USE OF ABRASIVE AND GLAZE WASTES IN EXPANDED CERAMICS

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ABSTRACT

A ceramic industry generates a large amount of waste. The residues are normally disposed of in landfills. These involve glazes, ashes, minerals, plastics, metals, glass, paper, lubricant oil, wood, abrasives, and others. Every three years, they pollute one hectare. Therefore, recovering and recycling residues with an economic value is an attractive solution for disposal, due the reduction of raw material consumption and reduction of environmental pollution. The material used to polish ceramic products is an abrasive product, made of SiC and magnesium chlorine cement. Nowadays these abrasives are disposed of in landfills, as usual with all ceramic residues generated in Brazil. However, a possible use for these wastes is the promotion of expansion in ceramic bodies. At high temperature, SiC decomposes generating CO_2. Added to a glazed ceramic body with relatively low melting temperature it can promote the expansion of this body. The final product will be an expanded ceramic material, with low density, good mechanical resistance and excellent acoustic and thermal properties.

Abrasive waste and glaze residues were mixed together to obtain expanded ceramics. SiC abrasives were used as expanding agent and melting residues as the matrix for the expanded artifacts. Both materials were milled (jar mill, #325 mesh) and pressed (25MPa) in cylindrical samples. The samples were sintered (1200°C, 2h); after surface preparation, microscopic analysis was performed to determine the amount of abrasive to be added at the glaze residue.

Key words: *Recycling; silicon carbide; glazes; expanded ceramic.*

1. SUMMARY

A ceramic industry consumes a great amount of raw materials; consequently, as in all industries, wastes are generated. Residues disorderedly deposited in landfills can cause innumerable problems, such as ground contamination, phreatic water contamination, river and lake contamination, disease spreading and reduction of non-renewable natural resources, even influencing the biological cycle of natural vegetation [MEDEIROS, 1999]. Today, the concerns regarding the Environment occupy an important role in company agendas. The awareness of the professional motivates them to work collaboratively in the solution of current or future problems. The residues are normally deposited in landfills; these residues mainly consist of ceramic debris, ceramic glazes, coal ashes, minerals, plastics, metals, glasses, papers, lubricant oil, wood, abrasive rocks, amongst others. It is estimated that each three years one hectare of land is occupied with these residues.

The reuse and recycling of residues in the ceramic industry are very effective. These activities enable reducing and eliminating wastes, as well as the excessive consumption of natural resources such as minerals, water and natural gas; materials reuse and recycling is also possible, because the rejects of one company can be considered raw material for another. Finally, there is recycling, which consists of the reintroduction of final products, by-products and residues in a new cycle of production and consumption. Recovery and recycling of residues that present economic value are one of the more attractive forms to solve the problems related to treatment and final destination of residues, according to industrial staff and environment agencies. Even, recycling is as an important factor for reducing the consumption of natural resources and a way of reducing the amount of pollutants launched into the Environment.

The residues derived from ceramic processing are generally defective tiles: products that present some type of defect and therefore are declassified and disposed of in landfills [MEDEIROS, 1999]. Other kind of solid residues are mineral coal ashes decanted from liquid effluents generated from furnaces. Also, rejects of liquid effluents from ceramic glazes and screen printing paints collected in the screen printing sector. The ashes generated from mineral coal basically consist of silica (50 wt%) and alumina (30 wt%). They are potentially polluting residues due their low pH, as much as to their content of soluble (not volatile) elements [RESID, 1999].

The liquid effluents are inorganic insoluble substances. The ceramic colorants contain oxides of Al, Co, Zr, Se, Cr, Zn, Ni, Ca and Sn; the glazes contain SiO_2, B_2O_3, Na_2O and PbO; the synthetic resins contain organic composites; the ceramic paints contain Pb, Ca, Se, Al, Fe, Cr and Mn; there are also fine solids in suspension (clays, glaze rests, silicates). The solid residues issue includes aspects referring their origin and production, as well as concepts of inexhaustibility and the consequences of Environment degradation, mainly ground, air and water.

Therefore, the definition of residues, their origins and formation, depend on diverse factors, such as habits and economic activity, among others. Not all waste is considered a "thing" without value, since this waste can be reused or recycled. Solid residues (solid and semisolid) are the result of community activities, and may be of industrial, domestic, hospital, commercial, agricultural or services origin [MEDEIROS, 1999; VILHENA, 2000]. Residues can be considered a source of high Environment pollution, affecting the quality of life on the planet.

However, residue concentrations are increasing; treatment techniques often become economically impracticable. The evolution and technological improvement of residue treatment depend on the recycling structure and the consumed volume of manufactured products. Industries generally considered residues as an inevitable by-product of mass production. But the industrials had already acquired recycling consciousness, interacting with the communities where they conduct their activities, since the consumer market also demands this concern from them [SENAI, 2000].

To define an adequate management of solid residue treatment, it is necessary to know them very well, or either, to classify them. The industrial solid residues can be classified as dangerous and non-dangerous. For an industry, this differentiation is important and becomes necessary, since management of each type of residue is very different, taking into consideration the technology and costs [BIDONE, 2001].

The ceramic industry of the south of Santa Catarina State is the second major Brazilian ceramic complex [MEDEIROS, 1999]. The ceramic tile industry of the Criciúma region does not have any recycling program for solid residues. The industrial solid residues are dumped directly in landfills. The ceramic companies dump the wastes of glazing and polishing (abrasives) products without any criterion. The glazing residues, also called "fangos" in Spanish, are the wastes of the glaze application processes, collected, stored and filtered to eliminate the residual water. The product of the filtration process, the so-called cake, is generally landfilled.

The abrasives are composed of diamond particles, agglomerated in magnesian chloride cements, or silicon carbide particles, agglomerated by the same type of cement. In this way, an alternative to the dumping of solid residues generated by the ceramic industry (glazing residues and abrasive wastes) is the use of these residues as raw materials for new products, as expanded ceramics. These products are useful in the construction industry as filling materials, substituting expanded polymers or even substituting wood and paper. Also, these products have excellent thermal and acoustic insulation characteristics.

Silicon carbide decomposes at a certain temperature, generating a certain amount of CO_2. If added to a ceramic with a softening point close to the SiC decomposition temperature, the resultant product will suffer a volumetric expansion due to SiC decomposition associated with the beginning of the ceramic material softening. The ceramic surface will be impermeable to the exit of the resultant gas derived from SiC decomposition; the gas will be caught inside the softened vitrified ceramic and the final product will be an expanded ceramic with low density.

2. MATERIALS AND METHODS

The raw materials used were two residues: glaze and silicon carbide abrasive wastes. The glaze wastes are obtained as filtered residues from the ceramic tile glazing process; such residues are a mixture of various kinds of ceramic glazes, usually applied on floor tiles in a single firing process. The single firing glazes have a characteristic chemical composition based on silica, alumina and calcium oxide; they have a melting temperature (softening point) above 800°C and often receive zirconia as an opaque additive or even zinc oxide, as a matte additive. Depending on the changeovers of products in the manufacturing lines and on the kind of manufactured products in the plant, the chemical composition of the glaze wastes can be more or less steady, resulting in a raw material with good characteristics, and not only a residue.

The abrasive is composed of silicon carbide particles agglomerated by a chlorine magnesian cement. It is enveloped by a high resistance polymer and is conveyed with this wrapping to the polishing machines. Part of the polymer wrapping remains with abrasive inside, without being consumed in the polishing process, thus generating the wastes. Thus, the first step is the separation of the abrasive from the polymeric wrap, a process carried out using a jaw crusher. The separation of the abrasive particles from the fragmented plastic was made by difference in density via sedimentation in water: the plastic floats and the abrasive decants, allowing easy separation.

The fragmented abrasives were then dried at 150°C for 48h. After the first separation, the fragmented particles were weighed and then milled in eccentric mill (500ml) with 250g of grinding elements (high alumina spheres), mixed with 100ml of water. The material was milled to obtain a residue between 0.8 wt% and 1.0 wt% on 325 mesh (44μm equivalent).

After grinding, the abrasive residue was dried again at 150°C for 48h. The dried material was disaggregated in the eccentric jar mill. The glaze residues were prepared following the same procedure, getting 1.0 wt% of residue on 325 mesh; particle size distribution was not carried out. After the milling and disaggregation of the samples, the milled abrasive was added to the milled glaze residue in ratios of 1 wt%, 3 wt%, 6 wt% and 12 wt%.

The compositions were pressed uniaxially at 25MPa in a laboratory press, forming cylindrical bodies with 40mm in diameter and 10mm height; the binder used was 2 wt% of polyvinyl alcohol diluted in water; compact density was measured by immersion in mercury, obtaining a mean density of 2.0g/cm^3 for all samples.

Finally, the compacts were sintered at 1200°C for 15min and final density was measured by mercury immersion.

3. RESULTS AND DISCUSSION

Figure 1 shows the expanded products obtained after sintering. The measured density is shown in table 1.

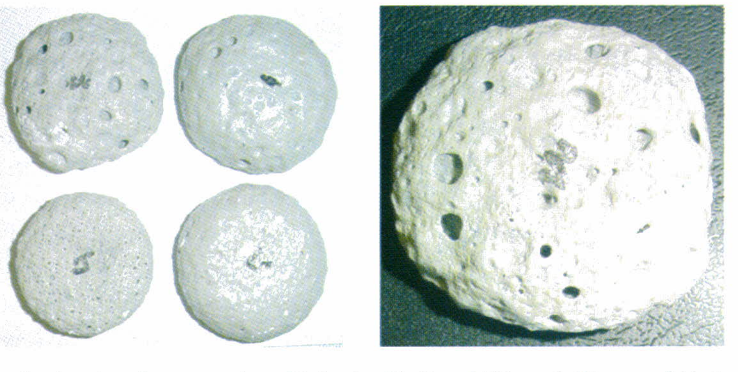

Figure 1. The final products showing the expansion obtained with the addition of silicon carbide to a glaze waste at 1 wt% (bottom, left), 3 wt% bottom, right), 6 wt% (top, right) and 12 wt% (top, left). In the detail, the sample is shown with 12 wt% silicon carbide.

% of additive [wt]	1%	3%	6%	12%
Density [g/cm³]	0.78	0.71	0.61	0.50

Table 1. Density of the expanded ceramics (measured by immersion in mercury).

As expected, the sample with 12% addition by weight of silicon carbide was the most expanded, with a density of $0.5 g/cm^3$. This work is a preliminary study, but it shows the potential for ceramic recycling.

4. CONCLUSION

As a preliminary study, some questions were not answered. Which softening temperature would be most suitable to get expanded products at a viable cost? What is the minimum amount of silicon carbide necessary to cause the expansion of the system to a determined density? Both questions could be answered by dilatometric analysis of the abrasive and glaze residues, which have to date not been conducted. Dilatometric analysis (or differential thermal analysis) of the compositions could supply the amount of silicon carbide that would be necessary to cause expansion of the compositions to a certain degree.

As the abrasives are composed of silicon carbide immersed in a chlorine magnesian cement, and as the SiC has concentrations and even particle size distributions that depend on the grade of the commercial abrasives used, the dilatometric analysis should be conducted in a mixture of several abrasive samples that could represent an average of the commercial compositions.

Regarding the glaze residues, as they are also a mixture of several types of glazes used by a particular company, dilatometric analysis is necessary to determine the softening point of the mixture, considering it homogeneous, which is not incorrect at all. The glaze residues are filtered together, resulting in a sample that represents the average of the glaze compositions used by the company.

Finally, it can be concluded that the project is viable. With only a few analyses it has been possible to determine that silicon carbide residue combined with ceramic glaze wastes can be formulated together to form expanded ceramic products, with some singular features. They present low density ($0.5 g/cm^3$), they are a solution to avoid the accumulation of ceramic wastes, and they can be used to form components that could substitute expanded polymer, wood or paper in the construction industry.

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