

PRODUCTION OF LARGE RAPIDLY QUENCHED ALLOY SAMPLES

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Abstract

A rapidly rotating mill device has been constructed and tested with the aim of producing large samples of rapidly quenched alloys of aluminium. A set of rollers equipped with a hard chrome surface rotate at a speed of about 7000 R.P.M. and the molten alloy is injected between them at a synchronous speed. The quenching speed achieved is of the same order as that obtained by Dixmier's splat cooling, but samples are much larger. It is believed that samples in the form of continuous strip may eventually be produced.

Introduction

One of the most frequently used methods of splat cooling achieves high quenching rates by crushing drops of the liquid alloy between cold metal pistons. This method produces rates of cooling of the order of $10^6 \text{ }^\circ\text{s}^{-1}$ assuming that pistons do not bounce. Alloy samples produced by this method tend to be small in area, a few square millimetres being typical. Their thickness has generally been difficult to control and a lot of selecting has to be done among samples produced. More recently much larger samples have been produced by this method too by the use of special techniques.

The use of very small samples for electrical measurements is difficult, owing to their size, and cutting and shaping of these small and often porous flakes is at best very difficult.

The apparatus

We describe here a device which we have been using to produce larger samples of rapidly quenched aluminium alloy. The method, we believe, is easily applicable to many other suitable alloys. The complete setup is shown on Fig.1.

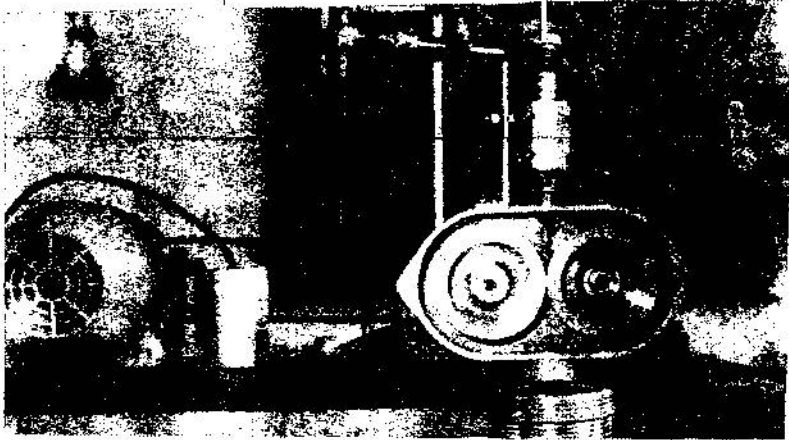


FIG. 1

The quenching part of the apparatus consists of two motor driven parallel counterrotating cylinders which roll the liquid alloy through a small adjustable clearance between them. The alloy is injected as a molten slug from a small injector furnace mounted between and above the rollers. The quenching occurs in the small zone where the rollers are closest to each other and the alloy emerges below in the form of a thin strip at a high speed that carries it into a dewar containing liquid nitrogen.

The injector furnace consists of two alumina tubes of different bore joined together. The upper tube has a diameter of about two millimetres and serves the purpose of containing the melt. The lower thinner tube has a diameter as small as 0.7 mm and plays the role of an accelerating tube. The whole assembly is wrapped with resistance wire so that it can be brought up to a suitable temperature. The alloy, having been prepared previously and cut into pieces of suitable dimensions, is introduced from above into the large tube, and the top of the furnace is then connected to a system that supplies it with a stream of helium which, after slowly passing through the furnace, fills the space around the cylinders. After passing helium for a period of time needed to secure a neutral atmosphere the furnace is heated to 1000°C . As the alloy melts, it falls to the bottom of the large tube where its further movement is halted by capillarity. At the same time the interruption of the flow of helium is signalled by a bubbler connected to the system through a narrow tube. The furnace is held in this state until the temperature is fully stabilized which takes about 30 seconds. The rollers are then spun to a speed of about 7000 to 10,000 r.p.m. and a short blast of a measured quantity of helium held at 4 to 6 atmospheres is introduced into the furnace. This causes the melt to proceed into the

2.3

accelerating tube. It emerges as a slug travelling at a synchronous speed of 30 to 45 m s^{-1} and is squeezed between the rollers emerging thereafter as a strip of quenched alloy. We have obtained large samples (Fig.2). We now prefer to adjust our parameters so as to obtain samples about 20 - 30 mm long, 1 - 2 mm wide and 7 - 15 microns thick. These are most suitable for our measurements.

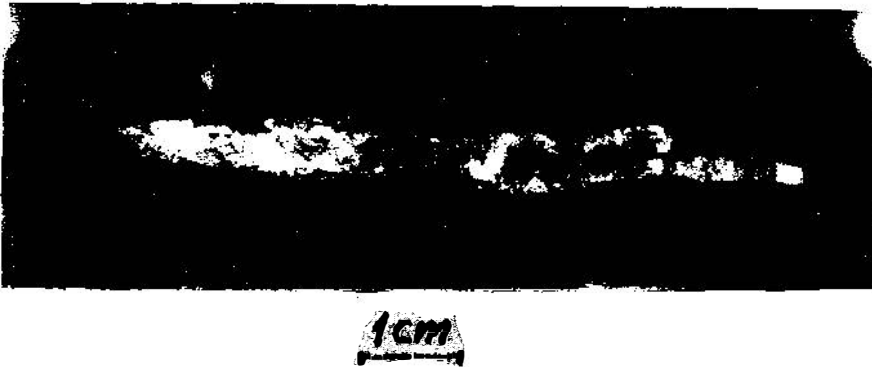


FIG. 2

We have calculated the quenching rate using approximations similar to those used by Dr. Dixmier, and obtain values of the order of $10^7 \text{ }^\circ\text{sec}^{-1}$. Since our device, is essentially free of vibrations, we believe this value to be correct. This is borne out by usual tests for supersaturated solution in an alloy such as Al-Fe. Thus, for example, Debye-Scherrer diagrams reveal no trace of separated Al_6Fe or Al_3Fe phase normally found in what we may call "bad" samples. Electrical measurements obtained with these samples also show them to be highly quenched and in this respect indistinguishable from those obtained by piston quenching. These results will be presented by one of us at another session.

We have employed rollers with a hard chrome surface as well as steel rollers. There is indication that chromium quenches more efficiently than steel and we are investigating this along with some other parameters that seem to be important in this technique.

Acknowledgements

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DISCUSSION

- R. Maddin : Is there any variation in thickness of the specimen along its length ?
- B. Leontić : Yes about a few μm .
- K. Mukherjee : Have you studied the microstructure of your samples. By this mean specifically the size and shape of the grains. Do they show any sign of elongation along the rolling direction ?
- B. Leontić: This study is in course now.
- R.W. Cahn : Have you tried rollers surfaced with copper or other material of very high thermal conductivity ?
- B. Leontić : Brass was used originally but quickly became ruined.
- G. Thursfield : How dense are the samples you obtain ?
- B. Leontić : Completely solid.
- A. Guinier : How do you adjust the rollers ?
- B. Leontić : This is done by an eccentric system holding the bearings and by a couple of conical pins holding the blocks in place.