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Analysis of research in the field of automatic production systems with rigid interaggregate relation and recomposed systems

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Abstract. Automatic production systems with rigid inter-aggregate relation are widely used: automatic lines, etc. There are alternative solutions as flexible production systems that allow quick changeovers for the production of various applications. The main trends in systems with rigid relations and reconfigured systems with flexible relations are discussed. The main tendencies are defined. The required properties of the recomposed production systems are determined. Two main directions of development of this type of systems are revealed.

1. Definitions

The automatic production systems with rigid inter-aggregate relation include in mass production: automatic lines (AL) [1], aggregate machines (AM); in large-serial and serial production: flexible automatic lines (FAL) [2], flexible production systems (FPS) [3], robotic technical complexes (RTC) [4] and other machine systems. Generally, creation of flexible production systems is carried out with the use of work stations (WS), multioperational machines (MM) with CNC, flexible production modules (FPM), equipped with automated loading, transportation and storing of workpieces, parts, automated change of tools and equipment, advanced control systems and the organization of flexible automated production (FAP) built on this basis [5, 6].

All of the above production systems have a rigid relations and stationary design.

2. Automatic production systems with rigid inter-aggregate relation

Layout selection is one of the main stages in the design of automated production systems. A significant contribution to the layout theory was made by scientists of MSTU Bauman [7, 8]. The layout is considered as a complex concept that determines, first of all, the system of nodes and guiding lines arrangement, which have different structure, proportions and properties.

The unified theory of technological, coordinate, basic and structural layouts is considered as a general scientific direction in the layout theory, called compositing [9, 10]. The formalization of the layout's structure description is carried out using the structural formulas of the layout, which contain: a sequence of symbols and codes of the aggregate nodes and blocks indicating the coordinate, and a pairing method [11, 12].

The theory of multioperational CNC machines' layouts was significantly developed according to the block-modular principle in the scientific papers [13, 14].

The machine tools as well as systems composed of aggregate units have the widest application among the technical solutions of the working stands of the automatic lines (WSAL).

Many studies [15, 16] are devoted to the study of aggregate machines' layouts which are manufactured for normalized and unified aggregate nodes. Aggregate machines are widely used in large-scale and mass production. They are used for processing of case-shaped parts as well as shafts. All of the above studies are related to automatic production systems with rigid inter-aggregate relation.

In such production systems, the aggregate units in the designs of aggregate machines are not automatically arranged, but they reduce the time of their design, simplify the production process, allow to unify parts and simplify manufacturing techniques, and also allow to create a variety of stationary layouts for aggregate machines as well as for mass production enterprises production, especially in the engineering industry [17, 18].

Despite the relatively low price of aggregate machines and the duration of their development, because of the design of unified aggregate units, the main disadvantage of aggregate machines is the lack of flexible inter-unit relation, their inability to multi-part processing in flexible production conditions. Therefore, flexible production systems with the possibility of a partial change of the tool are prevail in the aggregate units using an automatic manipulator and tool bank.

Flexible inter-aggregate relation can be used in various technological chains, including technologies of surface plastic deformation processing in order to optimize the selected microgeometry parameters [19, 20]. These technologies can be applied without lubricoolants that have a negative impact on the environment [21, 22]. The use of systems with flexible relation can also help to ensure product quality through operational monitoring of the instrument for cracks and other characteristics of wear [23].

3. Automatic production recomposed systems

Recomposed production systems (RPS) are self-controlled and self-regulated mechatronic production systems, and have main properties:

- Changing the layout and structure of layout based on automatically composed aggregate nodes and RPS modules has a multi-level, multi-tiered structure of mechatronic modules and mechanisms, inter-aggregate and inter-module relations in order to function during changing time cycle in multi-nomenclature processing;
- Replaceable units and modules compose a complex of automatically replaceable technical means and form an element-modular base for composing and creating RPS in real time functioning and recomposing in a single cycle of technology transformation and a machines' system as well.

4. Results and discussion

In order to solve technical and operational problems that determine the creation and usage of RPS, the recomposed production systems must have the following properties:

- Automatic modification and design of interchangeable modules with the ability to automatically change modules and change the process and structure.
- Automation of readjustment, tool replacement and auxiliary functions, automatic regulation of the operation modes of replaceable nodes and modules. Automatically replaceable units are used

with automatic adjustment of movement settings and tool changes. Both tools and units are replaced during the RPS operation and during the implementation of changes in the process.
- The recomposing process should be characterized by a rapid automatic change of units and modules of various functional and technological purposes with the possibility of automatic formation of a working area for processing and placement on the production area.
- Ensuring the required performance with a changing nomenclature and program of manufactured products with the achievement of the quality of the processed product specified by the documentation.
- The functioning and control of the machine system, subject to change and automatic maintenance of the required performance, reliability and quality of products. Maintaining and ensuring the possibility of processing the product by automatically changing aggregate units and modules at various levels and tiers of the structural hierarchy with the ability to automatically change and adjust the tool.

5. Conclusions
Two directions of development of recomposed production systems have been revealed:
1. Systems that provide and allow for a full range of recomposing of working stands and changes in inter-aggregate relations at all levels of the structural hierarchy and compositing tiers.
2. Systems with implemented recomposing of the executive aggregate units and other machine tools without disrupting the inter-aggregate relation of the basic and supporting nodes carrying the construction.

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