

PRESSING OF SPRAY-DRIED POWDERS. DERIVATION OF A COMPACTION EQUATION

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Based on the evolution that the porous texture of green compacts undergoes with pressing pressure, a compaction equation was derived, which adequately describes the densification that spray-dried powder beds undergo with pressing pressure.

The model was developed from the following assumptions:

i) The degree of compaction X reached by a powder bed on undergoing compaction at pressing pressure P is defined as:

$$X = \frac{Vp_o - Vp}{Vp_o}$$
 [1]

where:

Vp_o= specific pore volume of the non-compacted powder bed (cm³ pore/g solid)

Vp = specific pore volume of the resulting compact (cm³ pore/g solid)

ii) The increase of X with P is due to a reduction in intergranular (Vpg) and intragranular (Vpp) pore volume.

$$X = \frac{Vpg_o - Vpg}{Vp_o} + \frac{Vpp_o - Vpp}{Vp_o}$$
 [2]

or:

$$X = X_G + X_p$$
 [3]



iii) Intergranular pores start decreasing at very low pressures and their volume reduction with pressure can be described by the following equation:

$$-\frac{dVpg}{dP} = KVpg$$
 [4]

which by integration becomes:

$$\frac{Vpg_o - Vpg}{Vp_o} = a_1(1 - \exp(-KP))$$
 [5]

where: $a_1 = (Vpg_o/Vp_o)$

iv) Intragranular pores only start decreasing when the pressure exceeds a given pressure bound P_b, and the reduction of intragranular pore volume with pressure obeys an equation of the type:

$$\frac{Vpp_o - Vpp}{Vp_o} = a_2 \cdot \exp\left(\frac{-P_b}{P}\right)$$
 [6]

Eqs. [2], [5] and [6] then yield:

$$X = a_1 (1 - \exp(-KP)) + a_2 \exp(\frac{-P_b}{P})$$
 [7]

To verify the validity of the model, test specimens were formed at different pressing pressures from an industrial spray-dried pressing powder obtained from a suspension of natural clays and feldspars used in porcelain tile manufacture. The pore-size distributions (PSD) of the spray-dried powder and of the resulting compacts were used to calculate the specific volumes of the intergranular Vpg and intragranular Vpp pores, of the compacts and of the non-compacted powder bed, Vpg $_{o}$ and Vpp $_{o}$. The bulk density values of die filling ρ_{o} and of the resulting compacts ρ_{ap} allowed calculating the values of X.

The values of the degree of compaction of the compacts, X, have been plotted against pressing pressure for a spray-dried powder with a pressing moisture content of 0.055 kg water/kg dry solid in Fig 1. These data were then fitted to Eq. [7], adopting for a_1 the value determined experimentally of a_1 =0,597. It can be observed that a good fit was found (continuous curve).

The figure also includes the values of X_G and X_P theoretically calculated from the first and second term of Eq. [7] and the values obtained experimentally from the PSD values. The experimental and calculated values were again observed to match well.

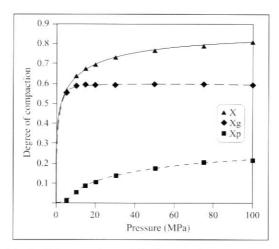


Figure 1. Match of the experimental findings to the proposed model (Eq. 7).

Table I details the values of K and P_b of the maximum bulk density attainable by compact ρ_{∞} at different spray-dried powder moisture contents. The value of ρ_{∞} is calculated from a_2 .

| H _p (Kg water/Kg dry solid) | K (MPa ⁻¹) | P _b (MPa) | ρ_{∞} (gr/cm ³) |
|---|---------------------------|----------------------|---------------------------------------|
| 3,0.10 ⁻² | 0,45 | 23,0 | 2,121 |
| $5,5.10^{-2}$ | 0,57 | 17,0 | 2,134 |
| $8,0.10^{-2}$ | 0,77 | 14,2 | 2,127 |
| $9,7.10^{-2}$ | 0,94 | 10,6 | 2,081 |

Table 1. Influence of pressing powder moisture content H_n on K, P_h and ρ_{∞} .