NUMERICAL SIMULATION OF STATIC LOAD OF SKELETON CASTING

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Abstract

Searching light construction capable of carrying concentrated mechanical static load was the fundamental target of undertaken problem. There were presented the numerical simulation results of 3D skeleton casting with regular built of elementary cell. The simulations were realized using CATIA software with use of Advanced Meshing Tools module. As a skeleton's material near-eutectic aluminum silicate alloy AlSi11 was used. The aim of the study was verification of the suitability of the regular geometry of elementary cells carrying mechanical loads (including stress) and deformation analysis of the model skeleton casting. The skeleton was tested for characteristic cell size of 20 mm and connectors diameter forming elementary cells equal to 6 mm. The value and the accumulation of localized regions of stress were shown that allows the precise modification of the skeleton macrostructure.

Keywords: Skeleton casting, stress, relocation, numerical simulation, optimization

1. INTRODUCTION

Technical progress makes that more and more important significances in the preparation of the prototype and finished product has a numerical optimization. One of the examples of optimization are strength calculations in a virtual form, that significantly speed up the design work. Among the most popular modelling methods the most important is finite element method (FEM).

Solving differential equations that appear in the strength of materials requires knowledge of advanced mathematical engine. For simple element sit is possible to obtain the results with no complicated calculations, whereas in the case of more complicated models numerical methods should be used [1].

Currently on the market a number of simulation programs are accessed, which software is dedicated e.g. MAGMASOFT® for foundry or big "calculated harvesters" like ANSYS or ABAQUS. At the disposal of designers there is also a CAD/CAM/CAE software, among others CATIA or NX. Software of this type, in spite of smaller numerical options in compare to typical numerical software, is sufficient in the majority in the most of typical engineering problems. What is more, in some cases is even better, for example due to the possibility of the dating input by the CAD module useful.

In the foundry using of simulation can speed up many works, for example:

- design of gating and feeding system,
- design of usable properties,
- design the casting structure,
- selection of technological parameters,
- determination of stress and deformation casting.

All above-mentioned problems are described in detail in the literature [2-12].

Foamed materials or the skeleton construction have many advantages. The most important are small density and good mechanical properties. They influence on the economics of these materials by lowering their weight with maintaining similar endurance parameters, for example impact strength. Weight optimization is important criterion in particular for automotive or aerospace [13].

Not only mass density is important for porous material and skeleton construction. Another important parameter is the ability of individual modelling the properties of this type of material. In case of porous (foam) material significant problem, because of the ambiguous definition of structure, is simulation of their behaviour under the dynamic and static loads. A different situation occurs in skeleton casting, for which is possibility of precise definition of their structure. For so-called skeleton is possibility of modelling the effective application of the FEM's metric method. Using the capabilities of modelling any shape of skeleton possible is modelling their behaviour in extreme working conditions. A great example is simulation of car collision make in LS-DYNA which enables crumple zone design.

2. SKELETON CASTINGS

The application and concept of skeleton castings (**Figure 1**), as a periodic, highly porous truss, in Department of Foundry Engineering of Silesian University of Technology were designed [14-15].

The production of items with complicated shape (e.g. skeletons) makes a lot of difficulties for designer and process engineer. A modern method creating this type of systems is among others 3D printing. This technology despite of many advantages, among others the ability to create almost any geometry, has two significant disadvantages - price and strength of their structures. More efficient method is traditional moulding technique and the cores production, devoid of these defects.

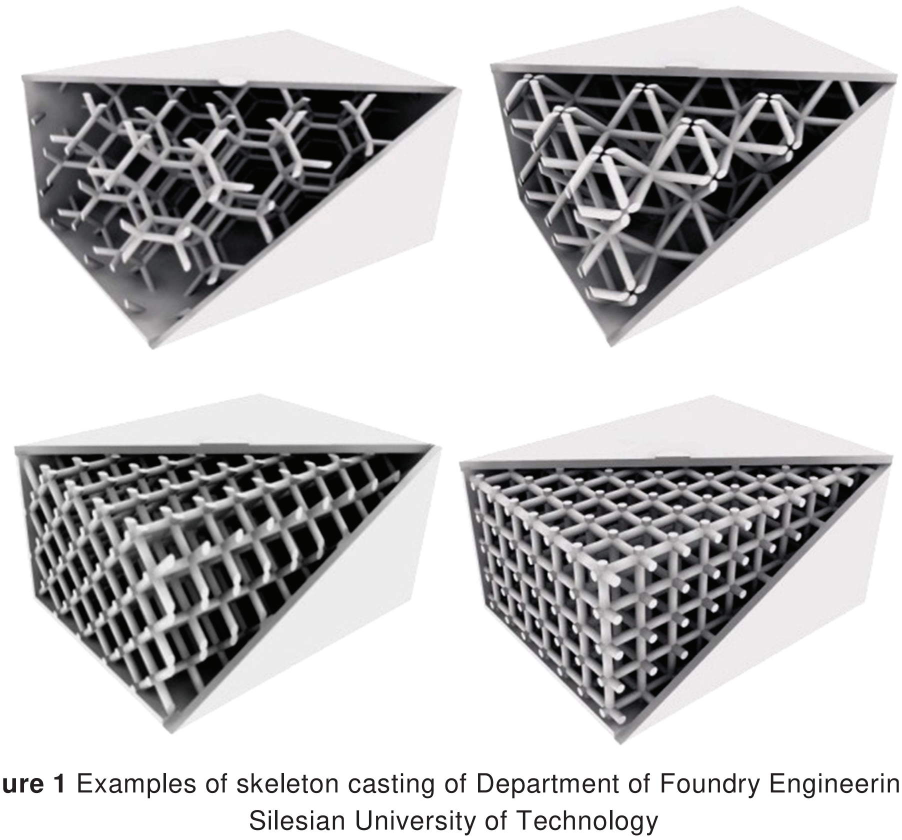

Figure 1 Examples of skeleton casting of Department of Foundry Engineering of Silesian University of Technology

3. OWN RESEARCH

The aim of the research was presentation and analysis of the results of strength properties simulation two skeleton castings based on elementary cell complex with node with the same geometry but other positioning relative to each other (**Figure 2**). To simulation AlSi11 alloy was used, which properties are shown in **Table 1**.

Table 1 Material's properties used in numerical pattern

Density	2.75 g/cm^3
Tensile strength	236 MPa
Yield strength during the tension	186 MPa
Yield strength during the compression	205 MPa
Young's modulus	71 GPa
Poisson ratio	0.33

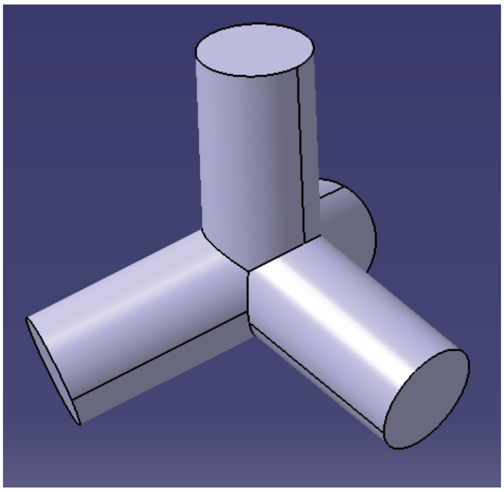

Figure 2 Tetrahedral node of elementary cell

In the calculation Advanced Meshing Tools modulus were used. Modelled technical parameters are: pressure applied to skeleton 140 MPa on the surface 314 mm^2 applied to the biggest wall of pattern, wall thickness 5 mm, connector diameter 5 mm, external dimension of cast 200x150x100 mm.

3.1. Case 1 - regular structure with rotated elementary cell

The first case based on regular connection of rotated node relative to each other about the angle of 60^0 making the elementary cell which structure look like diamond (**Figure 3**). The results of the biggest reduced stress according to Huber-Mises theory (2030 MPa) and displacement (1.7 mm) are shown in **Figure 4** and **Figure 5**.

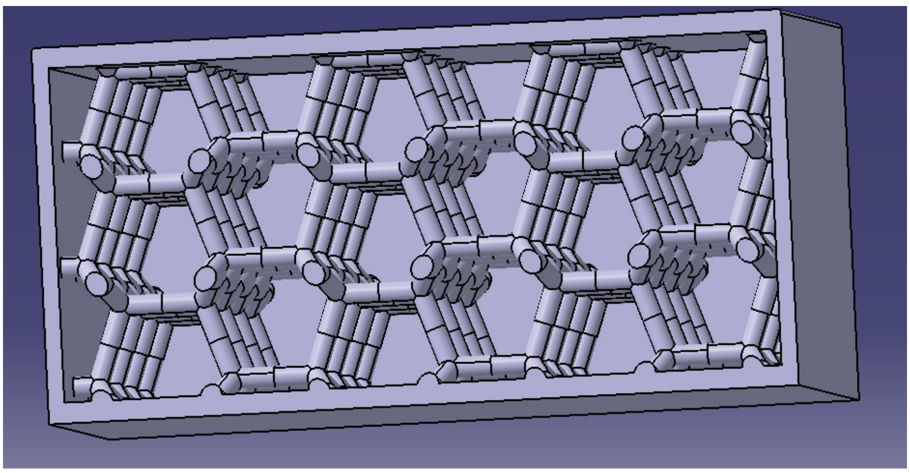

Figure 3 Regular structure of diamont (case 1)

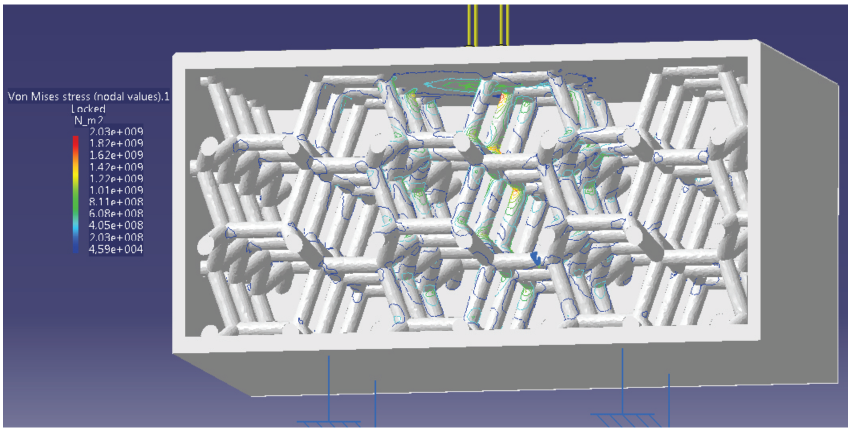

Figure 4 Stress distribution (case 1)

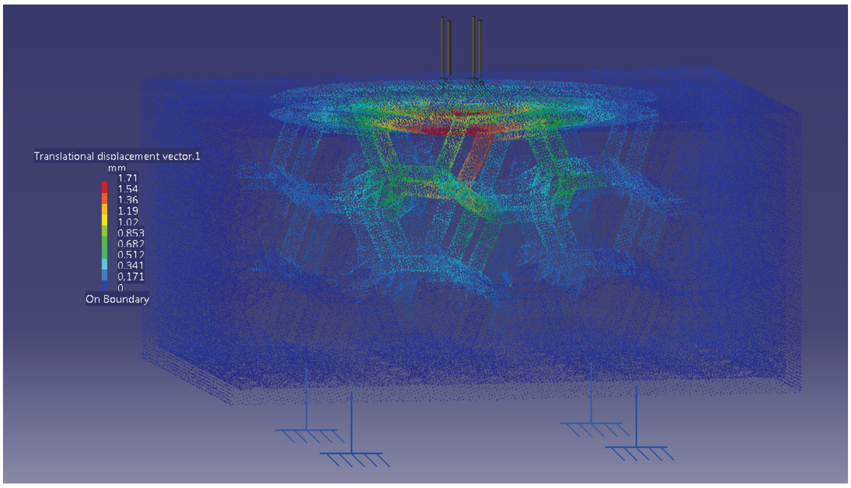

Figure 5 Displacement of regular structure (case 1)

3.2. Case 2 - regular structure with symmetrical elementary cell

The second case based on regular node connection without circulation to each other (**Figure 6**). Maximum stresses (2470 MPa) and displacement (1.74 mm) are shown in **Figures 7** and **8**.

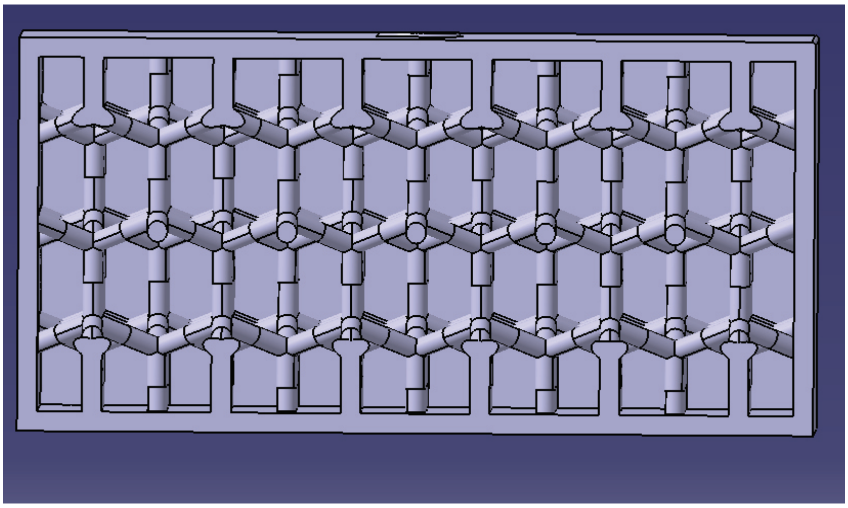

Figure 6 Regular structure (case 2)

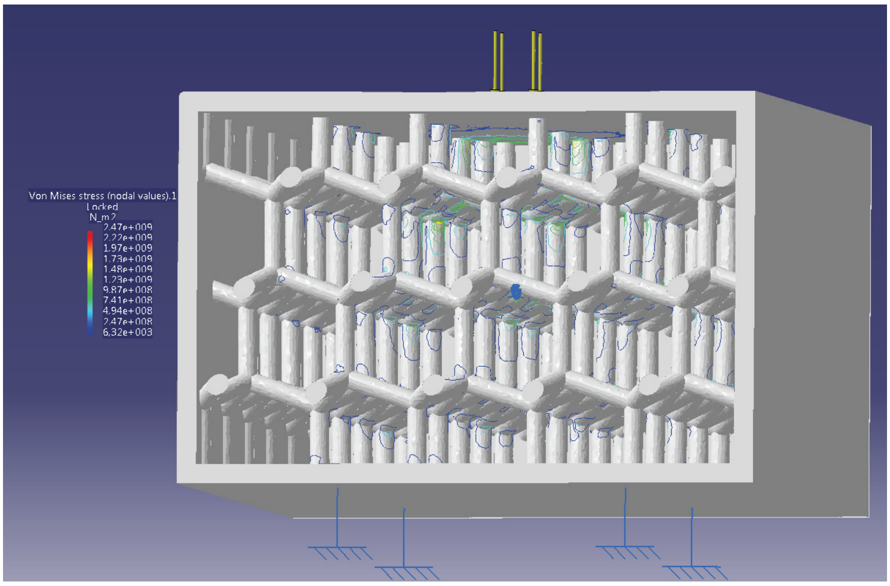

Figure 7 Maximum stresses (case 2)

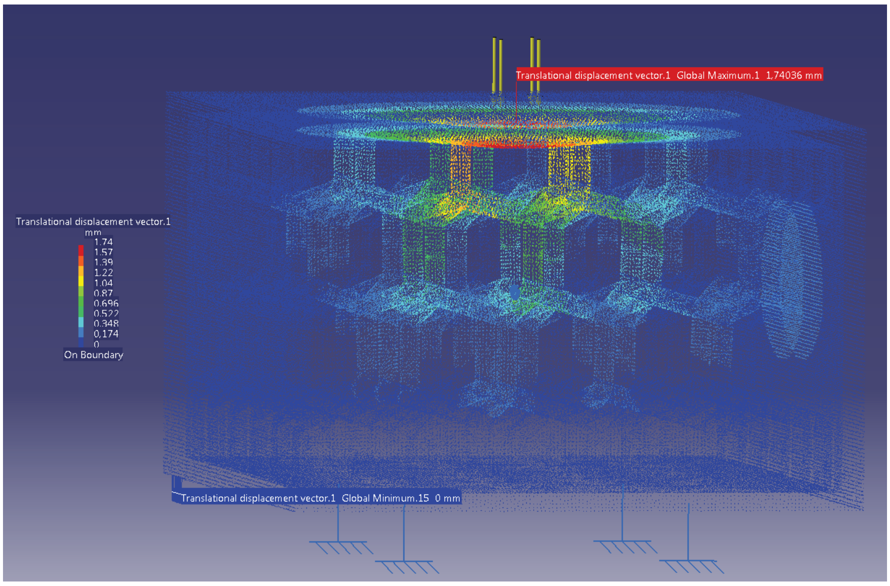

Figure 8 Maximum displacement (case 2)

4. CONCLUSIONS

Based on conducted studies **following** conclusions have been formulated**:**

a) Used simulation tools allowed for designation of areas of major stresses and deformation of skeleton castings under the influence of working force; it was found that effort applies major number of cells in the given volume of modelled castings.

b) It seems necessary to modify the nodes construction which presented geometry work as notch increasing the locally stress - proposed are mild round nodes that allow of its unload.

c) Simulation results indicate that the first structure shows more uniform stress distribution compared to the second structure, for what responded change the elementary cells with the same geometry.

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