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ASSESSMENT OF THE SAND-CASTING PROPERTIES OF ZINC-BASE ALLOY AZ-430 (AC121)

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

The sand-casting properties of AZ-430 alloy have been assessed in Dow cast-to-shape test bars and chilled and unchilled flat plates. No difficulties were met in melting or casting. The levels of tensile properties obtained were somewhat lower than those reported for permanent mould castings.

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INTRODUCTION

This report describes the results obtained from two experimental melts made to assess some of the sand-casting properties of a zinc-base alloy designed for gravity casting applications.[1] The study was undertaken in connection with a program of work carried out by the International Lead Zinc Research Organization. The alloy, designated AZ-430, has a nominal composition of 12% Al, 0.75% Cu and 0.02% Mg and is made up using high-purity zinc.

MELTING AND CASTING CONDITIONS

Melt charges were made up from 99.99% Zn, Zn-Cu-Al master alloy and Al-10% Mg alloy. Melting was carried out in a carbon-bonded silicon carbide crucible using a gas injector furnace. It was noted that as the aluminum content of the alloy was increased the appearance of the melt surface changed from that typical of molten zinc to that typical of molten aluminum, with a correspondingly reduced rate of oxide formation.

Both cast-to-shape "Dow" test bars (see Figure 1), and chilled and unchilled 1 in. x 4 in. x 6 in. sand-cast plates (see Figure 2) were cast. McConnellsville sand with 3% moisture was used for all moulds. The castings were of good appearance with no evidence of surface reaction or other defects except for a slight surface shrink on the unchilled plate near the riser.

CHEMICAL ANALYSIS

Samples for chemical analysis were taken from the gauge lengths of broken test bars. The results are given in Table 1. It will be seen that reasonably good alloying efficiency was obtained in both melts. Some iron pick-up apparently occurred since none of the major additions would be likely to contain as much as 0.01%. The reliability of some of the spectrographic results appears to be questionable.

TENSILE TEST RESULTS

Properties of Separately-Cast Test Bars

As-cast test bars from each melt were tensile tested and the results obtained are given in Table 2. The bars from the first melt were tested at an unknown loading rate (probably about 5000 lb/min) but those from the second melt were loaded at the rates shown. Yield strength results are not usually quoted for zinc-base alloys owing, apparently, to the marked effect of loading rate on the shape of the stress/strain curve. However, the results from the second melt (see Table 2) do not show this effect within the range of loading rates employed.

Tensile properties quoted for this alloy by Anderson and Werley[1] (ultimate tensile strength 48,000-55,000 psi) for test bars which had been "...gravity cast in a warm steel mould..." were somewhat higher than those obtained in the present work.

Tensile test results obtained on test bars from each melt after holding fifteen days in steam at 95°C are also shown in Table 2. It will be seen that a slight decrease in ultimate tensile strength and increase in elongation occurred.

Properties of Plate Castings

Table 3 gives the tensile test results obtained on test bars taken from chilled and unchilled 1 in. x 4 in. x 6 in. plate castings. The plates were cast horizontally with a riser along one 6 in. edge and, when chilled, a water cooled drill along the opposite 6 in. edge. Four test bars were taken from each plate parallel to the 6 in. edge.

The results obtained show no consistent trends and in particular, the alloys appear to show no improvement as a result of chilling. Further work is necessary to confirm these findings.

METALLOGRAPHY

The structure of the alloy was typical of a hyper-eutectic binary zinc-aluminum alloy. Primary dendrites of aluminum-rich solid solution were surrounded by a matrix of coarse and sometimes divorced eutectic. The primary dendrites were heavily cored. Isolated crystals occurred throughout the structure and these are thought to be an iron-rich constituent (probably $FeAl_3$).

The appearance of the fracture surfaces of broken test bars suggested that Melt 672 had a finer grain size than Melt 673 and that this might have contributed to difference in tensile properties between the two melts (see Table 2). Attempts to develop a suitable etching technique for quantitative estimates of grain size were unsuccessful however.

CONCLUSION

The limited experimental results obtained on the sand-casting characteristics of AZ-430 alloy have shown that no special difficulties seem likely to be encountered in the foundry and that the properties obtained in sand moulds are only slightly lower than those quoted(1) for chill castings. The alloy seems relatively insensitive to chilling effects.

Grain refinement of the alloy was not investigated but this might be a useful subject for future work.

REFERENCE

1. E.A. Anderson and G.L. Werley - "A New Zinc Alloy for Gravity Casting" - A.Z.I. Expanded Research Program. Research Summary-Project ZM5 (July 1962).

TABLE 1

Analysis Results

	Al %	Cu %	Mg %	Fe %	Mn %	Pb %	Si %
Melt 672 (1)	11.96	0.76	-	0.011	-	-	-
(2)	-	0.75	0.02	0.04	0.06	0.007	0.01
Melt 673 (1)	11.61	0.77	0.011	0.15	-	-	-
(2)	-	1.25	0.03	0.02	0.02	0.006	0.03
Nominal	12.0	0.75	0.02				

(1) Chemical (2) Spectrographic

TABLE 2

Tensile Test Results Separately-Cast Test Bars

	Ultimate Tensile Strength kpsi	0.2% Yield Strength kpsi	Elongation %	Loading Rate lb/min.
Melt 672* (As-Cast)	46.5	36.3	3.0	-
Melt 673+ (As-Cast)	42.5	34.5	2.5	1600
	43.5	34.6	3.0	4800
	42.3	33.7	3.0	1000
Melt 672±	45.5	34.9	4.0	-
Melt 673±	39.2	34.0	3.0	-

*Average of six results.
+Averages of two results.
±After 15 days in steam at 95°C, averages of three results.

TABLE 3

Tensile Test Results of Bars from Plates

Position of Bars*	Ultimate Tensile Strength kpsi	0.2% Yield Strength kpsi	Elongation %
Unchilled Plate 1	42.0	33.1	6.5
2	42.1	35.5	5.5
3	41.6	32.5	5.0
4	40.8	32.6	3.0
Chilled Plate 1	44.7	34.2	2.5
2	41.2	32.8	2.5
3	41.4	n.d.	3.0
4	44.0	34.2	2.5

*Bar No. 4 nearest riser, No. 1 farthest from the riser.

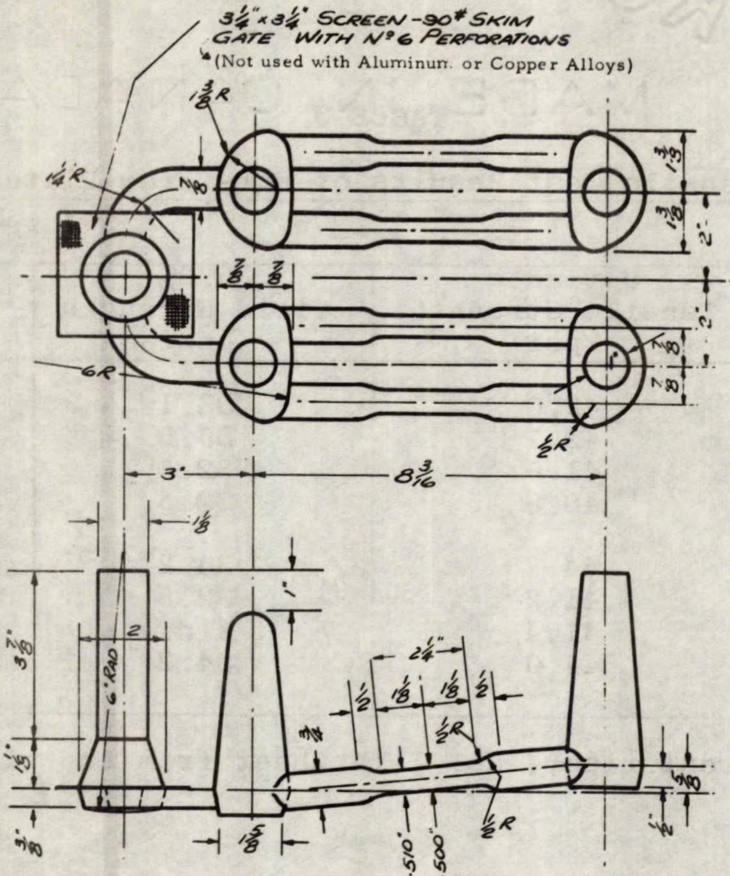

Figure 1. Test bar design according to U.S. Federal Specification QQ-M-56. Referred to in this paper as "Dow".

Figure 2. Plate casting showing gating and risering. The chilled face can be seen in the foreground.