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Using of the casting simulation system “PoligonSoft” for analysis of a temperature field of aluminum alloys.

Freiberger Forschungshefte A 892, ISBN 978-3-86012-319-5 (2007), p. 107 - 113

Today a great number of modeling systems in mechanical engineering are being used, the gain of their using is obvious in comparison with experiments. One of these systems is a simulation system “PoligonSoft”. This system allows improving some of the most important process variables not using of real casting, but using of computer modeling.

The program “PoligonSoft” is designed for modeling of casting processes and uses numerical methods for:

1) hydrodynamic processes of the mold filling;
2) thermal processes of the solidification;
3) processes of macro- and micro-porosity formation;
4) processes of pipe defects formation [1].

One of the basic questions of casting modeling is solving of cooling and solidification problems of different castings. The higher the adequacy of the solution of these problems the higher is the quality of the produced castings. It was suggested to make a comparison between the experimental data of solidification of aluminum castings poured in sand molds and the calculated data by computing system “PoligonSoft”. Hollow castings with different wall thickness were produced by new method, which is based on the low pressure casting method. The new method allows controlling the filling speed of metal, what gives opportunity to receive thin-walled and large-sized castings, which are difficult to receive by traditional methods.

By the Paterson-Englers classification the solidification is divided into two major groups – exogenous and endogenous solidification. The crystals grew either near the shape's wall (exogenous) or inside the melt (endogenous). During the growth there form stays compact or changes on the dendrite. The further classification of the exogenous and endogenous solidification types can be carried out (Fig.1) [2]. There are smooth wall, rough and sponge like solidification types for exogenous (Fig.1. A), pulpy and shell formatting solidification types for endogenous (Fig.1. B). The microstructure, which determined the solidification type, affects very strong the property of the casting in many cases.

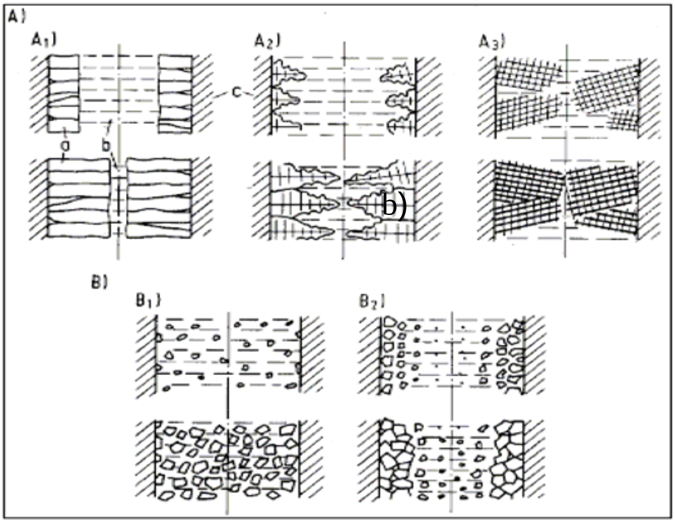


Fig.1. A) Exogenous solidification: A1) smooth wall; A2) rough; A3) sponge like.B) Endogenous solidification: B1) pulpy; B2) shell formatig

Three aluminum-alloys have been analyzed: AlSi7, AlSi9 and AlSi12, which are pouring in high-silica sand mold with different binder (furane resin binder and water glass binder). Alloys were poured with temperatures of 670 °C and 700 °C. Metal had been hold in mold for 25, 30 and 32.5 seconds, after that rest metal, which was not solidified , was poured back to a crucible. As an investigated pattern was taken the two-step cylinder 180 mm tall. The mold was composed of three parts, as can be seen in Fig.2.a. Below the ceramic ring is represented, in which metal have been fed. This funnel prevents wash-out of sand mold.

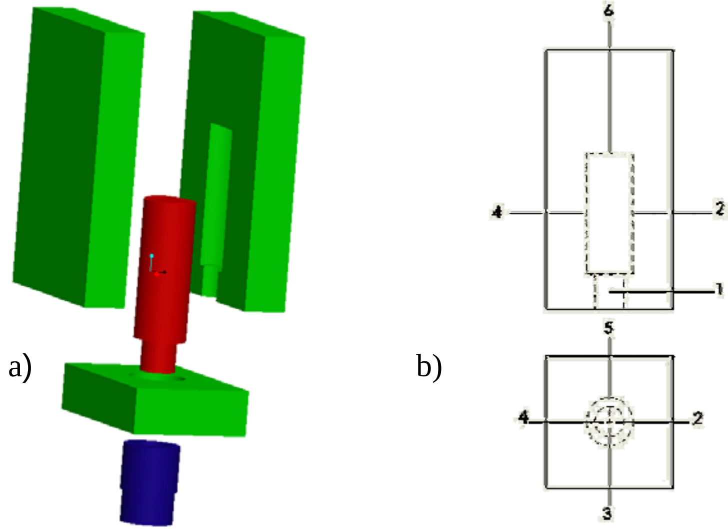


Fig.2. A volumetric view of pattern (a) and the circuit of an arrangement of thermocouples (b)

In all experiments the temperature has been measured in five places on the surface and in the entry point of metal in the mold cavity, as is represented in Fig. 2.b. Thermocouples 3 and 5 are opposite to thermocouples 2 and 4.

The melt had been fed under pressure of 0.22 bar. The calculated time of mold filling is 1.24 sec.

Two of three investigated alloys are hypoeutectic, and one is hypereutectic, as can be seen in the phase diagram of aluminums alloys.

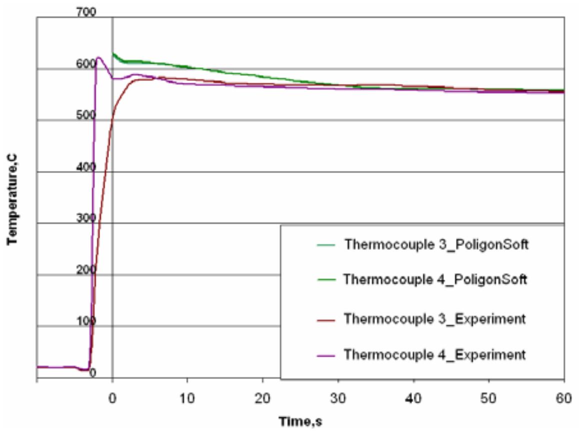


Fig. 3. Temperature curves T_{pour} = 700 °C.
Mold - furane binder. Alloy - AlSi7

Fig. 3. represents an compare between the experimental and calculated temperature curves for AlSi7 alloy at a pouring temperature of T_{pour} = 700 °C in a mold with furane resin binder and with the metal holding time in the mold 30 sec. Calculated curves show the process of solidification of metal, therefore experimental curves are moved to the left for 1.24 sec (pouring time). We can note a good correspondence of results when solidification interval is reached.

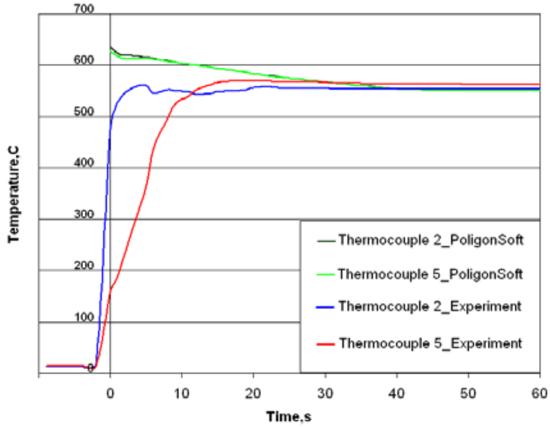


Fig. 4. Temperature curves T_{pour} = 700 °C.
Mold - furane binder. Alloy – AlSi9

In the same casting conditions (Fig. 4), the solidification of the AlSi9 alloy is very quickly, since this alloy has a narrow solidification interval. And once again data adequacy is confirmed.

Interesting results we have received in investigation of the solidification process of the hypereutectic alloy AlSi12 (Fig. 5). We had interlaced the holding time of the metal in the mold to 60 sec, in order to get approximately the same wall thickness, which we have received at other alloys in 25 seconds. By the type of inside surface of last castings we can determine the type of solidification. The hypereutectic alloy AlSi12 has rough type of solidification. This alloy has a solidification interval only 6 °C (from 582 °C to 576 °C).

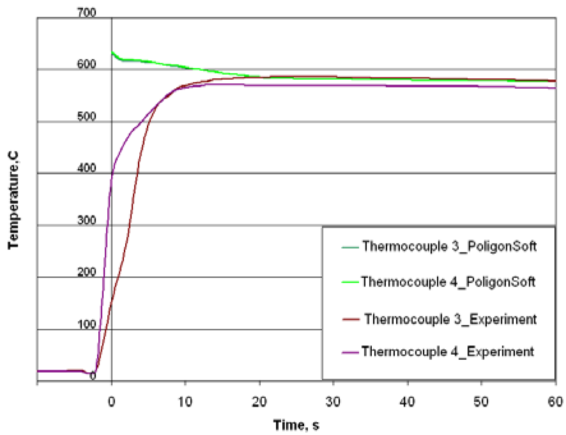
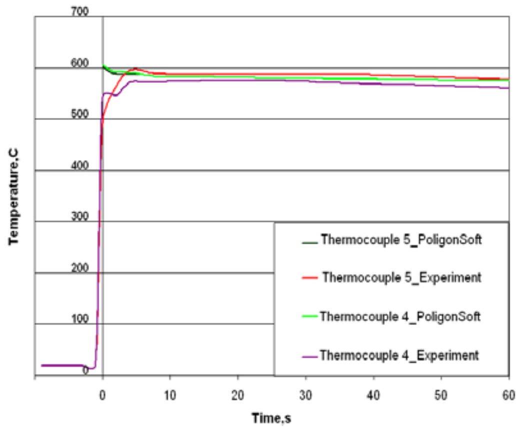
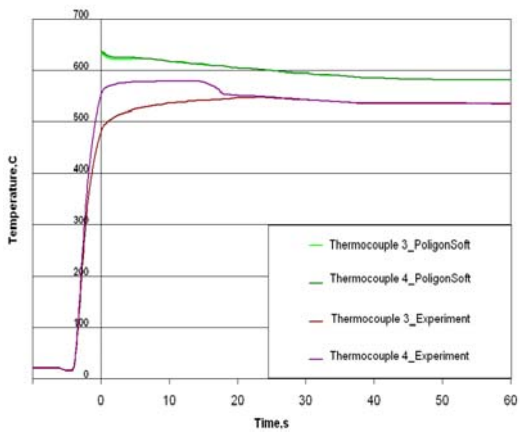


Fig. 5. Temperature curves T_{pour} = 700 °C.
Mold - furane binder. Alloy – AlSi12

Comparing solidification processes at different pouring temperatures (Fig. 3. and Fig. 6.b) it can be seen that at the lower pouring temperature of T_{pour} = 670 °C° the temperature curve approaches the solidification level immediately after pouring, but at the higher pouring temperature of T_{pour} = 700 °C° the temperature curve approaches the solidification level only after 18 sec. This difference can be explained very logically, the lower pouring temperature approaches the liquidus temperature and the solidification starts right after pouring.



a)



b)

Fig.6. Temperature curves. Alloy – AlSi7. Mold with a) water glass T_{pour} = 700°C; b) furane T_{pour} = 670°C.

To illustrate the comparison of experimental and calculated results the program “PoligonSoft” was used. In Fig. 7 real castings are confronted with calculated temperature fields of castings as a equiscalar surface of the liquidus temperature. Here results are represented for holding times 4, 10 and 14 sec. In the Fig. 7 we can also measure wall thickness. Comparing the wall thickness with hold time of metal in mold it can be seen clearly that the growth of the real and calculated wall thickness directly depends on the hold time.

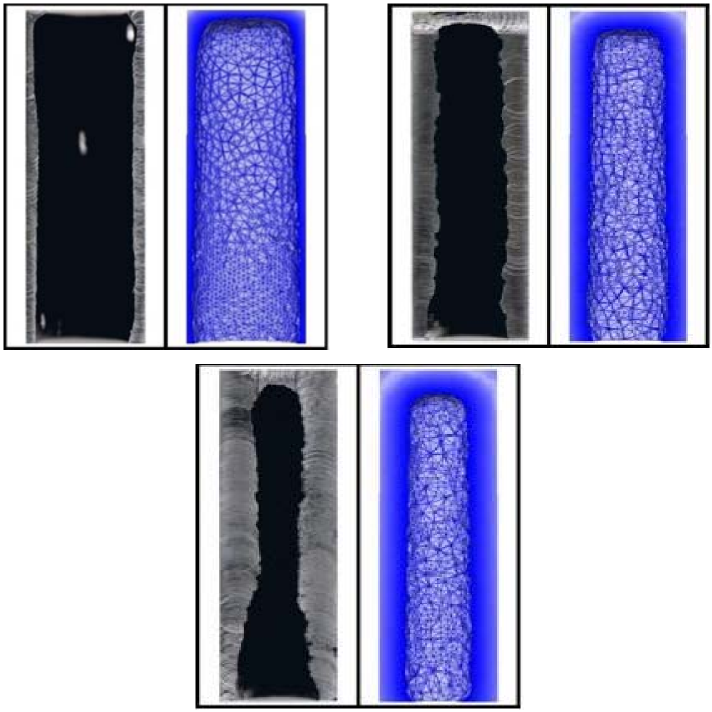


Fig.7. Comparison of the wall thickness of castings and simulation results after the preservation time from 4sec, 10 sec and 14 sec.

So, to get quality hollow aluminum castings, it was recommended to use AlSi9 alloy at the pouring temperature T_{pour}= 670°C and as a binder – furane resin. Also as a result we have proved the adequacy of calculated data in the system “PoligonSoft”. But it is significant to note that “PoligonSoft” - is a calculation tool and correct result can be received only by advanced user.

References

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