Simulation of the electron beam welding process of a bimetallic ring by means of ANSYS

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Abstract. The article is devoted to modeling the process of electron beam welding in the manufacture of electric motors with a bimetallic ring used in biofuel preparation reactors. The main problem at the current stage of production is the choice of the technological mode of welding and the repeatability of the result. In this work, the authors simulate the welding of electric motors with a bimetallic ring under various technological modes in the ANSYS simulation environment in the process of electron beam welding. The result of the work will be a graphical representation of the temperature distribution on the surface of the product at various values of the technological parameters (electron beam current, welding speed and welding process time). Today, the choice of modes for a new technological process is carried out experimentally, which entails high material costs. The approach proposed by the authors allows, with minimal time and material costs, to select a technological mode for welding products from new alloys.

1. Introduction
Today, a lot of research is being carried out in the ANSYS simulation environment. In work [1], the authors simulate the process of electron beam welding (EBW) for titanium alloy in order to find the optimal mode.

The authors of [2] are developing a model of energy distribution when the electron beam is introduced during welding. The subject of research is the process of connecting electric motors with a bimetallic ring. Such engines are widely used in biofuel preparation reactors [3, 4]. In [5], the authors consider the magnetic field required to initiate and maintain the discharge, which is created by a permanent magnet placed in the discharge chamber. Also, the authors in the study calculated the configuration and strength of the magnetic field in the regions of generation, acceleration and transport of electrons in the electron-optical system of the plasma source of electrons. Tynchenko V.S. et al. [6] simulated the process of electron-beam welding of a simulator sample made of two materials: titanium alloy and aluminum alloy, at different values of the beam current in the COMSOL environment. As a result, the authors obtained the temperature distribution in the weld zone of the product at different values of the beam current, which made it possible to compare with the results of field experiments and then apply this method to search for technological parameters when welding products from new alloys.
In work [7], the authors developed a model of beam input in electron beam welding and simulated heating of a product (made of VT14 and AMg6 alloys) at the joint of the weld. In the course of the study, the method proposed by the authors has proven itself and has shown its applicability. In addition, a number of authors investigated the possibilities of both predicting the microstructural evolution of the weld [8] and the parameters of the EBW process [9, 10], and optimizing the geometry of products [11]. However, in the above works, there are no studies of the EBW process for bimetallic structures, which confirms the relevance of this work.

2. Materials and methods

The ANSYS Academic Student system is widely used in the study of physical processes in technology. Such a system is widely used all over the world both for modeling electromagnetic fields and for modeling thermal processes.

ANSYS Discovery AIM is a software product for solving engineering problems from various fields of physics with the ability to customize workflows.

ANSYS Discovery AIM has advanced functionality for performing interdisciplinary calculations in a single graphics window, creating, editing and correcting 3D geometry, as well as investigating structures and products in a wide range of parameters.

ANSYS Discovery solutions are primarily intended for designers. Discovery Live enables rapid assessment of results with low loss of accuracy early in the design phase. The designer can quickly check his idea and choose the most suitable type of design from the many options available. Discovery Live delivers high quality results. An example of work is shown in figure 1.

In ANSYS Discovery AIM, the technician makes a final selection from the available set of design points that he obtained in Discovery Live, and verifies the results. Accuracy is key at this stage. These two components form the basis of the innovative ANSYS Discovery software package, which is based on the direct modeler ANSYS SpaceClaim, which, due to its flexibility, allows you to easily and quickly change the geometry of the structure. Further, the only selected design option, which was obtained at
the design stage, is transferred directly to the design department, where an in-depth analysis of the design is carried out using the flagship ANSYS products, all defects are identified and final adjustments are made. In this case, the priority is given to the high accuracy of the calculation.

ANSYS software product provides the following functionality:

- Analysis of strength, vibration and durability.
- Thermal analysis.
- Hydrogasdynamics.
- Low frequency electromagnetism.
- Multiphysics.
- Automation and revision.
- Optimization.
- Creation of geometric models and construction of meshes.
- High performance computing.
- Post-processing.

Thus, using a modern development tool, the authors will develop a new approach to search for welding modes in order to obtain a stable weld quality and repeatability.

3. Result and discussion

Let us carry out simulation modeling using ANSYS CAD for welding an electric motor with a bimetallic ring in electron beam welding. To do this, first we will make a drawing of the product in the KOMPAS-3D software product. Figure 2 shows a drawing of a part for which welding is performed. By changing the technological parameters (electron beam current, welding speed) and the time of the welding process, we obtain the temperature distribution on the product surface which is shown in figure 3.

**Figure 2.** Drawing of an electric motor with a bimetallic ring.
Figure 3. Temperature distribution during heating of an electric motor made of bimetallic alloy and various technological parameters, where: a – beam current is 50mA, welding speed is 4 cm per sec; b – beam current is 70mA, welding speed is 9 cm per sec.

As can be seen from Figure 3 (b), with an increase in the beam current and welding speed, the maximum temperature on the surface of the product increases, while the product itself in the zone distant from the weld seam heats up much faster, which confirms the increase in the minimum temperature. Figure 3 (a) shows the simulation with the worked out technological parameters, while the temperature
of the product is close to melting and the energy distribution itself is more uniform, which indicates the applicability of this approach to the development of new technological processes.

4. Conclusion
The article develops an alternative approach to search for technological modes in electron beam welding. In the course of the study, the authors carried out a simulation of a rotor with a bimetallic ring. As a result, by changing such values as: beam current and welding speed, the temperature distribution on the surface of the product in the process of electron beam welding was obtained, which showed that it is possible to work out a new technological process using simulation.

The proposed approach can be applied in electron beam welding of elements of biofuel reactors to increase the reliability of their operation by increasing the corrosion resistance at the joints.

Acknowledgments
The study was funded by a subsidy from the Ministry of Science and Higher Education of the Russian Federation for the creation of a youth laboratory “Laboratory of Biofuel Compositions” as part of a government assignment.

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