STUDY OF MAGNESITE BEHAVIOUR IN POROUS SINGLE-FIRE WHITE BODIES

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ABSTRACT

Physico-chemical and thermal tests were used to study the behaviour of a porous single-fire composition in which calcium carbonate was replaced by magnesite. This material is of some interest as it breaks down at lower temperatures than calcium carbonate, which could help solve problems relating to the outgassing of the carbonates, allowing frits to be used with lower sealing temperatures or faster firing schedules.

Formulations were prepared containing 0 to 20% magnesite, on which tests were run to determine their water absorption, linear shrinkage, moisture expansion, thermal expansion on drying and firing, and X-ray diffraction.

The results of these tests were compared to the findings obtained under standard conditions (with calcium carbonate).

The substitution greatly modifies product characteristics, sometimes so negatively as to make substituting magnesite for calcium carbonate quite unfeasible.

CONDITIONS USED

Calcium Carbonate (%)	Magnesite (%)				
Reference: 13,4	0	5	10	15	20

Tabla I: *Carbonate percentages tested.*

NB: The other constituents were kept proportionally unchanged in all the compositions.

- Type of mill: horizontal laboratory mills
- Mill capacity: 5 l
- Milling time: 17 min
- Pressing moisture content: 7%
- Specific compaction pressure: 250 kgf/cm^2
- Firing temperature: 1140°C
- Firing cycle: 62 min
- Kiln used: industrial roller kiln
- The magnesite and calcium carbonate used were natural minerals of great purity (this was measured)
- Tests run: water absorption, linear shrinkage, moisture expansion, thermal expansion on drying and firing, and X-ray diffraction on firing the compositions.

NB: The reported data correspond to the average of 5 measurements, except for the thermal expansion and X-ray diffraction tests, in which only one measurement was taken.

TEST RESULTS AND DISCUSSION

	Calcium carbonate	Magnesite (%)				
	Reference = 13.4%	0	5	10	15	20
Water absorption (%)	19.9	16.8	18.6	19.7	20.9	22.1
Linear shrinkage (%)	0.73	1.27	1.34	1.41	1.51	1.58
Moisture expansion (%)	0.33	1.09	1.09	1.04	0.92	0.95
Thermal expansion on firing (25-325°C)(×10^{-7}/ºC)	71.5	59.8	61.0	62.4	63.1	64.3

Table II: Summary of the data obtained for each composition.

THERMAL EXPANSION ON FIRING

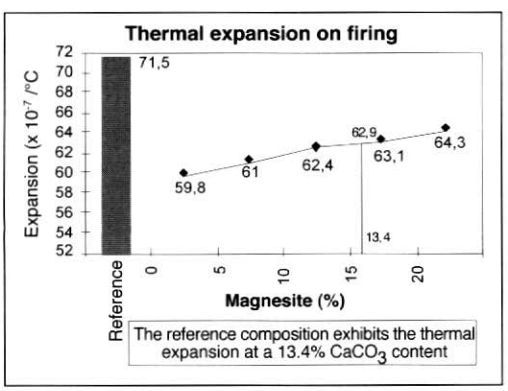

Figure 1

It can be observed in Fig. 1 that the composition containing calcium carbonate exhibited greater thermal expansion than the ones using magnesite. Raising the magnesite content also clearly increased thermal expansion.

WATER ABSORPTION

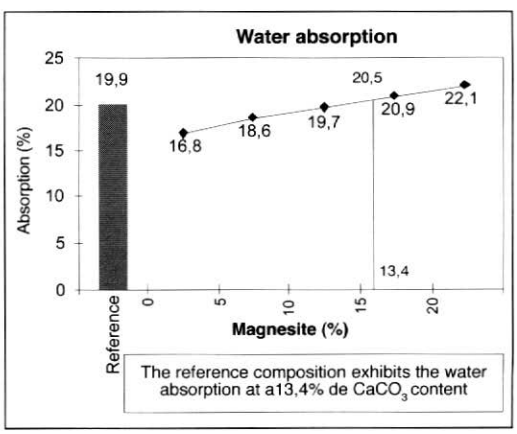

Figure 2

Fig. 2 shows that the composition containing calcium carbonate exhibited 19.9% water absorption, whereas the composition bearing 13.4% magnesite exhibited 20.5% water absorption.

Increasing the magnesite content raised water absorption.

LINEAR SHRINKAGE

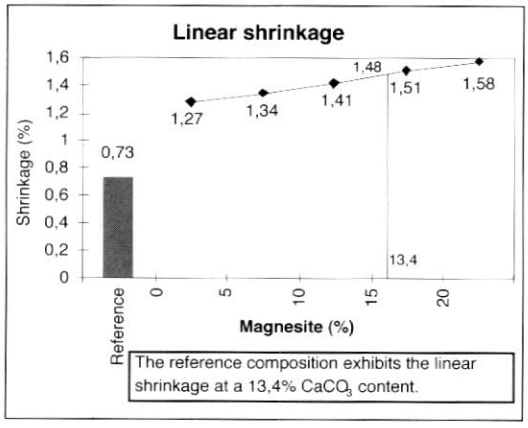

Figure 3

It can be observed in Fig. 3 that the calcium carbonate containing composition exhibited 0.73% linear shrinkage, whereas the formulation with a 13.4% magnesite proportion exhibited 1.48% linear shrinkage.

Increasing the magnesite content raised linear shrinkage.

MOISTURE EXPANSION

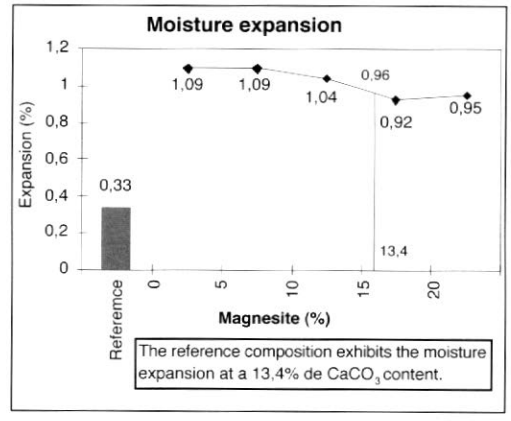

Figure 4

The reference composition exhibited 0.33% moisture expansion, while the composition with the same proportion of magnesite exhibited 0.96% moisture expansion.

Increasing the magnesite content did not however raise moisture expansion.

DRYING THERMAL EXPANSION

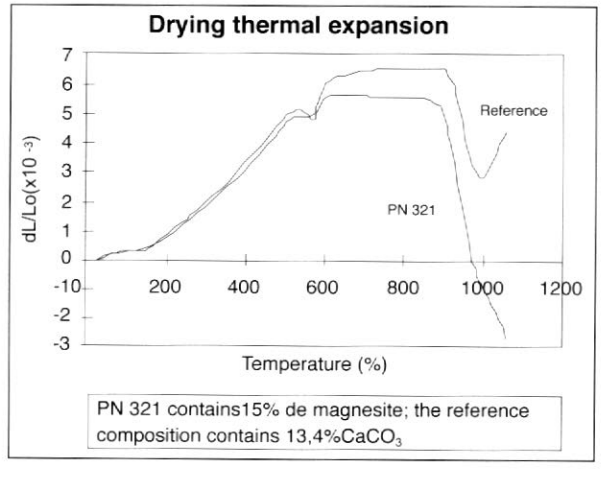

Figure 5

Fig. 5 shows that the drying thermal expansion of the reference composition with 13.4% calcium carbonate exhibited material expansion in the 973 to 1077°C interval owing to crystalline-phase formation. In curve PN 321 with 15% magnesite this expansion did not occur. For this reason magnesite did not reduce linear shrinkage like calcium carbonate.

X-RAY DIFFRACTION ON FIRING THE COMPOSITIONS

Calcium carbonate	Magnesita (%)				
Reference = 13.4%	0	5	10	15	20
Mullite ($Al_2Si_2O_{13}$) Quartz (SiO_2) Diopside ($CaMgSi_2O_6$) Anorthite ($CaAl_2Si_2O_8$) Ghelenite ($Ca_2Al_2SiO_7$)	Mullite Quartz Clinoenstatite ($MgSiO_3$)	Mullite Quartz Clinoenstatite ($MgSiO_3$) Periclase (MgO)	Mullite Quartz Clinoenstatite ($MgSiO_3$) Periclase (MgO)	Mullite Quartz Clinoenstatite ($MgSiO_3$) Periclase (MgO)	Mullite Quartz Clinoenstatite ($MgSiO_3$) Periclase (MgO)

Mullite and quartz were present in all the compositions.

The reference composition contained calcium and calcium/magnesium crystalline phases that formed during firing (diopside, anorthite and gehlenite).

In the composition without any carbonates, only clinoenstatite stemming from the talc (9%) in the composition could be observed.

The formulations containing magnesite exhibited periclase (MgO), whose peak height rose as the magnesite proportion increased.

NB: The XRD plots are presented in the poster.

CONCLUSIONS

Magnesite could not replace calcium carbonate in porous, single-fire bodies for the following reasons:

- Linear shrinkage rises, reducing dimensional stability;
- Thermal expansion on firing decreases;
- Moisture expansion rises and produces cracking.

In the reference composition containing calcium carbonate, there is more crystalline-phase formation than in the compositions containing magnesite, which explains why the latter exhibit higher linear shrinkage and greater moisture expansion.

- XRD shows that MgO hardly reacts with the other compositional constituents. $MgCO_3$ therefore acts as a pore-forming material owing to the outgassing of the carbonates, without however forming crystalline phases like $CaCO_3$.

- Moisture expansion does not rise as the magnesite proportion is increased, indicating that that the residual (periclase) and arising MgO react only slightly or not at all with the water.

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