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METALLURGY DIVISION

CASTING OF 8" DIAMETER BERYLLIUM BILLETS AT THE BERYLLIUM CORPORATION, READING, PENNSYLVANIA DURING THE PERIOD APRIL 12, 1949 TO MAY 25, 1949

BY

E. J. BOYLE

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By
E. J. Boyle

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June 10, 1949

To: J. H. Frye, Jr.

From: E. J. Boyle

Subject: Casting of 8" Diameter Beryllium Billets at The Beryllium Corporation, Reading, Pennsylvania During the Period April 12, 1949 to May 25, 1949.

INTRODUCTION

It was reported in the last memorandum on this subject, dated April 12, that it was felt a satisfactory technique had been evolved for casting 8" beryllium billets free from shrinkage pipe and cracks and of good surface quality. Twenty billets had been cast during the period from March 22 to April 12 and eleven of these had been rated as sound on the basis of radiographs of the billets as cast.

On the basis of the results obtained during the casting of these billets, a procedure was recommended for melting and casting. This procedure encompassed recommendations for casting temperature, mold temperatures, hot-top technique, preparation of the charge, degree of vacuum, pouring rate, etc.

[redacted]

SUMMARY OF WORK FOR PERIOD, APRIL 12 to MAY 25, 1949

During this period 12 billets were cast, with the following results:

Number sound	6
Number cracked	6

Of the billets which were cracked, the following explanations for this defect are offered:

Billet No.	Reason for Cracking
VM174	Low mold temperatures, i.e., 379°C. at bottom and 504°C. at top, instead of recommended mold temperature of 500°C. and 600°C.
VM175	Excessively rapid cooling after pouring, as shown by low mold temperatures during solidification and cooling to room temperature.
VM176	Low mold temperatures, i.e., 415°C. at bottom and 563°C. at top—also did not pour properly.
VM178	Somewhat low mold temperatures and insufficient feeding as shown by short hot-top.
VM186	Low mold temperatures, i.e., 404°C. and 532°C.
VM187	Low mold temperatures, i.e., 330°C. and 415°C. These very low temperatures resulted from leaving the insulation out of the bottom of the furnace.

In addition to the above 12 billets 5 others were attempted, but were unsuccessful because of difficulties with pouring.

[redacted]

During the period from April 21, 1949 to May 25, 1949, 17, fifty-pound batches of Brush pebble beryllium were melted and cast into a form suitable for remelting and casting into billets. It is necessary to have a large percentage of the charge for melting in the form of previously melted metal in order to avoid the excessive agitation associated with the release of magnesium and other volatile material when all raw metal is used. Since essentially all of the original lots of Beryllium Corporation raw beryllium beads were cast into billets about this time and the New York Office of Operations did not wish to mix the two varieties of metal, it was necessary to prepare these batches of metal for remelting. In addition there was considerable delay in obtaining heating elements for enclosure in the bottom of the furnace to raise the mold temperatures. Since it was felt that the chances of producing billets free of cracks were not sufficiently high without the accurate control of mold temperatures made possible by the heating elements, it seemed reasonable not to attempt the production of billets before these heating elements were installed.

Conclusions

The conclusions listed below, which were included in the memorandum issued on April 12, 1949, have not been changed by results obtained since that time:

1. Metal used in the charge should be clean and dry.

2. 77 lbs. of metal must be melted.

3. Melting time should be as short as possible.

4. Pressure in the furnace should be held as low as possible.

5. Ceramic hot-tops should be used. On the basis of two castings made with the big end down, as suggested by Mr. Corzine of M.I.T., it appears that more satisfactory feeding of the casting, with consequent smaller shrinkage pipe, is obtained with this technique than was obtained with the small end down.

6. The bottom chamber of the vacuum furnace should be adequately insulated and provided with heating elements in order to maintain the mold temperatures at 500°C. at the bottom and 600°C. at the top.

7. Casting temperature should be 1400°C.

[redacted]

The accurate control of mold temperatures appears to be especially important. A survey of 29 billets was made to determine possible correlation between crack formation and melting and casting variables. The most important factor appears to be mold temperature. The following summary seems to substantiate this.

	Mold Temperatures (average of the number of billets listed)	
	At Bottom	At Top
16 sound billets	435° C.	567°C.
13 cracked billets	373° C.	542°C.

A group of nine of the sixteen sound billets were machined and radiographed again. (These billets were rated as sound on the basis of radiographs made as cast) Four of the billets showed cracks after machining. These cracks, in every case, appeared to start at the center hole drilled in the bottom end of the billet. It is felt that the center hole may have acted as a notch and initiated cracking when the billet was stressed in compression during turning on the lathe. There is some reason to believe that a stress sufficient to cause cracking may have been imposed on the billets by pulling the tail-stock of the lathe up too tight against the billet. Also, it has been noted in the lathe turning of beryllium at ORNL that it is necessary to loosen up on the tail-stock of the lathe when the beryllium expands from frictional heat generated by the turning operation. This was not done in the case of the machining of these billets at The Beryllium Corporation.

Recommendations

It is recommended that the procedure outlined in the memorandum of April 12, 1949 and summarized in the present report be followed for future work. There is considerable evidence to indicate that the improvement in yield of sound billets, from 10% prior to March 22, 1949 to 55% after this date, can be substantially increased. The most significant improvement should come from accurate control of mold temperatures obtainable with heating elements in the mold chamber.

[redacted]

In conclusion, it can be said that a workable technique has been evolved for the production of 8" diameter beryllium billets for extrusion. The continued success in the production of these billets depends upon rigorous control of the variables involved and adherence to the procedures found to be successful in actual practice.

E. J. Boyle
Metallurgy Division

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