Journal of Mines, Metals and Fuels, *71(11): 2185-2190; 2023. DOI: 10.18311/jmmf/2023/36039*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Development and Study on Brick Composites

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Abstract

The role of various insulators is increasing day by day for applying High Voltage (HV) and/or allied fields. Authors are taken an attempt towards development of brick composites followed by powder metallurgy technique. Natural mud has been selected as raw material for finished products. Bricks having high hardness have been developed through sintering at various temperatures. Finished brick based composites are considered for surface morphology analysis. Various physical and mechanical properties are evaluated and reported. Finally, optimization has done based on evaluated physical and mechanical properties of brick composites.

Keywords: *Brick Composite, Ceramic Matrix, Density, Hardness, Porosity, Powder Metallurgy, Surface Morphology*

1.0 Introduction

Composites are the reliable source and have been used from ancients to meet certain amount of demands in different fields of electrical/electronics, mechanical and civil engineering. Ceramic matrix are good insulator by born and can tolerate certain amount of compression during its performance[1-8]. In addition, chemical inertness and ability to tolerate high temperature makes it suitable for utilizing in harsh environments[4-7].

Brick composites are the oldest member of ceramic matrix family. Brick composites are the backbone of masonry construction (structural applications). Not only is the sector of civil engineering, ceramics well demanded in electrical, electronic and mechanical applications for providing insulation or designing current limiting devices. China clay is a known name and popularly used as insulators in electrical/electronic industries and designing insulators for HV transmission for its ability to tolerate high strength and stiffness with reduced density[3-14].

Brick composite are preferred when reduction of weight is key parameter[1-4] without compromising its properties significantly. One can develop light weight materials with accurate dimensions and less investment by adopting powder metallurgy technique[5-14].

This research mainly focuses on development of brick composites at different sintering temperatures and finally found out the optimize sample based on various studies.

2.0 Experimental Procedure

2.1 Development of Brick Composite

Mud is one and only material used for developing brick composite. Here, mud was collected from river side of Ganga in West Bengal and considered as main raw material for this study. After drying and cleaning, it was

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considered for pre sintering at 450^{0}C for one and half hour at open atmosphere. It was blended and mixed into ball mill for half an hour until production of fine powder about ~400 µm and poured into a steel mold for shaping by applying 250 MPa pressure with 4 ton capacity hydraulic press machine. The powder follows the shape as the mold used. These green samples were sintered into a muffle furnace, made by "Nascor Technologies Private Limited West Bengal, temperature ranging from 900^{0}C to 1150^{0}C for two and half hours with heating rate 5^{0}C/min". After heating, samples were cooled into the same furnace.

2.2 Testing and Characterization

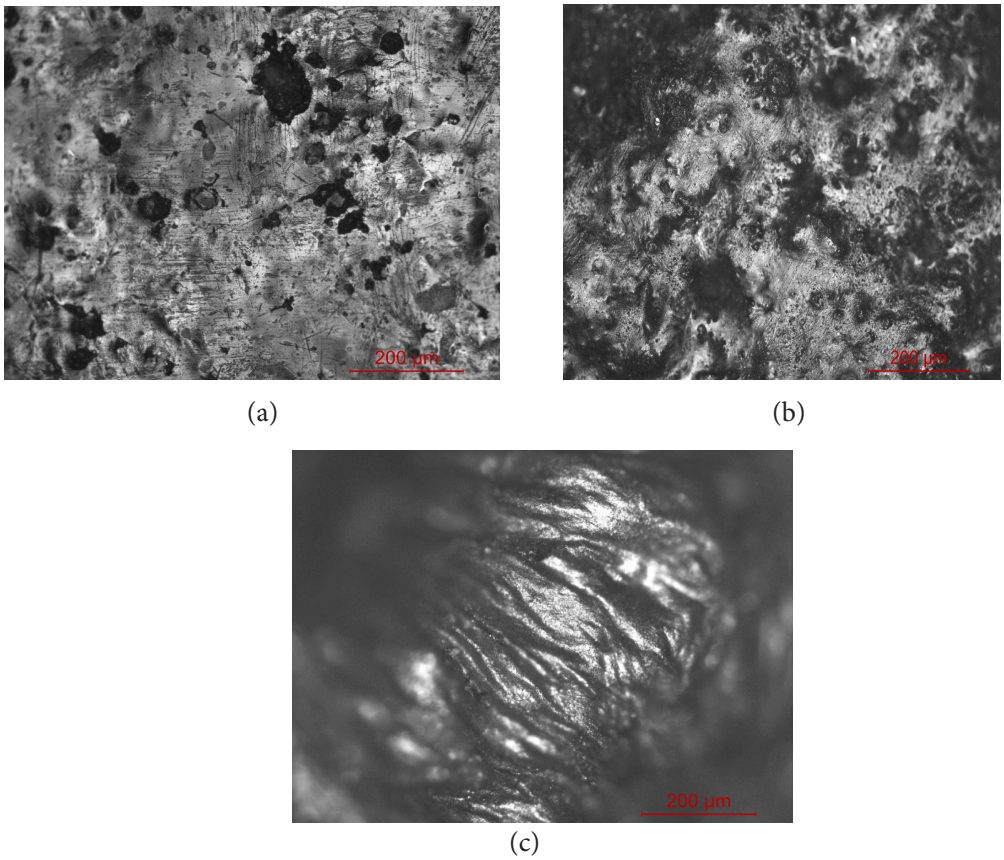
Finished brick composites were considered for morphological analysis using Optical Microscopy (OM) and Scanning Electron Microscopy (SEM). Optical microscopy based images were taken with "LEICA Optical Microscopy model no DM-2700M Image Analyzer at 20X magnification." SEM images were taken with "JEOL MAKE SEM model JSM 6360, operated by PCSEM software."

Micro hardness survey was carried out using "Vickers diamond pyramid indenter with 150 gf load and 15 sec dwell time." Hardness was measured in different positions of sample using "Leco Micro Hardness tester (Model LM248SAT)" and finally considered the average hardness for precise measurement.

3.0 Results and Discussion

3.1 Microstructure

Figure 1, show the images for the surfaces of brick composites sintered at 1000^{0}C, 1100^{0}C and 1150^{0}C temperatures respectively. The sample developed at 1000^{0}C has multiple numbers of pores distributed randomly throughout the surface of brick composite. Tendency of forming pores is reduced considerably with sintering temperature. The sample sintered at 1100^{0}C and 1150^{0}C has fewer pores shown in Figure 1(a) and 1(b).



(a) (b)

(c)

Figure 1. Optical micrograph of brick composite developed at (a) 1000^{0}C, (b) 1100^{0}C and (c) 1150^{0}C.

3.2 SEM Analysis

Figure 2, shows the structural image of brick composite developed at 1000^{0}C, 1100^{0}C and 1150^{0}C sintering temperatures. Trend of formation of pores is decreased with increasing the sintering temperature. Basically no pores have been observed for the samples developed at 1100^{0}C and 1150^{0}C shown in Figure 2(b) and 2(c).

3.3 Measurement of Density

Sintered density of brick composite is shown in Figure 3, and corresponding values are tabulated in Table 1. Density is increased with sintering temperature and hence maximum value of density is recorded for brick composite developed at 1150^{0}C. Noted that composite developed at 1100^{0}C shows nearly same density with the composite developed at 1150^{0}C with same environmental conditions.

3.4 Measurement of Apparent Porosity

Apparent Porosity is decreased with sintering temperature. Variation of porosity with temperature is shown in Figure 4 and corresponding values are recorded in Table 1. Sample sintered at 900^{0}C has large amount of porosity whereas porosity value is low and it saturates for the composites developed at 1100^{0}C and 1150^{0}C.

3.5 Measurement of Shrinkage

Shrinkage was measured for each developed composite and tabulated in Table 1. Shrinkage has increased with sintering temperature implies formation of more bonding with temperature.

3.6 Measurement of Hardness

The hardness is increased gradually with sintering temperature as reported in Table 1. Maximum value of

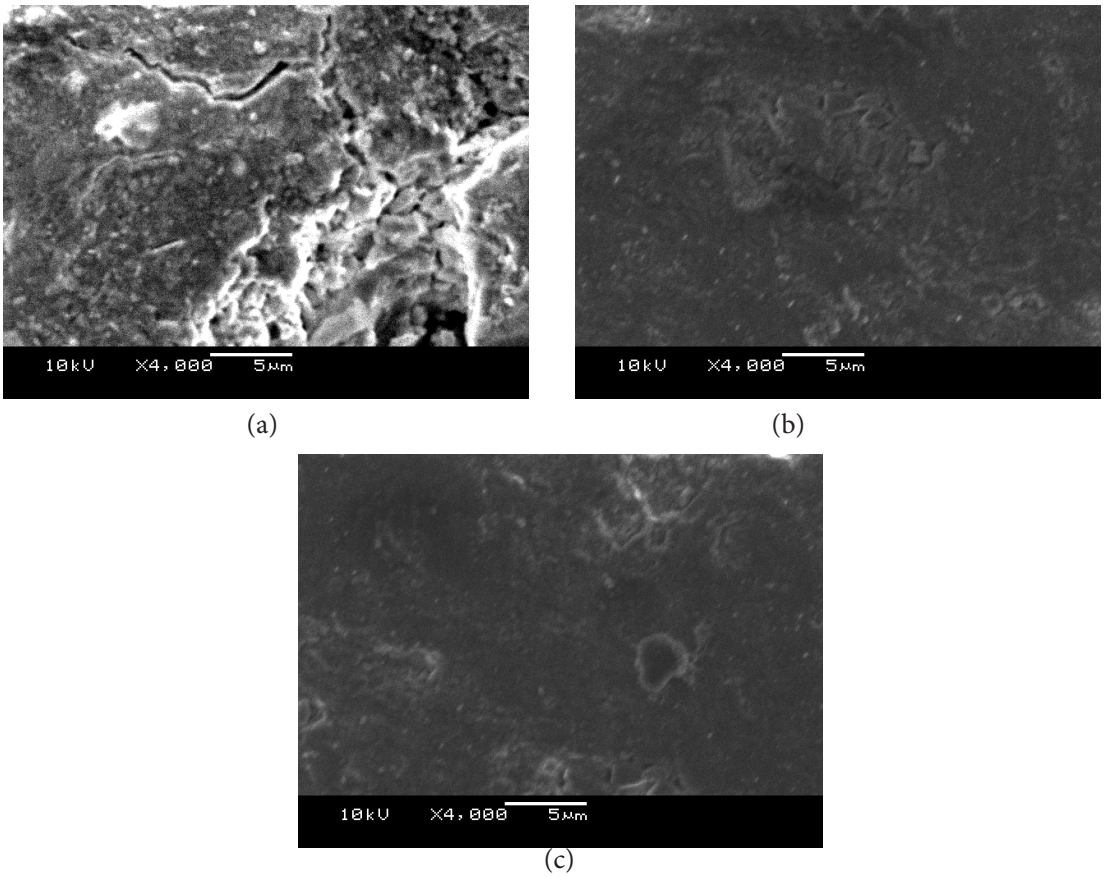


Figure 1. Scanning electron micrograph of brick composite developed at (a) 1000^{0}C, (b) 1100^{0}C and (c) 1150^{0}C.

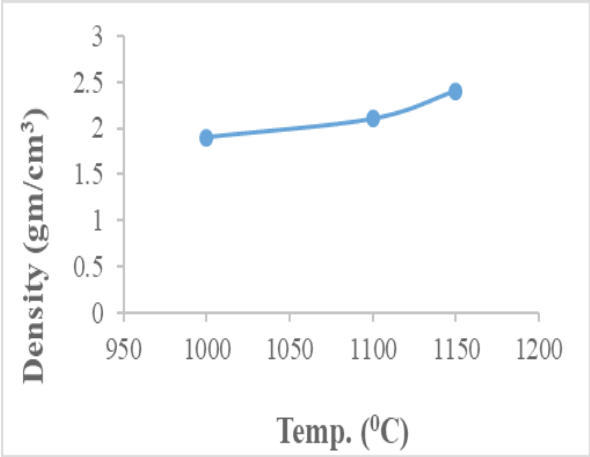


Figure 3. Variation of density with temperature.

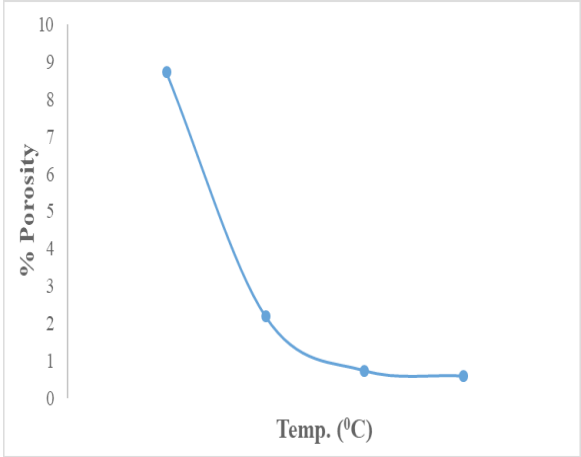


Figure 4. Variation of apparent porosity with temperature.

Table 1. Various Physical Properties of Brick Composite

Sample	Sintered density (gm/cm³)	Apparent porosity in percentage	Percentage of shrinkage
Brick composite developed at 900⁰C	0.9	8.73	0.5
Brick composite developed at 1000⁰C	1.9	2.18	3.1
Brick composite developed at 1100⁰C	2.1	0.73	5.3
Brick composite developed at 1150⁰C	2.4	0.50	6.0

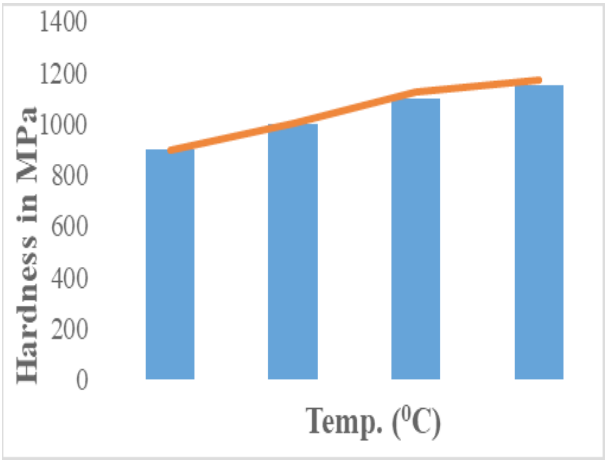
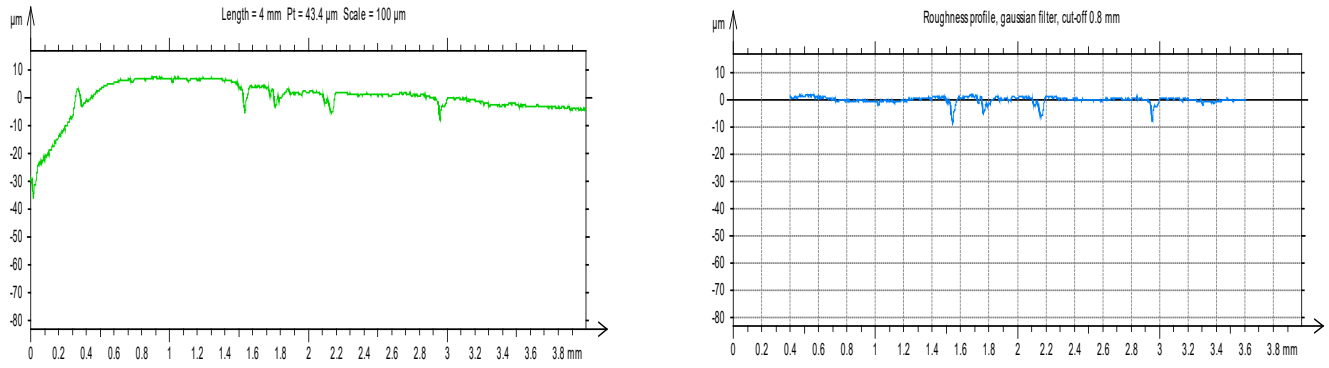


Figure 5. Variation of VHN with temperature.

hardness is found out for the sample developed at 1150⁰C with is slight greater compared to the sample developed at 1100⁰C as shown in Figure 5.

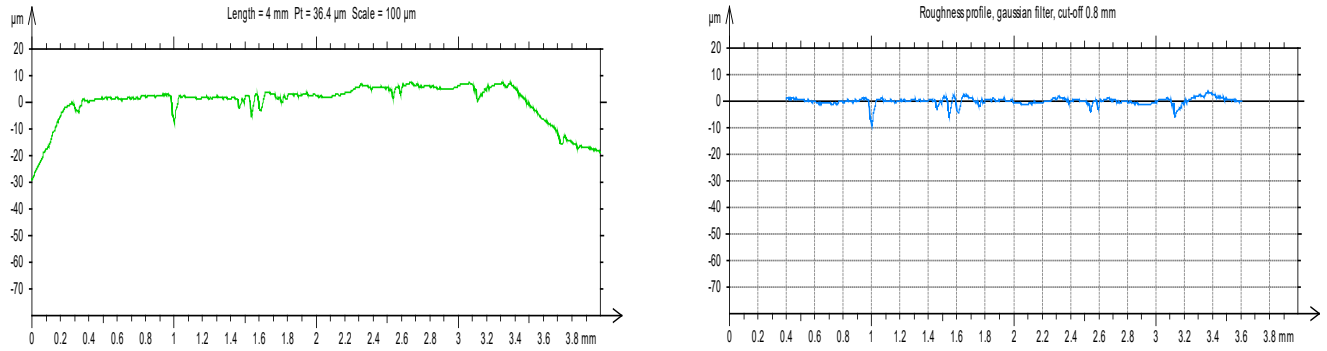
3.7 Surface Roughness Measurement

Surface roughness has measured for the brick composites developed at 1100⁰C and 1150⁰C respectively, maintaining ISO 5436-2 standards utilizing surface roughness tester, model "Taylor Hobson instruments/Sutronic 3+." Roughness of brick composites are shown in Figure 6 and 7; corresponding surface roughness are noted in Table 2. Roughness of the surfaces are slightly changed with temperature.



(a) (b)

Figure 6. Surface roughness for bick composite developed at 11000C with (a) roughness profile, (b) used filtration



(a) (b)

Figure 7. Surface roughness for bick composite developed at 11500C with (a) roughness profile, (b) used filtration.

Table 2. Surface Roughess of Brick Composite

Sample	Average roughness	RMS roughness
Brick composite developed at 1100^{0}C	0.815 µm	0.784 µm
Brick composite developed at 1150^{0}C	1.23 µm	1.27 µm

4.0 Conclusion

Brick composites are developed successfully from natural mud through powder metallurgy technique. Sample developed at 900^{0}C has large pores and mechanically not suitable for further evaluations. Sintered density is increased with temperature along with consequent reduction of pores which implies formation of more bonding into the ceramic matrixes. Improvement of hardness is also observed for this reason. It is also mentioned that not so much improvement of properties are found out beyond the sintering temperature 1100^{0}C and the corresponding sample with this sintering temperature is considered as optimized sample for this study. Brick composite developed at 1150^{0}C has moderately smooth surface according to measured standards. Basically a protective layer has formed with sintering temperature 1150^{0}C which covers the surfaces of the brick composite.

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