Simulation of gravity filling a metal mold with aluminum alloy (EN AC-46400 AlSi9Cu1Mg)

Krum Petrov
Technical University Sofia, Bulgaria[1]
kpetrov@tu-sofia.bg

Abstract: *This study presents a simulation of the casting process in a metal mold with aluminum alloy (EN AC-46400 AlSi9Cu1Mg). Based on the simulation results, a gravity die casting mold production technology is proposed.*
Keywords*: PERMANENT MOLD, ALUMINUM ALLOY, SIMULATION*

1. Introduction

The implementation of computer software in global foundry practice has long ceased to be an extravagant addition to the visualization of products and has evolved into an integral ingredient of research, design and development. This includes refining and optimizing casting technologies, designing castings with high performance characteristics, reducing metal consumption, achieving energy savings, significantly shortening the time for the project-implementation cycle, as well as fast and precise qualitative and quantitative diagnostics of a wide range of potential defects.

The proposed aluminum alloy (EN AC-46400 AlSi9Cu1Mg) is widely used in the foundry industry due to its excellent mechanical and thermal characteristics [1, 2]. This alloy contains essential elements such as silicon (Si), copper (Cu), and magnesium (Mg), which greatly improve its durability and corrosion resistance. The ratio of these elements provides a balance between strength, ductility and creep resistance at high temperatures, making it suitable to produce components that operate under harsh conditions [3, 4]. In addition, the alloy is known for its good casting qualities, providing excellent machinability and high accuracy to castings. Its applications cover a wide range of industrial areas, including the automotive and aviation industries, as well as the production of components for high temperatures and loads. The simulation modeling was carried out using the ProCast software product [7, 8, 9].

2. To simulate the process of casting and crystallization in metal casting mold with AlSi9Cu1Mg, it is necessary to perform the following steps:

1. Output Data:

- 3D model of the casting with the casting system (Fig. 1);

- aluminum alloy (EN AC-46400 AlSi9Cu1Mg).

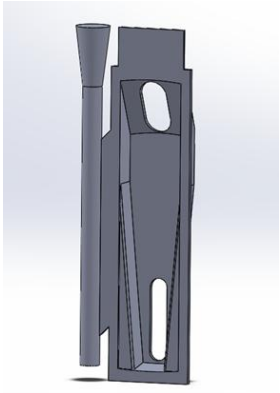

Fig. 1 *3D model of the casting with the gating system.*

2. Creating a 2D mesh (Fig. 2.) with a step to be selected by the "operator".

3. Calculation of the 3D mesh (Fig. 3.).

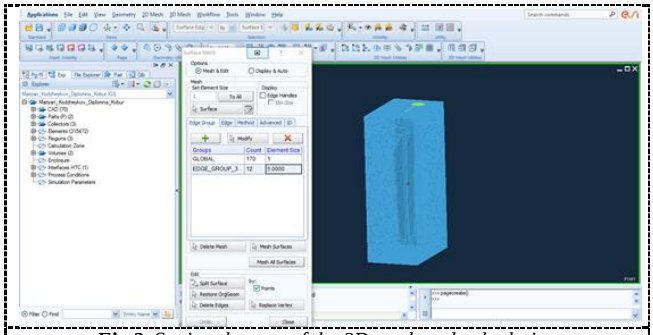

Fig.2. *Setting the step of the 2D mesh and calculating*

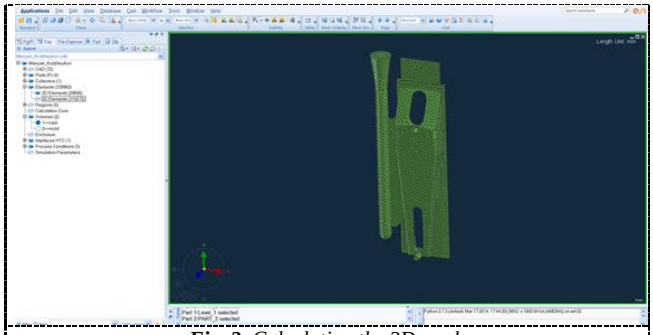

Fig. 3. *Calculating the 3D mesh*

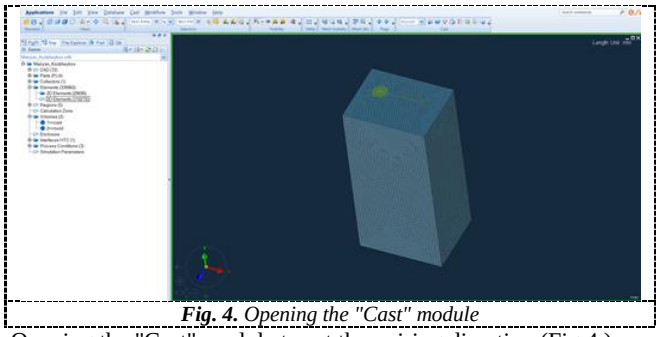

Fig. 4. *Opening the "Cast" module*

4. Opening the "Cast" module to set the poiring direction (Fig.4.).

5. Selection of material for the casting and mold and setting their temperature (Fig. 5.).

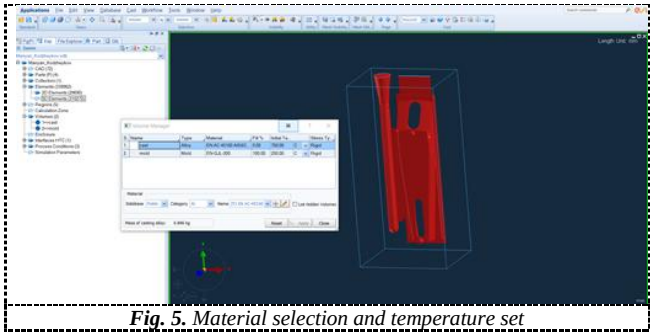

Fig. 5. *Material selection and temperature set*

4. Opening the "Cast" module to set the poiring direction (Fig.4.).

5. Selection of material for the casting and mold and setting their temperature (Fig. 5.).

For the casting were chosen aluminum alloy EN AC-46400 AlSi9Cu1Mg and alloy temperature 750^0 C. For the mold are set gray cast iron material GJL–200 [5] and mold temperature 250^0 C.

6. Setting the thermal conductivity coefficient (Fig. 6.).

7. Setting the pouring temperature, the area through which the metal enters the mold, the pouring rate and the type of cooling (Fig.7).

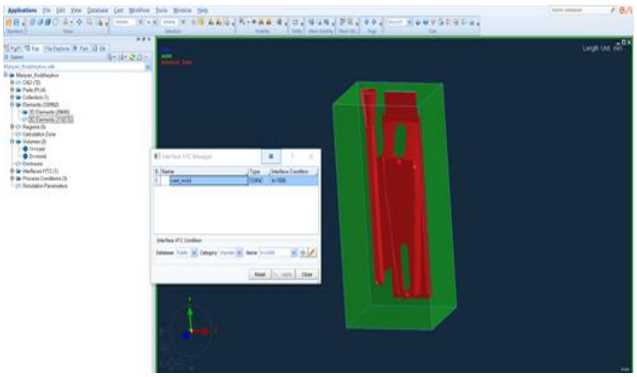

Fig. 6. *Setting the thermal conductivity coefficient.*

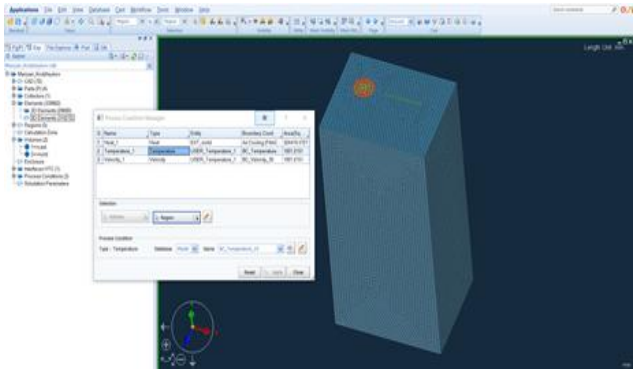

Fig. 7. *Setting the Pour Temperature*

8. Setting the method of filling the mold (gravitational, pressurized, centrifugal, etc.), entering the calculation step and the temperature at which the simulation should stop (Fig. 8.).

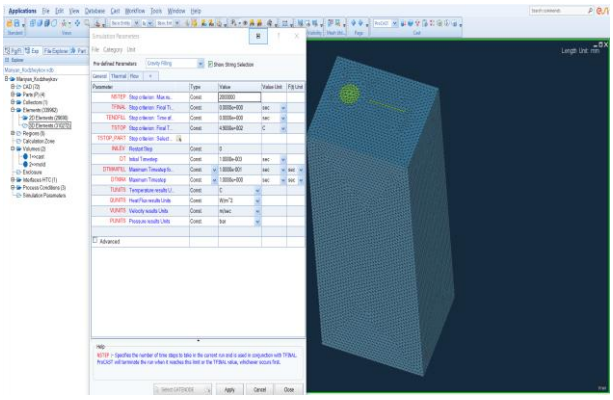

Fig. 8. *Setting the way to fill the mold.*

9. Running the simulation (Fig. 9.)

The pouring method is "Gravity Filling", the TSTOP final temperature is 490^0 C, and the NSTEP step is 200000.

After the start of the simulation, the "Visual Viewer" module opens, where at any moment of the simulation you can observe the flooding process (Figs. 9, 10, 11 and 12).

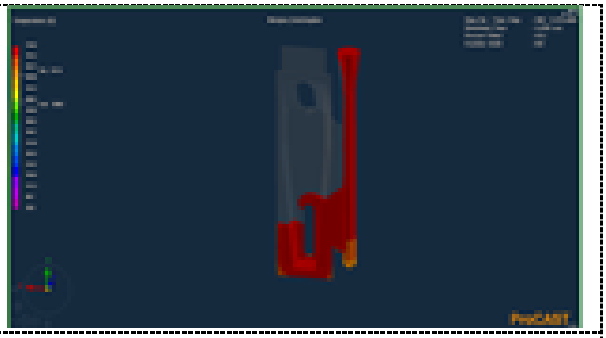

Fig. 9. *Start of pouring*

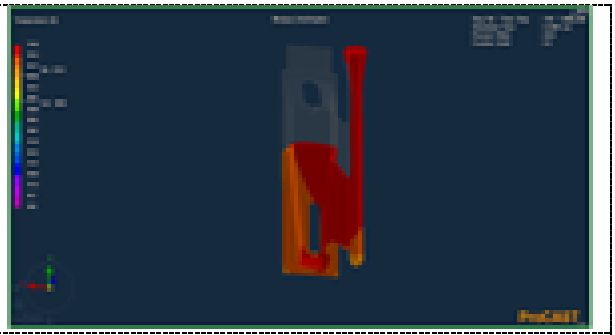

Fig. 10. *Pouring stages*

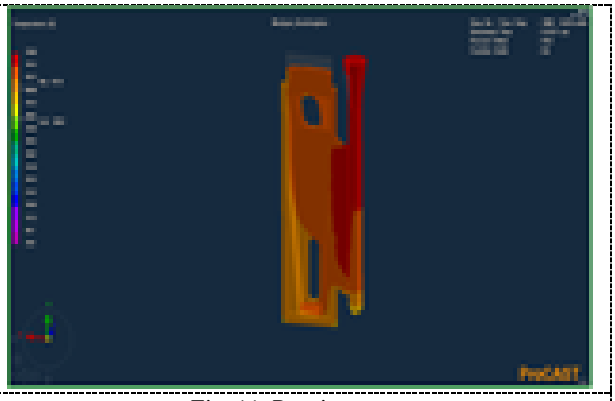

Fig. 11. Pouring stages

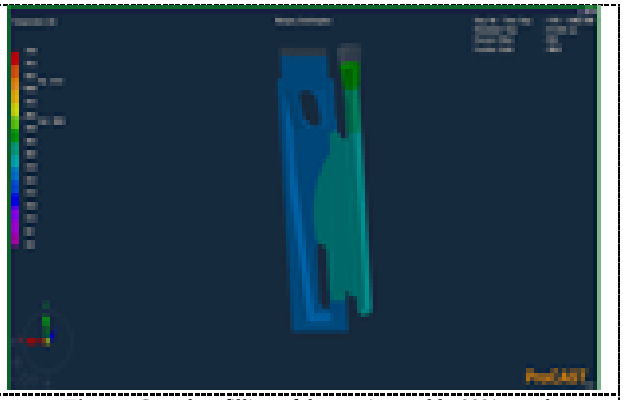

Fig. 12. *Complete filling of the casting mold 100% metal crystallization.*

The program allows visualization of the size and location of the voids (Fig. 13.) and porosity (Fig. 14).

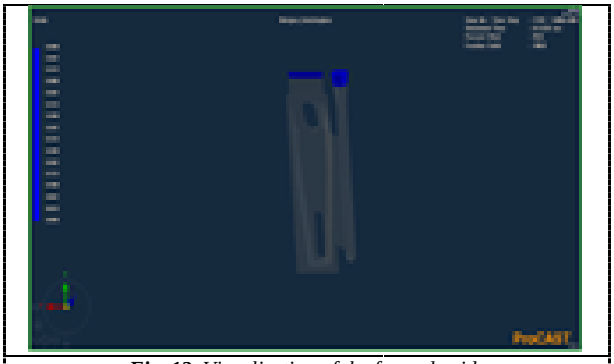

Fig. 13. *Visualization of the formed voids*

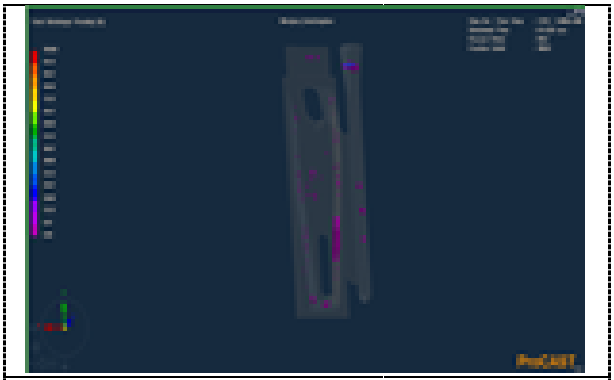

Fig. 14*. Visualization of porosity*

Results:

The results of the simulations of the process of filing the casting mold with liquid metal show that the voids are localized entirely in the gating system, and porosity exists in the casting itself. However, the resulting pores do not exceed 6.67%, which would not have a significant impact on the strength and performance characteristics of the workpiece, and there are no specific requirements for the tightness of the casting.

Based on the simple geometric shapes of the cast and the gating system, we recommend that the production of the gravity die mold is carried out using the vacuum forming (v-process) method, which is extremely suitable for creating molding tools.

3. Reference:

1. https://www.sabater-fundimol.com/customers/resources /pdf/ sabater-fundimol_catalog_p96-97.pdf

2. Brown JR (1999) Foseco Non-ferrous Foundryman's Handbook. In: Brown, J.R. (Ed.). Butterworth-Heinemann, Oxford

3. https://doi.org/10.1016/j.jallcom.2022.166504

4. R.R. Tang et al. Research on aluminum alloy automobile lightweight and welding technology, Mech. Elect. Eng. Technol. (2021)

5. CEN EN-GJL-200 (5.1300): Gray Cast Iron Producer or Source: European Committee for Standardization (CEN) Alloy Digest (2022) 71 (8): CI-96. https://doi.org/10.31399/asm.ad.8

6. https://doi.org/10.1016/j.prostr.2021.10.131

7. ESI Group, THE VIRTUAL TRY-OUT SPACE COMPANY

8. ProCAST User Manual

9. http://www.spacecad.bg/nx/leene-na-metali