APPLICATIONS OF ISOSTATIC PROCESSING TECHNOLOGY IN THE FIELD OF DURALUMIN ALLOYS

Virgil GEAMĂN[1]

Abstract: *Among of aluminium alloys, the development of the range of duralumin alloys is determined by the fact that alloying is enlarging the possibilities of precipitation hardening. The paper presents the influence of heat treatment applied to pieces made from duralumin alloys, before and after isostatic compaction. The particularities of the final heat treatment, applied to the test, to pieces from duralumin alloys - obtained through plastic deformation - especially through extrusion, are determined by the characteristics of the plastic deformation structure.*

Key words: *isostatic processing, CIP, duralumin alloy, heat treatment.*

1. Introduction

Isostatic Processing is an established process used for the fabrication of advanced engineering materials, involves the simultaneous application of heat and isostatic pressure to consolidate powder compacts, cast parts or other porous bodies.

Aluminium alloys offer the highest degree of hardness by heat treating consisting by chilling followed by ageing.

The diffusion, which allows dispersion of secondary phases - especially solid solution supersaturated in copper, was done very efficiently in the case of alloys with good plastic deformability [1], [4].

Besides these particularities, when choosing the heat treating conditions, the shape and dimensions of the samples, it must be considered also.

2. Experimental Procedure

The particularities of the final heat treating method made to parts from duralumin alloys are determined by the characteristics of the structure as: high granulation, micro-forging cracks, chemical segregation, aciculate and dendritical form of the inter-metallic compound etc.

Besides these particularities, when choosing the heat treating conditions, it must be considered also the shape and dimensions of the parts.

All types of experimental samples were made from extruded bars made from duralumin alloy $AlCu_4MgMn$ with dimensions: (∅20 x 20) mm. The chemical composition of these alloys is: 4% Cu, 0.5% Mn, 0.5% Mg, rest Al.

The increasing of the value for resistance by heat treating applied to bar strips is explained by the development of a solid solution with a better capacity of alloying as the one obtained by partial or total solidification and spheroidizing of secondary brittle particles [1], [5].

By hardening, the $CuAl_2$ particles from

[1] Dept. of Technological Equipment and Materials Science, *Transilvania* University of Braşov.

the eutectic Al-Si-$CuAl_2$ are mainly peeled and the fragile eutectic is ending his existence. The silicon is spheroidizing and the unpeeled $CuAl_2$ particles will be uniformly distributed in the structure.

The duralumin alloys are offering the highest degree of hardening by quenching in water from temperature of 510 ^{0}C followed by artificial or natural ageing.

With reference to Brinell's hardness variation (∅5/250), applied before and after the final heat treatment, where the maximal value is exactly the arithmetic mean of Brinell's hardness, measured after each type of treatment method and by analysing the results, it can be concluded [2], [3], [5]:

a) no matter what kind of isostatic compaction is applied, the sample's hardness is increasing after compaction;

b) after fast cooling, hardness decreases with (20-27) Brinell units comparing to the hardness after extrusion;

c) after ageing, the hardness of the samples is increasing generally with about 36 Brinell units;

d) for the duralumin alloy, there were made several kinds of final heat treatments, leading to the fact that maximum hardness of the alloy is achieved after maintaining in the ageing process for 5-7 hours, which will reduce substantially the cycle of the final heat treatment - compared with natural ageing period, which is approx. one week;

e) as it is known, the value of mechanical properties of non-ferrous alloys are lower in the immediate period after hardening, in the so called "*incubation period*".

This can be explained by the deformability of the material after rapid cooling, with the existence of solid solution α supersaturated in Cu, which is homogeneous and after hardening is preserved relatively mild, with a good tenacity and formability.

In the case of duralumin alloy, after 2-4 hours, it begins a spontaneous hardening, by ageing based on sub-microscopical sagging, extremely fine - molecularly dispersed - of the defined compound, followed by the increasing of volume, which, at this low temperature, determines the cold-hardening, the increasing of hardness, resistance and formability, which reaches a maximum (4-5) days after quenching.

With a slight heating to (120-170) ^{0}C and artificial age-hardening, the roughly same results, a little faded, can be obtained in few hours.

According to these, we have tried to intermediate a CIP treatment after quenching. It consists in a maintaining of the samples in a CIP equipment at 20 ^{0}C and 120 MPa, for a period of 40 min.

3. Results and Discussion

The experimental results are included in Table 1 and Table 2. We can see the variation of the porosity related to the time of compaction and the mechanical properties of forged duralumin alloy, respectively. Number of samples in each lot was five.

From this analysis it clearly results that the porosity is quickly eliminated, respectively at the same time of compaction the number of pores is decreasing with approx. 20-25%.

All mechanical properties are increasing with a medium value of 16.54 N/mm^2 for Tensile strength, with 42.44 N/mm^2 for Compression strength and with 8.30% for Elongation (Figure 1).

All tests were made on small samples with experimental volume of about 200 mm^3.

The hardened alloy is becoming mild and formable (as after solid-solution quenching), if it is reheated a short period 0.5-2 minutes, at the temperature of 250 ^{0}C, process called *reversion*. It is also useful from technological point of view, as high formability from the incubation period after quenching.

Experimental results for porosity tests Table 1

Lot Sample No.	Tensile strength [N/mm^2]		Compression strength [N/mm^2]		Elongation [%]	
	Classic test	**CIP test**	**Classic test**	**CIP test**	**Classic test**	**CIP test**
1	131.2	148.0	297.8	336.2	8.92	16.65
2	129.2	142.2	292.6	331.7	7.74	16.90
3	120.4	139.2	287.1	328.2	8.16	16.07
4	118.4	135.0	287.6	335.3	7.16	15.90
5	119.8	137.3	288.7	334.6	7.86	15.82

Mechanical properties of forged duralumin alloy Table 2

Lot number	Compacting time [min]	Initial porosity [%]	Porosity after applying classical heat treatment [%]	Porosity after classical heat treatment with CIP applied in the incubation period [%]
1	0	1.723	1.723	1.723
2	5	1.723	1.688	1.671
3	10	1.723	1.612	1.531
4	15	1.723	1.544	1.452
5	20	1.723	1.502	1.324
6	25	1.723	1.454	1.131
7	30	1.723	1.376	1.022
8	35	1.723	1.123	0.007
9	40	1.723	0.876	0.000
10	45	1.723	0.542	0.000

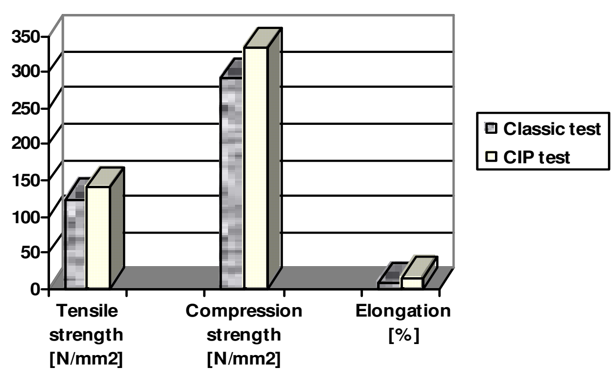

Fig. 1. *Mechanical properties comparison*

According to these aspects, the author is proposing a new technological way of compaction by using cold isostatic pressing process, for the given duralumin alloy, with the following parameters:

P = 120 MPa; T = 20 ^{0}C; t = 40 min.

The old technology used by applying CIP at the final treatment supposed:

P = 150 MPa; T = 20 ^{0}C; t = 60 min.

The new variant proposed gives us the following advantages:

- the working pressure can be reduced substantially;
- the time of exposure can be also reduced in comparison with the classical technology.

Although this decreasing in time is major in the case of an industrial production, it has an essential role concerning the productivity and with the decreasing of working pressure, all the components of the high pressure equipments are protected, which leads to the growing of working life and security in exploitation.

4. Conclusions

By analyzing the experimental results, it can be concluded:

- after fast cooling, the hardness decreases in all cases - comparing to the hardness after plastic deformation;
- after ageing, the hardness of the samples is increasing, but not so high as after applying CIP treatment in the incubation period.

The fact gives us the right to say that after plastic deformation, it must be applied the final heat treatment for the pieces that need higher hardness under working conditions - and we especially recommend this type of treatment - with applying CIP treatment after solid solution quenching - in the incubation period.

References

1. Atkinson, H.V., Rickinson, B.A.: *Hot Isostatic Processing*. Great Britain. Adam Hilger Publisher, 1991.
2. Froes, F.H., Hebeisen, J.: *Hot Isostatic Pressing*. In: Elsevier, London U.K. 1994, p. 71-90.
3. Mizuta, H.: *Preparation of High - Strength and Translucent Alumina by Hot Isostatic Pressing*. In: Journal of American Ceramic Society **75** (1992) Nr. 2, p. 469-472.
4. Rickinson, B.A., Tidbury, L.E.: *Hot Isostatic Pressing of Cast Aluminium Alloys*. In: Aluminium Industry **5** (1986) Nr. 5, p. 15.
5. Zeiter, H., Scharfenberger, W.: *Ausheilen von Gußfehlern beim Heißisostatpressen hochfester Aluminiumwerkstoffe*. In: Aluminium **60** (1984) Nr. 12, p. 899-904.