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# PREPARATION OF EXPERIMENTAL Al-Mg-Zn ALLOY EXTRUSIONS

by

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## SUMMARY OF RESULTS

The preparation of 1/2 in. diameter rods in eight experimental Al-Mg-Zn alloys is described. This work was done as part of a co-operative research programme for the Commonwealth Advisory Aeronautical Research Council.

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## INTRODUCTION

The work to be described was part of a cooperative research programme agreed upon by the Commonwealth Advisory Aeronautical Research Council.

In a letter dated 23 June, 1959, Mr. I. J. Polmear of the Aeronautical Research Laboratories, Department of Supply, Commonwealth of Australia, Lorimer Street, Fishermen's Bend, Melbourne, Australia, detailed requirements for a number of Al-Mg-Zn alloys in the form of 1/2 in diameter extruded rod.

The alloys fell into two groups, the first having a basic nominal composition of Al-6% Zn - 2.5% Mg -1.2% Cu and the second Al-5% Mg - 4% Zn. Within each group variations on these basic compositions were made by additions of Cu (in the second group), Mn, Cr and Ag. Ti was added to every melt as a grain refiner. Fe and Si contents were not specified except that they should be at normal impurity levels. The nominal compositions of the alloys are given in Table 1, together with the actual analysis of the cast billets.

## MELTING AND CASTING

Two master alloy melts were made up, one approximately 160 lb, corresponded to alloy No. 3 (Table 1) and the other (about 80 lb) to alloys 5, 6 and 7 without copper or silver. The remainder of the alloys were made up from these master alloys by appropriate additions. Manganese, chromium, titanium and copper were added in the form of commercial master alloys. Zinc, magnesium and silver were added as the pure metals. Commercial 2S aluminum (99.5% min.Al) was used as the base metal.

The master melt for alloys 1 - 4a was made in a refractory coated steel crucible, because of the relatively large size of this melt, but all other melting was done in carbon-bonded silicon carbide crucibles. Gas-injector furnaces were used and all melts were degassed by flushing with nitrogen.

The billets were cast in a thin-walled, water-cooled mould, dressed with china clay. The cast dimensions of the billets were about 3-1/2 in.diameter and 21 in.long and they were machined to 3-5/16 in.diameter for extrusion.

## CHEMICAL ANALYSIS

Chemical analysis samples were taken by drilling the heads cut from the billets. No account was therefore taken of any segregation which may have occurred in the billets.

Reference to Table 1 will show that the compositions fell within the specified limits with the exceptions of the silver contents of alloys 4 and 6 and the magnesium contents of alloys 5, 6 and 7. However, these deviations were of a minor nature, and it was decided to proceed with the extrusion of the billets.

## EXTRUSION

After removal of the top and bottom and surface machining, each billet was cut into three equal lengths (referred to as T-top, M-middle and B - bottom). This was done because of restrictions imposed by extrusion equipment and also to avoid committing all the material of any one composition should there be extrusion difficulties.

Alloys 1 - 4a were homogenized at 450°C for about 12 hours and alloys 5 to 7 at 400°C for about 12 hours. In each instance, the billets were charged into a cold furnace and allowed to come up to temperature with the furnace. The billets were furnace-cooled to room temperature after homogenizing and subsequently reheated to the required extrusion temperature.

The extrusion conditions are summarized in Table 2. The die was 1/2 in.in diameter and had a square edge, flat face and a 0.090 in.land. No lubrication was used. The extrusion ratio was 49:1 based on container area to which the billet is upset just before extrusion starts. The top face of the middle (M) and bottom (B) sections and the bottom face of the top (T) section of each billet was placed next to the die in each instance.

The "Middle-Speed of Ram" in Table 2 gives the ram speed approximately half way through the extrusion. These speeds correspond to a range of from 2.65 to 4.68 fpm for the extruded rod. For the conditions given, the upper figure approached the maximum above which cracking of the extruded rod occurred.

All of each billet section was extruded with the exception of a butt about 1/8 in thick. About 26 feet of rod was obtained from each section and this was stretch-straightened about 1/2%. Each straightened extrusion was cut into three lengths of 8 feet measuring from the back end of the extrusion, discarding the butt and a short "lead" end.

In order to permit later re-assembly of the bars as they were extruded, sections of each rod were stamped as shown in Figure 1. (In the figure, extrusion number 3 is given as an example).

TABLE 1. Chemical Analysis Results

| Alloy No. | Zn% N[x] | Zn% A[x] | Mg% N | Mg% A | Cu% N | Cu% A | Mn% N | Mn% A | Cr% N | Cr% A | Ti% N | Ti% A | Ag% N | Ag% A | Fe% N | Fe% A | Si% N | Si% A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.4-6.1 | 5.66 | 2.3-2.9 | 2.71 | 1.0-1.5 | 1.14 | 0.4 | 0.42 | nil | - | 0.05 | 0.06 | 0.25-0.30 | 0.26 | - | 0.23 | - | 0.09 |
| 2 | " | 5.71 | " | 2.80 | " | 1.16 | nil | - | 0.25 | 0.24 | " | 0.06 | " | 0.25 | - | 0.23 | - | 0.09 |
| 3 | " | 5.82 | " | 2.88 | " | 1.18 | nil | - | nil | - | " | 0.06 | " | 0.25 | - | 0.23 | - | 0.08 |
| 4 | " | 5.66 | " | 2.73 | " | 1.14 | 0.2 | 0.23 | 0.2 | 0.22 | " | 0.06 | " | 0.24 | - | 0.24 | - | 0.09 |
| 4a | " | 5.66 | " | 2.76 | " | 1.15 | " | 0.23 | " | 0.20 | " | 0.06 | 0.65-0.75 | 0.72 | - | 0.25 | - | 0.11 |
| 5 | 3.7-4.2 | 3.86 | 4.8-5.3 | 5.31 | 0.8-1.3 | 1.03 | " | 0.22 | " | 0.22 | " | 0.07 | nil | - | - | 0.24 | - | 0.12 |
| 6 | " | 3.92 | " | 5.31 | " | 1.08 | " | 0.20 | " | 0.21 | " | 0.07 | 0.25-0.30 | 0.22 | - | 0.22 | - | 0.12 |
| 7 | " | 3.92 | " | 5.45 | nil | 0.013 | " | 0.22 | " | 0.18 | " | 0.07 | " | 0.26 | - | 0.22 | - | 0.14 |

[x] N - Nominal Composition

A - Actual Analysis

TABLE 2. Summary of Extrusion Conditions

| Alloy No. | Melt No. | Alloy Designation | Section | Extrusion No. | Billet Temp. °C | Container Temp °C | Max.Pressure tons [x] | Min. Pressure tons [x] | Middle Speed of Ram in./min |
|---|---|---|---|---|---|---|---|---|---|
| | | | T | 3 | 390 | 420 | 55.5 | 34.4 | 0.68 |
| 3 | 391 | ZG62 | M | 4 | 400 | 420 | 58.0 cold die | 35.3 | 0.88 |
| | | | B | 5 | 400 | 420 | 56.4 | 31.7 | 0.83 |
| | | | T | 6 | 400 | 420 | 56.7 | 34.4 | 0.94 |
| 1 | 397 | ZG62 | M | 7 | 400 | 420 | 51.1 | 33.5 | 0.83 |
| | | +0.4% Mn | B | 8 | 400 | 420 | 53.9 | 33.0 | 0.65 |
| | | ZG62 | T | 9 | 400 | 420 | 50.8 | 32.6 | 0.75 |
| 2 | 398 | +0.25% Cr | M | 10 | 400 | 420 | 53.0 | 31.7 | 0.68 |
| | | | B | 11 | 400 | 420 | 53.0 | 30.8 | 1.15 |
| | | ZG62 | T | 12 | 400 | 420 | 53.0 | 31.8 | 0.71 |
| 4 | 399 | +0.2% Mn | M | 13 | 400 | 420 | 57.2 | 31.8 | 0.49 |
| | | +0.2% Cr | B | 14 | 400 | 420 | 55.0 | 30.4 | 1.15 |
| | | ZG62 | T | 15 | 400 | 420 | 50.2 | 30.9 | 0.83 |
| 4a | 400 | +0.2% Mn | M | 16 | 400 | 420 | 51.8 | 30.5 | 0.88 |
| | | +0.2% Cr | | | | | | | |
| | | +0.75% Ag | B | 17 | 400 | 420 | 53.0 | 29.5 | 1.15 |
| | | | T | 18 | 420 | 420 | 73.1 cold die | 43.6 | 0.83 |
| 5 | 401 | GZ54 | M | 19 | 420 | 420 | 66.2 | 37.6 | 1.15 |
| | | +1% Cu | B | 20 | 420 | 420 | 65.0 | 37.0 | 1.00 |
| 6 | 402 | GZ54 | T | 21 | 420 | 420 | 68.4 | 33.5 | 1.00 |
| | | +1% Cu | M | 22 | 420 | 420 | 64.2 | 34.7 | 0.65 |
| | | +0.25% Ag | B | 23 | 420 | 420 | 64.2 | 32.2 | 0.68 |
| | | | T | 24 | 420 | 420 | 67.0 | 30.0 | 0.68 |
| 7 | 403 | GZ54 | M | 25 | 420 | 420 | 61.9 | 29.2 | 0.88 |
| | | +0.25% Ag | B | 26 | 420 | 420 | 66.2 | 21.9 | 0.83 |

[x] short tons (2000 lb)

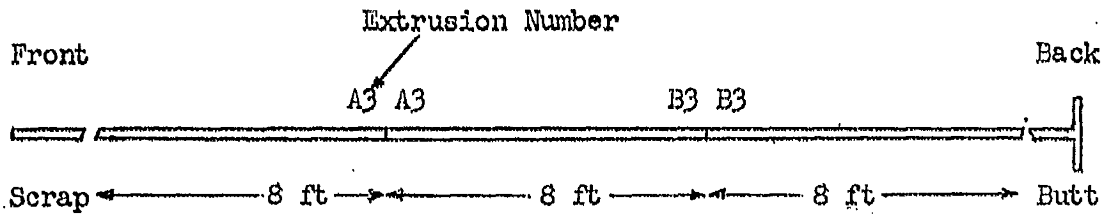


Fig. 1 - Diagram to show method of stamping sections of extruded rods to allow subsequent re-assembly as extruded.

WAP/gm