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Red ceramic industrial products incorporated with oily wastes

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Abstract

An industrial scale investigation into the effects of oily wastes incorporated into different red ceramic products for building construction was carried out for the first time. The oily wastes were a crude sludge derived from petroleum separation process and its inert treated form. Into clayey for brick and tile production were incorporated up to 5% by wt. of these oily wastes. The results showed that practically no change occurred in the main technological properties required to specify porous red ceramic products. On the other hand, the workability of the unfired material for extrusion may be affected and, in some cases, even improved by the oily waste incorporation.

Keywords: Industrial scale; Incorporation; Oily wastes; Red ceramics

1. Introduction

The incorporation of oily wastes into clayey ceramics is an environmentally correct solution which uses the ever increasing residues generated by the petroleum and related industries. In Refs. [1–9], the characteristics and properties of clayey ceramics incorporated with oily waste were investigated in a laboratory. All these works used electrical laboratory furnaces for firing relatively small samples at temperatures, extending from a minimum of 750 to a maximum of 1150 °C. It was found that this incorporating up to 5% by wt. of oily residues does not impair the technical requirements for common porous red ceramic products such as bricks and tiles [1,7,8]. Moreover, some advantages such as less wear of equipment and lower fuel consumption could be associated with the oily content in the waste [1,8]. Actually, the main change reported in the structure of red ceramics incorporated with oily wastes in comparison with that of waste-free ceramics was the presence of relatively small barite ($BaSO_4$) particles [7,9]. However, the quantity of these particles and the fact that they are well fixed to the surrounding silicate matrix, suggest that $BaSO_4$ does not significantly interfere with the ceramic strength [9]. By contrast, larger particles of quartz and complex silicates could be detrimental to the strength but since these larger particles are common features in the waste-free ceramic they cannot be directly related to the effect of incorporation. Exceptions to this behavior were reported [7] with above 10% by wt. of oily waste in association with temperatures higher than 1000 °C, which are not normally used to process porous red ceramics.

Based on these laboratory results, the objective of the present paper was to extend the investigation, for the first time, to an industrial scale by the incorporation up to 5% by wt. of oily wastes into different commercial porous red ceramic products.

2. Experimental procedure

Two types of oily wastes were incorporated into industrial clayey bodies to produce red ceramic bricks and tiles. The first was a crude oily sludge (COS) obtained in salt water/solid residues separation process from petroleum at

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offshore rigs in Brazil. The second was the compound that results from an oil encapsulation treatment of the COS with hydrophilic clay known as bentonite. This bentonite encapsulated oily waste (BEOW) was processed at an inland plant [7]. The BEOW is less toxic than its precursor COS and, consequently, is nowadays disposed in landfill. However, this may still pose a risk of soil and ground water contamination. Therefore, efforts are being made to render the BEOW even more inert through further processing such as the incorporation into ceramic products investigated as in the present work. The chemical composition and other characteristics of both COS and BEOW were reported elsewhere [9]. Table 1 reproduces the major constituents of both oily wastes.

Two different types of clay bodies from corresponding red ceramic industries were used as matrices for the oily wastes incorporation. Each clay artefact was a distinct extruded red ceramic product, being a clay brick (CB) or a clay tiles (CT), both used in building construction. The CB was processed at the Cerâmica R. P. Pessanha industry, while the CT was formed at the Rodolfo de Azevedo Gama Cerâmica industry, both in the city of Campos dos Goytacazes, State of Rio de Janeiro, Brazil. The major constituents of these industrial clay bodies are also shown in Table 1.

The plasticity of the clay was obtained through the Atterberg limits: PL for the plasticity limit and PI for the plasticity index [10,11]. The properties were evaluated for both dried and industrially fired ceramic pieces. Firing was carried out at appropriate temperatures to the corresponding industries using Hoffman type furnaces. For the extruded bricks, the temperature was 700 ± 50 °C and for the extruded tiles, 900 ± 40 °C. The drying and firing linear shrinkage were obtained by the relative variation in length measured using a caliper with ± 0.01 mm of precision. The water absorption was determined according to standard procedures [12,13] as was the mechanical strength, obtained by a standard compression test [14] for the bricks and bending test [15] for the tiles in an Instron testing machine.

In order to verify the mobility of pollutant metals, solution tests [16] were carried out on both clay bodies and the ceramic materials obtained with BEOW oily waste incorporation. The content of potentially toxic metals such as Cd, Cr, Pb as well as other metals required by norm, was determined in the solution extracts by ICP-OES using a Variant equipment. Gaseous emissions were analysed in a laboratory scale using a model URAS 14 – Hartmann Braun detector at 600–800 °C and following procedures described elsewhere [17].

3. Results and discussion

3.1. Extrusion behavior

Fig. 1 shows an extrusion prognosis using the plasticity of the mixtures [18]. The plasticity limit, PL, corresponds to the amount of water necessary for the clay to reach plastic consistence and which makes it possible to be formed by extrusion. The plasticity index, PI, is associated with the range between plastic and sludge (or liquid) consistence of the body. For practical purpose, the plasticity index must be above 10% [19].

The extrusion prognostic in Fig. 1 reveals that the incorporation of oily wastes, into both the COS and the BEOW resulted in different effects for the extruded brick and tile, clay bodies. As shown in Fig. 1, the waste-free clay bodies, CB and CT, are located inside the acceptable extrusion region with approximately the same PL but different PI. The lower PI for the CT can be attributed to a larger amount of quartz in the clay used in the tile.

Distinct behaviors were observed when the oily wastes are incorporated. The incorporation of 5% by wt. of oily waste COS (Fig. 1) moves the workability of the CT into the optimal extrusion region, while the same incorporation into the CB maintains the body inside the acceptable region. By contrast, the incorporation of 5% by wt. of BEOW hardly changes the CT workability, while moving

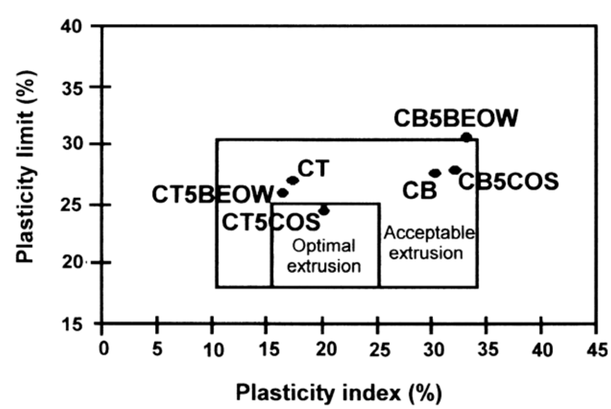

Fig. 1. Atterberg limits and extrusion prognosis for the different clays with incorporated wastes [16]. CT5BEOW – clay tiles with 5% by wt. BEOW; CT5COS – clay tiles with 5% by wt COS; CB5BEOW – clay bricks with 5% by wt. BEOW; and CB5COS – clay bricks with 5% by wt. COS.

Table 1
Chemical compositions (% by wt.) of the oily waste and clay material

	SiO_2	Al_2O_3	BaO	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Oily content	Others
COS	13.7	2.52	9.97	6.69	4.46	0.42	0.95	2.30	33.1	25.9
BEOW	40.0	6.56	7.73	7.33	5.55	0.71	1.54	1.10	9.3	17.4
CB	44.56	29.64	–	8.72	0.34	0.89	1.40	0.51	–	11.4
CT	54.58	29.54	–	3.05	0.24	0.81	1.84	0.30	–	7.85