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Denis Chemezov
M.Sc.Eng., Corresponding Member of International Academy of Theoretical and Applied Sciences, Lecturer of Vladimir Industrial College,
Russian Federation
chemezov-da@yandex.ru

SECTION 6. Metallurgy and energy.

MOVEMENT OF METALLIC MELT IN A COLD CHAMBER OF A DIE CASTING MACHINE

Abstract: *A calculation of required pressure of working liquid in a shot cylinder during movement of molten silumin in a cold chamber of a die casting machine is performed in the article. Velocities of displacement of a piston in the chamber of the die casting machine and character of movement of metallic melt in an injection phase are determined.*

Key words: *a cold chamber, a die casting machine, velocity, displacement of a piston, metallic melt.*

Language: *English*

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Introduction

Casting of non-ferrous and steel alloys is performed under high pressure on die casting machines with cold or hot chambers [1; 2]. In the cold chamber of the die casting machine there are provided a special hole for pouring of a required volume of metallic melt (by gravity casting) and a running channel (feeder), through which filling of a working cavity of a mould is occurred. Pressing of metallic melt in the cold chamber carried by a piston which is connected to a pressing mechanism. An injection phase is carried out at high pressure of the piston on metallic melt, which is located in the cold chamber of the die casting machine. For performance of the technological process of non-ferrous alloy casting (for example aluminium foundry alloy EN AC-42000) under high pressure it is necessary to determine maximum pressure of working liquid in a shot cylinder of the die casting machine. This will allow to select a necessary model of the die casting machine with appropriate technical parameters [3].

Materials and methods

A computer simulation of the piston stroke in the cold chamber of the die casting machine was implemented in the module «Flow and solid» of the special program LVMFlow [4; 5]. Overall dimensions of a model of the feeder (gate) and the chemical composition of aluminium foundry alloy EN AC-42000 (in liquid state) are presented in the work [6]. The model of the piston in the model of the cold chamber of the die casting machine was not displayed. Conditions of the computer simulation of movement of metallic melt in the cold chamber of the die casting machine are presented in table 1 and 2. The computer simulation of the casting process of silumin was carried out by the quasi-equilibrium model of the calculation.

Table 1

Conditions of the computer simulation of filling of the cold chamber by metallic melt [7].

Parameter	Value
Pouring type	Lip pouring
Volume of mould filled, %	100
Heat radiation	20
Friction factor	0.9
Flow, kg/s	0.325
Pressure height, mm	197.172
Stream diameter, mm	10

Stream area, mm^2	78.54
Teta	15
Fi	0
Section area, mm^2	2041.007

Table 2

Conditions of the computer simulation of displacement of the piston in the cold chamber of the die casting machine.

Parameter	Value
Chamber length, mm	151.56
Chamber diameter, mm	40
Capacity of chamber, mm^3	181353.2
Melt mass in chamber, kg	0.1
Downtime after filling, s	0
Pressure on piston, Bar	100
Effective piston mass, kg	0.084
Phase	1
Coordinate of phase beginning, mm	0
Maximal pressure on piston, Bar	1000
Section area, mm^2	1196.577

Results and discussion

The dependencies of pressure of working liquid in the shot cylinder of the die casting machine, velocity and displacement of the piston in the cold chamber from time of the casting process of silumin EN AC-42000 are presented in Figs. 1 – 3 [8].

The injection phase is characterized by low velocity of displacement of the piston in the cold chamber of the die casting machine and increasing of pressure of working liquid during compressing by the piston of the full volume of metallic melt. The mould cavity is completely filled by metallic melt when displacement of the piston in the cold chamber at 148.66 mm. Change of the piston velocity in the injection phase of molten silumin in the mould is presented by the logarithmic equations (1 and 2)

$$v = 1.587\ln s - 6.2218, \quad (1)$$

$$v = -1622\ln t - 1817.3, \quad (2)$$

where v – the piston velocity in the chamber during the injection phase of metallic melt into the mould, m/s; s – displacement of the piston in the chamber during the injection phase of metallic melt into the mould, mm; t – time of displacement of the piston in the chamber during the injection phase of metallic melt into the mould, s.

Subject to phase transitions in molten silumin and the specified overall dimensions of the cold chamber and the feeder, maximum required pressure of working liquid on the piston was amount to 452.64 Bar. Calculated pressure of working liquid on the piston is required for technical casting (pressure range is 400 – 800 Bar). Standard casting is performed in pressure range of 200 – 400 Bar, pressure tight casting in pressure range of 800 – 1000 Bar. On the rest of the time range, the injection process of metallic melt into the mould is occurred when pressure of working liquid of 99 – 100 Bar. Change of pressure of working liquid in the shot cylinder of the die casting machine during the injection phase of molten silumin in the mould is presented by the logarithmic equation (3)

$$P = -145.5\ln t - 63.567, \quad (3)$$

where P – pressure of working liquid in the shot cylinder during the injection phase of metallic melt into the mould, Bar.

The fields of movement velocities of metallic melt from displacement of the piston in the cold chamber of the die casting machine are presented in Fig. 4. The movement process of metallic melt in the cold chamber of the die casting machine is presented in a longitudinal section. An outline of a rectangle simulates the cavity of the cold chamber of the die casting machine. The piston moves on the right side of the cold chamber. The feeder was performed in the upper left corner of the cold chamber. An area in the rectangle, marked by different colors, is metallic melt. The value of movement velocity of metallic melt is determined by the color scale presented at the bottom of the figure. A movement direction of layers of metallic melt in the cold chamber of the die casting machine is indicated by vectors.

Minimal flow temperature of silumin in the cold chamber of the die casting machine and in the mould is 540 °C (viscosity of melt is $0.05 \cdot 10^{-5}$ m^2/s). During full compressing of the volume of metallic melt by the piston it is observed layers mixing which have a whirling direction in the cold chamber of the die casting machine (Fig. 4, F). At subsequent displacement of the piston in the cold chamber, velocity of some layers of metallic melt (in the

middle and in the bottom of the chamber) is constantly decreased. Flow velocity of metallic melt from the cold chamber of the die casting machine into the feeder does not change and has the maximum value.

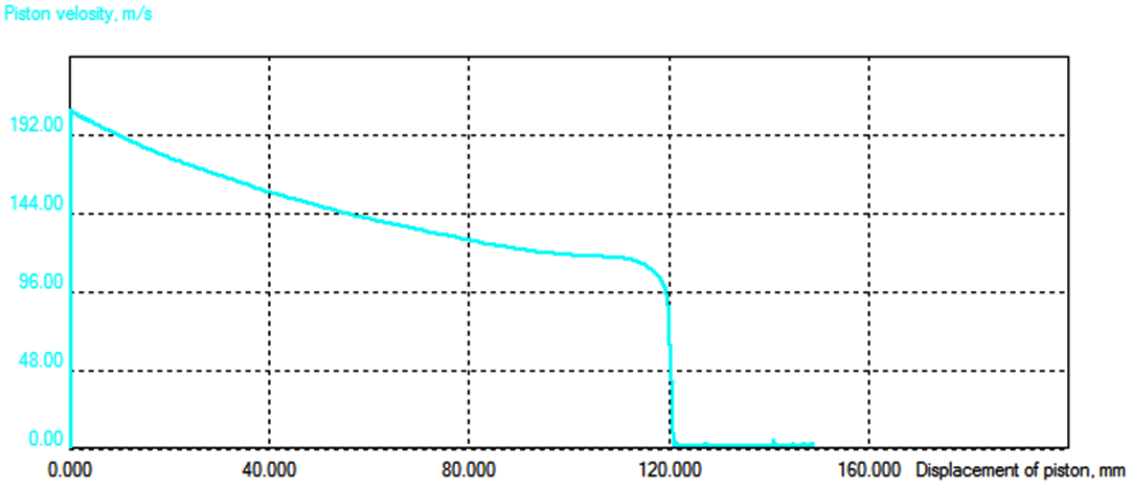

Figure 1 – The dependence of the piston velocity from its displacement in the cold chamber.

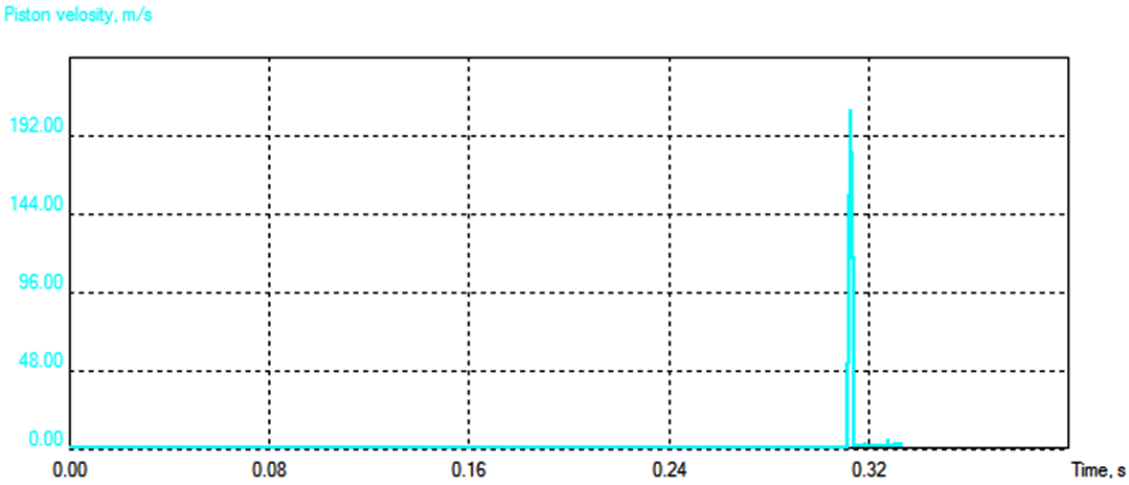

Figure 2 – The dependence of the piston velocity from time of its displacement in the cold chamber.

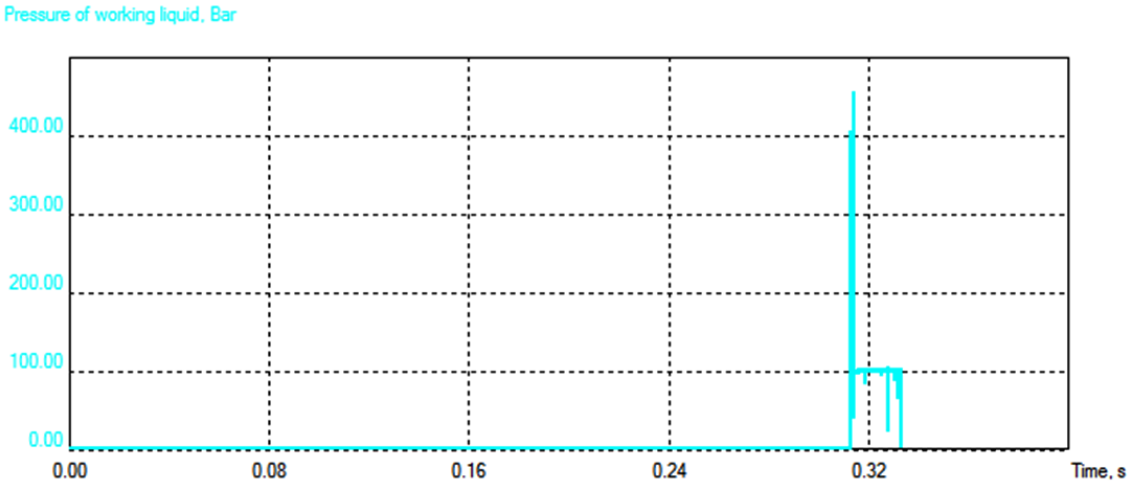

Figure 3 – The dependence of pressure of working liquid in the shot cylinder from displacement time of the piston in the cold chamber.

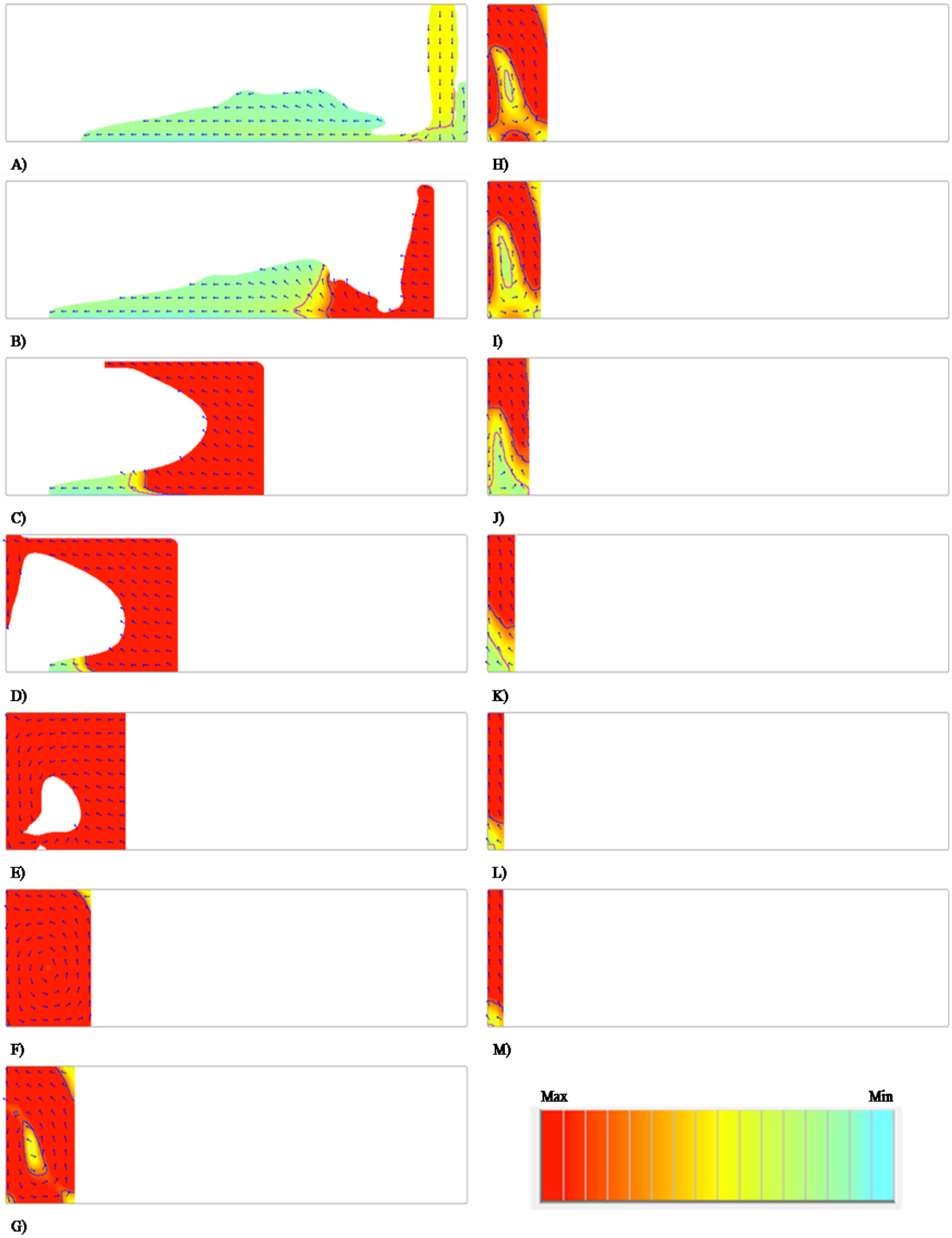

Figure 4 – Movement velocities of metallic melt in the cold chamber: A – filling of the chamber by melt, B – displacement of the piston in the chamber at 11.24 mm, C – displacement of the piston in the chamber at 68.44 mm, D – displacement of the piston in the chamber at 97.22 mm, E – displacement of the piston in the chamber at 114.42 mm, F – displacement of the piston in the chamber at 125.73 mm, G – displacement of the piston in the chamber at 131.17 mm, H – displacement of the piston in the chamber at 134.01 mm, I – displacement of the piston in the chamber at 136.43 mm, J – displacement of the piston in the chamber at 140.2 mm, K – displacement of the piston in the chamber at 144.98 mm, L – displacement of the piston in the chamber at 148.6 mm, M – displacement of the piston in the chamber at 148.66 mm.

Conclusion

Realization of silumin casting on the die casting machines it is possible when pressure of working liquid in the shot cylinder of 100 – 453 Bar. The calculated values of pressure were obtained when the ratio of cross sections of the feeder and the cold chamber of the die casting machine is equal to 1:10. In the module «PQ-Diagram» of the program LVMFlow a database of the die casting machines Buhler, Idra and Ital Presse is provided. The ranges of locking force from 150 to 800 ton, minimal and maximal diameters and lengths of the shot chamber, the maximal piston velocity are presented in the database.

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