ARCHIVES of FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 10
Issue 2/2010

23 – 26

4/2

Geometrical and mechanical analysis of 3D casted skeleton structure

M. Cholewa*, T. Szuter
Department of Foundry, Silesian University of Technology, Towarowa 7, 44-100 Gliwice, Poland
*Corresponding author: E-mail address: miroslaw.cholewa@polsl.pl

Received 16.04.2010; accepted in revised form 10.05.2010

Abstract

The article presents selection of the geometry of engineering casted skeleton structure using the analysis of the stress state of structural variants. The main criterion for selection was using the simplest geometry of casting techniques for the manufacturing of the skeleton castings. Preliminary simulations of stress in the casting virtual. Analyses were carried out in an ANSYS Multiphysics environment. Macrostructure of casting were selected for testing on the actual model.

Keywords: Casted Structures, Skeleton Castings, Macrostructure, Simulation, Aluminum

1. Introduction

Engineering casted skeleton structure in the assumption should meet the criteria for strength between the elements of a monolithic materials, and metallic foams and gasars. The main characteristic of the casted skeleton structure is ability to apply the basic casting techniques in order to obtain a ready-made elements. This gives a significant advantage as compared to the technology of porous elements. It does not require specialized equipment and expensive technological treatments. Moreover, the classical porous materials have a random distribution and geometry of the pores, while during the manufacturing process of casting it is possible to precisely shape the geometry and thus control mechanical properties. At the preliminary stage of analysis assumes isotropic mechanical properties of casted skeleton structure, while maintaining the characteristic that it is possible to manufacture using the means of production available in a typical Polish foundries. In addition, there are obvious, almost unlimited ability to modify the geometric form of skeleton casting connectors using techniques of rapid - prototyping in order to fabrication the cores. It is justified in cases of highly specialized applications such as the casted skeleton structure used in asymmetric states of the load of bearing elements.

The choice of many variable form of casted skeleton connectors makes it necessary to optimize them, taking into account the target application. Technological aspect of fabricating core for assumed geometry is very important. Essential to the structure usability is the geometric and dimension tolerance repeatability of cells shape and microstructure in the area of the whole structure. It is therefore necessary to obtain a symmetric core in all three axes. Another important factor is choosing the right proportions of the single cells under the assumption that the ratio of the volume switches to an empty shell of the intercellular space must be a minimum of 40/60. The geometry of the core should also allow for the consolidation of individual items in groups. In addition, it is important to reduce the possibility of occurrence of casting defects [1].

2. Aim and range of studies

In the paper the authors present a selection of macrostructure of engineered skeleton construction based on virtual and real model. Work is aimed to select the geometry in terms most favorable stress distribution. Most important is to disperse energy throughout the space of casting. Considered a special case of force. It is directed perpendicular to the casted skeleton closing surface.

3. Methodology of studies

To create the 3D model and carry out necessary simulation were used software ANSYS® Workbench 12.0. To model a static load of engineered casted skeleton structure was used Static Structural module. The value of force loading the structure adopted a priori equal to 150 N, wall thickness 8 mm, diameter of the connector 8 mm. We used the material available on the ANSYS database, for the material from the group of General Materials - Aluminum Alloys. Due to the need for approximations of the applied force to a point was used an additional element (Fig. 4) with dimensions R = 5 mm, h = 1 mm. This was used to make area of force deployment finitesimal (approximate point). This element was placed in the geometric center of the wall with largest surface. It should be noted that all assumptions of geometry and simulation conditions remained unchanged in all models. A preliminary analysis allowed to select the most favorable geometry in terms of the best force dispersing, taking into account the most important assumption, ie the application of the basic casting techniques of production. It should be noted that the studies are basic research.

4. Results

Figures 1÷3 show analyzed geometry. Figures 6÷11 present the results of a preliminary analysis of the burden on individual cases. Figure 1 shows a standard geometry presented in publications [2÷6]. The geometry of a single cell is based on the structure of cube. Figure 2 shows the variations of the first case. There was a core of cell turnover in relation to one axis of the coordinate system by angle 45°. Figure 3 shows another variant of the geometry of the skeleton casting. Connectors of a single cell of skeleton casting are in shape of octahedron. Single cell is shown in Figure 5. Two of the three presented solutions have something in common - symmetry with respect to three axes. This solution allows to expect a predictable behavior regardless of place on the casting and the angle of force application.

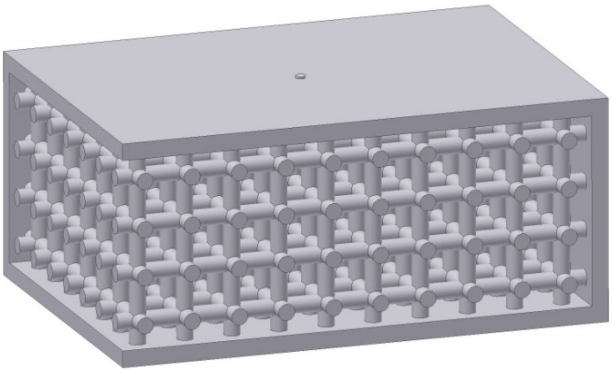

Fig. 1. Skeleton casting model with connectors arranged perpendicular to the wall

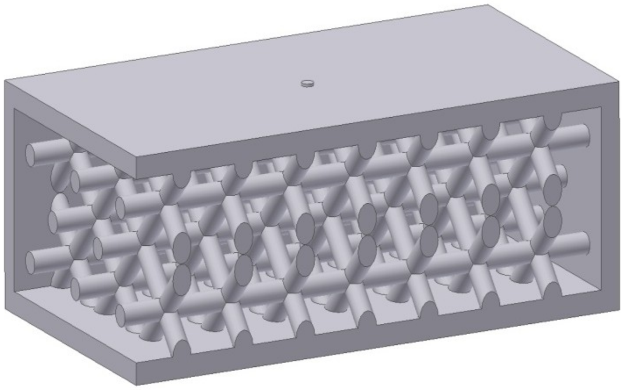

Fig. 2. Skeleton casting model connectors sloped 45° in relation to one axis

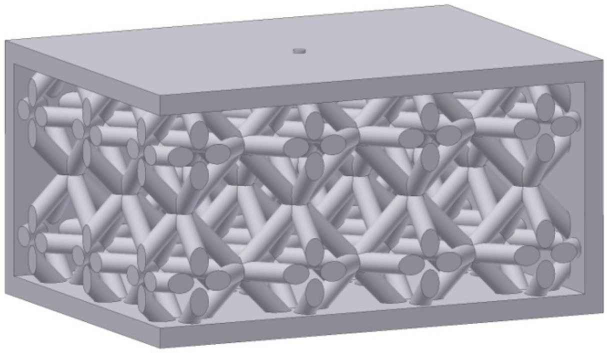

Fig. 3. Skeleton casing model with single cell based on octahedron

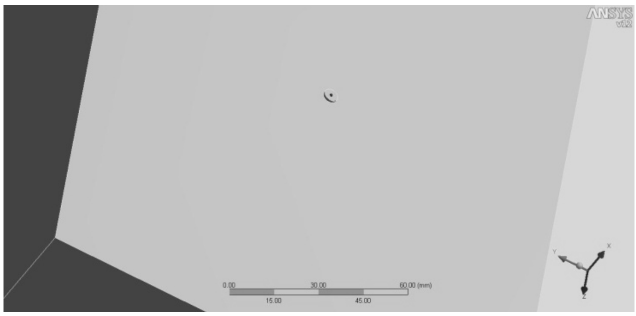

Fig. 4. Additional element of model allowing to approximations of the applied force to a point

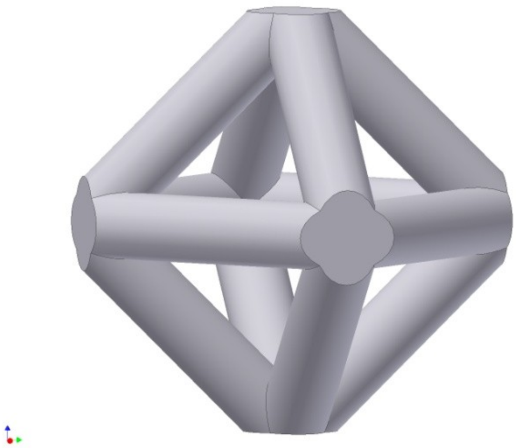

Fig. 5. Single model cell. Axial plane of the closing walls are determined by geometric centers of nodes of casted skeleton construction cells.

Figures 6÷10 presents the results of preliminary stress analysis for predestined skeleton casting geometry model. The main goal was to bound the highest, possible number of connectors in order to transfer mechanical stress. This allows to obtain the maximum possible energy dissipation in the volume of the structure. It is also necessary to minimize the possibility of buckling phenomena, which, which is characteristic of cellular materials [7].

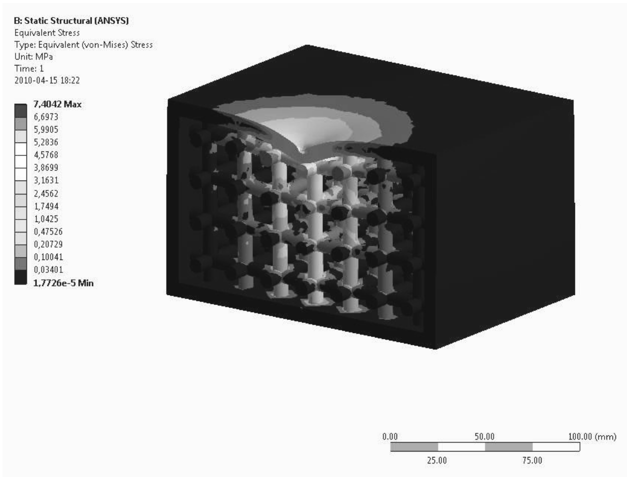

Fig. 6. Equivalent stress distribution for the model with perpendicular connectors and perpendicular single cell to the walls closing the construction (axial section)

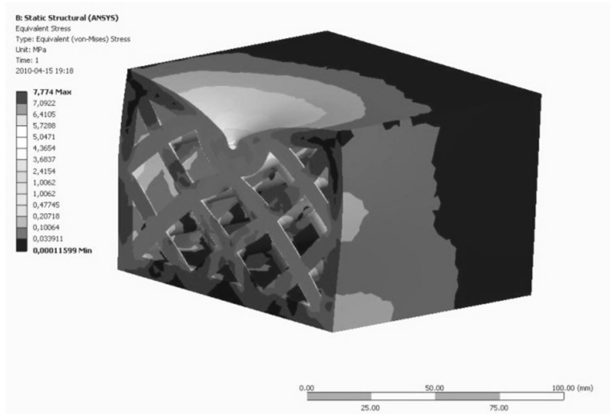

Fig. 7. Equivalent stress distribution for the model with connectors sloped 45° in relation to one axis (axial section)

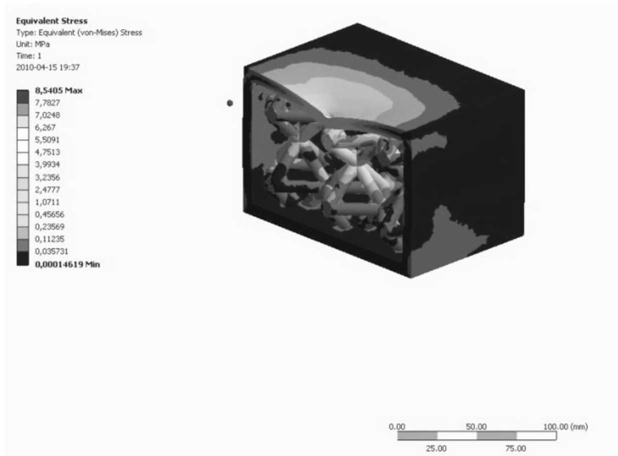

Fig. 8. Equivalent stress distribution for the model with single cell based on octahedron. Three dimensional symmetry (axial section)

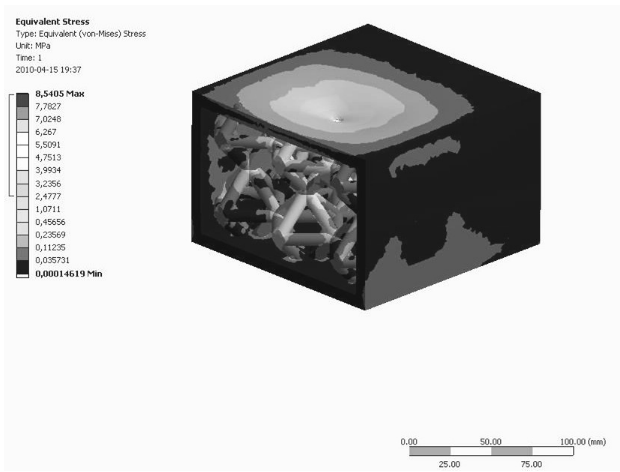

Fig. 9. Equivalent stress distribution for the model with single cell based on octahedron. Three dimensional symmetry (unaxial section)

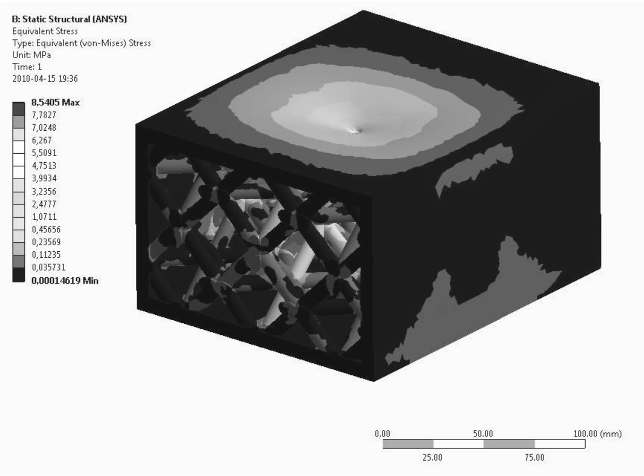

Fig. 10. Equivalent stress distribution for the model with single cell based on octahedron. Three dimensional symmetry (near wall view)

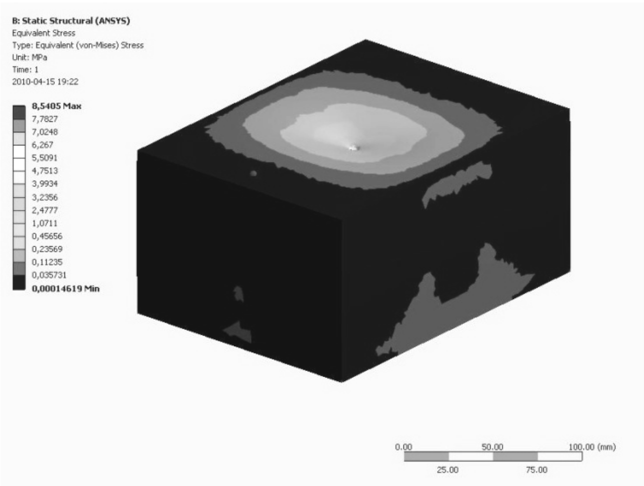

Fig. 11. Equivalent stress distribution for the model with single cell based on octahedron. Three dimensional symmetry (view)

5. Conclusion

Compared to the basic geometry with single cell based on a cube and the characteristic perpendicular angles confirmed the increase in construction connectors responsive to the applied load.

Obtained a significant reduction in the buckling of connectors, as a response to the load.

The results obtained confirm the advantages of casted skeleton construction with cell based on the octahedron.

Compared to porous materials with open or closed pores generated by the spherical shape with random size, it is appropriate form shape of cells to optimize the mechanical properties of casted skeleton structure.

Implication of computer analysis is creation of composite structure with polymer, metallic in order to maximize the selected mechanical properties.

References

[1] M. Dziuba Kałuża: Influence of technological aspects of manufacturing on structure of casted skeleton structure, PhD Thesis. Gliwice 2008 (in Polish)

[2] M. Cholewa, M. Dziuba: Selection of geometry and core material of casted skeleton structure with open cells, Archives of Foundry Engineering 2006, nr 19, s. 95 – 102 (in Polish)

[3] M. Cholewa, M. Dziuba: Desingning of geometry of aluminum casted skeleton structure with open cells, Archives of Technology, Archiwum Technologii Maszyn i Automatyzacji, 2006, vol. 26, nr 1, s. 15 – 23 (in Polish)

[4] M. Cholewa, M. Dziuba: Ceramic cores of casted skeleton structure with open cells, Archives of Foundry Engineering, 2006, nr 22, s. 170 – 177 (in Polish)

[5] M. Cholewa, M. Dziuba-Kałuża: Closed aluminum skeleton casting, Archives of Foundry Engineering 2008, vol. 8, Special Issue 1, p. 53-56 (in English)

[6] M. Cholewa, M. Dziuba-Kałuża: Structural analysis of aluminum skeleton castings, Archives of Foundry Engineering 2008, vol. 8, No. 3, p. 29-36 (in English)