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AUTOMATION OF TECHNOLOGICAL OPERATIONS IN THE MANUFACTURE OF WOODEN TOYS

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ABSTRACT

Traditional universal and specialized woodworking machines perform the industrial production of details for toys made of solid wood. The automation of such discrete technological processes and operations can be accomplished by designing and implementing automated complexes that provide high performance. The report presents three effective solutions for automated complexes for the automation of technological operations in the production of rotary details for toys of solid wood. These are key factors for automating discrete processes and specific prospects for the development and automation of the production of wooden toys.

Specific solutions are shown to automate the flow of details when processing the rotary parts. A theoretical analysis was carried out and cyclograms of the work of the specific automated complexes were presented.

Key words: wooden toys, rotary parts, automated complex.

INTRODUCTION

Toy manufacturers in Bulgaria face many difficulties on the European market:

- high competition in terms of quality and cost,
- high safety requirements for raw materials and inputs,
- comparatively small niches and series of finished products,
- large number and variety the shapes of their component parts,
- the predominant details with small dimensions,
- high requirements for accuracy and roughness of the surfaces, etc.

The prospects for successful development of these manufacturers are related to their ability to be more innovative and flexible, to eliminate the use of manual labor, to increase the productivity, efficiency and quality of finished products.

This is possible to achieve by attaining a high degree of automation in the manufacture of toys and wood furniture.

METHODOLOGY

For the automation solution to be effective, it must be able to meet the following requirements:

- To allow increased productivity of machines and equipment;
- To improve the quality of production and reduce scrapped output;
- Be economically profitable and justified;
- To provide a social effect, to reduce harmful, heavy, monotonous manual labor, to reduce accidents at work and the risk of occupational illnesses;
- Possibility of adjusting the automation technique for the execution of other production tasks;
- The automation equipment to work for a long time without human intervention;

- Allow the solution to be included in more sophisticated automated systems.

Trends in the development of automation technology and automatic systems (Chakarski D. 2018.) for the production of wooden toys are:

- Expanding the use of computer technology in the whole cycle (research - design - implementation - production - packaging - sales);
- Optimizing the construction of automatic systems, by using CAD / CAM/ CAE systems for 3D design, preparation for production and production itself;
- Improvement of the drives and controls of the Automatic Systems by using parallel kinematics, linear drives, etc. (Vasil V., Nikolov P., Camber G. 2019);
- Establishment of new constructions automatic multifunctional machines, industrial robots, automated mechatronic systems, etc.;
- Creating a range of new high-performance woodworking tools;
- Increasing the productivity of automation equipment;
- Development of innovative automated technologies for woodworking processes;
- Development and implementation of complex and efficient solutions for the automation of the production of wooden toys.

When designing and implementing automated complexes for the production of toys from wood, the following milestones can be distinguished (Chakarski D., Malakov I. and c. 2015.):

- Determining the suitability of wood toy constructions from the point of view of automation;
- Analysis of the existing technological process and the technological units used;
- Development of a feasibility study for the design of automated complexes (AC) for the production of wooden toys from wood;
- Preliminary calculations of the project indicators of the AC;
- Development of variants of AC;
- Analyzing and evaluating the options and choosing the optimal option of the AC decision;
- Development of constructive and technological documentation of the selected decision option of the AC;
- Production of AC for the production of wooden toys;
- Programming and setting of AC;
- Performing functional and technological tests of the AC;
- Implementation and trial operation of AC.

In the automation of existing machines and equipment, the flow of parts is primarily automated, with universal machines becoming automated machines. A mandatory condition is to ensure an automated working cycle of the production units.

When designing automation techniques, technical ideas are generated in the form of variants, using variation patterns. These signs are fundamental and additional.
The following are the main features:

- the technological process and the technological route;
- way of automatic power;
- class of automated structural components;

- the mutual accommodation of the structural units, etc.

Additional signs may be:

- model and type of structural units;
- way of management, etc.

The efficiency of the automation technique depends on the choice of optimal structure and rational operation. For this purpose it is necessary to create various working options in the design stages, based on basic and additional variation characteristics, in accordance with the objects of automation and the specific production conditions (Atanasov V., Gochev Z., Vukov G., Vichev P.& Kovachev G. 2018.).

By automating the flow of parts is understood the set of manipulations with the details that are performed automatically in the space and time to ensure the automatic operation of individual machines, lines and complexes for a certain period of time without the worker's intervention (Dimitrova R. & Hadzhikosev G. 2013.).

Due to the wide variety of manipulation objects for each case, automation of the flow of the parts must be approached in particular, taking into account the specifics of the details (shape, weight and dimensions), the production program, the type of machine working area, etc.

To display individual manipulations of the details, the corresponding symbols are used, which are simple images, giving a clear idea of the manipulations performed. Symbolic flow patterns of the details can be drawn using the symbols. They provide sufficient information about the manipulations performed, the classes of automation devices, their number and mutual placement.

The smallest component of the self-expression process for its structure is the operation. This is the starting point for planning, reporting and controlling direct production activity. Symbol details can be drawn with the symbols of Fig. 1.

signification	№	Symbol
Storage Storage of random detail and preparation is the formation of a stock before and after work equipment	1	
Arranged storage of parts in a store to form a stock before and after work equipment	2	
Displacement Moving in an orderly and unordered state from one place to another by using a jaw or a forced drive	3	
Branching Separation or sorting of details according to the characteristics of the shape or material	3a	
Collect Joining details	3b	
Arrangement Ripping of parts from a random position and direction (shrinking from a stored state to a stored state)	4	
Check the situation Determining the position of the parts for their proper alignment, which controls the position they occupy.	4a	
Rotate, change Establishing another position of the workpiece, by rotating about a point or axis beyond the workpiece or change the direction of movement	4b	
Separation Preparation of a certain number of details or quantity of material to be processed	5	
Submission Managed feed from the storage area in the work or metering zone (attachment, clamping)	6	
Positioning Establishing a precise position of the workpiece or workpiece for processing, or pass	7	
Tightening Pushing the processable object into a designated processing position	7a	
Release Release the processable object by removing the grip	7b	
Exporting Removing the workpiece from the work or metering zone	8	
Processing Processing is all the action that is required for shaping: cutting, turning, milling, grinding, etc.	9	

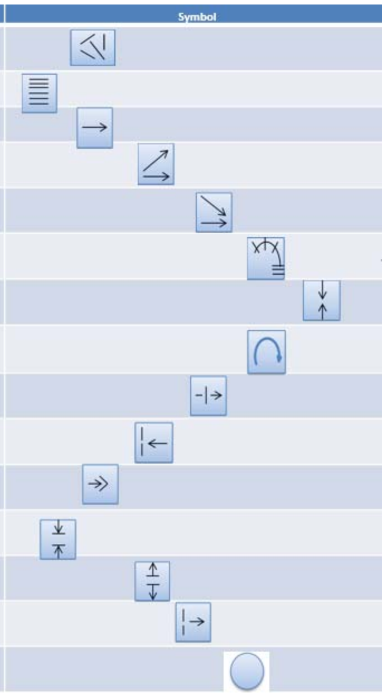

Figure 1: Operations and symbolic schemes.

Two types of tasks are solved: straight and reverse.

In the case of the tasks, based on the constructor's ideas, the corresponding symbolic schemas are depicted, which serve to compare the options for automating the flow of the details.

For reverse tasks when there are ready solutions to automate the flow of the details, synthesis can be performed and the result can be documented in the form of symbolic schemes. They provide sufficient information about the manipulations performed, the classes of automation devices, their number and mutual placement.

RESULTS AND DISCUSSION

Specific observations have been made of the production process in a plant for the production of wooden toys. Based on the results of these observations a theoretical analysis is performed to evaluate the capabilities to automate the work of specialized processing machines rotary parts.

A theoretical analysis is performed and cycles of the work of the specific automated complexes are presented (Petrov P. 2014.).

Cyclograms illustrate the duration of the action of the respective element of the automated complex and bind in a certain sequence the duration of their states.

By compiling the cyclograms, such interaction is achieved between the mechanisms involved in transport and processing manipulations to match them in time.

The goal is to achieve a minimum cost of time when receiving the finished product.

A spreadsheet is compiled of the inclusions of the executive and intermediate elements containing as many times as they are provided in the cyclogram. This improves the productivity of machines and automated complexes.

Automated complexes consist of a basic wood working machine for turning solid wood and suitable automation devices.

For each of the presented automated complexes, the *degree of automation* and the *growth of productivity* is determined.

The degree of automation A is determined by formula (1) and the automation factor K_a by equation (2) (Chakarski D., Malakov I. and c. 2015):

$$A = K_a.100\%, \quad \textbf{(1)}$$

$$K_a = t_m / (t_m + t_a), \quad \textbf{(2)}$$

where: A – degree of automation;

Ка – automation factor, ss^{-1};

t_m – automatic time, s;

t_a. – manual time, s.

Productivity growth - *λ* is determined by equation (3):

$$\lambda = Q_a / Q_o, \quad \textbf{(3)}$$

where: Q_a – the cyclic productivity of the automated complex AC, ph^{-1};

Q_o – cyclic performance of the existing machine.

1.1. Automated complex I

Part 1 of solid wood and the symbolic scheme is shown in Fig. 2

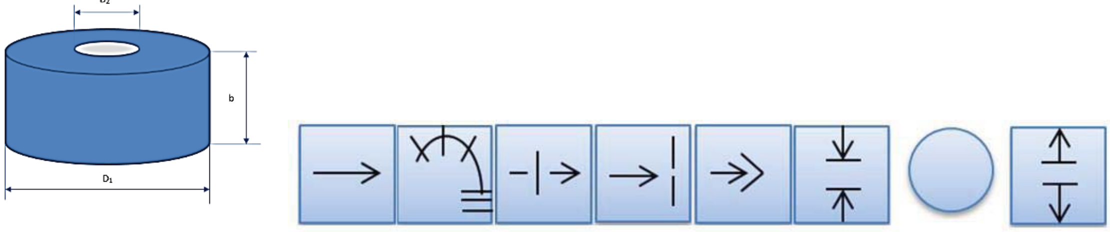

Figure 2: Part 1 of solid wood and the symbolic scheme.

Fig. 3 shows the cyclogram of the automated complex AC I.

Bunker - orientation	III							
Shop - arrangement		III						
Cutter - separation			III					
Device - feeding				III				
Device - tightening					III			
Release							III	
Taking away								III
Machine processing						IIIIIIIIII		
machine time						---t_m-		
cycle time	----------------------t_c----------------------							

Figure 3: Cyclogram of AC I.

For automated complex AC I, the indicators degree of automation and productivity growth are calculated: A = 73%, λ = 3,7.

1.2. Automated complex II.

Part 2 of solid wood and the symbolic scheme is shown in Fig. 5

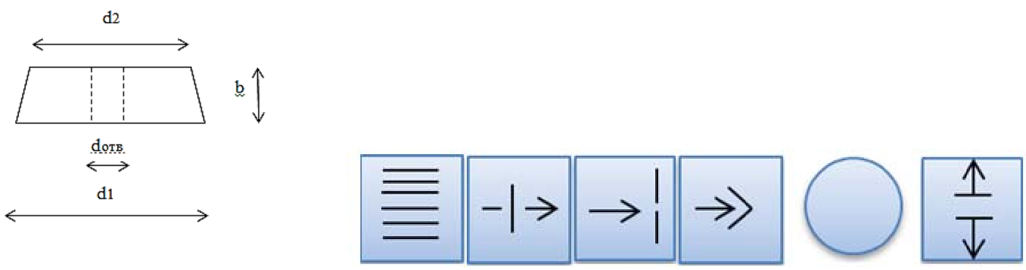

Figure 5: Part 2 of solid wood and the symbolic scheme.

Fig. 6 shows the cyclogram of the automated complex II.

Collector's shop			III			
Cutter - separation				III		
Device - feeding					III	
Device - tightening						III
Machine	IIIIIIIII					
Export - release		III				
machine time	--t_m---					
auxiliary, non-overlapping time		--------t_a-----------				
cycle time	---------------tc----------------					

Figure 6: Cyclogram of AC II.

For automated complex AC II, the indicators degree of automation and productivity growth are calculated: A = 77%, λ = 5,6.

1.3. Automated complex III

Part 3 of solid wood and the symbolic scheme is shown in Fig. 7

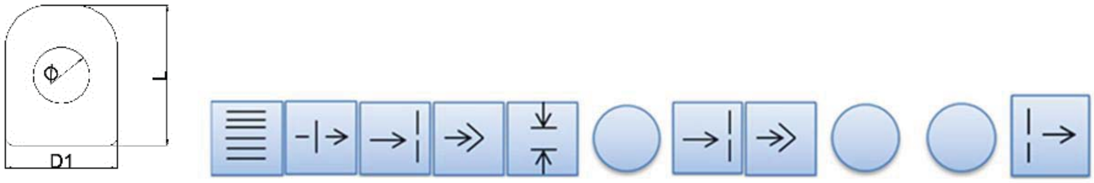

Figure 7: Part 3 of solid wood and the symbolic scheme.

Fig. 8 shows the cyclogram of the automated complex III.

Store - storage	III									
Cutter - separation		III								
Device - feeding			III							
Device - tightening				III						
Processing 1					IIIII					
Device - feeding								III		
Positioning									III	
Processing 2						IIIIIII				
Processing 3							III			
Export - release										III
machine time					--------t_m----------					
cycle time	---------------------------t_c-----------------------------									

Figure 8: Cyclogram of AC III.

For automated complex AC III, the indicators degree of automation and productivity growth are calculated: A = 80%, λ = 7,2.

CONCLUSION

The presented work contains the results of the research of the technology of three rotating parts, which are separate parts of a specific solid wood product.

There are key factors for automating discrete processes and specific prospects for the development and automation of the production of toys from wood.

The design, synthesis and analysis of various variants of solutions for the automation of the flow of the parts during the processing of each of the three rotary parts is carried out.

Through the evaluation methods of the designed options the optimal solutions are determined.

The three automated complexes for the processing of rotational details are shown.

Graphical representations of the different manipulations for each of the automated complexes are presented.

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