A GAMMA-RAY ATTENUATION TECHNIQUE FOR ASSESSING THE DISTRIBUTION OF POROSITY IN POWDER BEDS

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A common method of filling hard gelatin capsules employs a dosator nozzle which dips into a pre-formed powder bed, picks up a plug of powder and subsequently ejects it into an empty gelatin shell. In order to attain constant fill weight the powder bed should be of a uniform and reproducible bulk density. A technique has been developed by which local variations in bulk density or porosity can be detected.

Gamma rays of energy 60 keV from a 200 mCi point source of Americium-241 are collimated into a cylindrical beam 2mm in diameter and directed through a powder bed. The emerging photons are collimated, detected by a sodium iodide crystal and counted by a digital electronic counter. The porosity of that part of the sample through which the beam passes is given by ε in the following equation:

$$\varepsilon = 1 + \frac{\ln \frac{N}{N_o}}{\mu L}$$

where N = number of counts in time t with the sample in the beam, N_o = number of counts in time t with no sample in the beam, μ = attenuation coefficient of sample material and L = thickness of powder bed. By directing the beam through a number of different positions in a powder bed, a picture of local porosity variations may be built up.

The model powder system chosen for this work was α-lactose monohydrate, available in eight particle size fractions. Samples were contained in aluminium cylinders of depth 4.4.cm and internal diameter 1.9cm. Values of attenuation coefficient, μ, at 60 keV were determined for each size fraction at a range of overall porosities as follows: a composite count, N, was obtained such that it was representative of the sample as a whole, and it was substituted into the above equation along with the overall porostiy ε. The value of μ obtained was dependent on the overall porosity, and the best fit straight line to the relationship between μ and ε was found to be:

$$\mu = (0.289 + 0.0215\varepsilon)\ cm^{-1}$$

(number of points = 50, correlation coefficient = 0.805, significant at the 1% level). This provides the calibration for subsequent local porosity determinations.

Three particle size fractions of lactose were filled by a variety of methods into the sample containers described above. The collimated gamma-ray beam was directed vertically through the sample, and by adjusting the lateral position of the container by means of a micromanipulator, counts were recorded in a defined network of positions. A local porosity value was calculated from each count, and the network of results indicated the radial distribution of porosity. Computer processing of such porosity distributions produced images which could be displayed on a colour television screen, or reproduced by an electrostatic printer to illustrate local porosity variations pictorially.