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ROZPRAWA DOKTORSKA

SYMULACJA KOMPUTEROWA PROCESU WYPEŁNIANIA WNĘKI FORMY W METODZIE LOST FOAM Z UWZGLĘDNIENIEM WPŁYWU ZGAZOWANIA MODELU I EWAKUACJI GAZÓW

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„Symulacja komputerowa procesu wypełniania wnęki formy w metodzie Lost Foam z uwzględnieniem wpływu zgazowania modelu i ewakuacji gazów”

Dissertation entitled "Computer simulation of the mold cavity filling process in the Lost Foam method consideration of impact of model gasification and gas evacuation", was carried out at the Department of Foundry Engineering, Faculty of Mechanical Engineering, Silesian University of Technology in Gliwice, as part of the 3rd edition of the Implementation Doctorate program. The work is devoted to research on acquisition and implementation of the necessary data in computer simulation software, in the simulation of filling the mold cavity using the Lost Foam method, taking into account the quantitative model gasification and gas evacuation.

The first part of the work is a literature review in which, based on available data, an analysis of the current state of knowledge in the field of full mold technology is presented, with particular emphasis on the Full Mold / Lost Foam process. Which is currently used at the Rafamet Foundry, where the industrial research of the implementation doctorate was carried out. The characteristics of the Full Mold method and a description of the phenomena occurring during pouring the molds in this method are presented. This influence the course of the mold filling process and depend primarily on the amount of gasification products of the disposable model and the permeability of the mold. These issues constitute essential knowledge in terms of computer simulation of Lost Foam / Full Mold pouring. Literature data and personal own experience regarding casting defects, resulting from the unfavorable impact of technological factors of the full mold method on the quality of castings, were also presented.

Based on the analysis of literature data and experience from the Rafamet Foundry, theses were formulated, and research objectives were set, which were focused on several areas. The first one was the development of a methodology for obtaining data for computer simulation in laboratory tests. The next step is the implementation and verification of the obtained laboratory data into the simulation program environment. The last research area was the validation of computer simulation based on laboratory, quasi-industrial and industrial experimental tests.

The materials, research methodology, obtained research and calculation results, their analysis and implementation potential, used of the work in research are presented in the following chapters, whereas the whole ends with a summary containing numerous detailed observations and the most important conclusions.

The materials used in simulation, laboratory and industrial tests were characterized in Chapter No. 5. This chapter include a description of the materials used for disposable models intended for testing on a prototype stand designed and built as part of the work for the quantitative assessment of gasification products of disposable models. Molding materials that

were used to make samples for laboratory tests and test molds in laboratory, quasi-industrial and industrial tests are also described.

Detailed methodology of laboratory, simulation, computation, and experimental research work is presented in Chapter 6. This chapter describes the designed and built prototype station for gasification of materials for disposable casting models, which was developed in order to obtain quantitative data on the pyrolysis products of disposable models. The methodology of laboratory and simulation tests of the permeability of molding sand is presented as a way to obtain the gas permeability value of molding sand, which is the basis for the implementation of mold data into the MagmaSoft simulation software. Additionally, this chapter contains a description of simulation tests for the unmodified Ruff castability test, based on which the influence of virtual process parameters and virtual mold properties on the flowability and cavity filling rate in the full mold method were determined. In addition, the methodology of experimental and simulation research was presented for the Ruff castability test. Test was modified for the purposes of this work, which was the basis for the validation of the computer simulation based on about the results of pouring test molds. The last part of the chapter presents the methodology for testing the influence of the ratio of the surface area to the volume of the model/casting on the process of filling the mold. The tests were carried out by making test castings with specially designed geometry in laboratory and quasi-industrial conditions. The process of filling the mold cavity for both types of test castings was also simulated. The comparative analysis of the results of real tests and simulations was the next stage of verification of the implemented data and modeling validation.

The results of simulation and experimental tests, together with a comparative analysis, are included in Chapter 7. This issue covers a comparison of the amount of gasification products of the tested materials determined based on the pressure value in the combustion chamber, the results of laboratory and simulation tests of permeability, a comparative analysis of filling the virtual cavity and the actual unmodified and modified form. Ruff’s castability test, and the results of research on the influence of the ratio of the surface area to the volume of the model/casting on the process of filling the mold, were carried out in laboratory and quasi-industrial conditions.

The high implementation potential of the data acquisition methodology for computer simulation of full-mold casting, developed on the basis of the conducted research, their verification and implementation in simulation programs has been proven.in chapter 8. The

chapter presents a comparative analysis of the results of industrial measurements of the process of filling the mold cavity, simulation of this process for data and “default” settings of the simulation program and simulation for the acquired data and implemented in accordance with the developed methodology. The comparison was made for four castings typical for the Rafamet Foundry, manufactured using the full mold method.

Chapters 9 and 10 contain a discussion of the results and observations and conclusions.