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Features of planning an automated production line of manipulator-type machines

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Abstract. Features of the development of automated processing of parts of manipulator type machines are considered. Optimization of the solution of transport problems leading to a change in the production structure of the enterprise, a change in the specialization forms of its workshops and production sites, a change in freight flow patterns, freight turnover values and associated transport and process schemes for handling unit loads are presented. All these transformations of transport and process schemes result in a change in the general plan of the enterprise, layout schemes of its production buildings, workshops and production sites and other changes in the production and organizational structure. A more detailed solution of the problem of determining the optimal routes in a lean production system is the optimization of process routes at the level of developing routing maps of technological processes for manufacturing each part of the product and assembly processes. Relying on key business processes and organizing assembly production on new principles, the enlarged planning of the production process made it possible to design a modern production module.

A multi-function manipulator crane is installed on the vehicle's base and is designed to lay overhead power lines, correct malfunctions in the operation of communication lines, as well as to perform various tasks in the field of energy production and construction. Such equipment is often used by energy companies, construction organizations, housing and utility services, which especially appreciate its wide versatility.

The creation of manipulator-type machines on modern tractor bases is a complex multi-stage process with a clearly defined assembly flow, starting from small assembly units to large units and ending with the general assembly of the machine.

Technological processes (TP) of blanks processing on an automated production line and automatic machines should satisfy not only the usual economic and technical requirements, but also the conditions arising from the specifics of automated production. [1]. Route TP is developed taking into account the maximum concentration of processing transitions and finishing operations at the end of the TP. At the same time, additional positions (control the depth of drilled holes, removal of chips from blind holes, turning the workpiece, when changing bases) are provided [2].

Automatic assembly is a TP in which all main and auxiliary work on the assembly of the product, as well as transportation of the assembled product and its constituent parts in the assembly process, are performed without the direct participation of human.

When designing automatic assembly TPs, a number of features should be taken into account:

- when automating assembly processes, it is not always possible to effectively automate all technological operations (TO) and transitions;
- limited concentration of transitions on one assembly position due to the significant area occupied by loading and unloading devices;
- insufficient number of standardized or normalized technical means for the implementation of individual transitions during automatic assembly;
- wide variety of types of assembled products, which in many cases leads to the need to develop highly specialized assembly machines and automatic lines;
- need for automatic orientation, transportation, positioning of assembled parts with high speed and accuracy, which often leads to excessive complexity and cost of assembly equipment;
- large number of elements included in the same product, manufactured at the same time, in various workshops and in different areas, violation of the rhythm of their delivery leads to violations in the assembly process.

Automation of assembly processes involves a complex set of automatically operating devices that reliably perform all transitions of assembly operations: 1) hopper loading devices for parts of simple shape; cassettes or magazines loaded with more complex parts in a pre-oriented position; 2) drives connected to loading devices with open or closed type trays; 3) cutoffs; 4) feeders; 5) devices for connecting parts by pressing, flaring or screwing; 5) devices performing special functions (blowing with compressed air, lubrication, etc.); 6) assembly devices and tools; 7) devices controling the correct operation; 8) mechanisms for moving the assembled product into a container or for transferring it to the next assembly position without losing orientation.

The route of the product (procurement, part, assembly unit) forms the value flow (in Lean Production systems such route is called the spaghetti chart). The diagrams of this type depict the process route that the product passes at all stages of production. Analysis of the diagrams shows that any activity can be transformed into a flow [3-7].

The solution of the problem under consideration for streamlining transport and technological flows (schemes) in Lean Production systems relates to the class of transport problems. For the optimal solution of the classical transport problem, two types of criteria are distinguished: cost criterion (achieving a minimum cost of transportation) or distance and a time criterion (a minimum of time is spent on transportation), which are used, for example, in the application to linear programming methods or genetic algorithms to find the optimal solution.

Optimization of the solution of transport problems leads to a change in the production structure of the enterprise, a change in the forms of specialization of its workshops and production sites, a change in freight flow patterns, freight turnover values and associated transport and process schemes for processing unit cargoes. All these transformations of transport and process schemes result in a change in the general plan of the enterprise, layout schemes of its production buildings, workshops and production sites and other changes in the production and organizational structure. A more detailed solution of the problems of determining the optimal routes in a lean production system is the optimization of process routes at the level of developing routing maps of technological processes for manufacturing each part of the product.

In this case, it is proposed to use artificial intelligence methods. For the task of multicriteria optimization of a capital-saving technological process, this is a partially recurrent Elman network. For mathematical modeling and optimization of design and technological solutions for the development of optimal capital-saving technological processes at the level of development of route maps, the mathematical modeling system MatLab 7.1 is used.

Assembly processes are the final stage in the production of components and the machine (product) itself [1]. Thus, the assembly processes use a high level of cost, and they themselves have a significant role in its creation.

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When creating an enlarged layout, the key business processes adopted by the enterprise are important.

Relying on key business processes, and organizing assembly production on new principles, the enlarged planning of the production and technological process will allow designing a modern production module

Of 5 considered and proposed options for the production and technological line at the stage of preliminary approval, the most successful option should be taken according to the enlarged "product principle" with the organization of a common longitudinal flow with access to the assembly site with a transverse trestle of assembly processes. The line includes 3-4 loops of assembly directions with 4 positions determined by the technology.

In accordance with the Terms of Reference, the entire production and technological process [8] is based on adopted key business processes.

1. Sheet metal processing:
- metal cutting (plasma);
- sheet metal bending.

2. Assembly by welding:
- welding works (tacking, welding, stripping).

3. Paintwork:
- surface preparation of metal structures;
- powder coating and polymerization.

4. Assembly of units and their testing:
- performing assembly operations on units;
- tests of hydraulics units.

5. Assembly of machines:
- electric installation work;
- final assembly operations;

6. Service work and testing of finished products.

The area of the entire production module is proposed to be divided into different categories of premises:

1. Production room.
2. Administrative building with electrical installation site.
3. Test building.
4. Cold warehouse.

The enlarged "product principle" is that the entire production cycle is divided in accordance with the production technology under consideration and adopted business processes into production sites for:

- cold storage of materials;
- sheet processing;
- welding;
- paintwork;
- component assembly;
- production of machines.

In accordance with this, a finished "product" shall be left from each site in the right amount and of the required quality determined by the production task.

The proposed draft enlarged layout of the production and technological line provides for the possibility of changing the size of each site in connection (in future) with the development of a detailed layout.

Changing the size of production sites will entail the displacement of transverse technological driveways and, therefore, the production module shall be implemented according to the replacement principle of "window opening-gate", i.e. where the window opening is designed, it is quite easy to make the gate and vice versa.

The machine assembly platform is made with three transverse "loops" of assembly process directions, which is consistent with the main principle of organizing the entire production line, namely: "Organization of the total longitudinal flow of production with access to the assembly site with a transverse line of assembly processes."

In addition, it is possible to organize an additional 4th "loop" at the machine production site, for this purpose, the planned window opening between the test building and the production module follows the same "replacement principle".

Particular attention in creating an enlarged layout is given to the organization of a warehousing facilities, which is divided by functional and technological principles.

Ready-made large purchase units, such as gearboxes, hydraulic cylinders, cardan shafts, winches, etc.

Small components, including metalware, etc.

Accessories related to electrical equipment.

All listed components have different storage conditions, and they are also in demand by production in a constant current mode or are periodically claimed by the required time and place.

In this regard, warehouses are organized.

According to the results of marketing research, a multifunctional crane machine is in demand in the market of machines for electric grid companies.

Relying on key business processes, and organizing assembly production on new principles, the enlarged planning of the production and technological process will allow designing a modern production module.

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