abrasive cutting machine; 4 - guillotine; 5 - press scissors; 6 - cornice section.

The structure of the workshop is shown in Figure 3.

Fig. 3. Structure of the procurement workshop.

The general process of obtaining blanks is shown in Figure 4.

Fig. 4. Scheme of connection of the procurement shop and its main elements with the process of obtaining blanks.
It was necessary to understand and offer possible solutions and recommendations to correct the situation.

3 Preparation shop as a system

The system adopted the procurement shop. At the first stage, it was checked for "systematicity". To do this, it was necessary to understand whether it meets the requirements for systems. These, as a rule, include integrity, complexity of behavior, size, regularity/irregularity of disturbances, the presence of competing parties. By many of these criteria, the site did not represent a coherent system, combining chaos, geographic separation, disproportionality in size and many intersections of interests of competing parties.

The procurement shop as a system object can be represented by a diagram, Figure 5.

Fig. 5. Procurement area as a system object.

According to the results of the initial analysis, the inputs and outputs had significant "noise" in the procurement area. It was necessary to clarify the features of noise formation and improve the internal and external system connections of the procurement area. For this purpose, the main process of the procurement site was divided into components during monthly planning:

- receiving a plan - issuing labels - dispatching - ordering metal from the warehouse - receiving metal from the warehouse - delivering metal to the site - distribution to machines - cutting operations on machines - storing in containers - removal of containers with blanks to the center of the site - quality control inspection - preparation for removal - formation of a transport batch - removal to consumer workshops or transfer for delivery to other production facilities - removal using an invoice - transportation - acceptance at the consumer workshop - delivery of the invoice - drawing up a report.

The central place in all processes of the site is occupied by cutting of blanks in the broad sense, and the technological process from document verification to cutting and removal of blanks from the procurement site.

The next stage was the formation of a map of processes by their type, grouping them by their main nature. These included management, transport, shop autonomous subsystems, for example, gas cutting, guillotines, etc., quality control department, and documentary support of processes. The key connection between them was the following process: "planning - supply - transportation - production of blanks - paperwork - transportation", as well as feedback (managerial), in particular, coordination of process connections and prompt elimination of production delays.
For a better understanding of the movement of material and technical resources and management, operations were broken down by type of main flow:

- material - transformation of materials into workpieces;
- informational - support of the movement of materials and control functions;
- functional - function-oriented description of operations.

Comparing the main flows (material and information) and placing them within the framework of the functional description, it became clear that they are distributed unevenly according to the performance of functions. Thus, most of the functions of information and documentary support fall mainly on the operations of material preparation, removal and delivery of workpieces, while the “functional heart” of operations lies only in cutting operations. Since transport and information accompanying operations are only supporting and auxiliary to the main process, then, first of all, they will have to be curtailed. In addition, the restriction functions in the form of a target function for the timely issuance (registration) of workpieces and coercive connections (determined by the sequence of operations in the main process) significantly influenced the level of the height of internal barriers in the system and the intensity of plan implementation.

Next, the key problematic aspects of the procurement site as a system were identified, namely the shortcomings of the output, the shortcomings of the existing management methods, shortcomings in the organizational substructures and resources of the system and the features of the negative influence of the environment. The existing system did not provide the desired performance characteristics over a long period of time. It was necessary to design a system that would provide the desired characteristics. The level of need to solve this problem was determined by the importance of the site’s operation for the entire plant as a whole.

To calculate the ability of the system to meet its purpose and taking into account the fulfillment of the main target function (the main criterion for assessing the efficiency of the procurement site) - “fulfilling the plan just on time” - time intervals for operations were taken as the main characteristic. They were indicated as a percentage of the time spent on the game. The properties of the system were determined in accordance with the tasks of maximum structuring in time. For this purpose, the decomposition of the process into smaller subprocesses was continued and an average time recording was carried out. The results were as follows:

- Issue of task, 0.5-1%;
- Issuing labels and preparing them for work, 0.5%;
- Import of metal, 20-40%;
- Transportation of metal to the workshop, 10%;
- Metal cutting, 20-30%;
- Writing out outfit labels, 1%;
- Packing in containers, 3%.

As you can see, according to the main criterion - order fulfillment time - irrational time losses occur mainly in the delivery of metal and transportation.

In order to determine the limitations in the operation of the procurement site as a system, the issue of connections between the site and other departments was worked out according to the type of connections: immediate (1st order) and more distant (2nd, 3rd order). This made it possible to determine the connections between the most important properties and break them down into basic and supporting ones, form a logical structure of the problem and clearly define the supra-system, system and subsystem levels in the problem.

Since the main elements were established, it was possible to carry out their further ranking, highlighting the supporting parameters (creating conditions for the system to perform its functions), and the main parameters of the system that ensure its performance, Figure 6.
The specific environmental impacts were also taken into account. In particular, the strong influence of the administrative factor (management pressure), the low level of the social factor (poor demographic composition - mainly pre-retirement and retirement age workers), problems with equipment (technological factor) and low wages (economic factor) were noted. The work was also significantly influenced by the natural factor, since most of the work was carried out outdoors in winter.

By highlighting the environment and defining the internal elements and subsystems of the procurement shop as a system, all connections of the system were divided into external and internal. Taking into account the previously carried out timing, the biggest problem of the procurement section turned out to be external relations, mainly in the supply of blanks for cutting.

The problem was tested for centralization and decentralization in order to establish the level of rigidity of connections. The problem was largely decentralized, the workshop was not separated administratively, which did not make it possible to correctly distribute bonuses between people, to have its own “personality” among other workshops, its own production connections and planning bodies. Functionally, the workshop had long been separated, since the head of the workshop did not actually manage the site. This was done by a higher level in the management hierarchy - the production manager.

The connections were quite tight, since the procurement shop is the beginning of the entire production chain. He was under close attention from management.

4 Main problem

When changing equipment and installing more powerful and productive equipment, ensuring more complete implementation of the plan when it was increased, the system of production relations remained the same. Namely: the structure of metal delivery, organization of supply and storage of metal in a warehouse, organization of its removal, communications with planning, dispatch and supply authorities.

The main problem was recognized as a “hole of problems” in the structure of relations with the transport section, most notably with the crane group. There was a restructuring of
relations not according to the plan, but according to the transport section. Something that was previously hidden has surfaced.

5 Solution

The solution to the problem had to be found in the restructuring of the connections of the subsystems that implement the process, as well as the properties of the subsystems and the subsystems themselves. To do this, an analysis of the manifestation of the main problem was carried out across the main subsystems (management, transport, shop subsystems). The essence of the problem was the discrepancy between the actual output and the desired one for each of the subsystems. Nevertheless, the problem could be considered solvable, since most of the activities could be carried out using organizational, technical or economic methods without involving significant forces and resources.

A decomposition of the goals and criteria of the subsystems was carried out according to the main positions, Figure 7.

Fig. 7. Process goals.

To identify the possibilities of solving individual decomposed goals according to the developed criteria, the following was carried out: resource assessment, forecast and analysis of future working conditions, some alternatives and best practices for setting up procurement shops were considered. As a result, a comprehensive program for solving problems and developing the procurement site was developed. It was presented to management in the form of a memorandum, with recommendations indicated in it for an operational and long-term plan for reorganizing the work of the procurement site (abbreviated).

6 Report

To eliminate the problems of insufficient production efficiency of the procurement site, a system analysis was carried out and the following results were identified.

In the current state of affairs, the procurement site does not have the ability to stably and sustainably carry out the plan. This situation began to develop in March 20, when the procurement operations of the second production were transferred to procurement workshop No. 21. As a result of the increase in the plan, which is not supported by organizational and technical measures, there are constant failures in providing the workshop with materials, there is constant processing of transport work, reconciliation of documents, constant work on Saturdays is in progress, and in general there has been a deterioration in working conditions. Thus, the workshop is much more loaded with metal than before, the conditions for accepting cut workpieces have deteriorated, the labor intensity of the work for the delivery of metal and the removal of cut workpieces has increased, the number of injuries in the area has increased, staff turnover has not decreased, and the necessary containers are missing.

However, thanks to the recently installed new productive equipment and two-shift operation, the necessary prerequisites are in place to fulfill the plan. These problems can be
solved by reorganizing the structure of the site with the prospect of creating a procurement and stamping shop, changing the organization of connections with other departments, primarily with the transport section.

To solve the accumulated problems, it is proposed:

1. Change the staffing structure of the workshop
   - allocate the position of senior foreman;
   - allocate the position of a dispatcher instead of the position of a work distributor;
   - reduce the position of work distributor by half time.

Such a change in the staffing structure will make it possible to better distribute work among site management employees and develop daily shift assignments.

Fig. 8. New proposed layout of the enterprise site with the locations of the procurement workshop sections. 1 - a section of guillotines (large and small); 2. - a section of plasma cutting and gas cutting; 3. - a section of cutting machines; 4. - a promising area for the placement of a stamping area. 1.1. - the storage area of sheet metal for guillotines, 2.1. - the storage area of sheet metal for gas cutting and plasma cutting; 3.1. - the storage area of rods and pipes for the section of cutting and abrasive cutting machines and press scissors. arrows - the main directions of material flows.

2. Change production connections with the transport site.
   - expand the capacity of the site by assigning a loader supervising the site;
   - to separate the sheet metal warehouse from the rental warehouse, creating it located along the 22nd workshop, thereby transferring the bulk of the transport work for the delivery of sheet metal from the crane to the loader;
   - increase the number of metal storage racks in order to then separate the stored metal by grade and type of rolled product.

To solve this problem, within a limited number of racks, it is proposed to store the most commonly used types of rolled products separately, laying rolled products of small cross...
sections separately from large rolled products so that they can be picked up manually without the use of forces from the transport section, or use vertical racks.

**Fig. 9.** New layout of the procurement site with main traffic flows. 1 - a grinding machine; 2 - a cutting machine; 3 - an abrasive cutting machine; 4 - a plasma cutter and a gas cutter; 5 - press scissors; 6 - the area of the warehouse and the work of the telfer.

1. Change the organization of work on the site
2. In the vacated areas of the welding section, create a single area for gas cutting and guillotines, as well as cutting machines with the prospect of supplying sheet metal through window openings from the sheet warehouse at the 22nd workshop.
3. To enable self-service, install an additional hoist capable of pulling sheets, rods and pipes directly into the workshop without involving the forces of the transport department. Install hoists both for section 1 (guillotine), and for gas-plasma cutters (2), and especially for the section of cutting machines (3).
4. Carry out redevelopment of the area with the location of machines along the main flow of materials for each group of machines.
5. Install cutting machines in a row to allow multi-machine service.
6. Install enlarged roller tables on all cutting machines with the ability to supply metal to it for daily work directly from the warehouse racks. For these purposes, OMA (department of mechanization and automation) will develop a stacker store similar to the 8G663 machine for a daily shift assignment.
7. To increase the productivity of automatic cutting machines and the ability to cut rods of small diameters on cutting machines, purchase a special installation kit from the manufacturer (Minsk Machine Tool Plant named after Kirov).
3.7. To increase productivity, develop a holder with up to 3-5 rods of medium diameter or up to 19 rods with a diameter of 20 mm.

3.8. Move the guillotine to the cornice warehouse area and create a separate guillotine-stamping area.

3.9. Move the cornice warehouse to the cornice area, ensuring the unity of the warehouse and the production of cornices, thereby further obtaining the synergy of changes in the system.

A new promising layout of the workshop on the areas of the welding shop and the main transport flows are shown in Figure 8.

The locations of the main equipment according to the new layout of the procurement shop are shown in Figure 9.

As a result of the system analysis and the presented development:
- the number of transport operations is sharply reduced;
- the transport section is not involved in most cases;
- workshop controllability increases sharply;
- transport flows throughout the workshop - the flow of rolled products and especially sheets and the flow of finished workpieces are separated and practically do not intersect;
- a large area previously occupied by separate sections of the procurement shop is vacated;
- when specialized, warehouse areas eliminate most transport links;
- the cornice area receives an additional warehouse and reduces its transportation costs, and opportunities for better management of the area arise;
- in the future, the guillotine section has the opportunity to bring the material flow closer to the stamping section and then to the machine shop;
- the rack of the procurement area enters the general warehouse rack warehouse and increases the storage volume in the warehouse if necessary.

7 Conclusion

The idea was accepted by management and implemented in a slightly different format, namely, while maintaining approximately the same spatial layout in another production facility, where there was also free space.

Thus, a lot of work on a systematic analysis of the work of the procurement workshop led to the discovery of such internal resources (due to internal redevelopment of the workshop, consolidation of most areas around the compulsory medical insurance distribution warehouse), which significantly freed up staff time for greater concentration on core operations. The result was the successful operation of the procurement shop and its ability to significantly outstrip consumer shops in the production cycle, to easily resolve issues of quickly producing replacement items, etc. The basis for the implemented solutions and the evidence base was the system analysis carried out.

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