



Algorithm for Building Optimal Technological Routes in The Machining Industry

Kalandarov Ilyos Ibodullayevich

Navoi State University of Mining and Technologies, Navoi, 210100, Uzbekistan

Ravshanov Husen Rustamovich

Navoi mining and Metallurgical Combine JSC, Navoi, 210100, Uzbekistan,
hr.ravshanov@ngmk.uz

Gaffurov Tulkin Xolmurodovich

Navoi mining and Metallurgical Combine JSC, Navoi, 210100, Uzbekistan

Abstract

The article presents a human-machine management system for a motor industry tool shop, designed based on developed models and algorithms addressing production division management tasks. The economic efficiency of the proposed system has been analyzed, demonstrating its potential to enhance the operational effectiveness of modern vehicle production units. The system supports management decision-making by leveraging the operational staff's ability to adapt to informal situations, utilizing their experience, intuition, and predictive capabilities to address evolving production conditions. This management approach enables the activation of hidden reserves and additional resources within the production environment by fostering the creative initiative of unit leaders and site managers. Furthermore, the system's capacity for rapid adaptation to changes in the production environment allows it to stabilize production processes more effectively than traditional batch information processing systems, even under the influence of random factors.

Keywords: Workstations; human-machine interaction; tool shop management; automotive industry; production departments; non-standard scenarios; manufacturing environment; production workflow.



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1. Introduction

The ability to synchronize in real time the interaction of all workplaces (WP) of production sites is implemented, thereby significantly reducing the duration of production cycles for manufacturing products, work in progress, improving the rhythm of production, increasing labor productivity. The developed production division management system is an instrumental multi-user real-time system for the shop management level. The system is designed to manage the organization of production, control, accounting and operational management of manufacturing processes of technological equipment in the tool shop.

Hardware and software management system present the users the opportunity to obtain real-time information about the status and progress of production processes thereby increase efficiency of decision-making, providing performance targets for the volume and range of manufactured product.

The control system consists of two subsystems:

- Operational management;
- Management of production organization.

The software of the subsystem of operational management solves questions of operational architecture, operational accounting and control of the production process, operational control of the production process in the tool shop and consists of the following tasks:

- Formation and maintenance of an information base;
- Operational planning;
- Accounting and control of the production process;
- Regulation of the production process;
- Reporting.

The main function performed by the production management subsystem is to prepare the organizational structure of the production areas of the shop for the successful solution of the task of calendar planning and balancing the monthly production program with the production capacity available for this planned period of time. The subsystem includes one set of tasks: operational management of production organization.

A block diagram of the automated tool shop management system is shown in Fig.1.

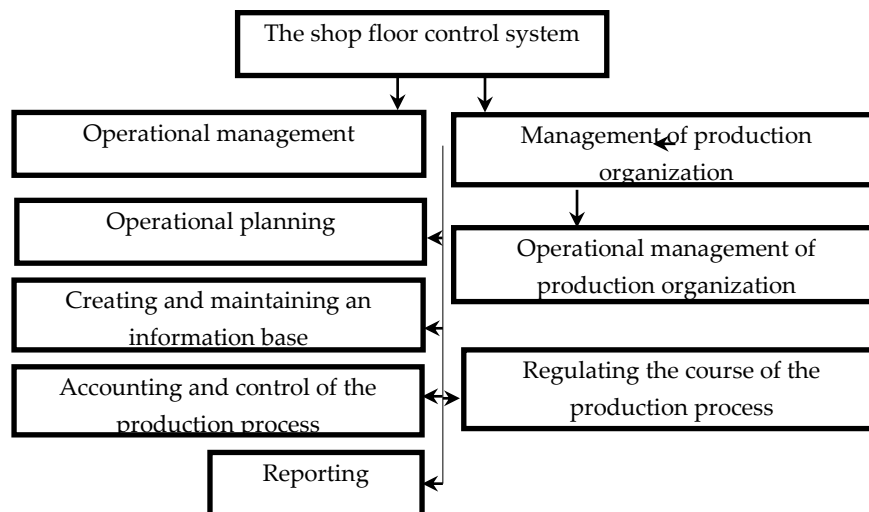


Fig. 1. Block diagram of tool shop management systems.

To analyze equipment utilization, you need information about operation and downtime for each WP. This information is normalized by the task “Forming a tape proofreading of equipment loading”.

Task “Order regulation” allows you to influence the progress of the production process by changing the order priority. At the same time, changing the order priority means changing the production process of all parts of the order (i.e., speeding up its completion or vice versa).

The solution of the problem “post-operative regulation” allows you to influence the progress of the production process by changing the priority of operations. In this case, changing the priority of operations means changing the production process of a particular order part.

2. Materials and Methods

Description of the dialog in the management system. A distinctive feature of the process of solving problems of a human-machine nature is the dialog mode (online mode, online mode), in which the machine reacts to individual events of the real environment so quickly that it allows you to influence their course. In this case, events are registered using data entered from terminals; data related to a single event is processed until operations on them are fully or partially completed, regardless of other input messages.

The interaction of a human with a computer will be considered as a process of exchanging messages between a human and a computer, due to the need for sequential and (or) parallel execution of operations by a human and a machine to solve any task.

When interacting with the user, dialog systems usually provide:

- Direct contact between users and the system, i.e. receiving and issuing various messages via a local or remote terminal;
- Immediate processing of received messages by the system, even if this processing is not fully performed, this function usually includes checking the syntactic correctness of the message, executing commands contained in the message, and displaying the results;
- Search for user-required data (and/or programs), i.e., manage the library of programs and data);
- The ability to serve multiple users almost simultaneously in an environment where the need for service is unpredictable.

3. Results

To ensure the work of operational shop staff in real time, the shop has organized automated workplaces (AWP) of shop staff (AWP - shop Manager, AWP - dispatcher, AWP - technologist, AWP - master, AWP - operator) on the basis of remote terminals (see Fig.2).

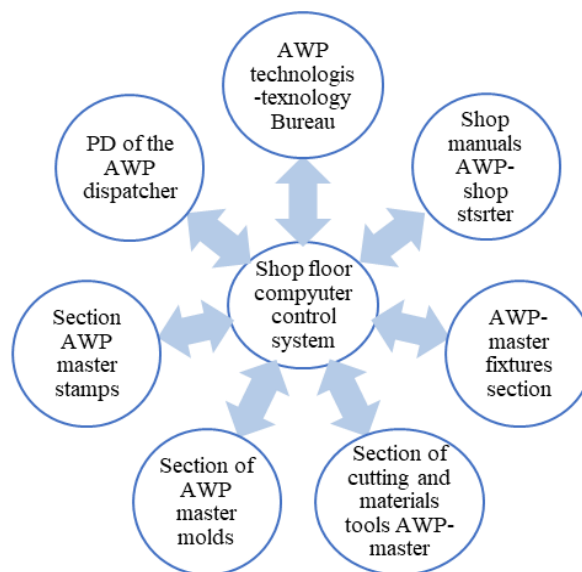


Fig. 1. Organizational chart of the tool shop structure.

For prompt input, processing of information and receipt of output documents, an information preparation group is organized in the shop.

Group training information (consisting of planning and control Bureau) shall collect baseline information (monthly plans, route-routing orders, exhaust replacement jobs at WP, the adjustment of the Fund's available time on the equipment), control over correctness of filling, entering information into electronic computer, receiving the output documents and their issuance to users. The organization of this group allows you to centralize the process of processing large amounts of information, which makes it easier to control the information and increases the reliability of the entered information. The information preparation group consists of an engineer and two operators who have completed a computer training course before starting the pilot operation of the system.

Let's consider the work of subsystems and task complexes of the control system, taking into account the AWP-users on which they are solved.

AWP Manager.

After calculating the priorities of orders and forming the basic information on machine carriers by the information preparation group (monthly site plan, route and process maps for orders), the dispatcher works with a set of programs that implement the tasks of managing the organization of production.

Having received reference information on the volume of work of various complexity (the task of forming aggregates) and the reserve (or shortage) of workers with specific qualifications, the dispatcher solves the issue of placing workers at the expense of other sites (if there is a shortage) or transfers to other sites (if there is a reserve). The result of solving the problem is an organizational arrangement of workers behind the equipment of the sites, taking into account the complexity of the work. This concludes the first stage of balancing the production program and production capacity.

AWP masters.

The main purpose of this automated place is to enable the operational shop staff working on production sites to quickly regulate the course of the production process and receive all the initial information about the passage of orders in production in an online mode for making management decisions. Having complete information about the conclusion of work on orders and a schedule of work on the details of orders for each day, built by the task "Simulation model of the site operation for a week" the wizard has the ability to quickly adjust the duration of product manufacturing cycles by changing the priorities of orders and operations. Increasing the order priority (operation priority) reduces the total production time of the product (part), while reducing it suspends or slows down its execution.

Operation status codes play an important role in planning hardware loading. The operation status code means that when calculating the priority of operations, this operation will be assigned the highest priority for the purpose of mandatory priority loading of its equipment, and its labor intensity will be recalculated based on the number of processed parts. If the operation status code is H, the process operation will not be scheduled for loading until it changes. Operation status codes allow the wizard to adjust the order in which parts are scheduled for processing, and not to start production of parts that cannot be processed for some reason.

Video grams "Information about the route details for working places on the site" and "Tape schedule of loading jobs on the site per shift" provide information about when and at which WP the order detail should be located, as well as how many equipment downtimes and at what time, which allows the master to efficiently and quickly organize work on the WP and effectively solve the issue of reloading production capacity or redistributing work in case of equipment failure.

4. Discussion

Input documents generated at production sites are:

- Completed shift assignments by work stations;

- Directory of the Fund of available time and skills of workers by jobs;
- Adjustment of the Fund of available time and qualification of workers by jobs;
- List of changes in the priorities of orders;
- List of changes to the operation priorities;
- A list of changes to the operation status codes.

A set of tasks is used for the operation of the AWP wizard “Regulating the production process”.

AWP - and head of production.

The organization of an automated workplace provides the shop management (shop managers, Deputy shop managers) with access to operational information about the course of the production process at the sites and by analyzing this information, the development of management decisions.

The automated workplace of the shop Manager uses a set of tasks “Accounting and control of the production process” and “Reporting”.

AWP-operator of the information preparation group.

The solution of the main task of operational management-scheduling of loading for a shift-is carried out by the AWP operator. set of tasks “Operational planning” it is solved in automatic mode and gradually calculates the operation priorities, forming queues, and calculating shift tasks for the WP.

The scheme of interrelation of sets of tasks of the tool shop management system is presented in figure 3.

The developed tool shop management system is implemented on the basis of a mini-computer in an interactive mode. The dialog mode of operation is based on the use of a real-time operating system, which allows you to organize multi-user work, and the creation of automated workplaces for operational shop staff.

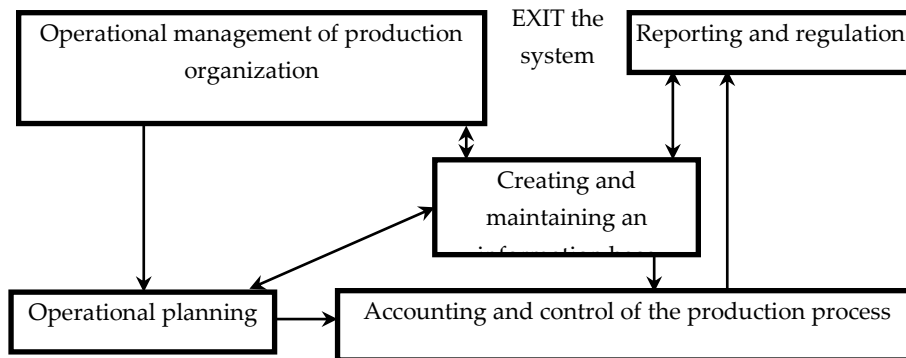


Fig. 2. Structural diagram of the relationship of task complexes of the tool shop management system.

5. Conclusion

The implementation of the calendar planning task allows you to calculate shift assignments for jobs based on a simple selection of work from the monthly plan, and taking into account the availability of orders and the performance of previous shift tasks. Creating and maintaining an order accumulation array improves the quality of the plan, since with a longer planning interval, there are more opportunities for optimization.

Implementation of production organization management tasks allows you to create a real production program. Forming a real monthly production program allows you to plan the work of supporting services in

advance, which significantly increases the rhythm of production and the probability of fulfilling the monthly plan.

Using the dialog mode for generating control decisions makes it possible to:

- take into account difficult to formalize factors and circumstances that characterize the state of the production process;
- apply heuristic techniques and methods in the process of solving combinatorial problems of high dimensions (for example, tasks of calendar planning);
- find the results of solving multi-criteria problems that are effective from the point of view of a given user, which generally have a number of competing indicators.

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