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INNOVATIVE TECHNOLOGY OF LARGE-SIZE PRODUCTS MANUFACTURE

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Advantages and prospects for the use of mobile robotic machine-tools in the manufacture of large parts in the mining, cement and nuclear industries are considered, as well as the importance of using welded structures to reduce production costs. Schemes for finishing mechanical machining of welded large-sized parts such as bodies of revolution with the use of mobile robotic machine-tools equipped with a belt-grinding tool, an enlarged description of the technological process for manufacturing a large-sized shell of a welded structure are presented. The conclusion is made that it is necessary to take into consideration the use in the industry of frameless production technology, especially for the machining of large-sized parts, and the use of small mobile robotic machine-tools is a productive approach and has a prospective character. The technological approaches proposed in the article make it possible to remove the restriction on the overall size and mass of the parts being manufactured, which are proposed to be manufactured directly at the site of future operation. The effectiveness of this technology is confirmed both by theoretical research and by practical data of the authors. It was noted that the production by the domestic machine-tool industry of mobile universal and special robotic machine-tools will allow the country's engineering industry to be brought to a new, high-quality world level.

Key words: mobile robotic machine-tool, large parts, belt grinding, welded structures, frameless technology, heavy engineering

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Introduction. The use in the mining, nuclear industry and industry of building materials of large-sized technological units is associated with significant costs both at the stages of the formation of production and the operation of the equipment used. Development of optimal production technologies and methods for restoring worn parts is a topical issue of heavy engineering [1, 3, 5-7]. In [4, 11, 13], the features of the technology of reductive machining of large-sized parts, the mass of which exceeds 60000 kg, and the size – 6000 mm were considered. A theory has been created that makes it possible to expand the possibilities of using small machines for processing large-sized parts.

Task decription. The article proposes to extend the practical results achieved earlier, completely to the whole technology of production of large-sized parts, including zero operations. This possibility can be realized provided a new generation of metalworking equipment is created – mobile robotic machine-tools. The creation of robotic machine-tools [14] allows to significantly expand the technological arms of enterprises, including mining and nuclear engineering enterprises.

The cost of manufacturing large-sized parts is substantially related to the costs incurred by the manufacturing enterprise when acquiring and operating its fixed assets and equipment. As a rule, when manufacturing large-sized machine components, unique machines are used that occupy huge production areas. To move parts in such shops, powerful lifting mechanisms are used. All this leaves its imprint on the requirements for the construction of the shop building, the construction of its foundation, bearing supports and ceilings, and consequently, the cost of these buildings.

Many large-sized parts, such as rotary kiln rings or crown gears, can not be transported to the place of operation as a whole, so they are constructed to be demountable, and the laboriousness of their subsequent assembly is significantly increased due to the appearance of significant deformations due to stress relaxation that have to be eliminated on place of assembly. For other parts, such as the hulls of nuclear reactors, which, according to known requirements, should be delivered immediately in a general form, since it is impossible to ensure the required quality of their welded seams outside the factory conditions, there are objective limitations in overall dimensions.

Methodology. There is a solution that will allow to abandon the use of unique equipment in the production of virtually any large-sized details such as the body of rotation, including details such as rings, shells and cogwheels. The solution is to manufacture such parts on the customer's premises using mobile equipment and frameless technology. In a number of cases, this equipment can completely replace the unique equipment of the workshops of heavy engineering, which will also lead to the economic advantages of the new production.

Undoubtedly, the currently used machining technologies for restoring worn and damaged working surfaces of large-sized parts remain far from perfect, since they are associated with a significant share of manual labor in setting up and adjusting the equipment used and, as a consequence, with a high degree of risk to workers' health, low labor productivity and long idle times of recovered technological equipment. After some improvement, these technologies are able not only to raise the quality of repairs performed to a new level, but also become applicable as the main methods of machining in the production of large-sized products. The use of robotic machine-tools is designed to solve these problems.

Depending on the specific task to be solved, the kind of part or surface to be manufactured, a number of requirements defining the technical characteristics of the mobile robotic machine-tool used should be formulated. For the robotic machine-tool designed for machining the rolling surfaces of the rotary kilns, the requirements will be as follows:

1. The mobile robotic machine-tool must provide the required accuracy of shaping, i.e. trajectory of motion of the executive organs of the machine-tool, performing the cutting processes, must be program-controlled [13, 14]. Robotic machine-tool must work in a wide range of temperatures, taking into account the length of the treated surfaces, wear of the cutting tool, the appearance of errors associated with the basing of the workpiece and the robotic machine-tool itself, as well as the errors in the shape of the initial surface of the bandage. All these factors the robotic machine-tools should be able to measure and take into account in the course of work in order to correctly adjust the trajectories of movement of their working bodies to provide the specified shapes of the treated surfaces of the bands.

2. The mobile robotic machine-toolbox must have a mass and overall dimensions, which, on the one hand, provide high strength, stiffness and vibration resistance, and on the other hand transportability on the roads and railways, excluding the cases where special permit is demanded, where complicated assembly operations and vehicle tracking by the traffic police needed. So, for example, the permissible vehicle width according to the regulations is 2.5 m, the length is 20 m for a road train or 12 m for a truck.

3. The mobile robotic machine-toolbox should provide for rapid deployment to the working position and at least prompt translation into the transport position. Consequently, these processes must be mechanized and automated.

4. The mobile robotic machine-toolbox shall be applicable both for the machining of new bands during their manufacture and for the processing of worn tires, dismantled from a cement kiln or without dismantling.

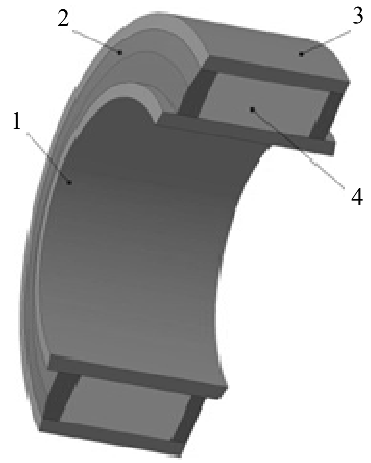

Fig.1. Welded construction of a welded hollow-filled bandage design for a rotary kiln
1 – inner ring; 2 – lateral ring; 3 – outer ring; 4 – concrete filler

Discussion. An important aspect of the new technology is the complete refuse of casting methods for the production of blanks for large-sized parts and the transition to welded structures [4]. This technology involves the preparation and cutting of sheet or strip rolled, its bending, welding and subsequent artificial aging. Examples of the design of welded parts are shown in Fig.1.

The technology proposed [4] allows after the assembly of the product to dispense with roughing methods of machining sur-

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faces and immediately proceed to finishing methods. It has been proposed in [2, 8-10, 12] to use grinding for machining large-sized parts and to give recommendations for optimizing this process. However, in [11] it was shown that the optimal method of finishing surfaces of large-sized rotating parts is centreless grinding with an abrasive belt in the transverse direction of the main movement of the cutting tool.

The applied cutting tool, in turn, imposes its own requirements on the design of mobile robotic machine-tools. In contrast, for example, from a lathe chisel, whose contact with the treated surface can be considered as a point, the abrasive belt interacts with the surface of the part over a large area, the shape of which depends on the shape of the cutting part of the abrasive belt (straight line, plane, cylinder). In this case, the working organ of the robotic machine-tool is affected by a complex set of transverse moments.

The design of the mobile robotic machine-tool developed by the authors makes it possible to perform mechanical processing of tires and shells both on the outer surface and on the inside as well as on the ends. And the scheme of basing of a processed detail can be both classical, on an end and an aperture (Fig.2), and centerless (Fig.3). Regardless of the baseline used, the mobile robotic machine-tool must provide the required accuracy of shaping.

The kinematic scheme of the robotic machine-tool (Fig.4) for grinding the bandages is a sequential structure providing not only the optimal access of the working organ to the machined surfaces, but also the necessary mobility, which, due to the movement of the robotic machine-tool links, compensates for the uncertainty of the base of the workpiece, the robotic machine-tool itself and other errors, changing dynamically. The use of parallel structure mechanisms in the developed robotic machine-tool is allowed to increase the rigidity of the structure, but imposes certain restrictions on the values of adjusting and compensating movements.

The possibility of using mobile robotic machine-tools for machining the surfaces of long shells and shells of nuclear reactors is promising. In this case, in fact, the machining

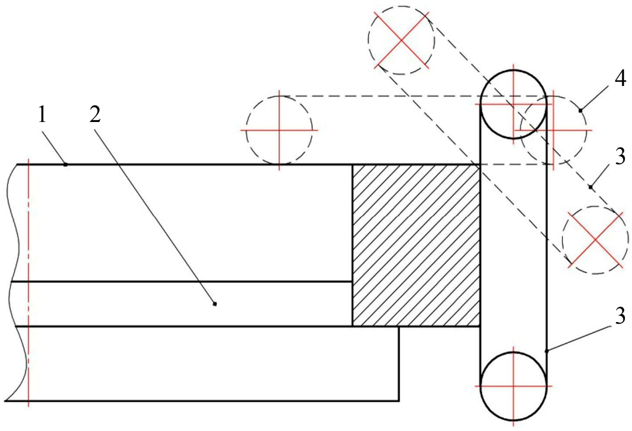

Fig.2. Belt grinding scheme when basing a bandage on a foundation or a special stand

1 – bandage; 2 – foundation or special stand; 3, 4, 5 – the location of the tool when grinding the butt, chamfer and the rolling surface of the band respectively

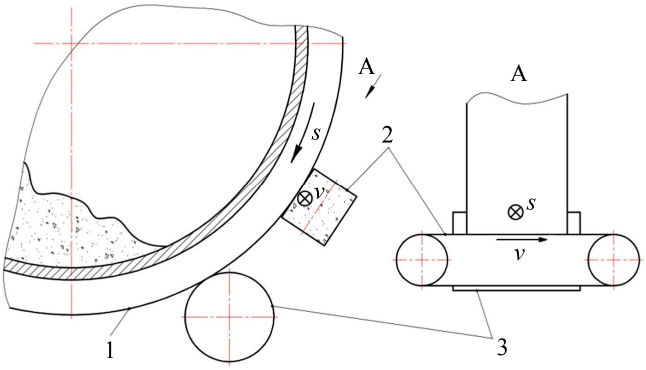

Fig.3. Scheme of band grinding of the bandage on a rotating furnace

1 – bandage; 2 – cutting tool; 3 – supporting roller

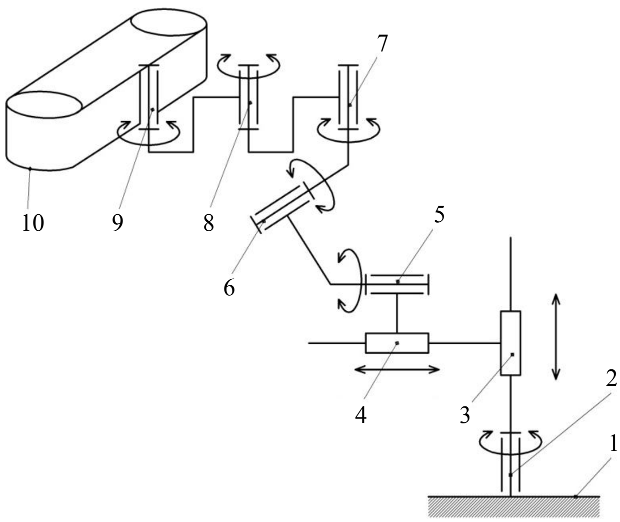

Fig.4. Kinematic diagram of the mobile robotic machine-tool for grinding the rolling surfaces of bandages rotating aggregates

1 – the rack; 2 – drive of rotary adjusting displacements; 3 – drive of vertical locating displacements; 4 – drive of radial adjusting displacements; 5 – tool for tilting the tool in the transverse plane; 6 – tool tilt drive in the longitudinal plane; 7-9 – Drives of adjusting movement tool; 10 – machine tool grinder

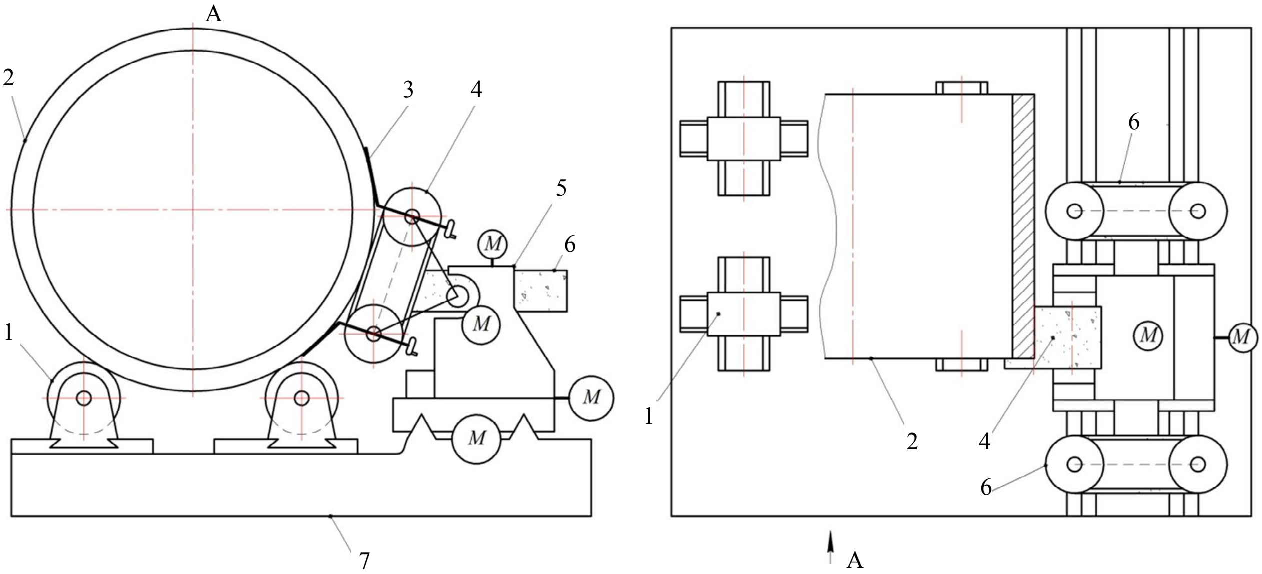

Fig.5. Application scheme of the robotic machine-tool for grinding shells and cases
1 – adjustable support with a roller; 2 – shell; 3 – control bodies of uncertainty of basing; 4 – grinding tool for the outer surface; 5 – support; 6 – grinding tools for face surfaces; 7 – mobile platform

schemes (Fig.5) differ little from the treatment schemes for bandages. The difference lies only in the length of the surfaces to be treated and the need for additional equipment that allows mechanical processing of internal surfaces at different depths or external step surfaces.

Thus, the technology of production of shells for large-size aggregates can be reduced to the following points:

- cutting the workpiece from sheet (strip) rolled, cutting edges;
- bending the workpiece on a heated roll;
- installation of spacers and welding of the closed edges of the workpiece into a ring;
- artificial aging of the shell;
- installation of the shell in the adaptation with alignment;
- belt grinding of external, if necessary internal and face surfaces of the shell to give the specified parameters of accuracy and quality.

To reduce the cost of large-sized products and their parts, the most rational solution is to transfer the production process to the consumer, i.e. on the territory of the enterprise using these large-sized products in its production cycle. As a material for the preparation of their blanks, sheet or strip steel, which can be subjected to bending on rollers, is best suited. The manufacturability of rolled metal is the reason for completely abandoning the processes of casting, for the organization of which significant volumes of fixed assets are required.

Thermal processing of the welded shell can be performed on an installation including mobile gas or microwave heaters and a protective dome. The conditions created in such an improvised furnace will be sufficient to heat the product to a temperature of 650-700 °C and slow cooling.

All equipment necessary for the implementation of this technology must be mobile. The rollers, dome oven, belt-grinding robotic machine-toolbox should be easily mounted and dismantled, and in the transport position it should fit into the overall dimensions of the vehicle. Rolling for the manufacture of blanks can be cut in advance and delivered to the assembly site in a prepared form.

The result of the introduction of such a mobile system will be a significant reduction in capital costs for the acquisition and maintenance of heavy machine tools, furnace and other technological and auxiliary equipment, the construction of unique shop buildings, transportation of oversized products. In addition, the manufacture of shells at the site of operation will significantly reduce the risk of deformation associated with transportation and handling.

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The universality of the proposed technology can promote its spread to other industries, and the productivity of work will lead to a significant reduction in the timing of the implementation of new technology projects.

Conclusion

1. A large volume of theoretical studies, multiple industrial approbations and inventions developed and implemented by the authors showed that the new paradigm of technological concepts related to machining large-sized parts with the help of small machine tools is productive and promising.
2. The new technology allows you to remove the restriction on the overall dimensions and weight of the parts produced.
3. The high technological and economic efficiency of the proposed technology is confirmed by practice.
4. The mastering of mobile universal and special machine tools by the machine tool industry will allow us to bring the machine-building industry of our country to a new, high-quality world level.

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