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DEVELOPMENT AND EVALUATION OF VARIOUS PROPERTIES OF CERAMIC BASED BRICK COMPOSITES FROM NATURAL MUD AT DIFFERENT SINTERING TEMPERATURE

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Abstract— In the present scenario, considerable research have been carrying on towards the development of ceramic based insulating materials for high voltage (HV) applications. To meet such demands, we made an attempt to develop ceramic based brick composites through conventional powder metallurgy technique from natural mud for using as a substitute of high strength conventional ceramic based insulator for HV applications. This research is directed towards the development of brick based composites from local mud with optimizing its sintering temperature based on its physical as well as mechanical properties. The surface morphology of the developed composites were observed and reported.

Keywords— Brick based composite, Ceramic matrix, Powder Metallurgy, Surface morphology, Shrinkage, Density, Porosity, Hardness.

1. INTRODUCTION

Ceramic matrix composites are only the oldest and newest materials widely demanded in all the sector of thermal, electrical and structural applications due to outstanding performance at high temperature, high hardness, and chemical inertness [1-3]. Ceramics generally made protective barriercoating during fabrication which makes them preferable for harsh environment application [4].

Brick, made from natural mud is an oldest member of ceramic family and traditionally used in the sector of civil, mechanical and electrical applications as masonry construction (means structural), protective or insulating materials respectively. Now-a-days, china clay have been used extensively in different commercial purpose such as insulating material in all the sector of electrical and electronics industries along with HV transmission due to their attractive feature such as---- high strength, high stiffness, with low density [3-4].

Mud based composite are preferred when component weight reduction is the key objective [1-3]. Powder metallurgy is an art and technique for developing low density material with exact dimension along with improvement of structural properties [5-6] of the developed material with low cost.

This study mainly focuses on the development of ceramic based brick composites at various sintering temperatures and finally optimize this sintering temperature based on its various physical and mechanical properties.

2. EXPERIMENTAL PROCEDURE

2.1 Development of Ceramic Based brick Composite by Powder Metallurgy Technique

In this present study, mud is the only component material which was collected from the river side of Ganga at North 24 Parganas district in West Bengal, India. This mud was clean, dried and finally shaped for making brick utilizing 600^0C for 6 hours in muffle furnace (made by Nascor Technologies Private Limited, Howrah, West Bengal, India) at open atmosphere. This bricks are crushed by using crusher and made fine powder, mesh size around -300 µm using ball mill. The compact powder was uniaxially hard-pressed using a steel mold having an internal diameter of 15 mm at a pressure of 200 MPa, with a 2-ton press for five minutes from PEECO hydraulic pressing machine (PEECO Pvt Ltd, M/C NO.-3/PR2/HP-1/07-08). Finally the samples were sintered in the same muffle furnace at temperature 900^0C, 1000^0C, 1100^0C and 1150^0C for 2 hours at a constant heating rate of 5^0C/min. After operation, samples were permitted for cooling in the same furnace.

2.2 Testing and Characterization

2.2.1 Microstructure

After sintering, samples were mirror polished and microstructures were observed at 100 X magnification by LEICA Optical Microscopy model no DM-2700M Image Analyzer.

2.2.2 SEM Analysis

SEM image were taken for each polished sample using JEOL MAKE SEM model JSM 6360, operated by PCSEM software.

2.2.3 Physical Property Measurement

Weight and dimension were taken for each sample to calculate various physical properties. Apparent Porosity was measured for each sample using the universal porosity measurement technique.

2.2.4 Micro hardness Survey

Hardness was taken by employing Vickers diamond pyramid indenter with 250 gf loads and 15 sec dwell time. Hardness was taken in four different positions and finally average the hardness values for precise measurement by using Leco Micro Hardness tester (Model LM248SAT).

3. RESULTS AND DISCURSION

3.1 Microstructure

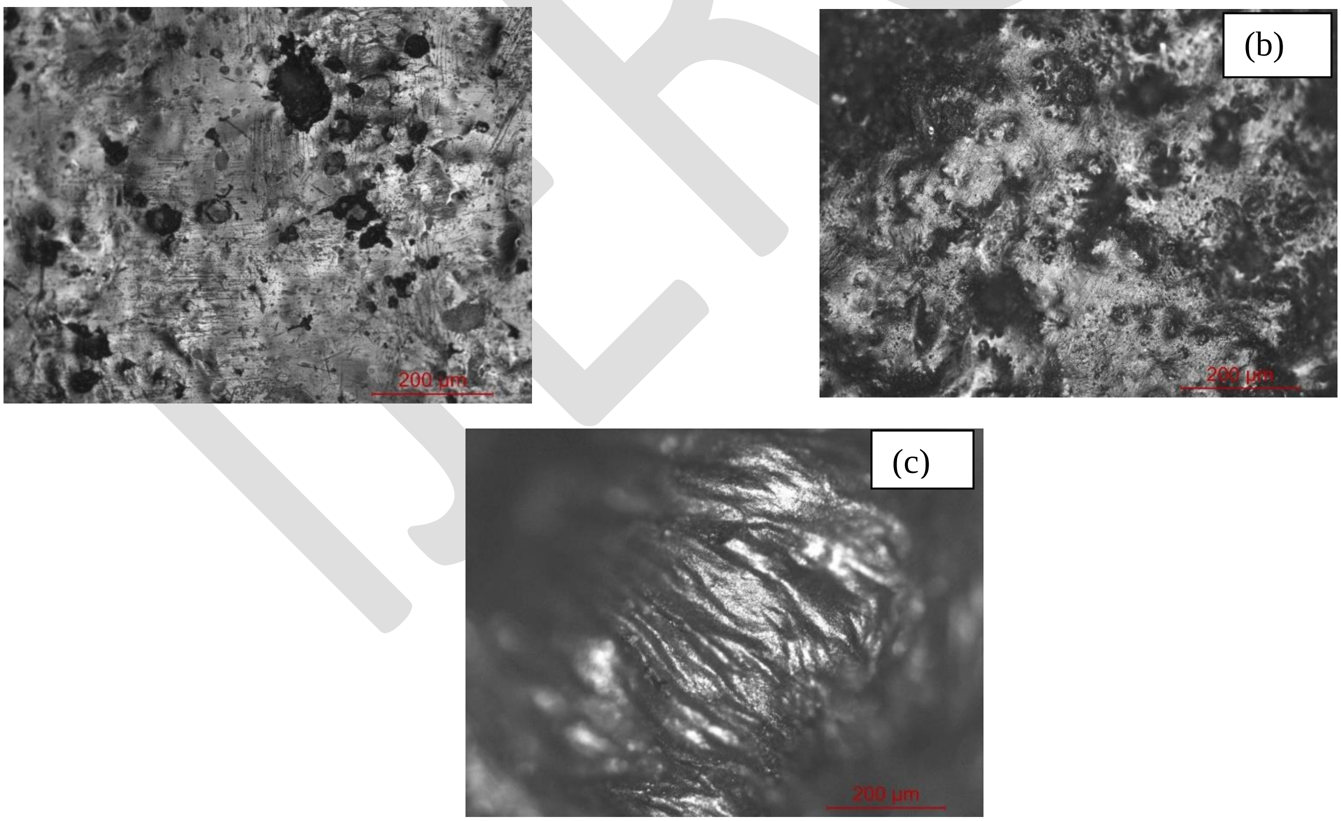

Fig. 1: Microstructure of ceramic based brick composite at 100 X magnification, sintered at (a) 1000^{0}C, (b) 1100^{0}C and (c) 1150^{0}C

Figure 1 shows the surface morphology at 100X magnification for the sample sintered at 1000^{0}C, 1100^{0}C and 1150^{0}C for two hours.

3.2 SEM Analysis

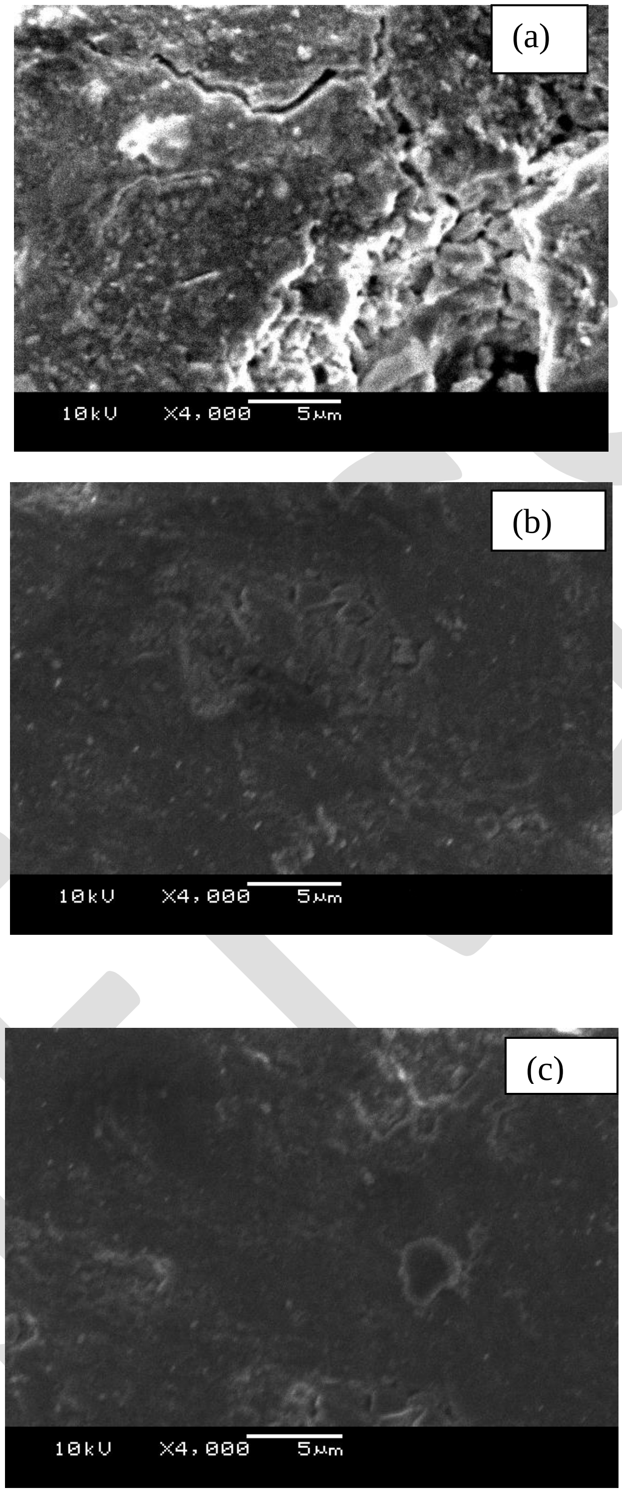

Fig. 2: SEM image of ceramic based brick composites sintered at (a) 1000^0C, (b) 1100^0C and (c) 1150^0C

SEM image was taken for studding the surface morphology of developed material comparatively high magnification than optical microscopy. Figure 2 shows that the tendency of pore formation decreases with increment of sintering temperature.

3.3 Shrinkage Measurement

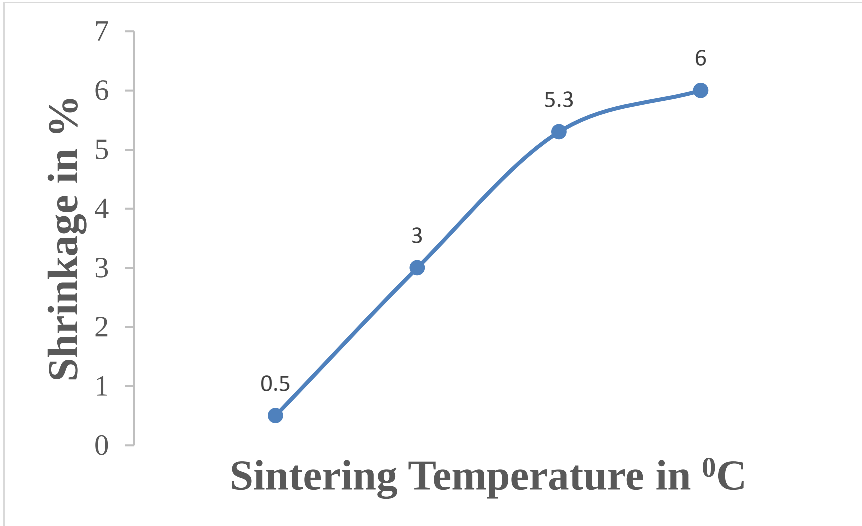

Fig. 3: Variation of Shrinkage with sintering temperature

From fig. 3, it is seen that maximum shrinkage value was obtained for the sample sintered at temperature 1150^{0}C, and the shrinkage value is almost equal to the sample sintered at temperature 1100^{0}C. From the measurement, it is observed that the shrinkage value increases gradually with the increment of sintering temperature.

3.4 Density Measurement

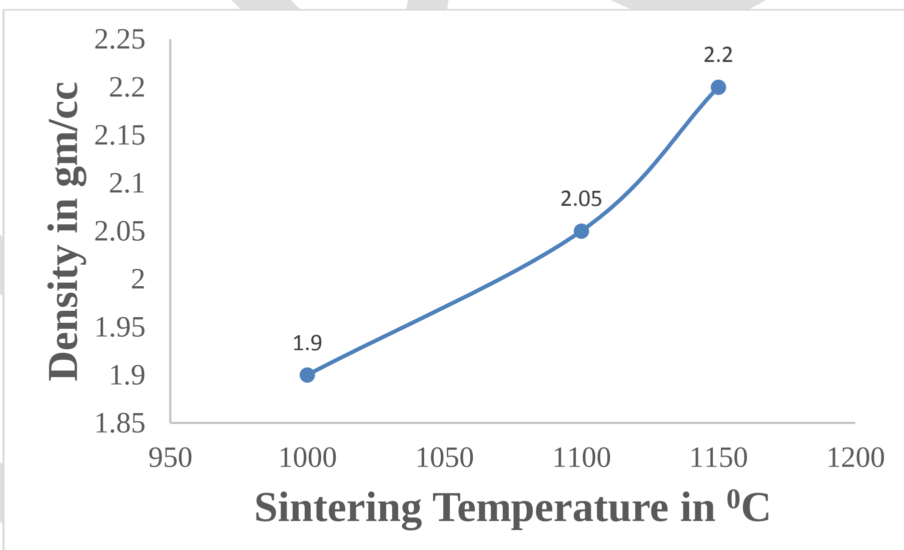

Fig. 4: Density of ceramic based brick composites sintered at different temperatures

Figure 4 shows that sintered density of brick based composite increases with the increment of the sintering temperature and the sample sintered at 1150^{0}C shows maximum density.

3.5 Apparent Porosity

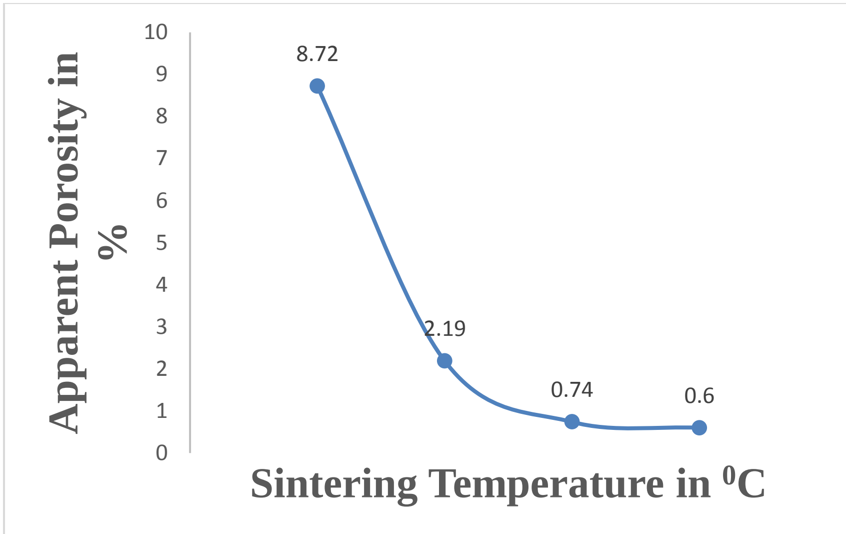

Fig. 5: Apparent Porosity for ceramic based brick composites sintered at different temperatures

From the data obtained, it is seen that apparent porosity value decreases with the increasing of sintering temperature as shown in fig. 5. Sintering was carried on number of steps with crystalline silica and the sample which was sintered at temperature 900^{0}C, gives 8.72 % porosity while the sample sintered at temperature 1150^{0}C gives minimum porosity. From fig. 5, it is also seen that the sample sintered at temperature 1150^{0}C gives almost same apparent porosity as that of the sample sintered at temperature 1100^{0}C.

3.6 Hardness

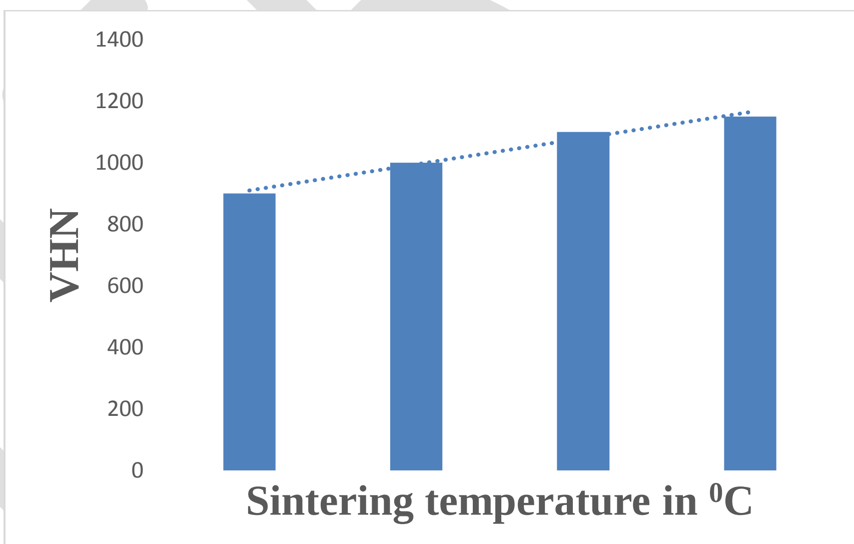

Fig. 6: Micro-Hardness Graph for ceramic based brick composites sintered at different temperatures

From the hardness data obtained, it is seen that hardness value increases gradually with the increment of sintering temperature as shown in fig. 6.

CONCLUSION

The significant conclusions of the study ceramic based brick composites are as follows:

- Ceramic based brick composites were developed successfully from natural mud by adopting powder metallurgy technique.

- From all the experimental data obtained, it is found that by analyzing different parameters like--shrinkage, density, apparent porosity and hardness---- optimum sintering temperature for this composite is obtained which is 1150^0C.
- For ceramic based brick composites, micro – hardness value also increases with the increment of sintering temperature.
- It is noted that percentage of shrinkage value were increased with the increment of sintering temperature.
- From all physical and mechanical behavior of the developed composites, it is expected that there must be formation of strong bonding with temperature (manufacturing issue). Actually, by physical observing, this was happened due to formulation of protective barrier surrounded the sample, sintered at 1100^0C or above. Hence, Properties are not improved so much beyond this temperature, ie 1100^0C. Optimum property of the developed material was observed in that sintering temperature.

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