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MINES BRANCH INVESTIGATION IR 59-26

EXAMINATION OF BRITTLE ALUMINUM CASTING ALLOY SAMPLES FROM IRON CRAFT COMPANY, VANCOUVER, B. C.

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

Metallographic examination and chemical analysis of five out of seven samples received showed that the extreme brittleness of three of these samples was due mainly to the presence of excessive amounts of iron in the form of coarse plates of an intermetallic constituent. The remaining two samples examined contained less iron and therefore were less brittle. The two samples, not examined in detail, showed a characteristic surface appearance due to the shrinkage of lower melting point constituents away from a network of high melting point constituents on solidification.

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INTRODUCTION

Seven samples from aluminum alloy castings were received from Mr. J. O'Donaughy, Iron Craft Company, 1570 S. Boundary Road, Vancouver, B.C. In a covering letter dated 5 February 1959, Mr. D.K. Faurschou, Mines Branch Regional Office, B.C. Research Council, Vancouver, B.C., stated that four of the samples (A, B, C and D) were taken from very brittle castings while sample E was from a satisfactory melt. Two other samples (F and G) showed a curious surface appearance.

It was stated that the Iron Craft Company produced small ornamental castings using scrap automotive pistons as their principal source of metal. There was no means of temperature control in the melting operations.

Comments and suggestions were sought on methods for improving the ductility of the castings, suitable degassing procedures and the nature of the curious surface appearance of sample F and G.

VISUAL EXAMINATION

Examination of the fracture surfaces of samples A, B and D showed very large shiny facets which suggested that fracture had occurred through or at the boundaries of large, brittle crystals. In sample C the facets were smaller. Sample E was comparatively ductile and had a dull, fine-grained fracture surface.

CHEMICAL ANALYSIS

The results of chemical analysis of drillings taken from samples A to E are shown in Table 1.

The specification limits for SAE 332 alloy are also included in Table 1 and it will be seen that the composition of each sample approximates closely to that specification which was widely used

for automotive pistons.

However, it will be noted that in each sample the iron content is above the specification range for the alloy and in particular, each of samples A, B and D has more than twice the maximum specified iron content. It is known that a high iron content in this alloy causes severe embrittlement.

TABLE 1

Chemical Analysis Results

Sample	Si%	Cu%	Mg%	Ni%	Mn%	Fe%
A	9.1	3.0	0.53	0.64	0.30	2.8
B	7.6	4.1	0.37	0.64	0.27	2.7
C	9.0	2.7	0.42	0.64	0.29	1.4
D	9.3	3.0	0.61	0.79	0.28	2.9
E	8.3	3.9	0.68	1.1	0.22	1.3
SAE 332	8.5-10.5	3.0-4.5	0.5-1.5	0.5-1.5	0.5 max	1.2 max

METALLOGRAPHIC EXAMINATION

Sections were taken from samples A to E and were mounted and polished for metallographic examination. Photomicrographs of typical fields from these sections are shown in Figures 1 to 5. It will be seen that samples A, B and D contained large numbers of long, thin plates (appearing, in section, as thin needles). These plates are formed by a complex constituent, probably AlCuFeSi (possibly modified by the presence of nickel and manganese), which is produced when the iron content of the alloy is high. Samples A, B and D were extremely porous.

In sample C these plates were also present but were much smaller. In sample E the structure was finer still and there were no coarse plates.

DISCUSSION AND CONCLUSIONS

The examination described above indicates that the principal reason for the brittleness in the alloys is the presence of excessive amounts of iron. Probable sources of iron are as follows.

(a) In the scrap. This can be eliminated by cleaning of the charges before melting, and if it is impossible to remove all the iron at this stage the bath should be constantly cleaned to remove iron pieces which may be either on the bottom, or suspended in the dross layer.

(b) Unprotected iron and steel tools such as ladles, skimmers, etc. Pick-up from this source can be reduced by coating the melting tools with a suitable wash. (Proprietary makes are available).

(c) Unprotected steel or iron melting crucibles. This also can be minimized by the use of a suitable wash.

Pick-up of iron from each of the above sources would be greatly increased by the use of high melting temperatures.

As noted above, three of the samples were extremely porous and, even in the absence of excessive iron, would be expected to be quite brittle. The use of high melting temperatures would increase the risk of gas pick-up but this could be counteracted, to some extent, by the use of degassing tablets (e.g. hexachlorethane). (The recommended addition is from 4 to 8 oz per 100 lb of metal.) In the presence of a high iron content, feeding of the solidification shrinkage is difficult as explained later.

In conclusion it should be emphasized that some form of temperature control is essential if consistent quality is to be maintained in aluminum alloy melting.

The curious surface appearance of samples F and G is the result of the shrinkage of lower melting point constituents away from a network of high melting point constituents on solidification, and it should be mentioned that this is likely to occur when the iron content is high since strong coherent lattices of iron compounds form at high temperatures and these inhibit both normal feeding and mass feeding of the casting as it solidifies. This may well be a contributing factor for the excessive porosity noted in samples B and D.

WAP/RB

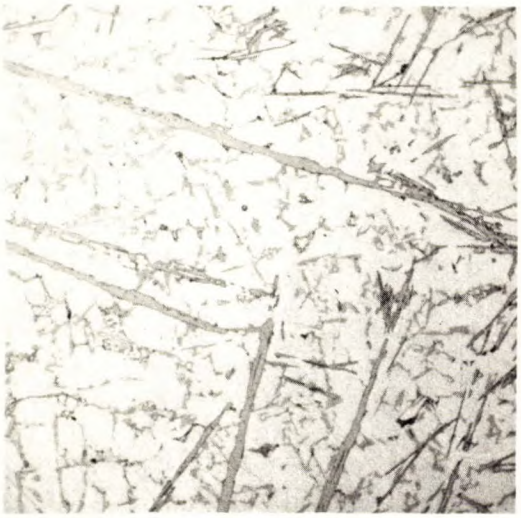

Fig. 1

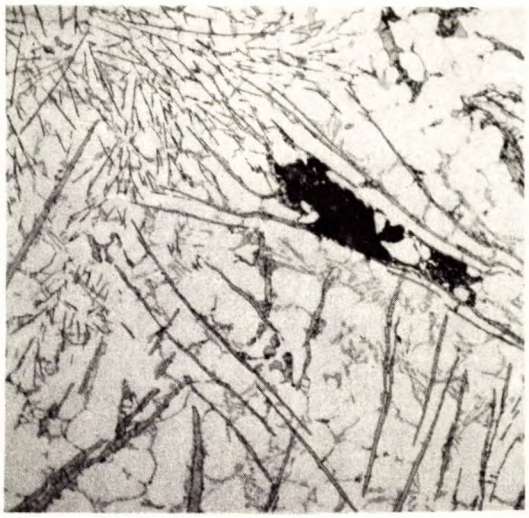

Fig. 2

Fig. 3

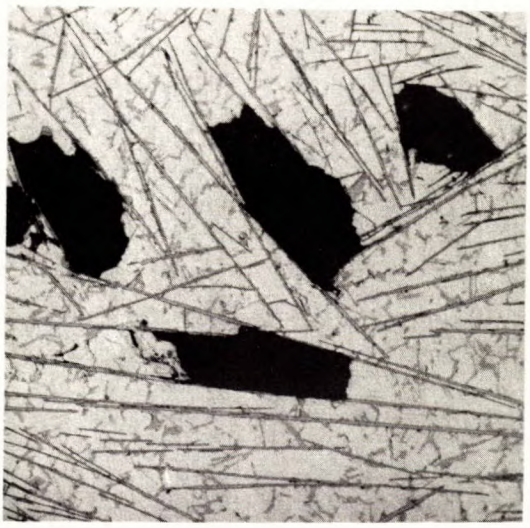

Fig. 4

Figures 1 to 5. - Sections from samples A to E (respectively). Note large plates (needles in section) in samples A, B and D. The plates are smaller in sample C (Fig. 3) and are absent from sample E. Gross porosity is shown in samples B and D (Figures 2 and 4).

(All unetched. Magnification X100)

Fig. 5