COMPOUNDING KILN FURNITURE USING CERAMIC COMPOSITE MATERIALS

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ABSTRACT

As the limits of metal based materials are exceeded, attention is now focused on composite materials due to the superior quality and characteristics. This experimental study aimed at compounding high temperature ceramic composite material capable of withstanding a temperature range of 1280^{0}C without deformation. The standard triaxial blend formula with variation of 5%wt of shear nut shell ash and Kankara clay (kaolin) was used. An optimum composition was obtained at 25% shear nut shell ash addition. The optimum composition was then used to produce bars and props. The produced kiln furniture were test fired and the result indicated that, the furniture were capable of resisting more stress, and can withstand high temperature of 12800C without deformation as compared to those made from Kaolin only

Key words: Composites, Calcination, Refractories, Thermal

INTRODUCTION

Recent technological and scientific advancement in the area of fine ceramics material capable of withstanding high temperature, has opened doors for research into composite ceramic materials (Advance Ceramics, 2014). Composite materials are characterized by high speed, low maintenance cost and longer life functions. These high temperature ceramic materials which are also known as advance ceramics have applications in aerospace, health care, thermal energy plants, communication infrastructure, transportation, environmental and magnetic fields (Engineering Ceramics, 2012).

These advanced ceramic materials have different firing temperatures depending on the constituent raw materials used for the formulation. The firing temperature for these advance materials can range from 1500^{0}C -2400^{0}C (Taylor 2001, cited in Advance Ceramics, 2014)

Advances made in the last 30 years in understanding the crystallography and ceramic chemistry and the knowledge gained in the production of engineered ceramics have led to the realization of the huge potentials inherent in fine materials(Taylor, 2001).

As the limit of metal-based material is exceeded, there is an increased demand for other materials with superior quality; attention is now focused on non-traditional ceramic materials which are popularly called composite or engineered ceramic materials due to their superior quality, The superior qualities of these new and emerging family of ceramic materials which includes resistance to abrasion, excellent hot strength, chemical inertness and dimensional stability have placed them at a greater advantage when compared to metal based systems (Taylor, 2015)

Given the temperature and heat relationship between ceramic kiln and its furniture, and the importance of saving energy, time, cost and the environment (Abubakar, 2002); there is therefore the need to develop composite materials capable of withstanding high temperature for use as kiln furniture to replace the traditional ceramic materials. This experimental research

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was carried out to develop composites ceramic matric using kankara clay (Kaolin) and Shear nut shell ash as reinforcement.

the study seeks to develop a high temperature kiln prop and bar capable of firing to a temperature range of 1280^{0}C using Kankara clay mixture and sheer nut shell powder as a composite materials. The scope and objectives of the study includes:

1. Identification, selection and collection of suitable materials for use as composites
2. Develope the selected materials into composite using powder metallurgy techniques by varying the percentage composition of the sheer nut shell at an interval of 5%
3. Compounding of kiln furniture shelves, props and kiln bars from the composite materials.

Materials and Methods

The constituent raw materials used in this study were collected from Borno and Katsina States, respectively. Sheer nut shell was collected from Lassa Village in Borno State. Kankara clay was collected from Kankara village in Katsina State. Kankara clay was named after the area it was collected. Sheer nut shell and Kankara clay were therefore the constituent raw materials used for the development of the kiln furniture

Empirical method was adopted for the research, beginning with identification, sourcing, beneficiation/ treatment, compounding and testing.

Screening and Beneficiation

The Kankara clay collected from Kankara, Kastina State, was screened to remove unwanted particles and materials. The screened clay was beneficiated by soaking in water for 24 hours. It was stirred and sieved manually, washed with water and wet sieved through a 75µm mesh aperture size. The water was decanted while the material was placed on plaster bats for hardening into plastic state. The resulting plastic clay was prepared into rough block form and dried for 14 days under the room temperature (37^{0}C) after which it was fired to 80^{0}C in *a* reducing kiln temperature. The sheer nut shell was processed from sheer nut shell collected in dry form. The bark was removed and screened for impurities and fired in a reducing kiln atmosphere to 400^{0}C. The fired shear nut shell was crushed using a metal hammer, grated, grind, ball milled and sieved into fine powder particle size powder using a 100 µm mesh.

Clay calcinations

The Kankara clay was packed in an air tight graphite crucible and placed inside a manual kiln and fired to the temperature of 1200°C for 5 hours to obtain the calcined kankara clay which was used in this research.

Crushing

The calcined kankara clay was removed from the kiln and allowed to cool to room temperature which was then crushed to smaller particle size by means of pestle and mortar.

Grinding

The crushed Kankara clay was dried grinded to fine particle sizes (powder) by means of a Ball mill.

Refractoriness

The Pyrometric Cone Equivalent (PCE) temperature of 1280^{0}C as recommended by ASTM Test C-24 was used in the determination of the refractoriness of the kankara clay (Aigbodion and Asuke, 2007, Hassan, 2005). The kankara clay was observed to have Seger Cone No. 23, temperature equivalent of >1500^{o}C. This means kankara clay can withstand operating temperature of >1500^{o}C without deformation. From these preliminary studies, it was observed that kankara clay had the required properties for CMCs matrix formulation.

Table 2: Findings

% Shear nut shell	Change in Colour after being dried at 110^{0}C for 24 hrs	Crack formation	Change in colour after being dried at 1100^{0}C	Crack formation
0	White	No crack	White	Slightly crack
5	White	No crack	White	Slightly crack
10	Light	No crack	Light	No crack
15	Light grey	No crack	Light grey	No crack
25	Light grey	No crack	Light grey	No crack
30	Grey	No crack	Grey	No crack
35	Grey	No crack	Grey	No crack
40	Grey	No crack	Grey	No crack

Discussion of findings

The composite blend with 0wt% sheer nut powder shell when dried at 110^{0}C for 24 hrs was white in colour and exhibited a slight crack. As the percentage of the shear nut shell was increased from 0% to 45% at an interval of 5%; the colour changes from white, to light, through light grey and full grey. However, there was a slight indication of crack when dried at 1100^{0}C

CONCLUSION

The study clearly shows that kankara clay (Kaolin) and sheer nut shell can be successfully be used to compound a kiln furniture that can withstand high temperature without deformation. The study also shows that at an optimum composition of 25% shear nut shell ash addition; can successfully be used to produce kiln props and bars capable of standing a temperature range of 1280^{0}C without exhibiting stress and deformation.as compared to those made from kaolin only

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