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SECTION 6. Metallurgy and energy.

SIMULATION OF THE TECHNOLOGICAL PROCESS OF HIGH-PRESSURE DIE CASTING OF SILUMIN

Abstract*: Simulation of the technological process stages of high-pressure die casting of an aluminium cast is presented in the article. The research was performed for one phase of a piston movement in a cold chamber of a die casting machine.*

Key words*: high-pressure die casting, a chamber, melt, a piston, a mould, a casting, filling.*
Language*: English*
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Introduction

Die casting is a process of filling a mould by metallic melt under low or high pressure with subsequent exposure of material to complete crystallization [1]. Due to combination of high velocity of melt injection from a chamber of a die casting machine and high pressure, a casting material is cooled in several times faster than when casting in sand moulds [2]. Rapid cooling of melt in the mould is contributed by improvement of the mechanical properties of the casting, getting of high surface finish and high dimensional accuracy, increasing corrosion resistance. The castings of a complex configuration are made with high productivity by high-pressure die casting. A specificity of the process allows to perform casting of steels possessing low casting properties, and non-ferrous alloys which are more exposed to various casting defects after cooling of the casting in conditions of gravity casting [3; 4; 5; 6].

The more accurate representation about the process of high-pressure die casting (from pouring of metallic melt in the chamber of the die casting machine to crystallization of alloy in the mould) can be obtained by a computer simulation in the special programs for engineering analysis.

Materials and methods

The process of high-pressure die casting of aluminium foundry alloy EN AC-42000 [7] in the software environment LVMFlow is simulated. The chemical composition of alloy includes aluminium (88.4 %), silicon (11.2 %), manganese (0.08 %), copper (0.03 %), iron (0.15 %), zinc (0.05 %) and titanium (0.09 %). Initial temperature of melt was taken of 690 °C. At this temperature, pouring of melt into the chamber was performed by gravity casting.

A feeder is a channel which connects the chamber with the cavity of the mould. The feeder was made of a rectangular shape. Dimensions of the feeder: width 6 mm, height 3 mm and length 14 mm.

The mould was made from tool steel X37CrMoV5-1 (EN) [8]. The mould cavities were filled by air at a temperature of 20 °C.

A piston was installed in the chamber. The piston was designed for forced displacement of melt to the feeder. Dimensions of the chamber: inner diameter 40 mm and length 151.56 mm. Pressure of 100 Bar acted on the piston.

Dimensions of the casting were: outer diameter 100 mm, inner diameter 75 mm and thickness 12 mm. Casting radii on the outer and inner diameters of the casting were taken of 1 mm, and in coupling sites there were taken of 0.75 mm.

All solid models were divided into finite elements for a subsequent numerical calculation of the process of high-pressure die casting. The size of the finite element of the models amounted to 1.95 mm. It says about average accuracy of the results of finite-element simulation of the process of high-pressure die casting.

The three-dimensional models of the chamber of the die casting machine, the sprue (feeder) and the casting (placed in the calculated field) are presented in Fig. 1. The outer surfaces of the models correspond to the cavities of the mould and the chamber.

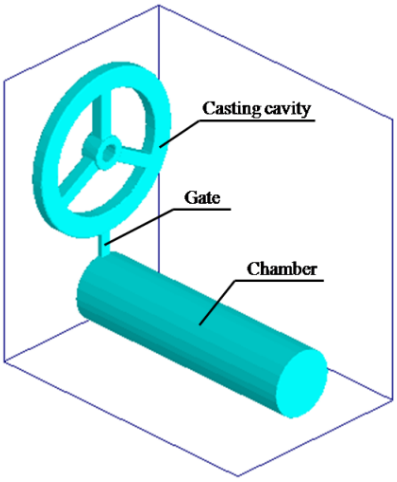

Figure 1 – The models of the chamber, the gate (feeder) and the mould cavity in the calculated field.

Results and discussion

The results of the simulation of movement of molten silumin in the mould are presented in Fig. 2. The cooling process (crystallization) of molten silumin in this article was not considered.

Calculated time of filling the required volume of melt into the chamber of the die casting machine amounted to 0.286 s. Total time of filling of the mould by melt amounted to 0.332 s. After filling of the chamber, the piston forcibly moves melt to the feeder. The injection phase of melt into the mould occurred under high pressure, as the cross section of the feeder in several times less than the cross section of the chamber of the die casting machine. Subject to the specific configuration of the casting, its orientation in the mould and the accepted number of feeders, filling of melt is performed unevenly. Three elements that connect in the middle of the casting are filled by melt in the last time. A temperature change of melt on all the time range of the process of the mould filling is approximately 100 °C. Herewith the liquidus temperature of aluminium foundry alloy EN AC-42000 is 598.974 °C.

Records of the filling process of melt into the chamber and into the mould are presented in table 1.

Table 1

Records of melt filling.

Time, s	Filled volume, %	Mass, kg	Liquid phase, %	Temperature, °C	Wall contact time, s
0	0.1	0	100	690	0
0.029	1.8	0.01	99.4	690	0.009
0.061	3.7	0.02	94.9	690	0.036
0.164	10	0.05	90.4	690	0.128
0.286	17.5	0.09	90	690	0.234
0.312	20	0.1	89.5	689.2	0.256
0.312	30	0.1	89.9	668.7	0.245
0.312	40.1	0.1	89.7	664	0.158
0.313	50.2	0.1	89.6	660.9	0.111
0.317	60	0.1	87.3	602.6	0.05
0.32	66.2	0.1	85	595.6	0.052
0.322	70	0.1	83.7	592.5	0.052
0.324	73.6	0.1	82.7	590	0.052
0.326	80.1	0.1	81.1	588	0.054
0.329	90.1	0.1	79	586.9	0.056
0.332	99.5	0.1	77.4	585.2	0.057
0.332	100	0.1	76.6	585	0.057

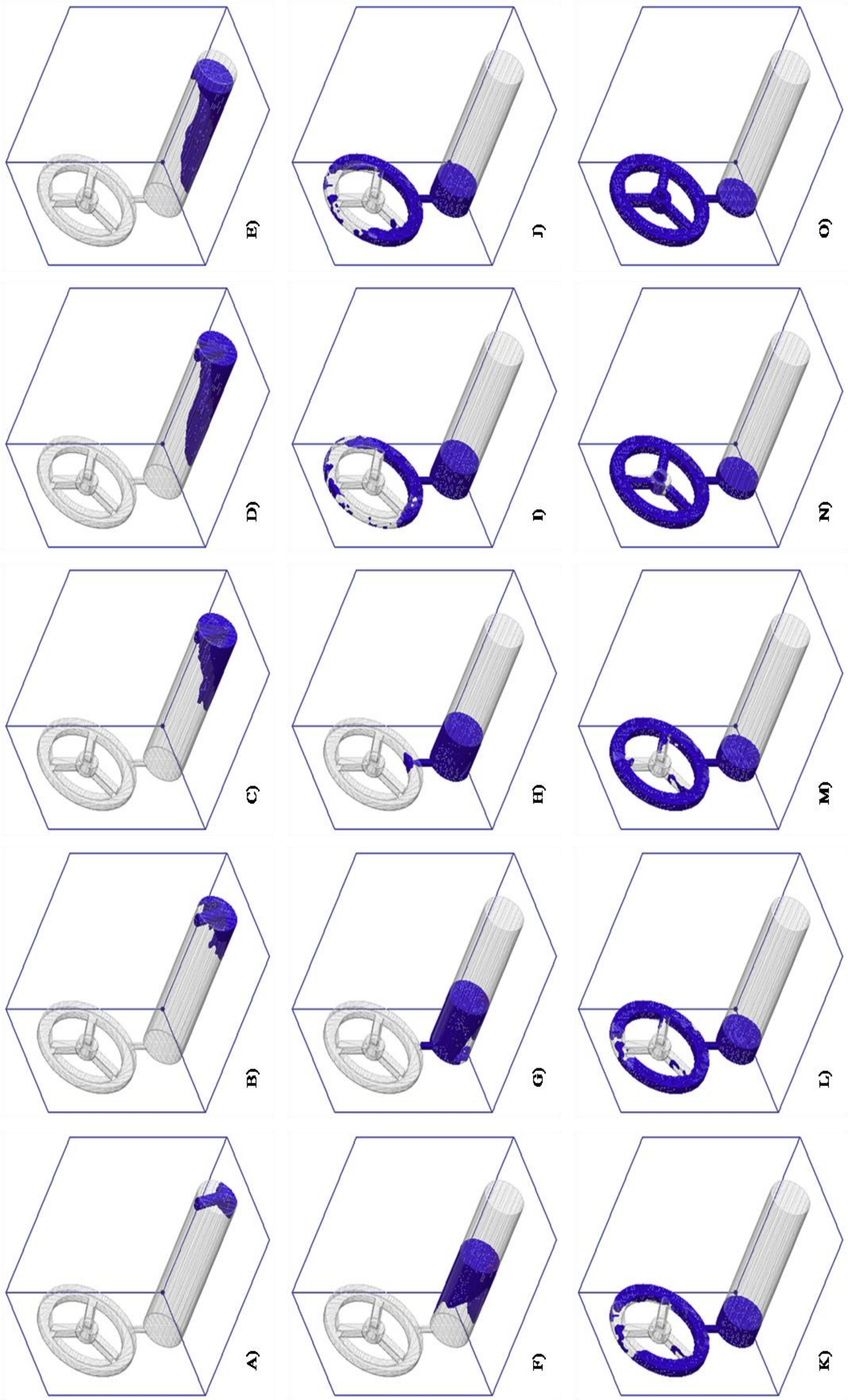

Figure 2 – The process of high-pressure die casting: A – D – pouring of melt into the chamber; E – O – the piston movement in the chamber and the injection phase.

Conclusion

Stages of the technological process of high-pressure die casting of the aluminium casting in three-dimensional formulation were demonstrated through of the computer simulation. Despite the high speed of casting about 25 % of melt passes in solid solution when filling of the mould. About the velocity of melt flow may be assessed by melt contact time with the chamber wall and the mould. The highest velocities were defined in the injection phase of melt into the mould.

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