MI-0174
May 1996

Simple Technique for Bumping Permanent Magnets to a Desired Strength

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In the case of large, permanent magnets with weak magnetic fields, one can either use a few fully-magnetized bricks or cover the area with partially magnetized bricks. The former case has the disadvantage of creating non-uniform fields. The latter requires that the magnets be adjusted one at a time. The purpose of this study was to find a simple and efficient way to adjust the magnetic fields of permanent magnets. The conclusion is that it appears that the desired results can be achieved with two "bumps" and one measurement.

Measurements

First, four $4x6x1in^3$ fully-magnetized magnets were demagnetized in 10-amp increments, with their magnetic fields being measured in the MP-9 tester after each demagnetization. The results for the three Crucible and one Hitachi magnets are presented in fig. 1. What should be noted is that, thought the curves are very different for the two manufactures, after the strength of the magnets drop by about 10% the slopes of the curves are almost identical.

It was then found that when (Crucible) magnets were taken from full magnitization to a partial magnitization in a single step (bump current), there was a greater spread in the resulting magnetic strengths than would be anticipated from the data in fig. 1. Fig. 2 shows the distribution in the fields of 27 fully-magnetized magnets that were "bumped" with a demagnetizing current of 168 amps.

Fig. 2 would appear to imply that every brick is unique and that it is unlikely to be a simple method for obtaining a desired final level of magnitization. The saving discovery was that, although they were at different magnitization levels, the slope of the dependence of the magnetic field on the bumping current was almost constant at about -10.7 gauss/amp. After an initial demagnetization and a measurement, the require current to obtain the desired level of magnitization could be accurately determined. This is illustrated in fig. 3 which shows the magnetic field of 13 Crucible bricks after a 168 amp bump and then after a second, calculated, bump.

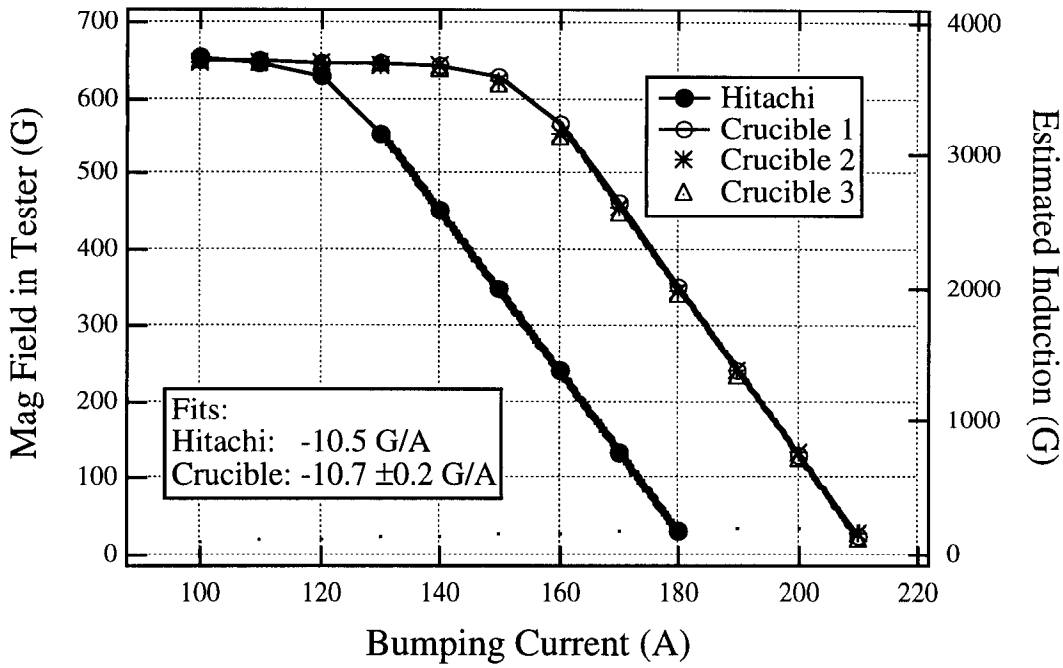

Fig. 1. Magnetic field in tester as a function of the demagnetizing current. The Estimated magnetic induction of the magnet is also correlated with the measured magnetic field.

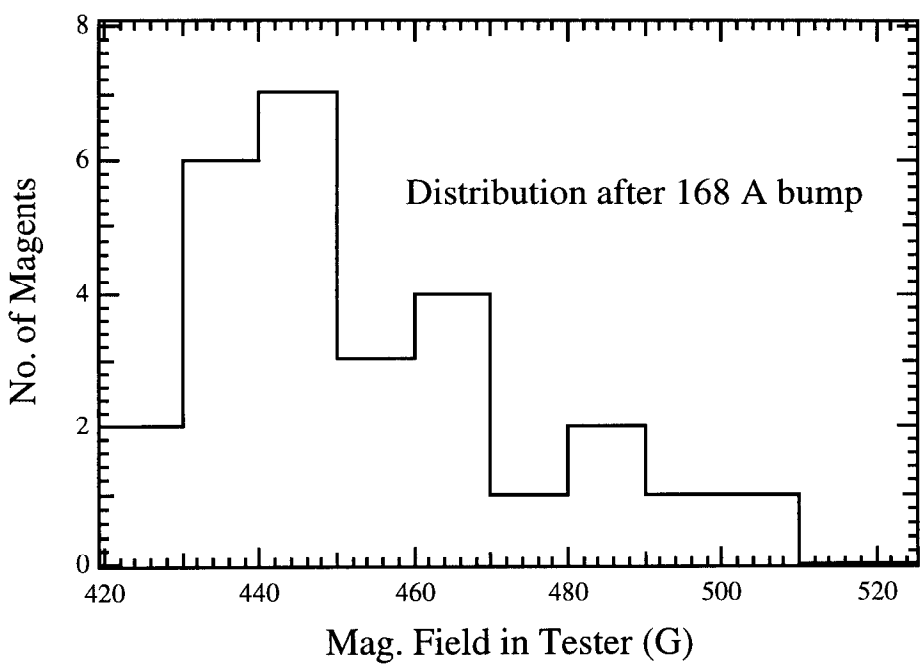

Fig. 2 Distribution of magnetic fields measured in the tester for 27-4x6x1in^3 magnets that were demagnetized with a current of 168 amps.

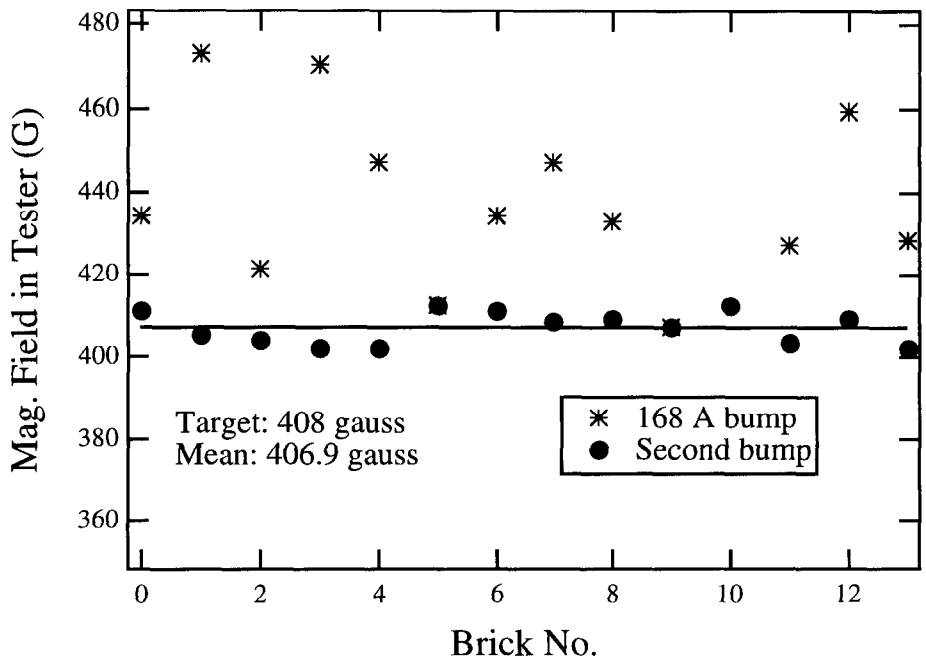

Fig. 3 The magnetic field of 13 Crucible bricks after a 168 amp bump and then after a second, calculated, bump.

To calculate the second bump current, I_c, for a 4x6 brick one simply uses the simple formula:

$$I_c = I_o + 10.7(B_f - B_o),$$

where I_o is the initial current, B_f is the desired final magnetic field (in the tester) and B_o is the field after the first bump. I_o is chosen such that the strength of the magnets after the first bump are as close to the target strength as possible without reducing the strength of too many bricks too far. The target field in fig. 3 was 408 G and the measured mean of the 13 bricks was 406.9 G. These results were obtained with a 1-amp resolution for the demagnetizing current. For a partial brick with area, A(in^2), the formula for the second bump becomes:

$$I_c = I_o + 0.445\ A\ (B_f - B_o).$$

It should be noted that these measurements were made with one Hitachi magnet and one lot of Crucible magnets. Therefore, the results are subject to the uncertainties of any measurements made with a sample that is (too) small. The conversion constant should be evaluated for every lot of magnets, and occasional second measurements should be made to verify that the technique is working.