Project aims

The aim of the project is to conduct basic, process and material research as well as to understand the mechanism of the formation and prevention of defects in the surfaces of castings. These defects are related to the kinetics of gas generation resulting from the thermal destruction of organic components of the binders used in molding and core sands. The Authors of the project will develop methods of preventing such defects by applying conformal (gradient) cooling of sand molds made with the incremental method. The other important aim of the project is to conduct research on the recycling of materials used in the additive manufacturing process of ceramic molds and cores using the binder jetting method. The current state of the art in the field of material and process engineering needs to be developed and additive technologies for the production of high-quality, defect-free cast components, especially those characterized by complex shapes and the required high dimensional accuracy, ought to be applied. This generates the need to conduct detailed research aimed at gaining a deeper understanding of the phenomena related to the process of forming the microstructure of the surface of castings, the possibility of using conformal cooling channels inside sand molds, increasing the autonomous ability of sand molds to absorb the heat of crystallization and cool the casting, and the possibility of reducing zone temperature at the molding sand/casting interface. The planned research will also take into account the aspect of recycling the matrix used in the production of molds and cores using incremental methods.

Description of research

As part of the project, the elements related to the sand mold, which are key from the perspective of surface formation, including the recycling of the used matrix and the reuse of the reclaimed material for the production of molds and cores using the additive method, will be subject to detailed analysis. The main research component will include:

- Determination of the amount and emission rate of gaseous products of thermal destruction released from the sand prepared on the fresh and reclaimed sand matrix, depending on the parameters of the conformal cooling system (temperature, time and intensity of extracted gaseous products).
- Comparative analysis of the influence of the type and composition of the molding sand on the surface condition of test castings under natural conditions and obtained with conformal cooling of the test casting microstructure.
- Research on the impact of process parameters of the mechanical, thermal, wet, mechanical-cryogenic and combined regeneration processes on the quality of the reclaimed matrix from used sand with an organic binder and its reuse in the process of additive manufacturing of sand molds and cores.
- Determination of the influence of material parameters of the reclaimed fine-grained matrix on the additive manufacturing process (grain size, shape, density).

Reasons for undertaking the proposed research topic

The projected development of additive technologies, also in the field of applying the technology of manufacturing complex-shaped cast components, made in ceramic molds produced using 3D printing, will soon result in the conversion of 3D printing technology from Rapid Prototyping to Rapid Manufacturing. The analysis of the literature on the subject indicates the importance and purposefulness of the proposed research, the results of which may contribute to the successful use of the discussed technologies in the serial production process. The existing laboratory facilities and their expansion planned for the implementation of the project are certain to make the positive effects of the project implementation more feasible.

Expected results

The expected result of the project implementation will be developing the basics of the theoretical knowledge and understanding of the formation and prevention mechanisms of defects in the surfaces of castings related to the kinetics of gas generation resulting from the thermal destruction of organic components of the binders used in molding and core sands, including the use of conformal cooling of sand molds made incrementally. An important element of the conducted works will be the development of theoretical foundations for the recycling process and reuse of waste materials generated in the process of additive manufacturing of casting molds using the binder jetting method. The knowledge gained will concern both the process and material aspects of this technology.

The expected result of the project, in addition to expanding scientific knowledge, will also be gaining the know-how, which, in principle, will result in the possibility of submitting an application in the TANGO (or other similar) program for the development and implementation of a proprietary solution of a device for additive manufacturing of ceramic molds and cores in the binder-jetting technology with conformal cooling channels with the possibility of using reclaimed material. The previous experience of the project team, evidenced by numerous implementations of research results in the industry, as well as the developed and implemented patents will allow the anticipated results of the project implementation to become a reality.