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Planning and Computerised Monitoring of an Experiment of Thermal Analysis of the Alloys in the Al-Cu-Si System

The paper presents an installation conceived for the automatic registration of the temperature in the thermal analysis, at the industrial and laboratory level, with application to the system of non-ferrous alloys Al-Cu-Si. The experiment performed on the above installation is compared to processes monitored through simulation with specialised software.

1. Introduction

The method of the thermal analysis is based on the monitoring of the time variation of a system's temperature, through its steady warming up or cooling. As proved by experience and as it can be explained theoretically [1], in the case of uniform cooling of a system where there are no phase transformations (considering the chemical reactions excluded) the temperature variation takes place uniformly (in the time-temperature diagram we obtain a continuous curve). In this paper we conceived at a lab scale a system for measuring temperature in thermal analysis, using the Lab-View software, the samples representing Al-Cu-Si alloys, and the computerised monitoring was performed with Magmasoft [5].

2. Setting up and performing the experiment

For the experiment we suggest to perform the thermal analysis during cooling [3], in the solidification process of three types of standardised alloys of the Al-Cu-Si : AlSi6Cu4, AlSi9Cu3, AlSi12Cu, (Table 1). The equipment used (Fig. 1) has a high degree of performance, making possible the computerised, correct and continuous registration of temperature. The metallic material (~300g), prepared for melting was introduced into the melting pot of the induction furnace, being heated with approximately 100°C above the melting temperature. The melted substance was poured into the cylindrical casting shapes made of furan (sand and linking material), having the interior dimensions: 50mm/60mm. The thermocouples placed into the melted substance, in the geometric centre of the part, will remain included in the metal after its solidification. We used K-type Cromel (positive)-Alumel (negative) thermocouples with the following characteristics [3]: Temperature range (°C): -270…1372 ; Voltage range (mV) : -6,548…54,74; Seebeck coefficient (μV/°C): 39,48 at °C.

Each thermocouple is connected to one 5B37 signal conditioning module (manufacturer Analog Devices), fixed into the socle on a connection card linking the measuring medium and the acquisition card. As the acquisition card mounted into the computer has the voltage inputs (0-10V), the signal received form the temperature transducer (the immersion thermocouple) must be converted by the signal-conditioning module.

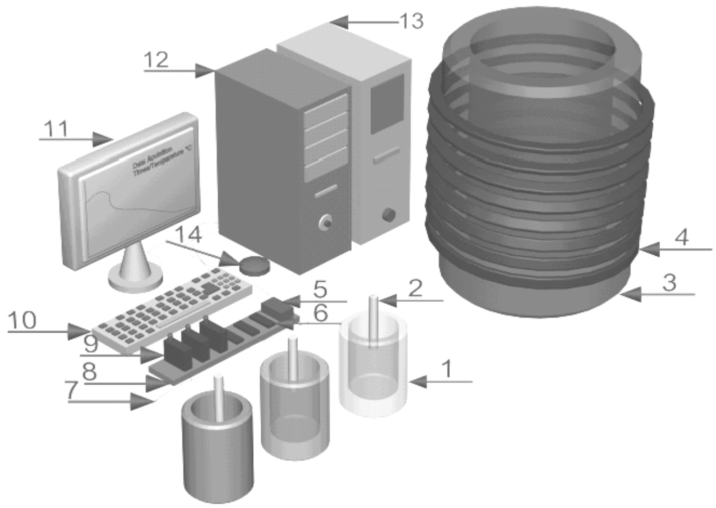

Figure 1 Sketch of the installation for the heat analysis of the Al-Cu-Si alloys

1- Casting shape mad of furan; 2- Cromel-Alumel immersion thermocouple; 3- induction furnace (melting pot) ; 4- Induction reel (copper serpentine cooled with water) ;5- Power source in commutation; 6- Commutation socles for modules; 7- Connecting cables ; 8- Motherboard where the modules are mounted; 9- 4B37Modules (Analog Devices) ; 10- keyboard ; 11- monitor ; 12- PC, where the ISA-type serial interface of the data acquisition card is mounted is ; 13- uninterruptible source; 14-mouse.

It converts the physical dimension electromotor voltage (θ) obtained at the thermocouple output into a continuous (U), measurable by the acquisition card, dimension proportional with the one at the module input, according to the variation law [4]:

$$U = C_0 + C_1\theta + C_2\theta^2 + ... + C_n\theta^n \qquad (1)$$

where, for a K-type thermocouple, within the 0^oC-1372^oC temperature range, the specific coefficients C_n with n = 0÷ 9, have the values [4] :

C_0= -17,600413686, C_1= 38,921204975, C_2=1,85587700·10^{-2},
C_3= -9,9457593·10^{-5} C_4=3,18409457·10^{-7},C_5=-5,607284·10^{-10},
C_6= 5,6075059·10^{-13}.C_7= -3,202072·10^{-16}
C_8= 9,7151147·10^{-20} , C_9= -1,210472·10^{-23}

After the data acquisition into the computer memory (Pentium II with the LabView software) we obtain a matrix of values corresponding to each acquired signal. Through the software created for the application of temperature measuring the terms of the matrix will be converted into temperature and displayed on the monitor in the Excel format. It is also displayed the graphical shape of the temperature variation in (fig.2-5). The experiment of the thermal analysis, performed at a lab scale, using small quantities of material (~300g) is not too relevant for observing the modification of the solidification curve (fig. 2). At an industrial scale [2], the thermal analysis was performed using larger quantities of material (40 Kg), and the formation of the palier of the cooling curve through the apparition of the solid phase being obvious. (fig. 4-5). During the analysis interruptions of the cooling curves may occur due to the short-circuiting of the contacts at the thermocouples, without the melting of the insulating materials of the conducting wires, when the temperature is raised. We may consider the examples of the cooling curves for the AlSi12Cu alloy (STAS 201/2-80).

Table 1 *Al-Cu-Si – type alloy, STAS 201/2-80 ; DIN 1725-2*

Alloying element % mass	**AlSi6Cu4**	**AlSi9Cu3**	**AlSi12Cu**
Si	5,0-7,5	7,5-9,5	11,0-13,5
Cu	3.0-5.0	2.0-3,5	0,1-1,2
Mg	0,1-0,3	-	-
Mn	0,3-0,6	0,2-0,5	0,2-0,5
Al	base	Base	base
Ni	0,3	0,3	0,2
Fe	0,8	0,5	0,5
Zn	2,0	1,2	0,5
Ti	0,15	0,15	0,15
Mg	-	0,3	0,3
Pb	0,3	0,2	0,2

Sn	0,1	0,1	0,1
(Kg/m^3)	27,5	27,5	26,5

The monitoring of the solidification process at a laboratory and an industrial scale used the LabView software(fig.2, 3), and for the simulation of the cooling process we used MagmaSoft ® Version 4.2 produced my the company MAGMA GeissereiTechnologie GmbH D-52072 Aachen Germany [5]. The comparisons of the cooling recording process and is simulation allow us to appreciate the exactness of the lab method conceived.

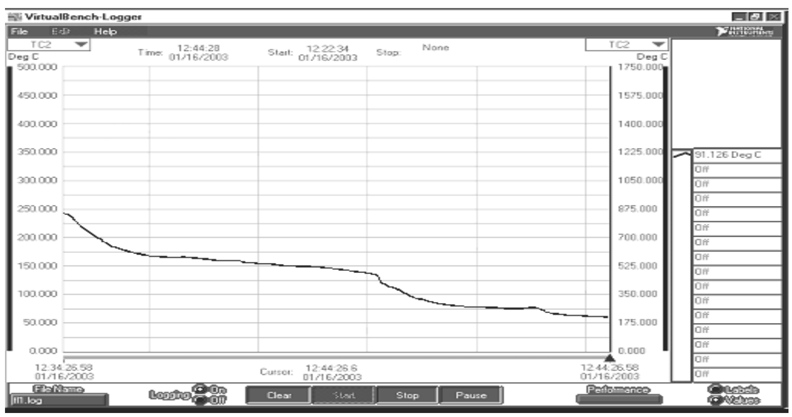

Figure 2 Cooling curve for sample AlSi12Cu, 302g ; recording time 10 min. (soft LabView).

From the thermal analysis of the 40 Kg sample of AlSi12Cu alloy, (fig.4) we appreciate the temperature of beginning and end of solidification as 580^{o}C and 515^{o}C respectively.

Figure 3 Cooling curve, sample AlSi12Cu, 40 Kg, cooling time 54 min. (soft LabView)

From the thermal analysis of the 40 Kg sample of AlSi12Cu alloy, (fig.4) we appreciate the temperature of beginning and end of solidification as 580°C and 515°C respectively. Through simulation with MagmaSoft of the solidification of a charge of 40 Kg of AlSi12Cu alloy, (fig. 4) we obtain the following characteristics: initial temperature : 700°C; temperature of the beginning of solidification: 570°C, temperature of end of solidification: 529°C.

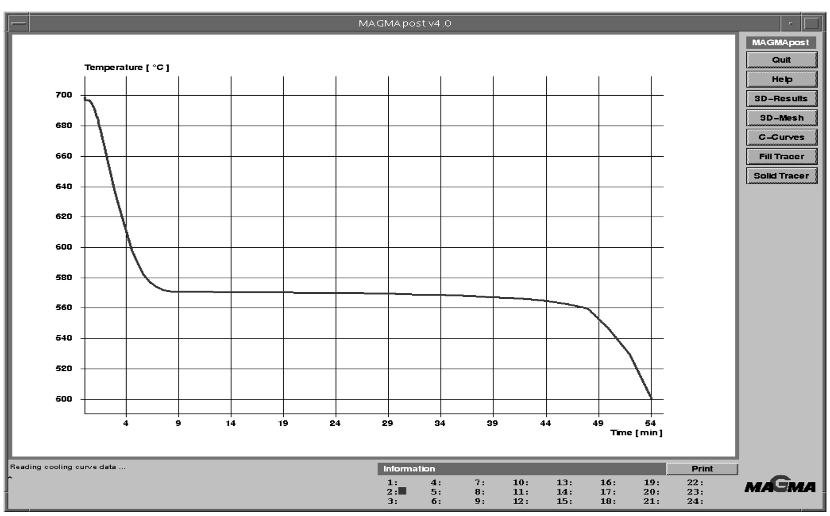

Figure 4 The cooling curve temperature(°C)- time(min) of the AlSi12Cu alloy

The results of the lab findings, compared to the computerised simulation, for all the samples of Al-Cu-Si alloys are presented in table 2

Table 2

Test alloys (samples)	Beginning of solidification (°C)		End of solidification (°C)		End of solidification (°C)	
	Lab View	Magmasoft Simulation	Lab View	Magmasoft Simulation	Lab View	Magmasoft Simulation
AlSi6Cu4	615	610	540	530	75	80
AlSi9Cu3	580	578	490	479	90	99
AlSi12Cu	580	570	515	529	65	41

3. Conclusions

The temperatures determined through simulation have evidently smaller values than those obtained from the experiment with the Lab View software. The difference may be due to:

- the influence of the alloying elements and of impurities from the alloys used in the experiment, through the interatomic interactions.
- the errors brought by the measuring devices,
- the cooling regime and the quantity of material subjected to the thermal analysis;

The proposed measuring installation (fig. 1) may be utilised with success in the thermal analysis for any type of material, provided the technological cooling regime is observed..

References

[1] CHIREEV V.A., - Course of physical chemistry, (translation form Russian), Technical Publishing House, Bucharest, 1974

[2] DEAKY, A., PERJU, D., TODINCĂ, T, - Contributions to the measuring of the temperature with turbulent pneumatic resistances. *The Scientific and Technical Bulletin IPT, series Chemistry,* vol 25(39), fasc.2, 1980, p.71.

[3] GROPŞIAN, Z., CZIPLE, F. –*On methods of experimental determination of equilibrium in solid-liquid systems* , Twenty-.five years of academic education in Reşiţa 25-26 October 1996, p.195

[4] RUJA, I. –Techniques of automatic adjustment, Eftimie Murgu Publishing House, Reşiţa 1998, p.172-174.

[5] *** MAGMA SOFT, Geisserei Technologie GmbH D-52072 Aachen,