



# Numerical simulation of pouring and solidification of closed skeleton casting

M. Cholewa, M. Dziuba Kaluza\*

Foundry Department, Institute of Materials Engineering and Biomaterials, Faculty of Mechanical Engineering, Silesian University of Technology, 44 – 100 Gliwice, Towarowa 7, Poland

\* Corresponding author. E-mail address: maria.dziuba@polsl.pl

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## Abstract

In this work authors showed results of simulation manufacturing closed skeleton casting. The aim of conducted simulations was the choice of thermal and geometrical parameters for the needs of designed calculations of the skeleton castings and the estimation of the guidelines for the technology of manufacturing. During simulation effect at mould filling process for the skeleton casting was analyzed. Analysis of temperature distribution and analysis of solidification closed aluminium skeleton casting were conducted. It was confirmed that the metal is flows at the external surfaces and fills internal channels of skeleton, until the moment of overall filling of the mould. Whole casting is solidification in finish of pouring mould. It is advantageous by reasons of satisfactory mould filling. Part of casting which was connected with feeder, on upper surface of casting solidified the slowest. in consequence to the lowest heat give up.

**Keywords:** Skeleton castings, Simulation, AISi, Solidification

## 1. Introduction

Because of great possibilities for porous materials application in today industry [1÷6] it is advisable to find low-cost methods of its manufacturing.

Skeleton castings are the intermediate of solutions metal materials between the monolithic casting and metallic foam. Skeleton castings should compete with the other ones used [5,6] in the industry of porous materials.

The process of producing the skeleton casting mainly depends on the creation of the core that has designed geometry. The hypothetical process of creating such core was presented in the studies [9, 10]. Element of core geometry shown in the Fig. 1 was used to produce the experimental castings. The profitable features of this geometry are: perpendicularity of cell connectors, their circular sections and the simplicity of creating the core. Manufacturing of the casting according to given geometry, is connected with its application as a consequence with the selection of specific proportion between the section of the circular

connector and the cell dimension. Proposed geometry of the core enables liquid metal flow with minimal hydraulic resistance in order achieve the maximum capability of filling the space of the mould cavity in the same time preserving apparent density of the casting. Moreover, the skeleton having equal structure along tree main axes is profitable because of equal strength in all directions [7÷10].

Model of core presented in Fig. 2 based on cell (Fig. 1), which meets assumptions and was used in numerical simulation. This model of core enables manufacturing of:

- opened skeleton castings with discontinuous external surface (Fig. 3),
- closed skeleton castings with external surface of wall which close the internal skeleton (Fig. 4).

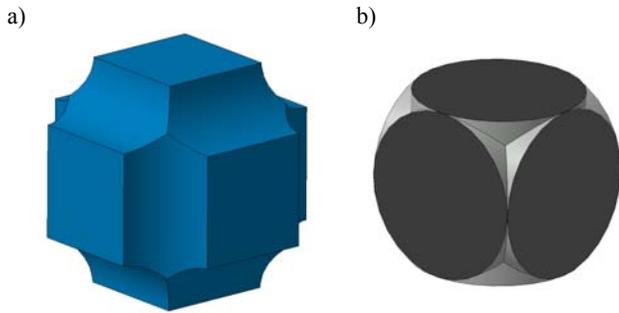


Fig. 1. Virtual model of: a) single element of core; b) node of metallic skeleton

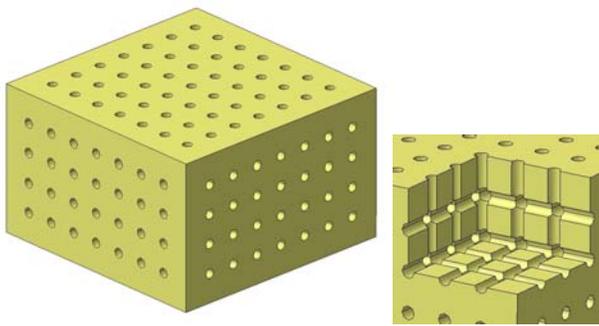


Fig. 2. Virtual model of core

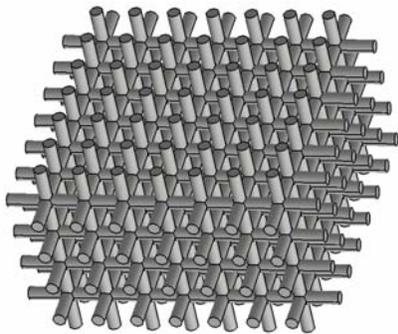


Fig. 3. Virtual model of opened skeleton casting

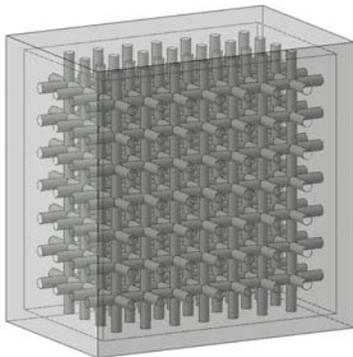


Fig. 4. Virtual model of closed skeleton casting

## 2. Numerical simulation

The simulation was conducted with use 'NovaFlow & Solid' software [14]. AlSi11 alloy was used for simulation tests. Its properties [14]:  $\lambda = 130 \text{ W/m}\cdot\text{K}$ ,  $c = 1190 \text{ J/kg}\cdot\text{K}$ ,  $\rho = 2500 \text{ kg/m}^3$  and crystallization heat:  $L = 389 \text{ kJ/kg}$

The chemical composition of AlSi11 alloy was presented in the Table 1.

Table 1.

The chemical composition of AlSi11

Add	Al	Si	Mg	Mn	Cu	Ni	Zn	Sn
Composition %	82,95	10,50	0,10	0,50	2,50	0,30	3,00	0,15

The typical properties of core and mould sands [7, 11, 13] were established. The temperature of pouring was  $740^{\circ}\text{C}$  and the temperature of the mould and the ceramic core was set to  $100^{\circ}\text{C}$ .

Antimony was used to improve the castability of the alloy. Antimony gives very high castability to the alloys without gassing it. The addition of Sb in the amount of 0,4 % mas was applied [7].

The shape of the model casting with its core and getting system were presented in Fig 2.

The simulation assumptions took into account manufacturing the casting of the bottom getting system.

The basic subject of computer simulation was the analysis of ability of filling the channels of core by liquid metal, analysis of temperature distribution and analysis of solidification closed aluminium skeleton casting.

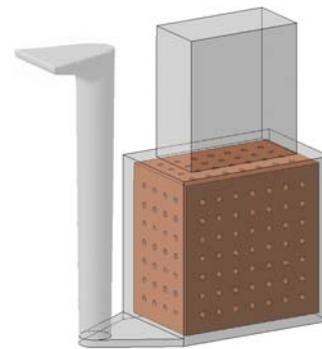


Fig. 5. The view of the model cast with its core and gating system

## 3. The results of numerical simulation

During simulation effect at mould filling process for the skeleton casting was analyzed.

During pouring moulds distribution of the temperatures was analyzed. In the beginning metal is flowing at the external surface of the skeleton casting (Fig 6a). The external surfaces are perpendicularly to ingate. First metal is filling the horizontally channels of a core, next filling perpendicularly channels of mould (Fig. 6b). Metal is flows at the external surfaces and fills internal

channels of skeleton (Fig. 6c), until the moment of overall filling of the mould (Fig 6d).

Presented graphs (Fig. 7) pouring mould show solidification in individually channels of a core and on external surface of wall which closed the skeleton (Fig. 7a, b, c). Whole casting is solidification in finish of pouring mould. It is advantageous by reasons of satisfactory mould filling. First solidification is in the external part of casting; next solidification is in the upper and middle part of skeleton casting. Wall which closed the skeleton solidified fastest. Central elements of skeleton was solidified slowest. Part of casting which was connected with feeder, on upper surface of casting solidified the slowest. in consequence to the lowest heat give up (Fig. 7d).

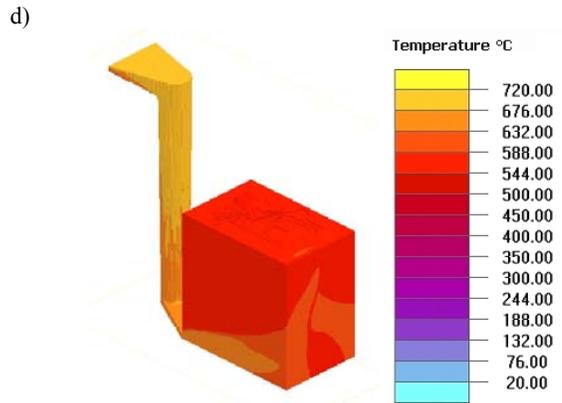
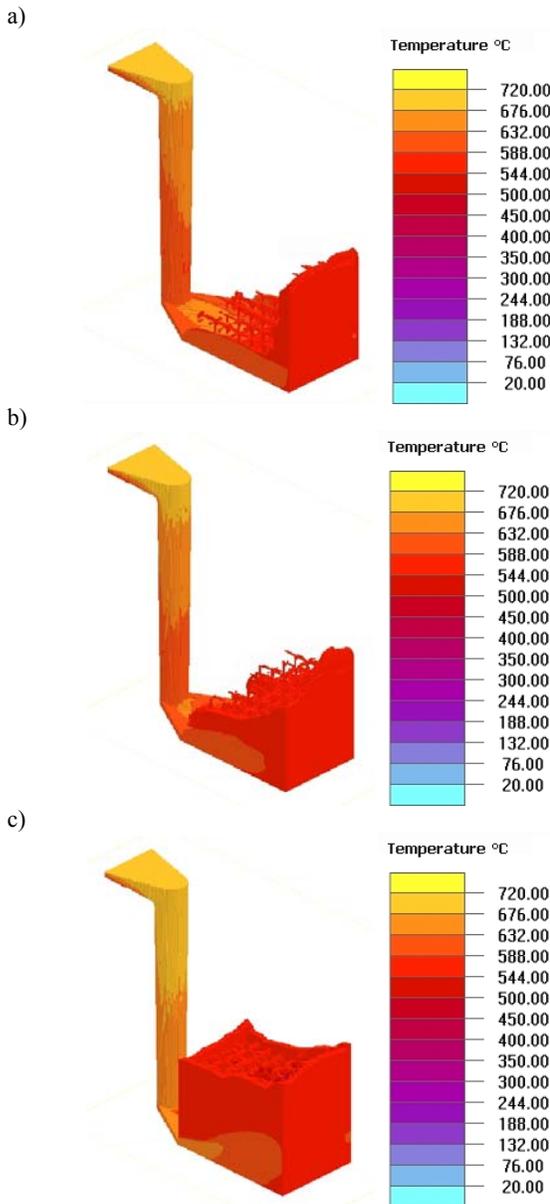
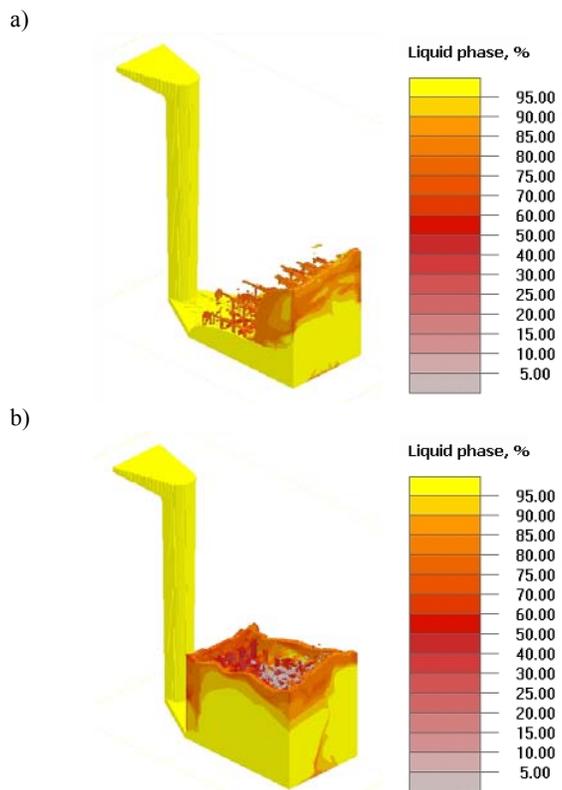


Fig. 6. Temperature distribution during casting and cooling the virtual cast. The scale is adequate to the established local temperature of the cast



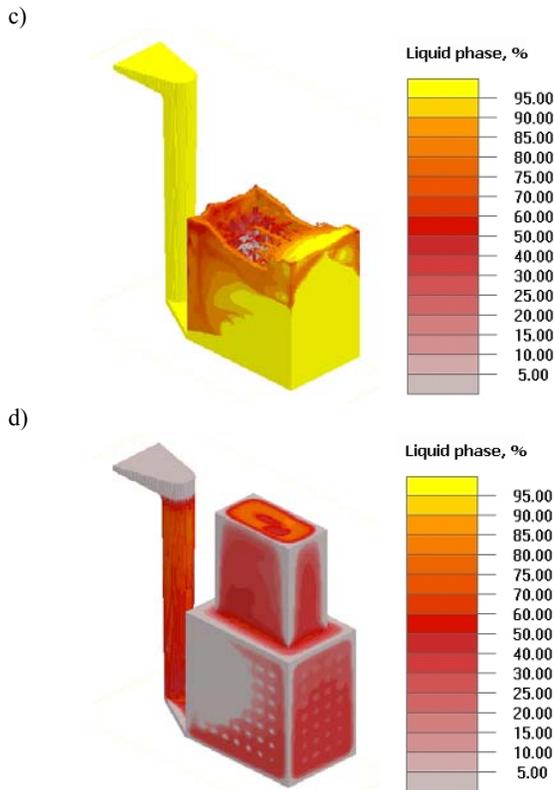


Fig. 7. Liquid phase in different time

## 4. Conclusion

Based on conducted studies following conclusion were formulated:

1. Casting at establishes thermal and geometrical parameters was investigated. It was obtained satisfactory filling the channels creating the skeleton shape and prepared in form of a core.
2. Based on obtained results of research it was determined directions of following experimental and simulation studies.
3. Numerical studies enable determination of regions, in which heat give up is slow and these regions solidify longer. Results of numerical simulation provide possibility of structure forecasting for closed skeleton castings manufactured with established technological conditions.
4. Regions of casting were selected for structure difference, which was maximied. These were: the upper corner of external surface and node of connector in geometrical centre under the feeder.

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