O T T A W A April 8th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1199.

Report on Low-Temperature Impact Tests
on a Zinc-Base Die-Casting Alloy.

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(Copy No. 14.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Problem:

In a letter dated March 20th, 1941, Major C. W. Jones, Assistant Director of Inspection (d), Inspection Board of the United Kingdom and Canada, Ottawa, Ontario, requested that low-temperature impact tests be carried out on zinc-base die-casting alloy specimens as supplied to the Turnbull Elevator Company, Toronto, Ontario. Fourteen specimens for Charpy impact tests were received on March 25th, 1942. These bars were machined from traverse gear parts which were die-cast

(Origin of Problem, cont'd) -

under high pressure, low temperature conditions.

The analysis of this material ("Zamak 5"), as determined by Turnbull's, was said to be:

| | | Per cent |
|---|---|---|
| Aluminium | - | 3.74 - 3.94 |
| Copper | - | 1.19 - 1.27 |
| Magnesium | - | 0.039- 0.041 |
| Lead | - | 0.002- 0.007 |
| Zinc | - | remainder. |

It was stated that for the production of this alloy, "Horsehead Special Zinc (99.99+ %)" was used.

It was requested that Charpy impact tests under low-temperature conditions be carried out. The proposed temperature range was 0, -10, -20, and -40 degrees Centigrade.

Results of Impact Tests:

The submitted specimens were marked 1 to 14 for identification purposes in these Laboratories.

Although the dimensions of the specimens conformed to those given in A. S. T. M. Specification B 86-41T, the shape of the cross-section was square, not a regular trapezoid as intended.

The tests were carried out on an Amsler Charpy impact tester (capacity, 240 foot pounds; weight of hammer, 44 pounds), using a 50-foot-pound blow and a linear velocity of the hammer of 7.5 feet per second.

The low temperatures used for this testing were obtained by the use of a mixture of dry-ice and acetone. The specimens were immersed in the mixture for 30 minutes with the temperature held exactly at the desired point. The bars were handled with tongs at the temperature of the medium, the exact position of the specimens on the machine being predeter-

(Results of Impact Tests, cont'd) -

mined before removing from the low-temperature bath. The time interval between the removal from the bath and the impact was 3 to 4 seconds.

Table I shows the results obtained:

Table I.

| Specimen No. | Temperature of the test, °C. | Impact strength, foot-pounds | Remarks |
|---|---|---|---|
| 1 | - | - | Adjusting the machine; (results disregarded). |
| 2 | - | - | |
| 3 | 20 | 11 | |
| 4 | 20 | 30 | |
| 8 | 20 | Not broken | |
| 9 | 20 | Not broken | |
| 11 | 20 | 17 | |
| 14 | 20 | Partly broken | |
| 13 | 0 | 7.5 | |
| 10 | -20 | 5 | |
| 12 | -20 | 5 | |
| 5 | -40 | 3 | |
| 6 | -40 | 2 | |
| 7 | -40 | 2 | |

Discussion of Results:

The size of the impact tester used for this investigation was not exactly suitable for both the material and the size of the specimens, although the results obtained are comparable, and also very similar, to results reported in the literature on zinc alloys after using smaller-sized impact testers.

The results of the low-temperature tests are very uniform. However, those at room temperature vary within wide limits. This possibly may be due to the size of the machine but more probably is caused by this particular alloy's

(Discussion of Results, cont'd) -

being in its transition zone at this temperature.

References from the Literature:

The following abstracts from the literature concerning the low-temperature impact strength of zinc-base alloys may be of interest:

1. B. E. Sandell - "Effect of Temperature upon the Charpy Impact Strength of Die-Casting Alloys" - Trans. A.I.M.E. 99, 1932, 359-362.

2. H. A. Anderson - "Zinc Alloys for High- and Low-Temperature Service" - Symposium on Effect of Temperature on the Properties of Metals, published jointly by A.S.T.M. and A.S.M.E., New York, 1931, pp. 271-289.

B. E. Sandell tested the impact properties of Alloy No. XXI ("Zamak 2") at temperatures between 0 to 500° F. He used a 15-foot-pound Amsler Charpy impact tester. The author concluded that this zinc-base alloy is brittle at temperatures below normal and exhibits increasing toughness with rise in temperature, reaching a maximum somewhere below the critical temperature of decomposition of the beta phase.

Figure 1 shows the results obtained by Sandell.

(See Figure 1 on following page)

(Continued on next page)

(References from the Literature, cont'd) -

Figure 1.

3. K. Bayer and A. Burkhardt - "Impact Bend Strength of Zinc-base Alloys at Low Temperatures" - Zeitschrift für Metallkunde, Vol. 31, 1939, pp. 131-132.

Impact properties of various zinc alloys were tested at temperatures between -40° C. and 20° C. In addition to four commonly used die-casting alloys, eight permanent mould alloys and fifteen extruded alloys were tested.

Figure 2 shows the behaviour of zinc die-castings in lower temperatures. Alloy No. 3 conforms with "Zamak 5". Figures 3 and 4 show the results obtained on permanent mould and extruded zinc-alloys. These are given for comparative

(References from the Literature, cont'd) -

purposes.

The results show that cast alloys are very sensitive to cold and rapidly become brittle below the freezing point, as also do all extruded alloys containing copper or those free from copper but containing less than 12 per cent Al. The alloy with 15 per cent Al and 0.05 per cent Mg, however, is, in the extruded state, just as resistant to impact at -40°C. as at +20° C. Alloys with 10 to 20 per cent Al and 0.05 per cent Mg become only slightly more brittle on cooling to -40° C., if they have first been aged for 10 days at 95° C. in air; and the same applies to similar alloys with 12 to 17 per cent Al, after ageing in steam for 10 days at 95° C.

Figure 2.

Low-temperature impact strength
of zinc-base die-casting alloys.

(NOTE: Translations:-
Schlagbiegefestigkeit = Impact bending strength;
Prüftemperatur = testing temperature (in ° C.)
Leg. = alloy)

(Continued on next page)

(References from the Literature, cont'd) -

Figure 3.

a b c d

Low-Temperature Impact Strength.

a, b, - permanent-mould zinc alloys.

c, d, - extruded zinc alloys.

Figure 4.

a b c d

Low-Temperature Impact Strength
on Extruded Zinc Alloys.

a - immediately after extruding (copper-free alloys).
b - " " " (copper-containing alloys).
c - after 10 days' ageing (95° C.).
d - " " " " in steam (95° C.).

(NOTE: Translations:- )
( Schlagbiegefestigkeit = impact bending strength; )
(Versuchstemperatur = testing temperature (in ° C.);)
( Leg. = alloy )

Conclusions;

The results of the investigation and the cited abstracts from the literature agree that the zinc-base alloys show, at low temperatures (below freezing point), a considerable decrease in the impact strength.

Investigations made in Germany on this problem showed that only one extruded alloy (Figure 4, Alloy No. 3), containing 15 per cent Al and 0.05 per cent Mg, is not affected by low temperatures. However, the manufacture of this alloy presents many difficulties.

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