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:

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

where:

Vp_o= specific pore volume of the non-compacted powder bed (cm^3 pore/g solid)

Vp = specific pore volume of the resulting compact (cm^3 pore/g solid)

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

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

or:

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

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

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

which by integration becomes:

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

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:

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

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

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

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.

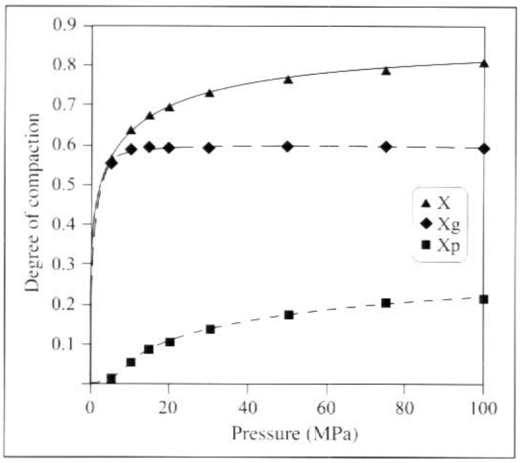

Figure 1. *Match of the experimental findings to the proposed model (Eq. 7).*

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_p on K, P_b and ρ_∞.*