by G. C. Kuczynski and I. Zaplatynskyj

SINCE the excellent studies of metal powder compaction executed by Kamm, Steinberg, and Wulff,^{1,2} no work on the subject has appeared in the technical literature. Kamm et al. were the first to investigate quantitatively the distribution of density in a powder compact, as a function of pressure, height and diameter of the die, powder particle size, etc. For this purpose they devised a very ingenious method. They inserted a thin lead grid into a die and then filled the die with powder. During cold pressing, the lead grid moved downward. Due to its deformability it followed closely the downward descent of the adjacent powder. The die was then radiographed and, from the deformations of the grid openings measured on the radiographs, the density in the vicinity of each opening was evaluated. Their findings led them to the conclusion that the friction on the side walls of the die is a major controlling factor of the density distribution inside the cold pressed powder compacts.

However, it is difficult to conduct tests similar to those of Kamm, Steinberg, and Wulff in a processing plant laboratory, which usually lacks the necessary expensive radiographic equipment. The purpose of this note is to describe a method which makes it possible to determine the density distribution in green powder compacts with the same accuracy as the lead-grid method but which is far simpler and faster and requires only standard laboratory equipment. Instead of using a lead grid, the hardness at selected points of the sectioned compact is determined. If the relationship between hardness and density is known the density distribution is readily obtained. This relationship is easily found from measuring hardness and densities of thin compacts. In such compacts the density, for all practical purposes, is constant throughout.

The method was tested on a Plast nickel powder, grade F1A-A20, kindly supplied by Plast Metals Co. Thin compacts (height to diameter ratio 0.2) were

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Fig. 1—Distribution of densities in a green nickel compact pressed at 46 psi is charted. Die diameter D is 0.79 in.; h/D , 0.87.

pressed in a single action cylindrical die at various pressures. The density of the compacts was determined by weighing and by measuring the height and diameter with a micrometer. Subsequently the RH hardness was determined. Up to ten readings were taken on each specimen. The difference in hardness readings on each compact was never greater than three corresponding to about 0.1 g per cu cm uncertainty in density. By varying the compaction pressure of the samples, a whole scale of densities was obtained allowing construction of a set of density-hardness calibration curves. To test the method several compacts of different height were pressed under varying pressures. Die walls were always well lubricated. After pressing, the compacts were mounted in bakelite and halved by grinding, and hardness readings taken along the diameters of the specimens. The distance between adjacent indentations was about 2.5 mm.

After hardness readings were translated into densities, *contour maps* of densities of the compacts were prepared. One of them is reproduced in Fig. 1. The areas encompassed by the curves are labeled with numbers representing the density in g per cu cm of those regions. In Fig. 2 the same results are replotted to emphasize the radial density changes at various depths. The results thus obtained confirm the findings of Kamm, Steinberg, and Wulff^{1,2} mentioned previously. They are recapitulated here briefly.

1—The densest part of a compact pressed from one side is at the outer circumference at the top and the least dense part at the bottom, at the outer circumference. Figs. 1 and 2 show this clearly.

2—The density near the cylindrical surfaces of the compact decreases uniformly with height from top to bottom.

3—The density variation increases with the height to diameter ratio.

References

- ¹ R. Kamm, M. A. Steinberg, and J. Wulff: *Trans. AIME* (1947) 171, p. 439; *METALS TECHNOLOGY* (February 1947).
- ² R. Kamm, M. A. Steinberg, and J. Wulff: *Trans. AIME* (1949) 180, p. 694; *METALS TECHNOLOGY* (December 1948).

Fig. 2—Density as a function of radial distance is charted for the same compact as is shown in Fig. 1. Line 1 is 16.0 mm; line 2, 11.0 mm; line 3, 6.0 mm; and line 4, 2.0 mm from the bottom of the die.