LIQUID SUCTION BY POROUS CERAMIC MATERIALS. INFLUENCE OF FIRING CONDITIONS.

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1 INTRODUCTION

The suction rate in porous ceramic materials may be calculated by Equation [1]:

$$m_s = K_s \cdot t^{1/2} \tag{1}$$

where m_s is the liquid mass absorbed per unit area normal to the suction direction (kg/m^2) and K_s is the suction coefficient (kg/m^2·s$^{1/2}$). This last parameter depends on the physical properties of the absorbed liquid [1] and the solid's porous structure [2-3] according to the equation:

$$K_s = \rho \cdot (\sigma / \mu)^{1/2} \cdot (\varepsilon^* / \tau) \cdot r_0^{1/2} \cdot (\cos\theta / 2)^{1/2} \tag{2}$$

where ρ is the density of the liquid (kg/m^3), s the surface tension of the liquid (N/m), μ viscosity of the liquid (N·s/m^2), r_0 pore mean radius (m), ε^* suction effective porosity [1], τ the mean coefficient of tortuosity and θ contact angle.

This work sets out the findings obtained on studying how the firing conditions affect the characteristics of the fired body's porous structure and the suction coefficient. The values of the following properties of the fired material's porous structure were experimentally determined: permeability K_p (m^2), suction effective porosity ε*, the size-uniformity index S_g, pore mean radius $r_0(50)$ (m), calculated from the plot of the void volume versus pore radius on a log-probability chart and $r_0(16)$ (m) as a product of the size-uniformity index (S_g) and r0(50) [4], as well as the water suction rate ms, (kg/m^2).

2 EXPERIMENTAL PROCEDURE

The assembly and procedure used for determining the values of m_s, of the suction coefficient (K_s), and suction effective porosity (ε^*) have been described elsewhere [1-2], as well as the calculation of the other parameters used in the study. The absorbed liquid involved in all the experiments was water at 22°C.

A spray-dried pressing powder was used of the type employed in porous wall tile manufacture. This powder was used to form 10 sets of test specimens by unidirectional pressing, under different pressing conditions (pressing pressure and pressing powder moisture content). These specimens were then subjected to two different firing cycles in a SATER electric kiln (Table 1). In both firing cycles, the heating step took place at a heating rate of 70°C/min, up to a temperature of 800°C, which was then held for 30 min. Heating was then continued (at the same heating rate of 70°C/min) up to the cycle's peak temperature, which was then held for 6 min (cycle R) or for 30 min (cycle L). The test specimens were then cooled to room temperature in round 30 min. Pore-size distribution of the fired materials was determined by mercury poresizing. An electron scanning microscope was used to examine the microstructure of the resulting materials.

3 RESULTS AND DISCUSSION

On comparing the suction coefficient (K_s) (Table 2) with peak firing temperature, for the three pressing conditions studied, it can be observed that the suction coefficient decreases on raising peak firing temperature. It can also be observed that the variations of K_s arising as a result of the different degrees of green compaction tested, are greater than the ones resulting from the modification of the peak firing temperature. However, the influence of peak firing temperature becomes relatively more important as the materials are formed at greater pressing pressure and moisture content, on requiring less glassy phase to achieve a high degree of sintering.
On comparing the values of K_s, obtained for different specimens, the conclusion may be drawn that the duration of the dwell at peak firing temperature does not appear to affect the value of the suction coefficient of the fired material, when the dwell exceeds 6 min.

On plotting the values of the suction coefficients obtained for all the tested firing conditions, in the form K_s versus $(\varepsilon^*/\tau)\cdot[r_0(16)]^{1/2}$, in rectangular coordinates, a straight line was found with a value of practically zero at the intercept and a correlation coefficient of 0.994, which confirms the validity of Equation (2), independently of the firing conditions used (Fig. 1).

4 REFERENCES

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Table 1.

SPECIMEN No.	P (kg/cm²)	X (kg water/kg dry solid)	T_{max} (°C)	Firing cycle
1	150	0.040	1025	R
2	150	0.040	1075	R
3	150	0.040	1125	R
4	250	0.055	1025	R
5	250	0.055	1050	L
6	250	0.055	1075	R
7	250	0.055	1125	R
8	450	0.070	1025	R
9	450	0.070	1075	R
10	450	0.070	1125	R

Table 2

SPECIMEN No.	K_s (kg/m^2·s$^{1/2}$)	m_s (kg/m^2)	ε^*	$(\varepsilon^*/\tau)\cdot[r_0(16)]^{1/2}\cdot 10^4$ (m$^{1/2}$)
1	0.393	3.100	0.288	1.502
2	0.379	2.650	0.246	1.437
3	0.350	2.320	0.218	1.354
4	0.254	2.620	0.245	0.943
5	0.253	2.690	0.247	0.960
6	0.224	2.180	0.204	0.807
7	0.124	1.420	0.136	0.460
8	0.107	2.130	0.199	0.556
9	0.089	1.860	0.176	0.444
10	0.023	1.010	0.096	0.173

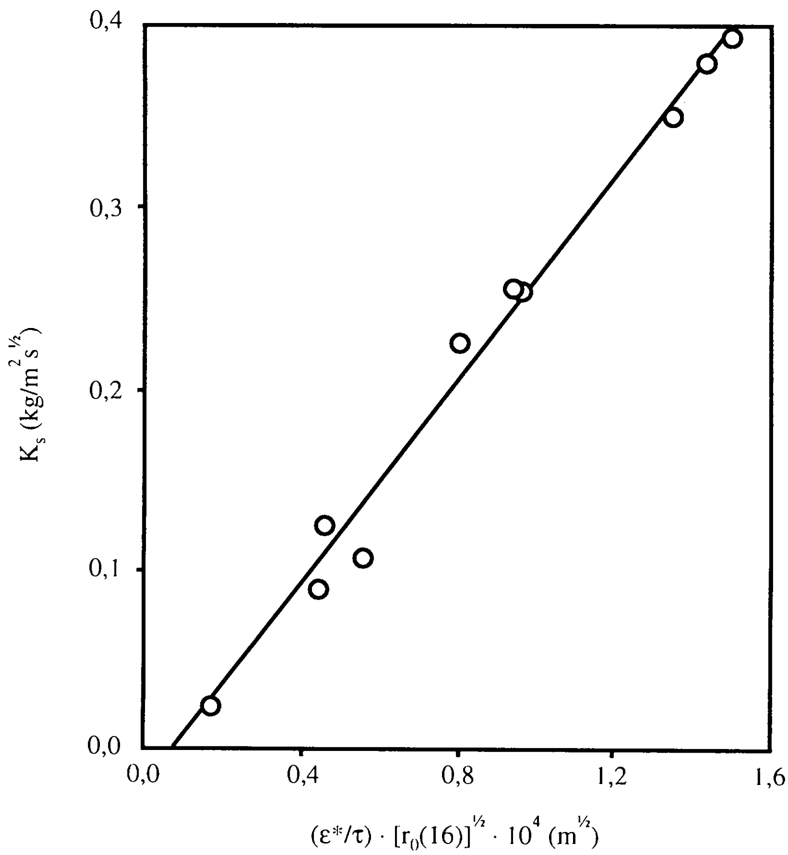

Figure 1.