INFLUENCE OF THE ADDITION OF HEAVY ASHES FROM MINERAL COAL ON THE PHYSICAL PROPERTIES OF CERAMIC MATERIALS

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ABSTRACT

The heavy ashes of coal mineral are originated as by-products of mineral coal combustion in thermal electric plants. The physical, chemical and mineralogical characteristics of these heavy ashes are compatible with several raw materials used in ceramic tile industries, which indicates the possibility of partial or complete substitution of these raw materials by this by-product. In this context, this work evaluates the effect of the addition of that by-product on the water absorption and the flexural mechanical strength properties of the resulting ceramics. For the formulation of the ceramic masses, experimental planning was used {3,3}, which led to ten formulations of the three components (two different clays types and heavy ash from mineral coal). The ceramic materials developed with the addition of heavy ashes deriving from mineral coal presented more appropriate values for water absorption and flexural strength module, compared with a typical ceramic industrial material made with the use of conventional raw materials.

1. MATERIALS AND METHOD

The coal bottom ash used in ceramic materials formulation is the by-product of under-bituminized mineral coal at Usina Termoelétrica de Jorge Lacerda, located in Capivari de Baixo, Santa Catarina State/Brazil. Clay raw materials, referenced clay 1 (ARG 1) and clay 2 (ARG 2), were dried in a greenhouse at 100ºC (±10ºC) to constant mass, and manually disaggregated with the help of a mortar. Experimental planning was accomplished for the formulations studies, through mixtures delineating (Simplex system planning).

Formulations	Raw materials		
	ARG 1 (%)	ARG 2 (%)	CP (%)
M1	47.00	41.00	12.00
M2	23.00	41.00	36.00
M3	23.00	65.00	12.00
M4	39.00	49.00	12.00
M5	31.00	57.00	12.00
M6	23.00	57.00	20.00
M7	23.00	49.00	28.00
M8	31.00	41.00	28.00
M9	39.00	41.00	20.00
M10	31.00	49.00	20.00

Table 1. Ceramic masses formulation obtained through L-simplex {3,3} delineating.

2. RESULTS AND DISCUSSION

Table 2 shows the ten ceramic mixtures in terms of independent components obtained through experimental planning of mixtures delineating. It also shows values of the resulting ceramic materials physical properties after sintering: water absorption (ABSQ) and mechanical resistance to flexure (RMFQ).

Mixture	Fractions by Weight			ABSQ (%)	RMFQ (MPa)
	ARG 1	ARG 2	CP		
M1	0.47	0.41	0.12	3.85±0.16	42.37±3.93
M2	0.23	0.41	0.36	3.96±0.22	43.53±5.4
M3	0.23	0.65	0.12	4.17±0.21	38.54±6.9
M4	0.39	0.49	0.12	5.07±0.08	34.50±4.48
M5	0.31	0.57	0.12	4.05±0.18	37.33±3.48
M6	0.23	0.57	0.20	4.45±0.30	38.98±5.47
M7	0.23	0.49	0.28	3.10±0.25	47.21±6.26
M8	0.31	0.41	0.28	7.05±0.10	29.30±4.50
M9	0.39	0.41	0.20	6.86±0.14	27.77±2.12
M10	0.31	0.49	0.20	3.20±0.40	44.09±4.47

Table 2. Ceramic mixture compositions and correspondent measurements of ABSQ and RMFQ.

Through coefficient analysis of equation (1), it is possible to observe that clay 1 and 2 and coal bottom ash fractions contribute favourably to the increase in water absorption in the developed ceramic materials. The binary mixtures, except the two clay mixture, also have a synergic effect on the ABSQ value. The ternary mixture, among all components, contributes to obtaining ceramic materials with lower water absorption.

ABSQ $= 3.99x_1 + 4.19 x_2 + 3.80x_3 + 2.11x_1x_2 + 13.77x_1x_3 - 0.99x_2x_3 - 66.10 x_1x_2x_3$

Equation 1.

In relation to the effect of the raw materials in the system, clay 1, clay 2 and the coal bottom ash fractions contribute favourably to the increase in ceramic material mechanical strength (equation 2). The binary mixtures, except the clay 1 and clay 2 mixture, tend to decrease RMFQ. The ternary mixture, among all components, contributes to obtaining ceramic materials with higher mechanical strength.

RMFQ $= 41,62x_1 + 38,19x_2 + 44,63x_3 - 17,95x_1x_2 - 65,66x_1x_3 + 7,58x_2x_3 + 298,55x_1x_2x_3$

Equation 2.

3. CONCLUSION

The use of experimental planning {3,3}, which led to ten formulations of the three components (two different types of PF Clay and mineral coal bottom ash) was shown to be adequate. A regression model was obtained with the composition, related to water absorption and to the mechanical resistance module of sintered ceramic material flexural strength. Statistical analysis showed that the models are significant, do not present adjustment failures and that the errors are random, with an average tending to zero and almost constant variance. The mineral coal bottom ash by-product was confirmed to be an attractive raw material source of SiO_2 and Al_2O_3 for obtaining ceramic materials. In this work, it was found that it is possible to add a higher percentage of CP in ceramic material formulation, compared with the maximum percentage recommended in the literature (30,0%), without decreasing the RMFQ values.