POWDER RETENTION WITHIN A CAPSULE DOSATOR NOZZLE

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Capsule filling systems which rely on a dosator nozzle transferring powder from a feed bed to a capsule shell, depend on the formation and retention of a powder plug within the nozzle. This plug must then be ejected completely with minimal force. Powder retention requires the formation of a stable arch at the nozzle outlet. The conditions which govern the formation of stable powder arches in parallel sided containers have been discussed by Walker (1966), who also presented equations to calculate the conditions necessary to form such arches. These equations require a knowledge of the bulk density $\underline{\gamma}$, the angle of powder/wall friction $\underline{\phi}$, and the effective angle of internal friction $\underline{\delta}$ of the powder. According to Walker's theory, the existance of a free surface at the arch, implies that the strength of the powder under these conditions is the unconfined yield strength $\underline{f}_c$, whose value can be calculated from the expression:

$$f_c = \frac{R\gamma}{\sin 2\phi} \qquad 1.$$

where $\underline{R}$ is the radius of the container. The value of $\underline{f}_c$ which exists at the arch depends on the vertical compressive stress ($\bar{\sigma}_z$), which in turn depends on the transmission of stress through the powder bed; a factor controlled by $\underline{\delta}$ and $\underline{\phi}$. Extension of Walker's theory by Walters (1973) shows that variation in the length and diameter of a parallel sided container changes the magnitude of the vertical compressive ($\bar{\sigma}_z$) and horizontal ($\underline{\sigma}_r$) stresses and also the shear stress at the wall $(\tau_{rz})_w$. Substituting differing values for $\underline{\delta}$ and $\underline{\phi}$ in Walters' (1973) equations, shows that distribution and magnitude of the stresses are changed; the changes in the former being affected to a greater extent.

Experimental values of $\underline{\delta}$ and $\underline{\phi}$ were determined for 8 closely graded size fractions of lactose (DMV 125#). The value of $\underline{\delta}$ was found to be approximately constant for all the particle size fractions, but $\underline{\phi}$ decreased with increase in particle size up to the size fraction of 41.3 μm when it became constant. Using a size 2 capsule dosator nozzle it was possible to remove samples from powder beds of particle size fractions, up to that of mean volumetric diameter 41.3 μm, over a range of bulk densities. Samples could only be removed from powder beds with high bulk densities for the particle size fraction of 80.8 μm. Above this particle size, samples could not be removed at any bulk density tested. This change in retention ability occurs at the same particle size range over which $\underline{\phi}$ ceases to decrease and becomes effectively constant, and therefore indicates a minimum value of $\underline{\phi}$ for the formation of a stable arch. Equation 1 predicts that unconfined yield strength $\underline{f}_c$ requirement for arch stability increases with decrease in the value of $\underline{\phi}$. The approximately constant value of $\underline{\delta}$ for the sizes studied, and the theoretical approach of Walters (1973) suggest that this factor has little influence on the retention of a powder within the nozzle.

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