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DESIGN OF TECHNOLOGICAL COMPLEXES FOR HIGHLY EFFICIENT TREATMENT

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Abstract: *The structural synthesis of technological complexes for highly efficient combined thermomechanical and electromagnetic treatment of surfaces of revolution and end and flat surfaces showed the expediency of setting up universal technological complexes in the form of a flexible production module that consists of unified units that carry out principal, additional, and adjusting movements of the parts and tools and provide their mounting and fastening. Unification of combined treatment of surfaces of revolution and flat surfaces using additional units permits the creation of flexible treatment centers.*

Key words*: technological complexes, thermomechanical and electromagnetic treatment, flexible treatment centers*

1. INTRODUCTION

One of the ways to improve the efficiency of machine building is to create the complexes of technological, transport, energy, and information machines and apparatuses which realize the work process as a logically complete part of the production cycle. Such a combination of machines has come to be known as a technological complex [1, 2]. Therefore, shortening the time for the new technological complexes creation and implementation is a pressing problem of modern machine building industry.
Principles of optimum design of a technological complex have been developed by Artobolevskii [1] and Koshkin [2]. A two-stage design was proposed:
1) structural synthesis in which principal schemes of solutions that are in conformity with initial technological conditions are considered;
2) parametric synthesis in which a schematic solution is embodied in a structural form as a combination of specific mechanisms, blocks, devices, and elements of the technological complex.
Analysis of the technological complexes grouping involve the following [3]:
1) study of the structure and preselection of the types of grouping;
2) study of the effect of the latter on quality, rigidity, accuracy, and wear resistance of the elements and consideration of the methods of their optimization.
Methods of analysis and optimization of selection of groupings [4] for automated assembly technological complexes [1, 2], aggregate machines [5, 6], automatic rotor lines [2, 7], and multioperation machines [3, 5, 8] are presently known. However, the problems of structural and parametric synthesis in design of technological complexes implementing processes of highly efficient combined treatment have not been studied as yet.
By virtue of this, development of the methodology of synthesis of technological complexes of highly efficient treatment, strengthening, and recovery of articles is of primary importance. It includes:
a) giving reasons for choice of highly efficient combined methods of treatment which provide the resource saving and repair of machine elements;
b) design of the structure of a universal technological complex for highly efficient treatment, strengthening, and recovery of machine elements;
c) optimization of the parameters of the processes implemented by a technological complex of highly efficient treatment.
Shortening the design time for the new advanced technological processes involving the use of tools, assembly units and systems, machines, and modules that form a single technological complex, is among topical problems of modern machine building industry.
A key problem in designing a technological complex is the setting up of a structure that provides smooth operation and flexible readjustment of a complex for highly efficient treatment [9].
Rational reliability and adaptivity are provided in structural synthesis based on analysis of elements and study of corteges of the technological complex [1].

2. ANALYSIS OF ELEMENTS OF TECHNOLOGICAL COMPLEXES

A technological complex in the general case is considered as a hierarchical «man-machine» system [1] that

comprises the following levels:
I) functional elements that implement the principal movement, the feeding movement, and the tool movement;
II) functional subsystems in the form of assembly units;
III) functional systems that provide operational and transport movements, feeding and removal, and maintenance;
IV) technological modules or assembly machines, and power and information machines;
V) automatic and semiautomatic lines and sections that form the technological complex.
Each subsystem of the *n*-th level is an element of a subsystem of the (*n* + l)-th level. The makeup of the technological complex and each functional system and subsystem that are involved in a technological module and the functions of their constituent elements comply with the intention of the technological operations for which the given technological complex is set up.
In the general case each subsystem consists of several elements whose naming involves the names of the functions (movements) performed. During the technological process, a subsystem of a given type performs a certain typical function, i.e., a typical technological operation.
Plants for highly efficient turning, milling, and abrasive treatment, rotational cutting [10], electromagnetic facing [11, 12] with plastic surface deformation [12], and magnetic-abrasive polishing [11] that have been designed to date are functional systems with a set of various subsystems.
The makeup and number of interlevel links of the elements of technological complexes for combined electromagnetic and thermomechanical treatment are analyzed using a two-digit numbering of the constituent systems and elements. The first digit corresponds to the level of the constituent: 1, denotes functional elements; 2, functional subsystems; 3, functional systems; 4, technological machine; 5, technological complex. The second digit is the ordinal number of each constituent of the given level.
Thus, the following code numbering is obtained for constituents of the fifth level: 51, technological complex for combined electromagnetic and thermomechanical treatment for surfaces of revolution; 52, the same for end surfaces; 53, the same for flat surfaces.
We consider a technological complex for combined electromagnetic and thermomechanical treatment of pans with surfaces of revolution.
The fourth level of technological complexes is made up of technological modules by the method of treatment: 41, turning treatment; 42, abrasive treatment; 43, rotational cutting; 44, electromagnetic facing with plastic surface deformation; 45, magnetic-abrasive polishing.
The third level represents functional systems: 31, operating system that includes elements needed for fulfilling the designated purpose of the functional system; 32, auxiliary system that effects adjusting movements of the tool and the workpiece; 33, servicing system that provides replacement of the workpiece and the tool and filling of the facilities for feeding the powder and the lubricating fluid.
The second level is functional subsystems: 21, of the workpiece movement; 22, of the tool movement; 23, of the feeding movement; 24, of the electromagnetic system movement; 25, of additional heating of the treated surface; 26, of feeding of the lubricating fluid; 27, of the powder feeding; 28, of the tool adjusting movements that can coincide with the principal movements; 29, of replacement of the workpiece and the tool.
The first level involves functional elements that implement: 11, principal movement of the workpiece (111, rotational movement; 112, translational movement); 12, principal movement of the tool (121, rotational movement; 122, translational movement); 13, additional movement of the tool (131, rotational movement; 132, translational movement); 14, feeding (inward) movement (141, lengthwise movement; 142, lateral movement; 143, movement perpendicular to the plane of the lateral and lengthwise movements); 15, movement of the electromagnetic system: 16, movement of the facility for feeding the powder; 17, adjusting movement of the work-piece (171, lengthwise movement; 172, lateral movement; 173, movement perpendicular to the plane of the lateral and lengthwise movements); 18, adjusting movement of the tool (181, lengthwise movement; 182, lateral movement; 183, rotational movement).
On the basis of an analysis of the sets of constituent functional systems, functional subsystems, and functional elements, which are called corteges [1], we determine links between them.

3. STRUCTURAL SYNTHESIS OF CORTEGES OF TECHNOLOGICAL COMPLEXES

Study of the graphs of corteges (Fig. 1) permits establishment of the number of interconnections between the various levels that make up the technological complex.

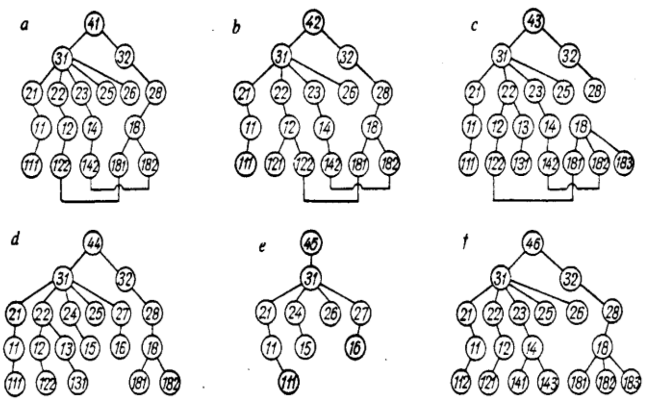

Fig. 1. Graphs of corteges of: turning treatment (a), abrasive treatment (b), rotational cutting (c), electromagnetic facing with plastic surface deformation (d), magnetic-abrasive treatment (e), milling treatment (f)

All technological modules (the IV level) include functional systems (the III level) 31 and 32 (operating and auxiliary), except for technological module 45.

Functional subsystem 22 (tool movement) is absent in technological module 45; functional subsystem 23 (feeding and inward movement), in technological modules 44 and 45; functional subsystem 24 (movement of the electromagnetic system), in technological modules 41, 42, 43, and 46; functional subsystem 25 (additional heating), in technological modules 42 and 45; functional subsystem 26 (feeding of the lubricating fluid), in technological modules 43 and 44; functional subsystem 27 (dispenser), in technological modules 41, 42, 43, and 46; functional subsystem 28 (adjusting movements), in technological module 45.

Thus, in most cases technological complexes involve: functional subsystem 21 (workpiece movement) - rotation (111); functional subsystem 22 (tool movement) - translational movement (122); functional subsystem 22 (additional movement of the tool) - rotation (131); functional subsystem 23 (feeding or inward movement) - lateral movement (141); functional subsystem 28 (adjusting movements of the tool) - lengthwise and lateral movement (181, 182).

To design a universal technological complex for combined thermomechanical and electromagnetic treatment, we unify corteges and determine coincident links and functional elements. The match of corteges (Fig. 2) reveals the expediency of setting up a universal technological complex that combines highly efficient thermomechanical and electromagnetic methods of treatment of surfaces of revolution.

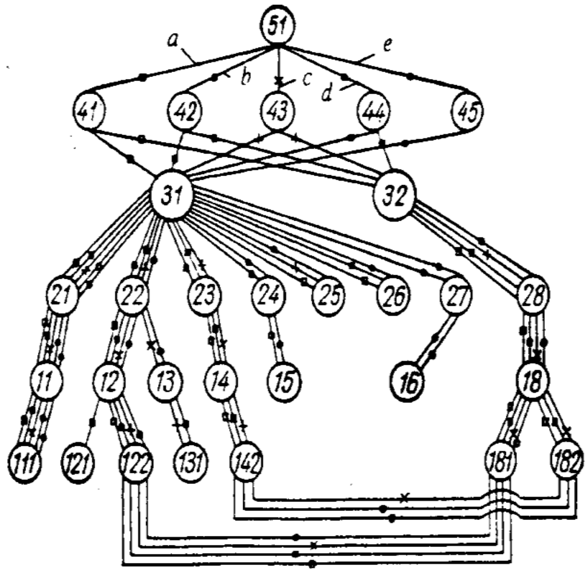

Fig. 2. Graphs of corteges of a technological complex for treatment of surfaces of revolution: turning treatment (a), abrasive treatment (b), rotational cutting (c), electromagnetic facing with plastic surface deformation (d), deformation treatment (e)

The structural synthesis of the elements based on the considered links permits identification of a number of unified units in the makeup of the technological complex: 1) of principal movement, which provides workpiece rotation about the horizontal axis; 2) of the tool drive: a, of translational movement along the axis of rotation of the workpiece and inward movement and b, of rotational movement, whose velocity is determined from the forces applied during the treatment; 3) of feeding: a, of the powder for facing or polishing and b, of the working lubricating-cooling fluid; 4) of the drive of the electromagnetic system, which are used for: a, control over the technological process and b, control and regulation of the treatment quality; 5) that serve for: a, energy supply and b, control over the energy actions on the surface layer of the treated workpiece.

Unit 2, a can be made in the form of a lathe support, and unit 2, b is fastened to unit 2, a, which offers the opportunity to use the existing mechanisms of unit 2, a to implement some of the tool movements.

Let us consider the links (Fig. 3) between functional elements of a technological complex for treatment of end surfaces.

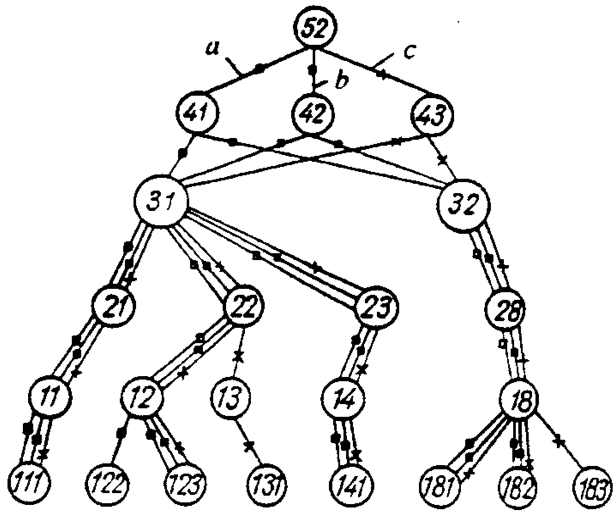

Fig. 3. Graphs of corteges of a technological complex for treatment of end surfaces: turning treatment (a), abrasive treatment (b), rotational cutting (c).

The match of corteges indicates that the units of the complex for treatment of surfaces of revolution are totally suited for treatment of end surfaces except that the principal movement should be replaced by tool feed (the translational movement should be replaced by lateral movement).

We next consider the links (Fig. 4) between functional elements of a technological complex for treatment of flat surfaces.

The match of corteges of the technological modules for treatment of flat surfaces shows the following: 1) the unit of workpiece movement provides translational movement, 2) the unit of tool movement provides rotational movement, and 3) the translational movement of the tool in the technological module for magnetic-abrasive polishing can be replaced by feeding movement, and therefore, the unit will carry out one movement.

An analysis of the match of corteges of the technological complexes for treatment of surfaces of revolution and end and flat surfaces revealed that, for carrying out combined thermomechanical and electromagnetic processes, the operating functional system should be provided with the principal movement, feeding movement, adjusting movement, and additional movement.

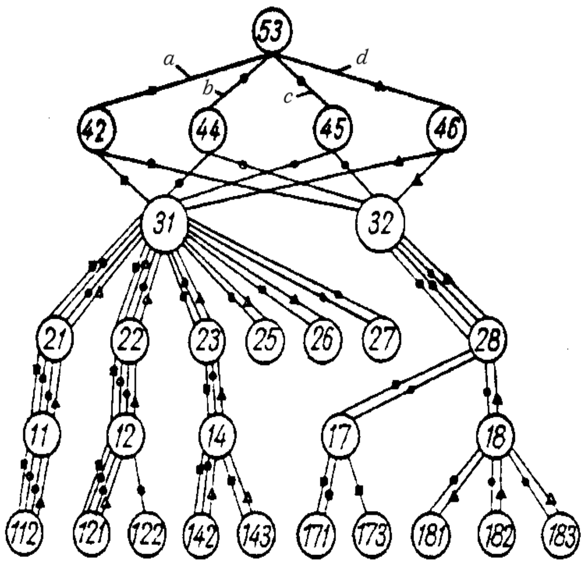

Fig. 4. Graphs of corteges of a technological complex for treatment of flat surfaces: abrasive treatment (a), electromagnetic facing with plastic surface deformation (b), magnetic-abrasive treatment (c), milling treatment (d).

In the general case, for carrying out the set of movements, it is advisable to construct the technological complex from unified blocks that effect: 1) rotational movement of the workpiece, 2) rotational movement of the tool, 3) three mutually perpendicular translational movements of the table, 4) additional rotational movement of the tool, 5) adjusting turning movement of the axis of the rotational tool, 6) mounting of the work-piece on the table in treatment of flat surfaces, and 7) fastening of the tool in turning treatment.

Units 1 and 2 can be structurally united with the units that carry out adjusting movements for regulating the distance between the axis of rotation and the frame (table) of the complex, and units 4 and 5 can be integrated.

4. CONCLUSION

The structural synthesis of technological complexes for highly efficient combined thermomechanical and electromagnetic treatment of surfaces of revolution and end and flat surfaces showed the expediency of setting up universal technological complexes in the form of a flexible production module that consists of unified units that carry out principal, additional, and adjusting movements of the parts and tools and provide their mounting and fastening.

Unification of combined treatment of surfaces of revolution and flat surfaces using additional units permits the creation of flexible treatment centers.

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