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Bases of Increasing Operational Characteristics of the Equipment for Cement Production

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Abstract To reduce the size and weight, increase productivity, simplify operation, reduce energy consumption in the cement production, the body is screwed and mounted horizontally. The technical solutions protected by patents of the Russian Federation are offered. Designs of body of the rotating furnaces, which, in comparison with known designs of similar purpose, are executed screw with internal screw surfaces, are shown. Technologies of assembly of screw bodies for single and serial production are offered. Over the past ten years, we have not only proposed design solutions to solve this problem, but also offered the opportunity to implement them into production. The development of technology of assembly of the screw body of rotary screw systems is presented in the article. Studies aimed to optimize the design parameters of the number of curved surfaces of the rotary kiln body are of particular scientific and practical importance. At the same time, the features of the proposed screw bodies include: (1) the area and shape of the cross-section of the screw bodies are different along the entire length from loading to unloading, which changes the speed and trajectory of the particles of the raw cement mass, expands the technological capabilities, increases productivity; (2) the design of the screw bodies allows providing for consistent discharge of raw cement mass particle flows during the transition from one section to the next as the flows move from the cold end of the furnace to the hot end, increase productivity and expand technological capabilities; (3) due to the mutually directed broken and smooth helical lines, the velocity vectors of the particles of the raw cement mass during transportation from loading to unloading change, which expands the technological capabilities; (4) along the inner perimeter of the screw bodies, broken or smooth screw surfaces are formed along their entire length, which provides a violation of the stationarity of the particle flows of the raw cement mass, increasing productivity and expanding technological capabilities.

Keywords Screw Body, Screw Surfaces, Cement Clinker Granules

1. Introduction

In the production of building materials (cement), technologies and equipment are used, in which cylindrical

bodies are used as working bodies and are inclined towards unloading, which ensures the movement of building materials. The consequence of this is as follows: significant energy costs due to large dimensions, losses in the process of heat exchange and execution of the process, limited technological capabilities, complexity of operation and a large mass of equipment [24, 25]. The development and implementation of technologies and equipment can serve as the elimination of these shortcomings, which will be used as working bodies the original design of screw bodies with a horizontal axis of rotation, which will reduce energy costs, improve technical and economic performance. For example, in the technology of cement production, when firing the particles of the raw mixture, rotary kilns are used, the product of which is the granules of cement clinker

In industry, rotary kilns with a cylindrical body that rotates slowly (0.4–1.2 revs/min) are widely used. In the process of preparation of cement clinker using rotary kilns, there is a feature of transportation of the raw mixture, which is carried out by creating a slope of the body from loading to unloading. The consequence of this is as follows: large dimensions (4.5 m×170m; 5m×185m; 5.6 m×185m), significant energy costs, losses during heat exchange, limited technological capabilities and operation, large weight [1].

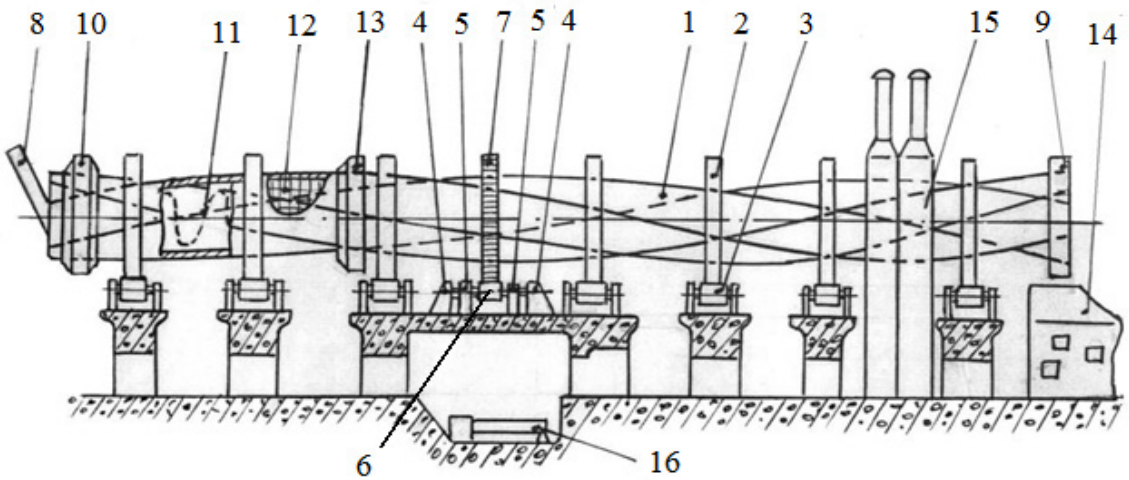
We found design proposals to solve this problem [2-10]. This is the development and implementation of cement production equipment based on screw bodies. Therefore, their research and creation of manufacturing technology, clarification of their design features is a timely and relevant task.

2. Methods and Materials

Known designs of rotary kilns for cement production are tilted to the horizon to ensure the movement of sludge from loading to unloading. In this regard, such furnaces are characterized by large dimensions in length, complexity of operation, low productivity [1].

To overcome these shortcomings, it is proposed to produce rotary kiln body screw, which allows them to be placed horizontally, and thus simplify maintenance and increase productivity.

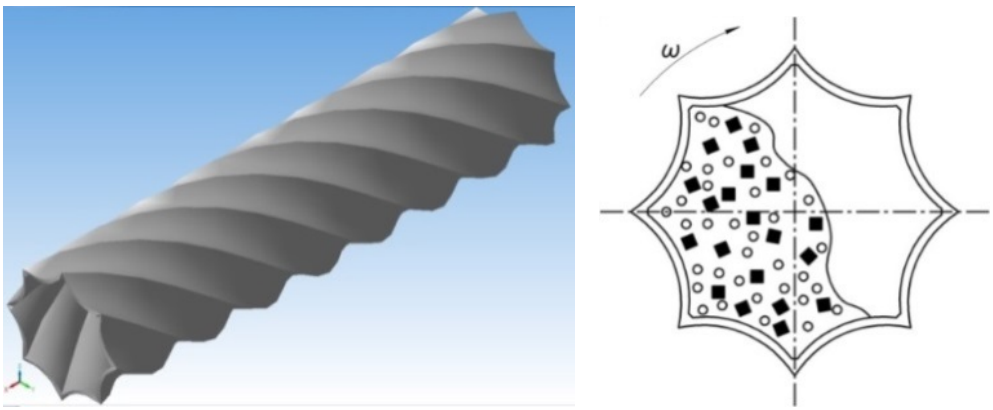
For example, figure 1 shows one of the proposed designs of a rotary kiln with a horizontal axis of rotation of the screw body, the novelty of which is confirmed by patents of the Russian Federation for inventions [2-10]. Therefore, the development of technology for the manufacture of screw bodies and optimization of their design parameters is a timely, relevant task and allows planning and implementing an innovative way of cement production development, reducing energy costs, improving technical and economic indicators [10-23].



(1– screw body; 2 – bandages; 3 – support rollers; 4 – electric engines; 5 – two reduction gears; 6 – two under rim gears; 7 – rim wheel; 8 – substantial pipe, 9 – head for fuel and air supply; 10 – heating; 11 – screen; 12 – heat exchanger;13 – reloader; 14 – freezer; 15 – water cooling;16 – unit for lubrication).

Figure 1. Rotary kiln for cement clinker preparation with screw body:

a)



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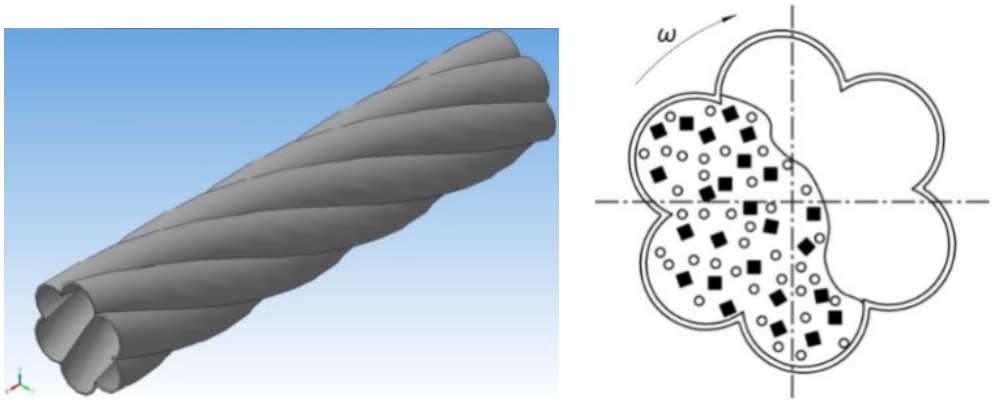

Figure 2. Visual images and cross-section of the screw body *1* of the rotary kiln with the centers of curvature located:(a) –outside of the screw body *1*; b) – inside the screw body *1)*

3. Results and Discussion

To create the spatial forms of the screw bodies of rotary kilns, the program complex "Compass-3D" was used.

Let us model screw bodies. We show their visual images and their cross sections in (figure 2).

Let us consider the cross sections of the screw body of a rotary kiln with a different number of screw edges (lines) along the perimeter of the body at the same radii of curvature of the screw surfaces:

1) with three screw edges (figure 3);

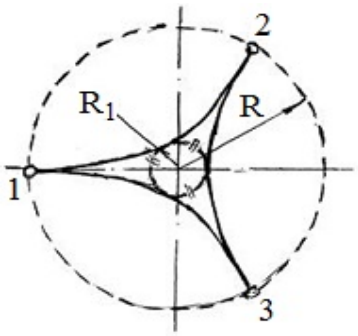

Figure 3. The rotary furnace body in cross-section with three screw edges

2) with four screw edges (figure 4);

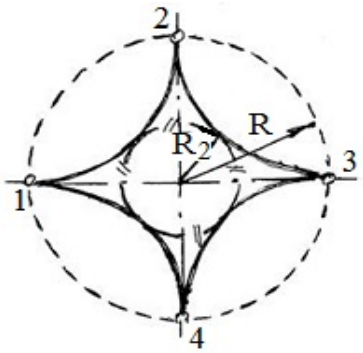

Figure 4. The rotary furnace body in cross-section with four screw edges

3) with five screw edges (figure 5);

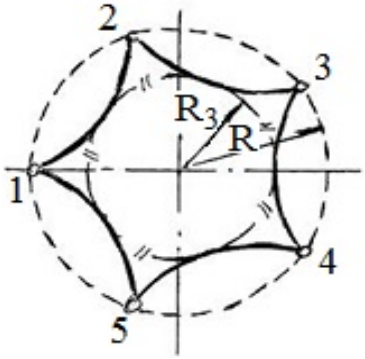

Figure 5. The rotary furnace body in cross-section with five screw edges

4) the rotary furnace body in cross-section with six screw edges (figure 6).

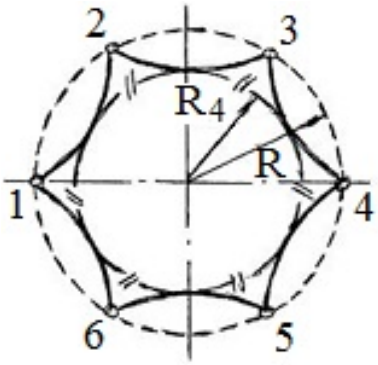

Figure 6. The rotary furnace body in cross-section with six screw edges

As a result of the simplest mathematical calculations, we obtain:

$$i_1 = \frac{S_1}{S} = \frac{R_1}{R} = 0{,}1; \quad (1)$$

$$i_2 = \frac{S_2}{S} = \frac{R_2}{R} = 0{,}386; \quad (2)$$

$$i_3 = \frac{S_3}{S} = \frac{R_3}{R} = 0{,}64; \quad (3)$$

$$i_4 = \frac{S_4}{S} = \frac{R_4}{R} = 0{,}73; \quad (4)$$

Therefore:

$$S_1 < S_2 < S_3 < S_4 < S, \quad (5)$$

where S – circular flow section of the cylindrical body of the rotary kiln; R– the radius of the circular flow section of the cylindrical body of the rotary kiln; R_1, R_2, R_3, R_4 – the radius of the flow section of screw bodies

The dependence scheme of the area on the number of screw edges of the screw body.

According to the research results, to optimize the design parameters, the number of curved surfaces of the furnace body should be more than n>6 and the width of the screw surface should be more than 400 mm (figure 7).

Figure 7. The dependence scheme of the area on the number of screw edges of the screw body

To implement the results of the research, the technologies of assembly of screw bodies are proposed:

- manual assembly for single production:

The body of the rotary kiln is mounted from individual flat elements in the form of, for example, triangles, and trapezoids. These flat elements are made, such as thread and stamping. In the body of the rotary kiln flat elements are mounted with each other by welding. Before connection on flat elements bevels are carried out.

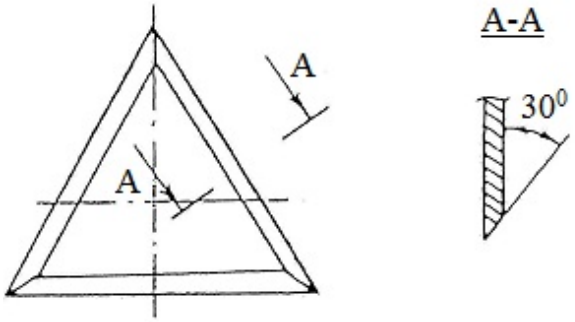

Figure 8. Flat elements with bevels

Figure 8 shows, for example, the bevels of a triangular element – the body of a rotary kiln for firing sludge for the preparation of cement clinker. Experience in the manufacture of furnace bodies showed that such treatment should be subjected to flat elements with a thickness of 3 mm or more.

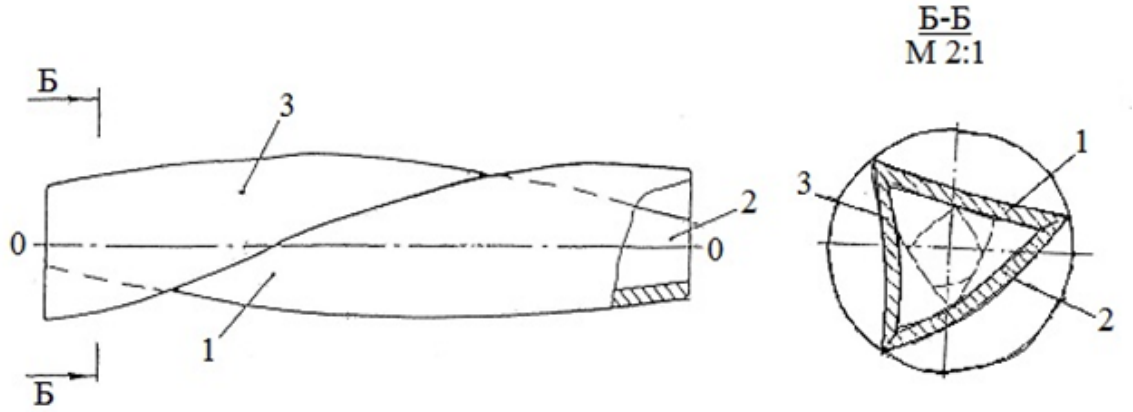

Figure 9. Screw body of the rotary kiln made of rolled strips, general view and section B-B

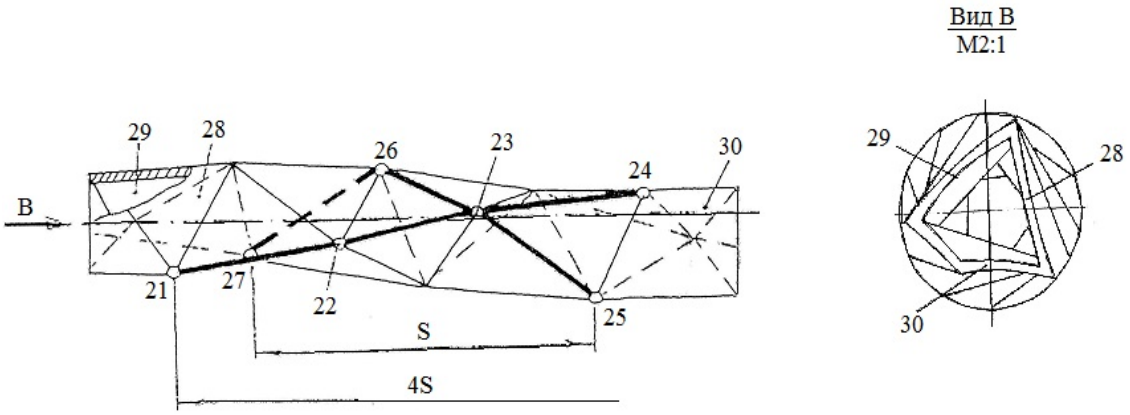

Figure 10. Screw furnace body, general view and view on the arrow B

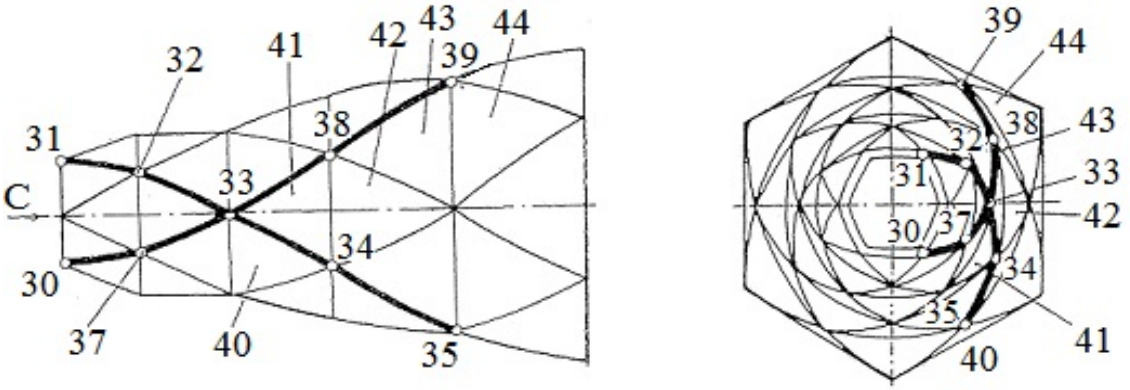

Figure 11. Rotary kiln screw body

- Mechanized assembly for a serial production:

Manufacturing and assembly technology in this way is shown in figure 9.

Figure 10 shows a mechanized assembly of the screw body, which has alternating faces in the form of equilateral triangles along the perimeter.

A sample of screw body is conventionally conical in shape with an increasing flow section is shown in figure 11. This design of the rotary kiln body ensures the stable movement of clinker granules from loading to unloading. The technology and assembly of such a body is shown in work [6].

Figure 11 shows the body of a rotary kiln for firing sludge in the preparation of cement clinker.

- Automated assembly for serial production:

Figure 12 shows a diagram of the automated assembly, with the formation of sections inclined at an angle to each other. The angle of inclination of sites to each other passes through top of an incision deepening.

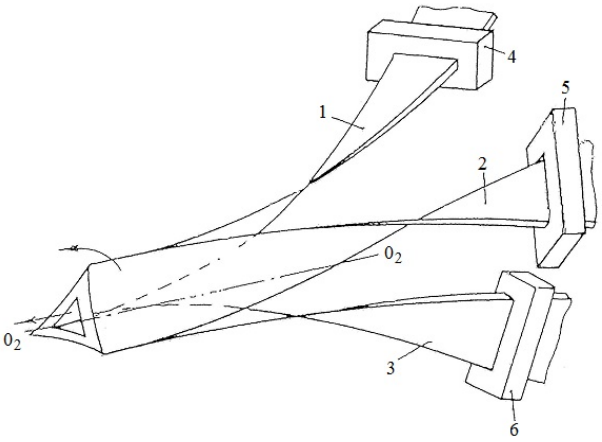

Figure 12. Scheme of automated assembly

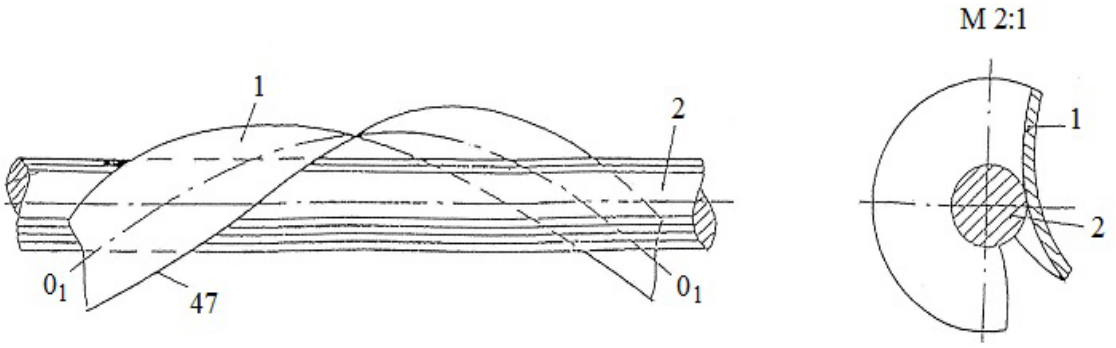

Figure 13. General view of the folding of one of the elements of the screw body

Figures 13-14 show the assembly technology of the body, made of three bands *1, 2, 3* of constant width, and figure 15-17 shows the manufacturing technology of the body from the trapezoidal bands.

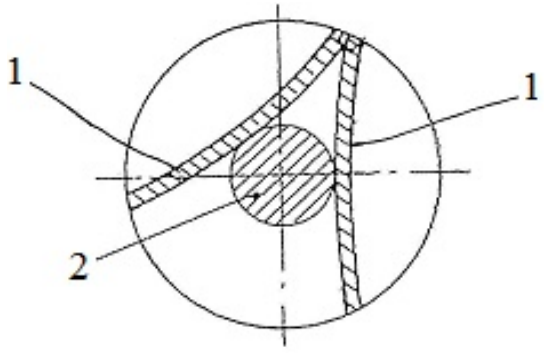

Figure 14. Scheme of connection of two bands

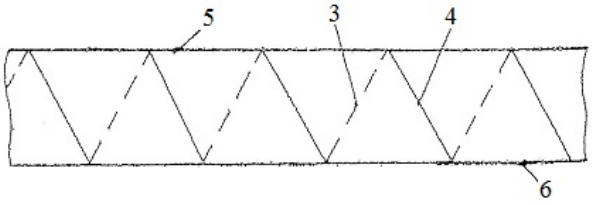

Figure 15. The scheme of the weakened zones of constant width bands from which the screw body of the rotating furnace is assembled

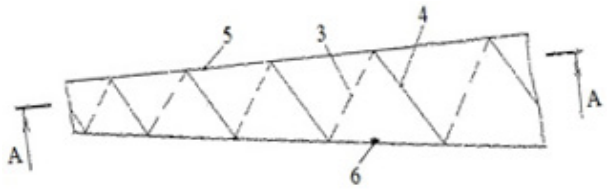

Figure 16. Scheme of weakened zones of trapezoidal bands, from which the screw body the rotary of kiln is assembled

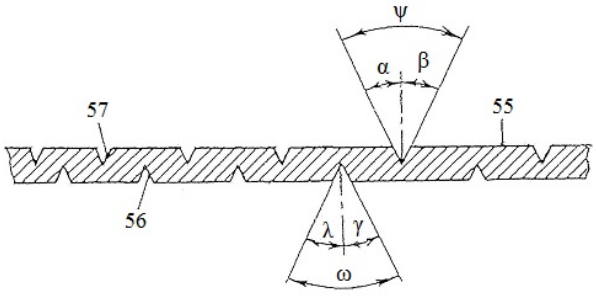

Figure 17. Section A-A in figure 16

After joining the edges of the bands (figure 14), you can join the edges of the notches, for example by welding (not shown).

The results of the research is that not only the technology of assembly of screw bodies for single and serial production is developed, but also work to optimize their design parameters is performed. The number of

curved surfaces of the screw body of the rotary kiln should be greater than n > 6, and the width of the screw surface more than 400 mm.

It should be considered that the features of the proposed designs of the screw body include:

- along the inner perimeter of the screw bodies, broken or smooth screw surfaces are formed along their entire length, which provides a violation of the stationarity of the particle flows of the raw cement mass, increasing productivity and expanding technological capabilities.
- the design of the screw bodies allows for consistent rarefaction of raw cement mass particle flows during the transition from one section to the next as they move from the cold end of the furnace to the hot end, increase productivity and expand technological capabilities.

4. Conclusions

Results of researches of technological and theoretical bases of increase of operational characteristics of the equipment for cement production are presented.

The offered technologies and designs of the equipment are used due to application of screw bodies for preparation of cement clinker, which allows an increasing speed of rotation of the screw body of the rotating furnaces, and an increasing productivity and reducing dimensions of the rotating furnaces and their weight, reducing power inputs.

A method for constructing screw bodies of rotary kilns with the help of the software complex "Compass-3D" is proposed and tested.

Visual images of screw bodies are shown, which provides an idea of their shapes and design features.

The technology of assembly of screw bodies for single and serial production is developed.

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