Constructions of Toroidal Screw Drums

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Abstract: Design solutions are presented for the implementation of working chambers in the form of relative toroidal screw drums, intended for the finishing treatment of components in the conditions of rotary-screw technological systems

Keywords: Screw drums, Toroidal-screw, Finishing treatment of components.

INTRODUCTION

Research aimed at improving the efficiency of performing technological operations using rotary-screw technological systems has shown that the performance of these systems largely depends on the structural features of the working elements – screw drums. Below are new structural solutions for the design of working chambers in the form of relative toroidal-screw drums designed for finishing treatment of components in rotary-screw technological systems.

The scientific novelty of the article, compared to the works of other researchers, in-cluding those from the provided list of literature, lies in the improvement of the geome-try of toroidal screw drums, which affects their efficiency. Conceptually important is the ability to combine and experiment with such geometric parameters of helical lines, heli-cal surfaces, and the passage section of a toroidal screw drum as shape, area, and side dimensions. This freedom in adjusting parameters provides a unique opportunity for ex-ploring and optimizing the design, emphasizing the significance of flexibility in adjust-ing geometric characteristics to achieve optimal results.

MODELS AND METHODS

The toroidal-screw drum

(Figure **1**, **2**) is assembled from 5 sections, one of which is highlighted by double lines 49-71-(29)-(91) and 89-47-(69)-(27). The sections 5 are connected to each other through the free sides of triangles, for example, by welding to form a toroidal-screw drum. On the outer and inner surfaces of the toroidal-screw drum, broken screw lines are formed, such as those shown with thickened lines, the closed broken screw line 14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-14 and the closed broken screw line 54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-54 (on invisible sections, the screw lines are shown as two parallel lines – solid and dashed, and invisible points of the broken screw line are enclosed in round brackets).

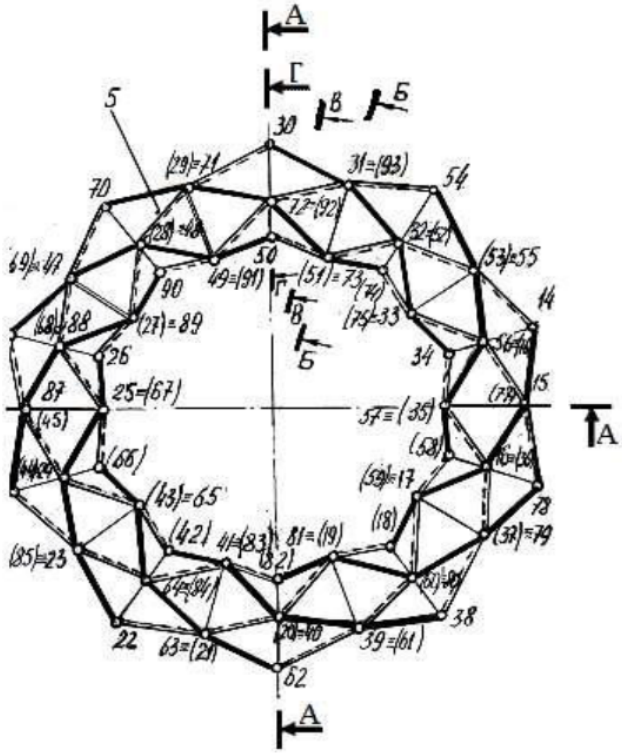

Figure 1: Toroidal-screw drum (top view).

Thus, on the inner and outer surfaces of the toroidal screw drum, screw surfaces made up of triangles of various shapes, areas, and sizes between broken screw lines are formed, and the toroidal screw drum itself has a cross-sectional shape that changes in terms of the shape, side dimensions, and area (Figure **2**).

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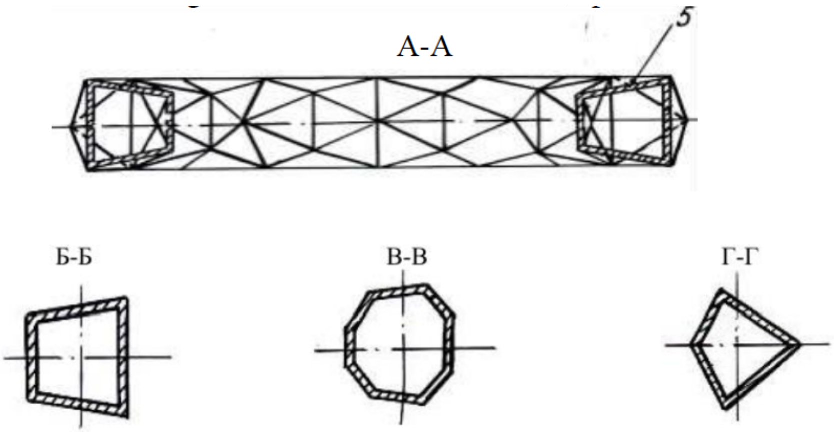

Figure 2: Toroidal-screw drum (in cross-section).

A тoroidal-screw screw drum with a curvilinear shape of screw grooves

(Figure **3**-**10**) is designed as a torus ring with a curvilinear shape of screw grooves. Each of the 5 sections is made in the form of a circular sector and assembled from strip 12, on which rectangles 13 and bending lines 14 are marked at equal distances from each other, equal to the development length of the curvilinear pockets perimeter. For example, for pockets 6, 7, 8, 9, 10, 11 at distances L and at an angle α to the edges of strip 12. Cutting lines 15 of the strip edges 12 are also marked on strip 12, shown in Figure **6** with a dash-dotted line and two dots. After cutting along the cutting lines 15, the sections of strip 12 (these sections of strip 12 are crosshatched) are cut off, and strip 12 takes on the appearance shown in Figure **1**, where the bending lines 14 of the strip have different lengths L1, L2, L3, L4, L5, L6, forming quadrilaterals with two parallel sides - the bending lines 14, parallel to each other.

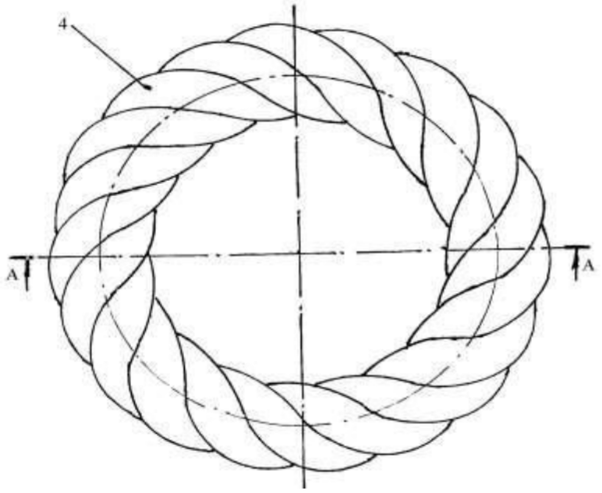

Figure 3: Relative rotary drum, top view.

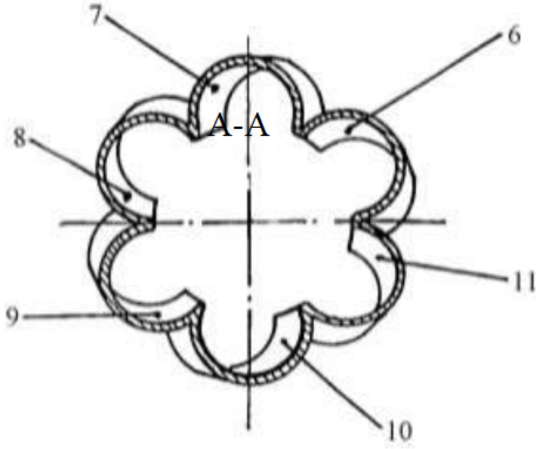

Figure 4: Relative rotary drum (section A-A).

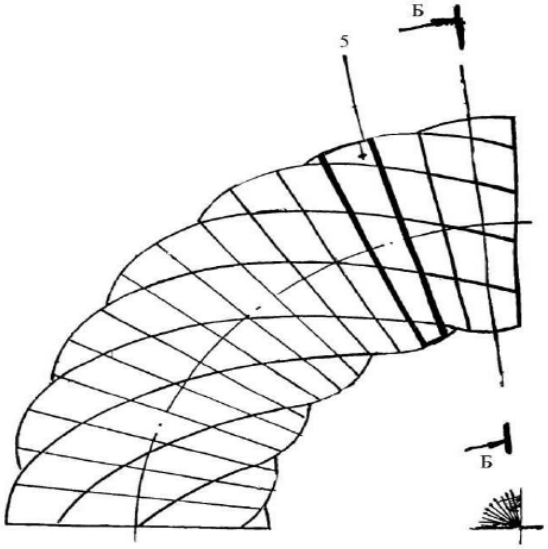

Figure 5: One of the sections of the toroidal-screw drum Б-Б.

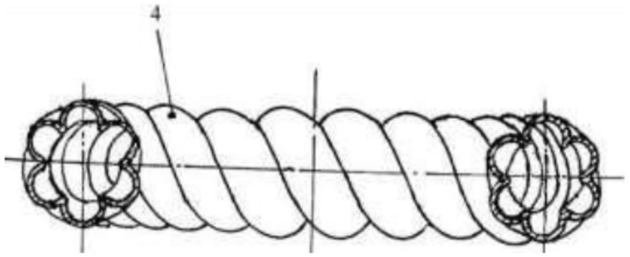

Figure 6: Section Б-Б.

After trimming the edges of the rectangular panels 12 along the trimming line 15, strip 12 is bent and then folded into a ring 19 with a curved inner surface in the form of pockets. The edges 17 and 18 of strip 12, after being folded into ring 19, are joined by known methods, such as welding, soldering, etc., to form section 4 in the shape of a circular sector.

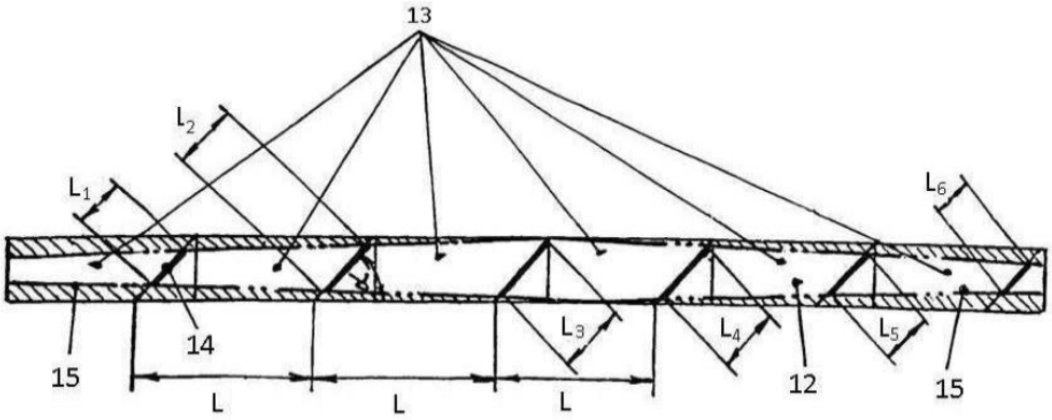

Figure 7: Strip with marked fold lines is called trimming lines.

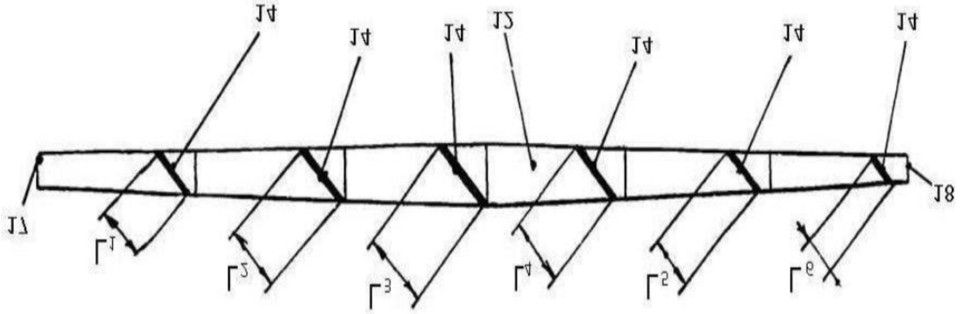

Figure 8: A strip after trimming sections.

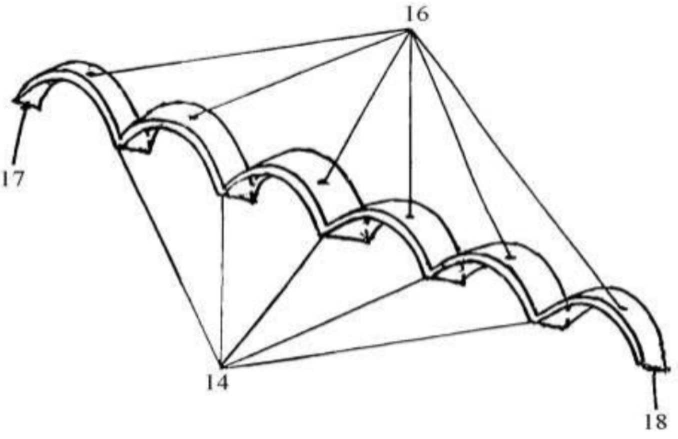

Figure 9: A strip bent along fold lines.

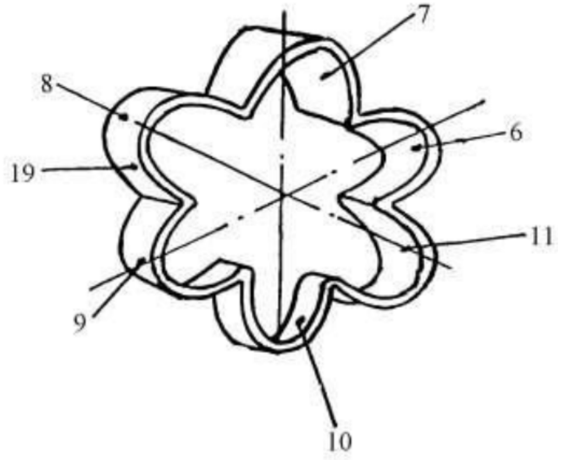

Figure 10: A strip folded into a ring of sections of a relative threaded drum.

RESULTS AND DISCUSSION

Thus, the relative toroidal-screw drum (Figure **3**-**10**) is manufactured in the form of a torus with a multi-threaded surface featuring thread lines and thread grooves inside the threaded relative drum, specifically, pockets of curvilinear shape at an angle to its longitudinal axis

Thus, the relative toroidal-screw drum (Figure **3**-**10**) is made in the shape of a torus in the form of a multi-start helical surface with helical lines and with helical grooves inside the relative torus screw drum, or rather curved pockets at an angle to its longitudinal axis.

Our research findings have indicated that the use of relative torus screw drums contributes to a notable enhancement in the efficiency and productivity of rotary screw technological systems. These screw drums, designed with unique inherent features, play a crucial role in optimizing specific technological procedures.

A torus screw drum is a specialized type of tooling utilized in rotary screw technological systems. The distinguishing characteristics of these drums, particularly their relative design, make them ideally suited for their function. They possess a specific design formation that allows for high efficiency and ease of use in various technological operations.

When these drums are used in certain technological processes, their influence is significantly observed in the increased effectiveness of the operation. The unique configuration of these drums, couple with their innovative features, enables operations to be executed more smoothly and swiftly, drastically improving their overall productivity.

As a general note, the efficiency of a technological process is a key determinant in its productivity level. Higher efficiency typically translates to faster operation completion and fewer resources consumed, which in turn contributes towards enhanced productivity. In light of this, our study has clearly demonstrated that the integration of relative torus screw drums into rotary screw technological systems significantly amplifies operational efficiency and consequently, the productivity of these systems as a whole.

The presented design solutions enable an enhancement in the efficiency of techno-logical operations in rotary-screw systems as follows. The optimized design of the toroidal screw drum, achieved through the use of various shapes and sizes of triangles in helical lines, helical surfaces, and the passage section of the toroidal screw drum, ensures geometric optimization. This contributes to a more efficient transfer of energy and mate-rials in rotary-screw systems, thereby increasing their productivity. The ability to alter the shape, side dimensions, and area of the passage section of the toroidal screw drum provides adaptability to different technological operations, enhancing the system's flexibility to effectively respond to various working conditions. Furthermore, the capability to experiment with different parameters offers a practical basis for selecting optimal settings in real operating conditions. In summary, the proposed design solutions aim to satisfy the requirements for improving the efficiency of technological operations in rotary-screw systems through the flexible adjustment of geometric parameters.

The designs of the proposed toroidal screw drums incorporate features that con-tribute to the enhanced performance of these systems. Specifically, the drum takes on a toroidal shape, ensuring even load distribution across its entire surface, thereby reducing wear and increasing the system's durability. The helical lines on the drum's surface are engineered to facilitate the efficient movement of material or working fluid. The toroidal shape of the drum and the optimal geometry of the helical lines reduce friction, improving the efficiency of energy transfer from the rotating element to the working medium. To enhance strength and resistance to wear, special high-strength materials such as alloys or polymers with reinforced structures are employed. The application of modern material processing technologies enables the creation of more precise and efficient drums. The designs of toroidal screw drums allow for the adjustment of parameters, such as the angle of the helical lines, depending on operational conditions. This flexibility enables the optimization of system performance in various modes. Finally, such drums can effectively mix materials or the working medium, expanding their application in various technological processes.

However, the implementation of toroidal screw drums may present several potential issues and/or limitations, warranting further research in this direction. Here are some possible aspects that could be considered in such studies. Implementing toroidal screws may face mechanical constraints, such as material strength requirements, the need for high precision in manufacturing, and complexities in installation. Depending on specific applications, toroidal screws might exhibit varying degrees of efficiency. Energy consumption requirements during the operation of toroidal screws could impact their economic viability and operational stability. The materials used may influence the durability and reliability of toroidal screws, making material property research crucial for optimizing their design. Technical aspects like control systems, monitoring, and maintenance could pose challenges in implementing toroidal screws. Research could encompass assessing ergonomics and safety in using toroidal screws to ensure their suitability for end-users. All these aspects could serve as the basis for further research aimed at gaining a more comprehensive understanding of the issues and potential improvements in implementing toroidal screw drums across various application domains.

When selecting the features of the construction of working chambers, numerous technical, economic, and environmental considerations and factors were taken into ac-count, aimed at enhancing the overall efficiency of the system. The efficiency of the sys-tem depends on the ability of the working chambers to effectively transfer heat. Improved heat exchange methods and insulation reduce energy losses and increase overall efficiency. The choice of suitable materials for the working chambers affects their thermal conductivity, strength, and durability. Optimizing these parameters leads to an improvement in the efficiency of the system. Optimal sizes and shapes of the working chambers are chosen based on the needs of the process and efficiency requirements, including the optimization of the surface area for heat exchange and the reduction of energy losses. The implementation of advanced control and management systems in the working chambers allows for more precise regulation of processes, contributing to efficiency optimization and energy consumption reduction. Working chambers are designed with environmental aspects in mind, such as reducing emissions, increasing energy efficiency, and minimizing the impact on the environment. Considering the rapid pace of technological development, working chambers are designed to be compatible with innovative methods and technologies, contributing to their long-term efficiency.

The proposed design solutions can be adapted to optimize various industrial processes beyond the final processing of components. For instance, they can be applied in the energy sector or in the production of fuel briquettes; in thermal processing of materials such as annealing metals and other heat-related processes; in the chemical industry for conducting chemical reactions and crystallization; in glass manufacturing, where strictly defined conditions are necessary for the formation and processing of glassy materials; in the production of ceramic materials, where specific thermal regimes are crucial for firing and shaping; during the processing of composite materials with controlled thermal processes.

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