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Effect of the Hold Time and Temperatureon Characteristic Quantities of TDACurves

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Abstract

This paper presents the effect of the temperature and hold time in the holding furnace of 226 silumin on the characteristic quantities of TDA curves. The temperature of phase transformations and the cooling rate were tested.It has been shown that increasing both the hold time and the temperature in the holdingfurnace cause the decreasethe end of$\alpha+Al_9Fe_3Si_2+\beta$ and $\alpha+Al_2Cu+\beta$ternary eutectics crystallizationtemperature in the tested silumin. This is due to the fact an increase in amounts of impurities as a result of reacting theliquid alloy with the gases contained in the air.It has been shown, however, that examined technological factors ofthe metal preparation do not cause systematic changes in the cooling rate.

Keywords: Theory of Crystallization, Pressure Die Casting, TDA Method

1. Introduction

Paper [1] presents the results of the effect of 226 silumin hold time in the holding furnaceon its crystallization process. These studies were carried out in Innovation Implementation Company Wifama-Prexer Ltd. To study of the 226 silumin crystallization process a thermal and derivative analysis (TDA) method was used.This method consists in continuously recording the temperature and its first derivative versus time.The results are presented as graphs of functions $t = f(\tau)$ and $dt/d\tau = f'(\tau)$ called the temperature curve and the derivative curve,respectively. TDA method is also used to study the crystallization of iron, copper or magnesium alloys [2 ÷ 5]. The process of the 226 silumin preparation presented in paper [1] and used in Wifama-Prexer company is as follows. Silumin is melted in a gas-fired crucible furnace.After melting and metaloverheating a slag is removed and refining with used of constant refiner is executed. Then the metal is transported from the melting furnace to the device with a rotating head, where re-refining with using nitrogen andconstant refiner is realised.Refined metal is transported to the holding furnace, and then is taken directly to the cold-chamber die casting machines. Research carried out with use of TDA method shown the effect of the silumin hold time in the holding furnace on the temperature and derivative curves course. For a hold time less than 40 minutes on the derivative curve there is a single maximum of the thermal effect coming from$\alpha + Al_9Fe_3Si_2 + \beta$ ternary eutectic crystallization, while for the time of 40 minutes and longer on the curve a double maximum of the thermal effect can be observed .The appearance of the double maximum on the thermal effect comes from the eutectic crystallization is probably due to a high level of the gas in silumin, which is relatively long held in the holding furnace. Currently, in Wifama-Prexer company to silumins melting a gas-fired shaft furnace is also applied, inside which a refiningwith using the constant refiner is carried out.In this technology of preparing a liquid alloyan additional refiningwith use of nitrogen is not executedand metal after pouring into a ladle is transported directly to the holding furnace.

The aim of this study is to examine the effect of hold time and temperature in the holding furnace of 226 silumin melted in a shaft furnace for TDA curves course and their characteristic quantities.

2. Work methodology

To the study 226 grade silumin was used. The chemical composition range of examined silumin is shown in Table 1.

Table 1.
Chemical composition range of tested silumin

Chemicalcomposition, wt. %							
Si	Cu	Zn	Fe	Mg	Mn	Ni	Al
8.51 ÷ 9.28	2.08 ÷ 2.51	1.05 ÷ 1.09	0.75 ÷ 0.81	0.30 ÷ 0.33	0.19 ÷ 0.24	0.11 ÷ 0.14	rest

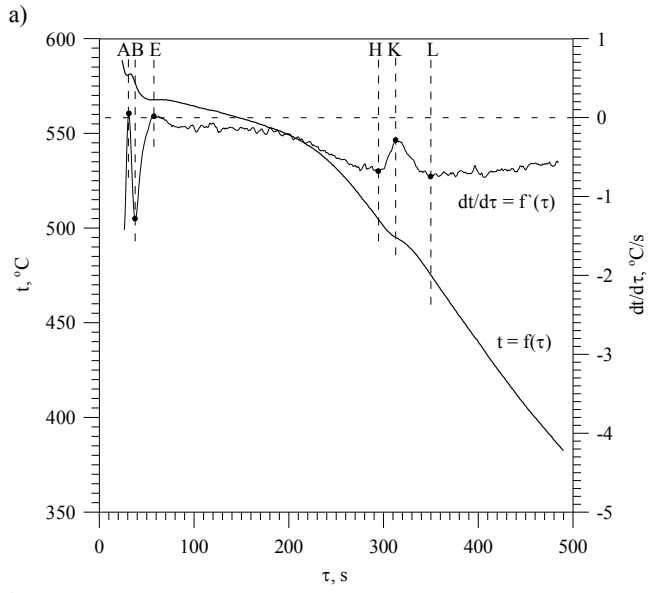
Silumin was melted with use of the technology using a shaft furnace.After melting a metal was poured into the ladle and transported to the holding furnace with a preset constant temperature. 680 and 770°C operating temperatures in the holding furnace were used. Liquid metal was taken from the furnace for analysis of its crystallization by TDA method at intervals of 10 minutes, in the range of 10 ÷ 60 minutes from the moment of pouring a metal into the holding furnace.

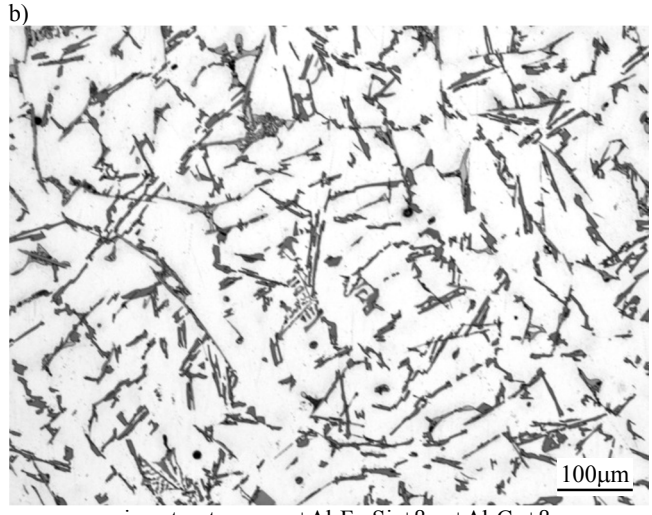
3. Results

Figure 1(a, b) shows representative TDA curves of silumin, for which 680°C hold temperature was used. On TDA curves there are three thermal effects coming from phases crystallization. 226 silumin crystallization process was described in paper [1]. According to it the first thermal effect on the derivative curve marked as AB comes from the crystallization of α primary phase.The next thermal effect described as BEH corresponds to the α+$Al_9Fe_3Si_2$+βternary eutectic crystallization. Hypoeutectic silumins crystallization with the addition of Fe is described in paper [6].It follows from it that depending on the concentration of Fe $Al_9Fe_3Si_2$ intermetallic phase can crystallize as eutectic mixture component or peritectic phase. In silumins containing about 1% Fe $Al_9Fe_3Si_2$ phase crystallises before α + β eutectic mixture as a peritectic phase, whereas in silumins with a lower concentration of Fe such as investigated 226 alloy thisphase crystallizes as the above-mentioned component of theternary eutectic. Last HKL thermal effect comes from next ternary eutectic crystallization i.e. α +Al_2Cu + β.For all silumins cast from 680°C analogical TDA curves was recorded, were the same three thermal effects occurred. The coordinate values of the characteristic points are given in Table 2. Tested quantitieswere as follows:

– the temperature of the beginning and the end of phase transformations (tB, tH and tL),
– the temperature at the moment of the most intense heat generation coming from a crystallization of individual phases (tA, tE and tK),
– the first derivative of the temperature versus time K = dt/dτ determined for individual characteristic points on TDA curves.

The quantity "K" shows the cooling rate of the alloy.





microstructure: α, α+$Al_9Fe_3Si_2$+β, α+Al_2Cu+β

Fig. 1 (a, b). Representative TDA curves (a) and the microstructure (b) of 226 silumin after holding at a temperature of680°C

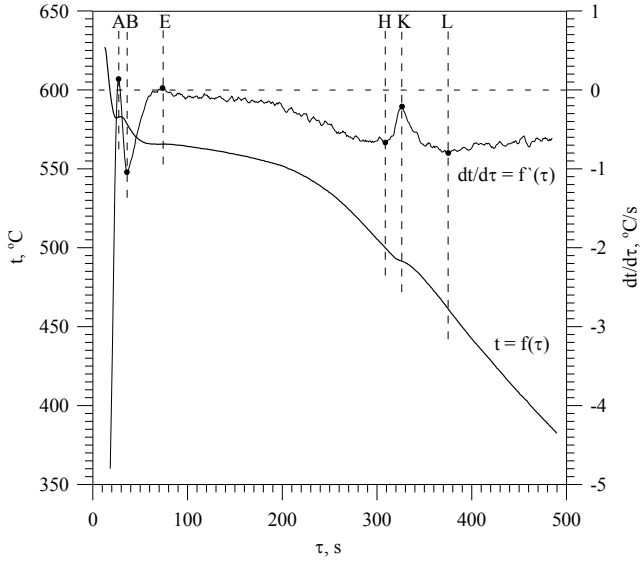
Table 2.
The values of the quantitiesdescribing TDA curves for silumins holding at 680°C

No	Holdtime, min	t, °C						dt/dτ, °C/s					
		tA	tB	tE	tH	tK	tL	KA	KB	KE	KH	KK	KL
1.	10	581	577	564	505	495	475	0.52	-1.28	0.02	-0.68	-0.29	-0.75
2.	20	581	576	564	503	493	474	-0.41	-0.75	0.13	-0.77	-0.30	-0.81
3.	30	582	577	564	501	493	473	0.17	-0.85	0.09	-0.69	-0.29	-0.81
4.	40	583	576	563	500	493	474	0.92	-1.19	0.08	-0.70	-0.28	-0.81
5.	50	586	576	564	500	494	473	0.23	-1.35	0.09	-0.74	-0.28	-0.81
6.	60	586	578	564	499	494	473	0.21	-1.31	0.12	-0.72	-0.27	-0.78

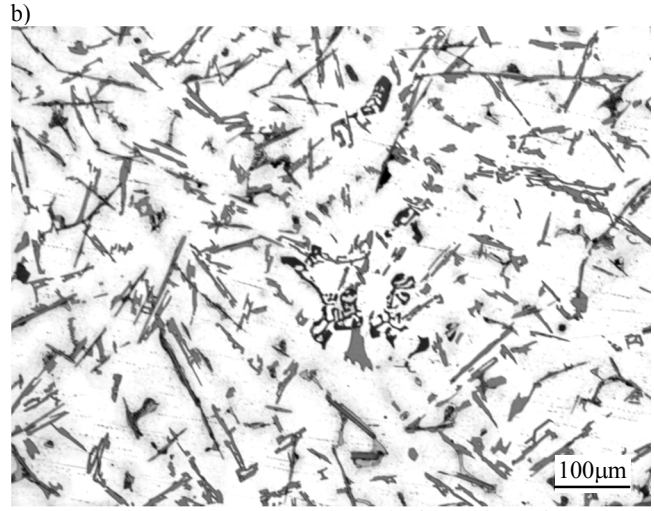
The presented data show a slight decrease in “tH” and “tL” temperature with an increase in hold time of silumin in the holding furnace.They means respectively the temperature of the end of α +$Al_9Fe_3Si_2$ +β andα +Al_2Cu+βternary eutectics crystallization. The observed trend is probably due to the increasing an amount of impurities in the liquid silumin, which is held in the maintaining furnace.It is a result of its increasingly prolonged contact with the ambient air. For points describing the beginning of phases crystallization and maximum of thermal effects an elongation of the hold time did not result in lowering the temperature.

Figure 2 (a, b) shows representative TDA curves of silumin, for which 770°C hold temperature was used.Both TDA curves and the microstructure are similar to those obtained for the temperature of 680°C.The temperature "t", and the cooling rate "K" in the characteristic points describing TDA curves of silumins holding at 770°C are shown in Table 3.

a)



b)



microstructure: α, α+$Al_9Fe_3Si_2$+β, α+Al_2Cu+β

Fig. 2 (a, b). Representative TDA curves (a) and the microstructure (b) of 226 silumin after holding at a temperature of 770°C

The data presented in Table 3 shows an analogous trend of lowering the temperature “tH” and “tL” with an increase in hold time in the holding furnace as it was for the temperature of 680°C. Comparing the data from Tables 2 and 3 also lower temperature “tH” and “tL” for the temperature of 770°C may be observed. It is assumed that increasing the temperature in the holding furnace increases the reactivity of the molten metal and gases contained in the air, and consequently the amount of contaminants present in it. There were no effects of both time and holding temperature of the silumin in the holding furnace on “K” cooling rate.

Table 3.
The values of the quantities describing TDA curves for silumins holding at 770°C

No	Holdtime, min	t, °C						dt/dτ, °C/s					
		tA	tB	tE	tH	tK	tL	KA	KB	KE	KH	KK	KL
1.	10	583	578	564	501	492	470	0.32	-0.97	0.03	-0.79	-0.24	-0.78
2.	20	579	573	560	500	492	470	0.04	-0.88	0.01	-0.69	-0.28	-0.99
3.	30	583	579	565	500	491	469	0.14	-1.04	0.02	-0.67	-0.21	-0.80
4.	40	579	575	562	500	492	468	0.17	-0.98	0.05	-0.71	-0.27	-0.78
5.	50	575	571	559	496	490	469	0.34	-0.95	0.03	-0.64	0.30	-0.72
6.	60	578	575	563	495	487	468	0.15	-0.93	0.06	-0.64	-0.25	-0.88

4. Conclusion

The research results presented in the current work enable coming to the following conclusions:

- the technology of the preparing a liquid silumin presented in this paperwith using shaft furnace does not result in the presence on TDA curves a double maximum on the thermal effect coming fromα + $Al_9Fe_3Si_2$+ βternary eutectic crystallization even after a hold time equal to 60 minutes,
- increasing both the hold time and the temperature in the holding furnace decrease thetemperature of the end of α + $Al_9Fe_3Si_2$ + β and α + Al_2Cu+ βternary eutecticscrystallization occurring in the microstructure of the tested silumin,
- lowering the temperature of the end of the ternary eutectic crystallization is caused by increased amount of impurities in the liquid silumins as a result of its contact with the ambient air,
- increasing the temperature and hold time in the holding furnace not affect changes in the microstructure of the tested silumin.

Acknowledgements

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