A THEORETICAL APPROACH TO OPTIMISING CAPSULE FILLING BY A DOSATOR NOZZLE

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The retention of powder within a capsule filling dosator nozzle during transfer from the feed bed to the capsule shell requires the formation of a stable powder arch at the nozzle outlet. It has been previously shown (Jolliffe and Newton 1978) by the application of hopper design theories that the ability to form an arch depends on the angle of wall friction, ϕ. Further application of these theories (Walker 1966 and Walters 1972) enables the calculation of the compression that must be applied during filling to ensure arching will occur at the outlet. The vertical compressive stress that is required to act at the top of the powder bed, $\sigma_{z,o}req$, shows a dependence on the effective angle of internal friction, δ, the Jenike flow factor, FF, and the bulk density, γ, of the powder, nozzle dimensions and the angle of wall friction, ϕ.

The relationship between these factors and $\sigma_{z,o}req$ has been investigated by using typical values for each of these factors and varying each one in turn. The variation of $\sigma_{z,o}req$ with ϕ produced the most significant effect. Initially, as the value of ϕ is increased, $\sigma_{z,o}req$ decreases, since it is easier for arching to occur on rougher walls. However, as larger values of ϕ are used, $\sigma_{z,o}req$ levels off and then increases again. Although rougher walls enable arching with smaller compressive stresses acting at the potential arching zone, these large values ϕ make it more difficult to transmit stress to this zone resulting in a large $\sigma_{z,o}req$ being necessary.

The relationship between the other factors δ, FF, γ and container dimensions and $\sigma_{z,o}req$ show either linear or exponential relationships. The effect of these factors on the minimum value of $\sigma_{z,o}req$ varies with the factor. Increasing the value of δ causes the optimum value of ϕ (at which $\sigma_{z,o}req$ is a minimum) to increase. Large values of δ are due to greater friction between the particles enabling better stress transfer through the bed to the arching zone. Large values of FF cause the optimum value of ϕ to decrease because in free flowing powders, particles tend to slide over each other, resulting in poor stress transfer. Increasing the bulk density of the bed does not affect the optimum value of ϕ, but the improved stress transfer through a tightly packed bed means less compression is required. If the nozzle length is increased, a greater $\sigma_{z,o}req$ will have to be applied since the stress has to be transferred through a larger distance.

In general, cohesive materials will be retained with minimal compressive stress on rough nozzle walls, whilst smoother walls provide the best conditions for retaining powder that is free flowing.

Jolliffe, I.G., and Newton, J.M. (1978) J.Pharm.Pharmacol. 30: 41P
Walker, D.M. (1966) Chem. Eng. Sci. 21: 975-997
Walters, J.K. (1973) Chem. Eng. Sci. 28: 13-21