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STUDIES CONCERNING ENERGETIC CONSUMPTION OF SOME HEATING EQUIPMENTS WITH RESISTORS

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ABSTRACT

In order to increase the resistance of aluminium alloys a complex heat treatment is usually performed. Therefore, we must consider the reaction time between aluminium alloys and furnace atmosphera. These atmospheres contain oxygene and nytrogene. Aluminium is an active element, therefore the oxidation is a very fast one.From the experiments made, the oxidation kinetics of aluminum alloys proves to depend on many factors, such as: temperature, alloy activity, chemical saturation and partial pressure of oxygen in gaseous phase. For a heat treatment process, the oxidation time became heating time. The furnace design provides to minimize the losses by untights and to realise a uniform air stream in the furnace chamber. These facts are going to minimise the oxide layer of the treated parts. For the studied furnaces, used at aluminum alloys heat treating, the functioning curves were first made. It must be mentioned that all experiments were made in different days, in order to assure the same pre-heating conditions for the equipment. As a conclusion, studying the heat chamber geometry is a step forward to a new concept of heat treatment furnaces. This idea leads to important economical effects, on a long term, for a constant development of the industry.

KEYWORDS: Aluminum, Energy, Temperature, Consumptions

1. Introduction

The evolution of heating methods has an important role on the quantitative and qualitative development of heat treatment technologies. This evolution is decisive for the charge heating speed, for the value of energetic consumption of the process and for the technological effects subsequently obtained. These things can be achieved by the functional-constructive improvement of the furnaces used in aluminum alloys heat treatment taking into account the following aspects:

-Reduction of energetic consumption and basic materials per product unit through the optimization of work chamber construction,

-Increase of labor productivity and furnace reliability by using some new leading systems with high automation degree of the heat treatment furnace,

-Reduction of service personnel that is to be implied in heat treatment technology process and in furnace exploitation,

-Cost reduction of the furnace and of its dimensions in comparison with the existent equipments in country by using adequate refractory and thermo-insulated materials.

1.1. Methodology

Work methodology includes the next stages:
- the adoption of heat treatment technology for the used aluminum alloys;
- the election of the used installations and devices for the structural analysis of the chosen aluminum alloys;
- the election of necessary equipments and installations for making the heat treatment cycles of the chosen aluminum alloys;
- the management of the experiment and analytical interpretation of the results.

1.2.Adoption of heating technology of the used alloys

The two chosen alloys - AlCu2,5Mg and AlCu4Mg1 are Al-Cu-Mg ternary alloys used widely in machines manufacturing. The chemical composition of the alloys according to SR EN 573-3 is presented in table 1.

Table 1.*Chemical composition of the used aluminum alloys*

Alloy	**Chemical composition, %**							
	Cu	**Mg**	**Mn**	**Si**	**Fe**	**Zn**	**Ni**	**Ti**
AlCu4Mg1	3,8-4,9	1,2-1,8	0,3-0,9	0,2	0,3	0,25	-	0,15
AlCu2,5Mg	2,2-3,0	0,2-0,5	0,2	0,8	0,7	0,25	-	-

The pieces that make the charge have cylindrical geometry and the dimensions of the pieces depending on the type of the alloy are included in table 2.

Table 2.

	d_0, mm	L_0, mm
AlCu4Mg1	15	150
AlCu2,5Mg	20	104

1.3. Election of the equipments necessary to heat cycles

The heating of the pieces and blanks of aluminum alloys for quenching it will be made in electric furnaces with air-forced circulation. The adjustment and control of heating mechanisms temperature must be made with automate auto registration apparatus, with a better precision class, so that measurement precision stands in limits of ±3°C. The control and adjustment of control apparatus must be made in the moment where in workspace exist the maximum temperatures.

The researches will be directed towards the research of energetic consumption of electric furnaces that function in mean temperatures (500 - 600°C). Thus, to study the energetic consumption we chose a classical heat treatment furnace;

The classical heat treatment furnace is presented in figure 1 and has the characteristics: rapidly cooling and heating possibility, small weight and compact design; the door opens vertically; programming and control system in 8 segments for the exact adjustment of temperature; digital setting of heating curve (temperature-time) and digital indicating temperature of workspace.

Each program can have three stages that need each three parameters: heating speed, heating time or holding time.

Technical and functional characteristics of this heating device are:

- intenseness 1800 W, tension 220V c.a, 50 Hz
- programming possibility or some complex treatment programs, each program includes until 8 grades and 8 holding levels.
- Possibility of election and adjustment of the main parameters of the treatment in large limits:
  - heating speed: 0.1…400 C/s
  - holding periods on level: 0,0….999,9 h
- Possibility of using neutral treatment mediums (Ar , N_2)

Fig. 1. *Unit picture of the classical furnace*

Through the controller can be connected more programs or repeated the same cycle under identical conditions more than once.

2. Experimental and analytic interpretation of the results

To achieve mathematical simulation is necessary to program the experiment.

This supposes to:

- Establish the necessary and adequate number of experiences and realization conditions;
- Determination of regression equation which represents the process model;
- Determination of the optimum value for the achieved process.

Hereby, for each variable it determines the basic levels and variation intervals.

By adding the variation level to basic level the superior level is obtained and by its subtraction is obtained the inferior level of the variable.

The election of variation interval must be done so that it has as accurate values as possible from functional point of view.

A first step is the establishment of basic levels and variation intervals.

The interpretation of experimental results consist in determining some experimental variation curves of charge weight according to the energetic consumption of the equipment; the interpretation of experimental results will be finalized through the determination of some analytical equations that describe the curves experimentally obtained.

2.1. Management of the experiment

For simulating the final heat treatment process of AlCu2,5Mg aluminum alloy it is necessary a minimum number of three experiments according to 3^k factorial experiment theory previously presented. In this case k = 1 particularly it is a variation factor: heating time.

There are presented in table 3. the variation interval and basic level for programming the experiment, and to determine the energetic consumption for the two alloys.

Table 3. *Programmed experiment*

Factor	weight, g
Basic level	500
Variation interval	200
Superior level (+1)	700
Inferior level (-1)	300

With the help of the obtained experimental results it determines the energetic consumption for each charge. I mention that heating temperatures, holding times and cooling conditions are similar for each experiment and variable is the weight of the charge.

2.2. Experimental results for AlCu2,5Mg aluminum alloy

The experiment made in different days holding the initial heating conditions for equipments and for charges.

The experimental results for AlCu2,5Mg alloy are presented in tables 4 and 5.

Table 4. *Temperature variation for classical furnace for AlCu2,5Mg alloy*

Time, sec.	Temperature variation, °C					
	0	100 g	300 g	500 g	700 g	900 g
0	19	21	23	27	25	22
60	33	40	35	40	45	32
120	63	61	63	69	76	60
180	97	94	96	104	109	93
240	133	130	133	138	144	127
300	168	165	163	171	178	160
360	201	198	196	203	209	192
420	240	229	227	234	241	223
480	267	259	255	263	271	253
540	297	288	283	291	299	281
600	325	315	308	317	322	307
660	352	341	333	341	346	331
720	378	365	357	364	369	354
780	402	387	379	387	390	375
840	425	409	399	406	410	395
900	448	430	419	425	429	414
960	468	450	438	444	446	432
1020	487	469	457	461	464	449
1080	507	487	473	477	480	465
1140	525	505	492	493	495	481
1200		525	506	508	511	495
1260			525	525	525	509

Table 5. *Variation of heating time and total consummated energy at heating depending on the weight of the charge for AlCu2,5Mg alloy*

Weight, g	Classic	
	Total heating time , s	Total energy, Wh
0 g	1134	567
100 g	1200	600
300 g	1256	628
500 g	1256	628
700 g	1260	630
900 g	1319	659,5

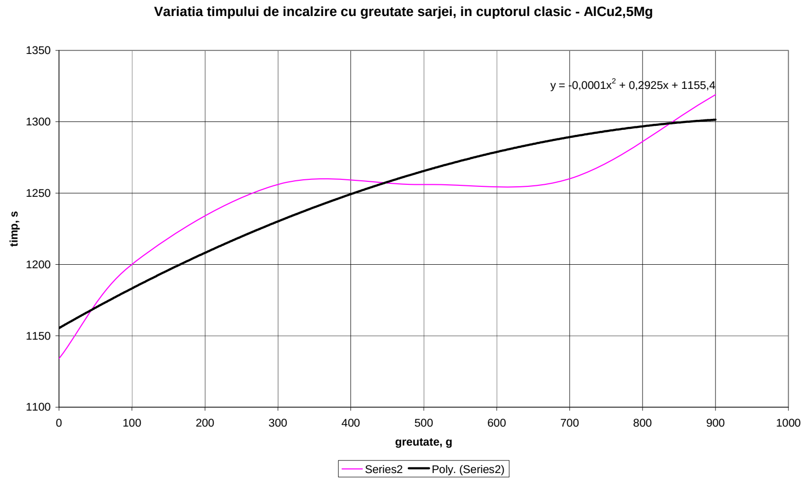

Fig. 2. *The diagram of heating time variation with charge weight from AlCu2,5Mg, in classic furnace.*

Total energy consummated in heating was calculate taking into account the function time at maximum power with the relation:

$E = P\ t.$

2.3. The experimental results for Cu4Mg1 aluminum alloy

The experimental results for AlCu4Mg1 alloy are presented in table 6.

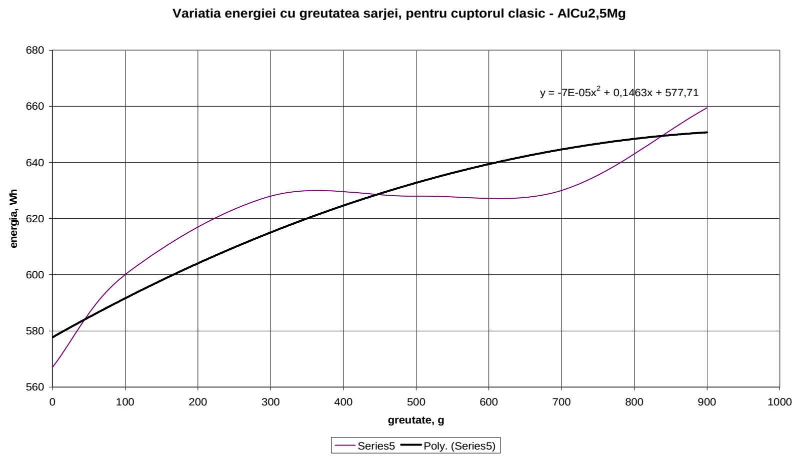

Fig. 3. *The diagram of consummated energy variation with charge weight of AlCu2,5Mg, in classic furnace.*

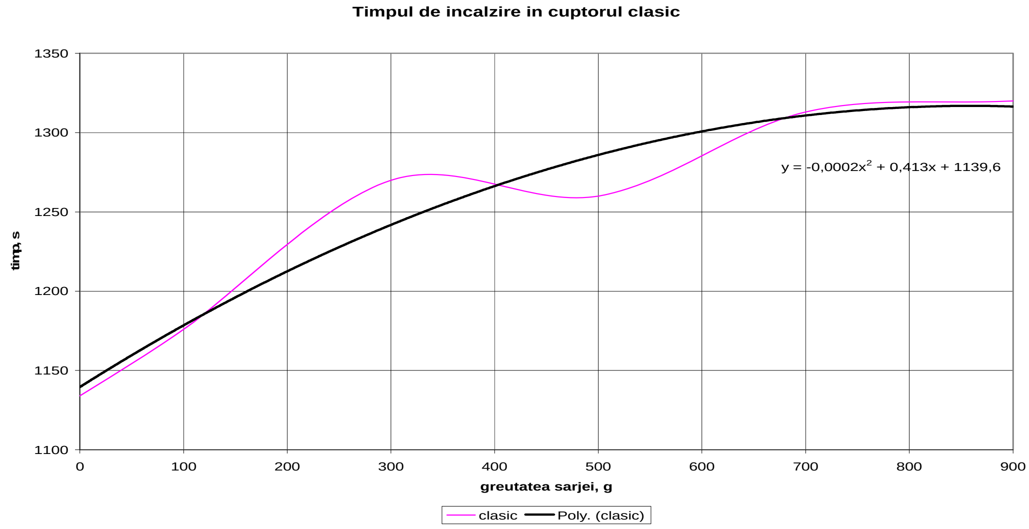

Fig. 4. *The variation diagram of heating time with weight charge of AlCu4Mg1, in classic furnace*

Table 6. *The variation of total heating time and consummated energy according to charge weight for AlCu4Mg1 alloy.*

Weight, g	Classic	
	Total time, s	Total energy, Wh
0 g	1134	567
100 g	1176	588
300 g	1270	635
500 g	1260	630
700 g	1313	656.5
900 g	1320	660

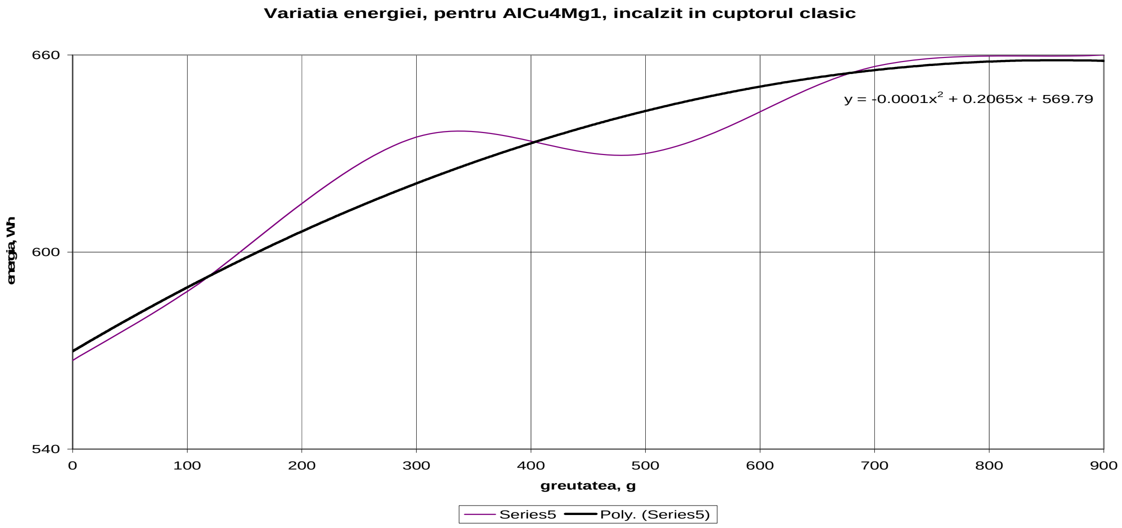

Fig. 5. *The variation diagram of consummated energy with charge weight of AlCu4Mg1, in classic furnace*

3. Conclusions

The chosen research methodology permits effectuation of the experiments for studying the energetic consumption of chosen heating equipments through:

- The correct adoption of a heat treatment technology for the study of the two different aluminum alloys;
- The election of some performing furnaces to control heating process for the made heating operations;
- The election of some modern installations to determine the exact chemical composition of the studied materials;
- The management of the experiment and possibility of analytical interpretations of the results.

After the experiment were made it was remarked the increase of energetic consumption respectively heating time once with the increase of charge weight. The charge weight was varied with 100g.

At the same time, there were experimentally found out the variation equations of heating time until a certain temperature with charge weight; the variation equations of the consumed energy with charge weight.

Thus, from the analysis of experimental data, there are noticed bigger heating times for AlCu2,5Mg alloy.

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