Preparation And Characterization Of Ceramic Sponge For Water Filter

M. S. Sharmiwati, R. M. Mizan, A. B. Noorhelinahani

Abstract: This paper studies the effect of various polymeric sponge and solid loadings on the properties of ceramic sponge. The study was based on four different polymeric sponge pore size ppi (pore per inch) with pore sizes ranging from 30 until 100 ppi. The polymeric sponge was impregnated in ceramic slurry with solid loading ranging from 20 to 60 wt.%. Effects of polymeric sponge and solid loading quantity were evaluated based on porosity, density and mechanical properties of resulted ceramic sponge. The ideal temperature for sintering is 1250℃ where the highest density and porosity are 0.83499 g/m^3 and 69.965%. The maximum compressive strength that produces from ceramic sponge is 0.276324 MPa at 60 wt% solid loading.

Index Terms: ceramic foam, ceramic replication method, ceramic sponge method

1 Introduction

THE water filter removes impurities from water by means of a fine physical barrier, a chemical process or a biological process. Filters cleanse water to different extents for purposes like irrigation, drinking water, aquariums, and swimming pools. Some people use a home water treatment unit to improve the taste of their tap water and treat their water because of health concerns. Drinking water can reasonably be expected to contain at least small amounts of some contaminants as long as it is in safe level to drink. Nowadays, the typical water filter in the market used cylindrical hollow filter cartridge to have a combination of filter pads consist five layers; activated carbon, silica sand, zeolite, bioball and mineral sand. So in this work, the typical water filter was replaced with ceramic sponge via polymeric sponge method. This ceramic sponge is designed to remove suspended matter from muddy water using sedimentation and filtration in order to produce clear water.

1.1 Polymeric Sponge Method

Ceramic sponge is a class of highly porous materials that is used for a wide range of technological applications. In this study, ceramic sponge was produced by polymeric sponge method. This process, commercial polymeric foam was used as a template and dipped in ceramic slurry followed by drying and sintering to yield a replica of the original polymeric foam. Ceramic sponge also known as open-cell ceramic, ceramic foam and porous ceramic. Basically, previous literatures [1-3] used polymeric sponge methods because of its properties are high temperature stability, high resistance of chemical and high hardness.

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2 Literature Review

Ceramic foam a porous, brittle material with closed, fully

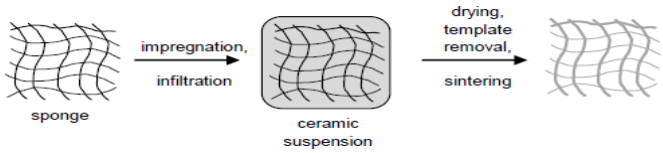

Fig. 1: Schematic drawing illustration of polymeric sponge method

opened partially interconnected porosity. Other than that, ceramic foam used wide range of ceramic material such as oxide and non oxide. Oxide ceramic is developed specifically for reinforcement of metal and ceramic matrix composites which good strength, microstructure stability and long-term creep resistance at high temperature. For non oxide ceramic, it contains carbides, nitrides, silicides and others. Their applications range from super hard abrasives and cutting tools. Ceramic foam can be used as filter for molten metal and hot gases. The potential application of ceramic foam such as catalyst carrier, burned head or fuel-cell electrodes which high contact surface between gases and solid. The ceramic have wide range application such as filtration, high specific strength material and biomechanical perform. Engineered foams have cellular structures which are categorized as either open cell or closed cell foams. Ceramic foam consists of an assembly of irregularly shaped prismatic or polyhedral cells connected to each other with solid edge (opened cell) or faces (closed cell). Engineered foams have been manufactured from polymers, metals, glasses and ceramics. Ceramic foams are a special class of porous materials comprised of large voids (cells). Closed cell ceramic foams are commonly used for thermal insulation and fire protection materials. Meanwhile, open cell ceramic foams are used for metal filtration, hot gas filtration and diesel engine exhaust. Ceramic foam has been a procedure in a variety of material with various cell sizes, densities and interconnectivity. Foams are usually produced with the density between 10 and 40% of the theoretical and the pore sizes between 100 μm and 1 mm. Porous ceramics are produced in many ways, such as the infiltration of reticulated polyurethane which performs with aqueous particulate ceramic slurries. Another method is the use of insoluble organic fugitive materials in ceramic suspensions, which the burn out leaving the porosity. This method requires a large amount of fugitive materials in order to produce highly porous bodies. The mostly used fugitive materials are

starches, carbon black and sawdust. Besides that, a fused deposition method has been used to produce porous mullite bodies.

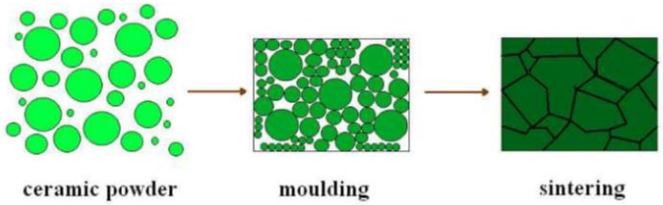

Fig. 2: Schematic figure during fabrication of ceramic products significant structural changes are observed

From previous research, the procedure used in the synthesis of ceramic foam replication method where polymer sponge that used are different size such as 20 ppi, 50 ppi, 80 ppi and 100 ppi and cut the sponge into pieces of about 30 – 60 mm. The preparation of ceramic slip, the ceramic powder should be mixed with the water according the accurate ratio. The coating was performed by immersing the sponge pieces in the slurry, squeezing them, and passing them through rollers preset at 80% impression to expel the excess slip. The solid content (based on the mixtures) was varied to produce ceramic slurries with densities of 1.1845, 1.2798, 1.3567, 1.54332, 1.6543 and 1.7234 g/cm3, in a distilled water medium. The green body was dried 24 hours at room temperature and heated at 1 at 1℃/min to 700℃, and then a further at 10℃/min to the final temperature (1800℃), which was held for 500 min to achieve sintering of the ceramic. The properties of the ceramic foam produced were characterized according to ASTMC 271-94 and the porosity was characterized using the Archimedes method. The density of ceramic slurry will increase when porosity of slurry decrease. The quality of ceramic foam is strongly influenced by the density of the slurry, as this reflects the degree of porosity.

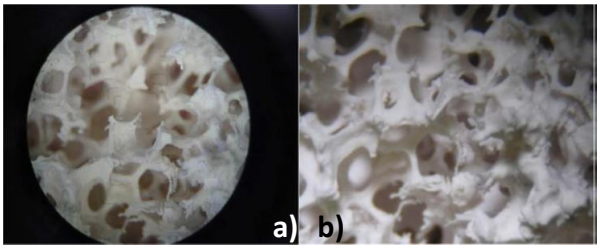

Fig. 3: Image of ceramic sponge; (a) Ceramic synthesized by normal procedure and (b) Ceramic sponge under high thermal treatment.

3 METHODOLOGY

This chapter provides information about polymeric sponge method and the equipment to use in the experiment.

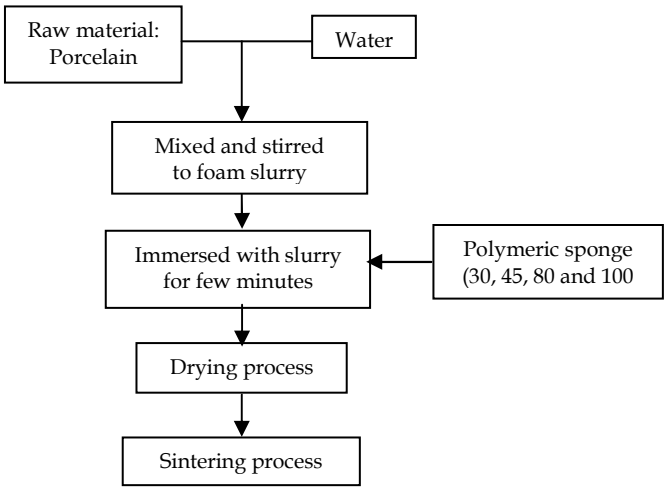

Fig. 4: Methodology method to prepare the ceramic sponge.

3.1 Characterization of ceramic sponge

The ceramic sponge is prepared was analyzed shown in Table 1 on the effect of its physical properties.

TABLE 1
METHODS AND PROPERTIES

Method	Properties
Linear shrinkage measurement	Determine measurement change
Archimedes method	Determine density and porosity
Universal tensile machine	Determine the compressive strength analysis
Microscope	To observe pore size and microstructure of ceramic sponge

4 RESULT AND DISCUSSION

This chapter discusses about the relationship between linear shrinkage, density, porosity and strength of sintered products with different pore size of ceramic sponge.

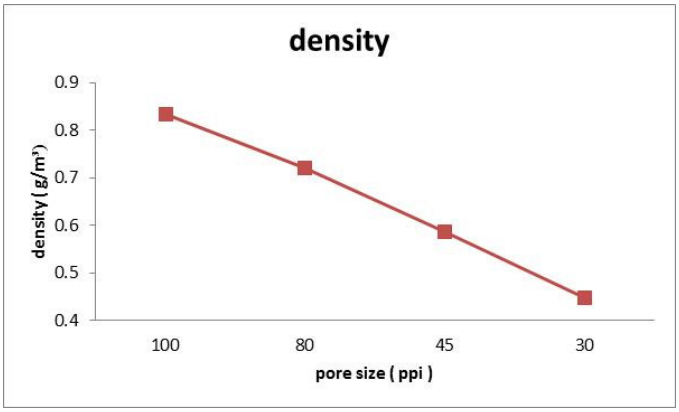

Fig. 5: Density (g/m³) changes with pore size (ppi)

The density of ceramic sponge decreases when the pore size of ceramic sponge decreases. These are due to coat the polymeric sponge and complete the replication of sponge from the low percentages of ceramic slurry. Basically, the low viscosity ceramic slurry easily the slurry to enter the foam structure, while higher solid loading will affect the impregnation process especially ability to shape the structure.

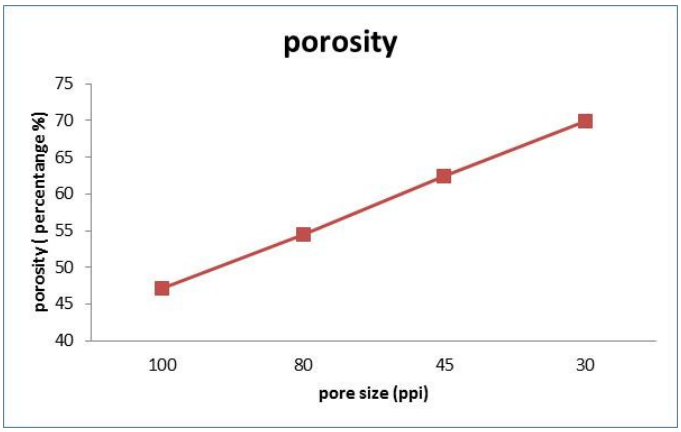

Fig. 6: Porosity (%) changes with pore size (ppi)

As the density decrease, the amount of porosity was expected to increase. It is clearly seen the method with density, where the solid loading is lower the porosity of ceramic sponges is not much can depend on the polymeric sponge density.

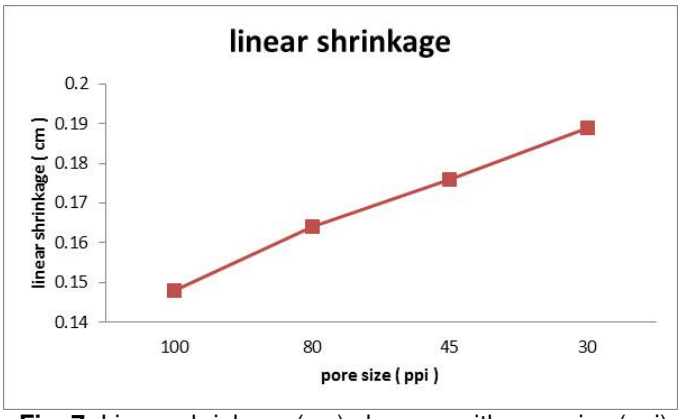

Fig. 7: Linear shrinkage (cm) changes with pore size (ppi)

The measurement of ceramic sponge will decrease after through the sintering process. During the sintering process, the holes of polymeric sponge became smaller and shrink the foam. These phenomena happen because the any particles of polymeric sponge removed. The linear shrinkage also effect with percentages of solid loading and sintering temperature. The pore size of ceramic sponge depends on pore size of polymeric sponge. Commonly for sponge size 30 ppi (pores per inch) the void is bigger. The maximum size for pore size is 1.601 mm^2 and can provide high permeability to ceramic sponge.

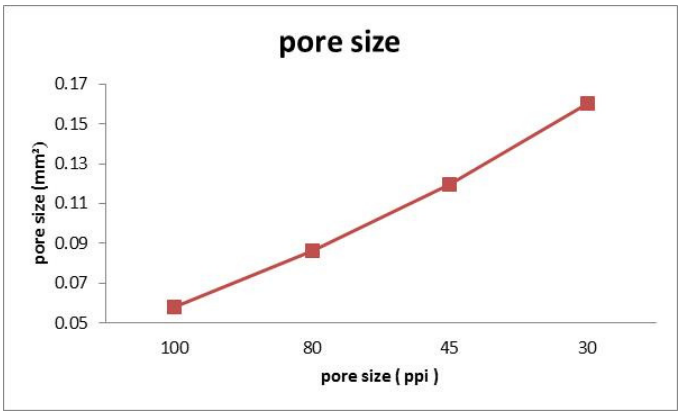

Fig. 8: Pore size (mm^2) changes with pore size (ppi)

The compressive strength of ceramic sponge increase due of the viscosity slurry. The percentages solid loading for 30 (ppi) pores per inch is 55 wt % and it became a maximum compressive strength at 0.276324 MPa. The compressive strength related to percentages of solid loading.

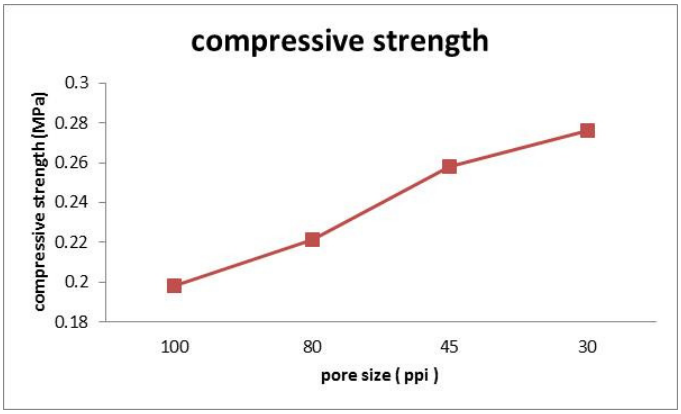

Fig. 9: Compressive strength changes (MPa) with pore size (ppi)

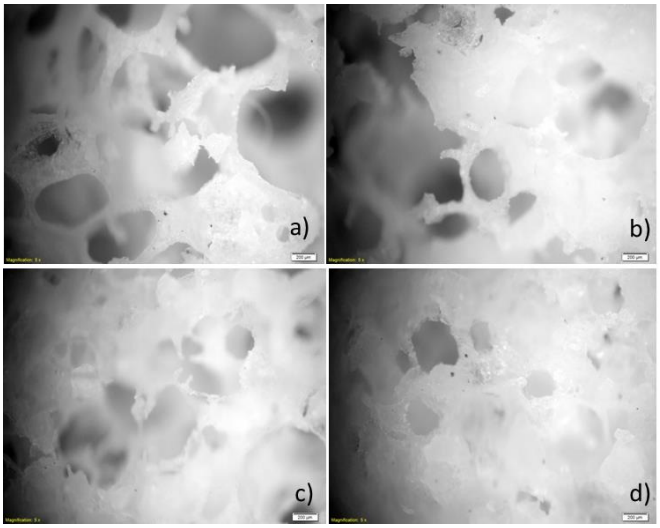

Fig. 10: The microstructures of ceramic sponge a) 30 ppi, b) 45 ppi, c) 80 ppi and d) 100 ppi

To demonstrate the potential of ceramic sponge and its suitability for the application in water filter, the typical cartridge of water filter in the market was replaced with the ceramic sponge, layer by layer as shown in Fig. 11.

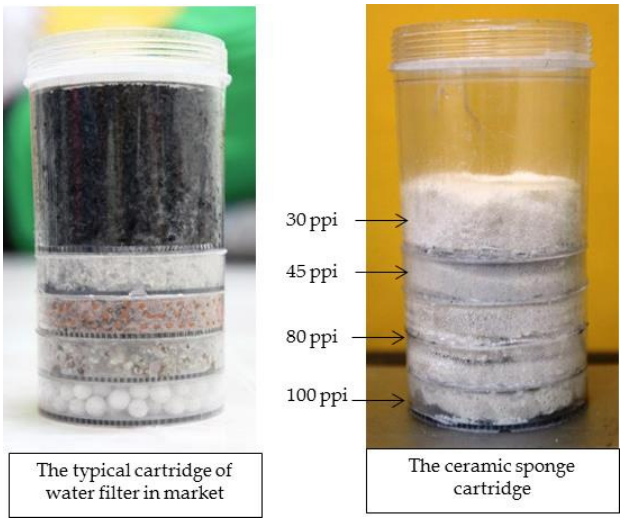

Fig. 11: The typical cartridge of water filter and the ceramic sponge cartridge

The muddy water was filtered using the ceramic sponge cartridges by replace each layer of cartridge by using ceramic sponge with different size of pores to remove suspended matter from muddy water. As a result, clear water is produced as shown in Fig. 12. However, it is not safe to be consumed yet as it is not been disinfected or chemically treated to remove bacteria and other micro-organisms.

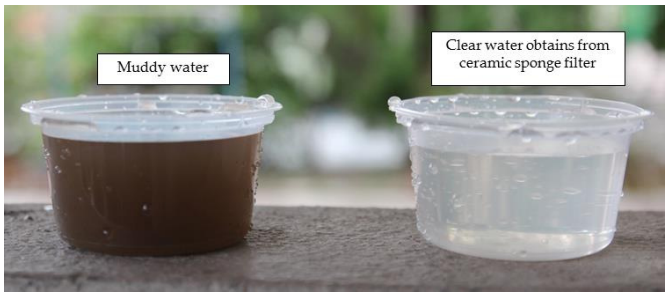

Fig. 12: The clear water is produced.

5 Conclusion

The present work demonstrates the possibilities of ceramic sponge as the filter to get the clean or clear water via ceramic sponge method using porcelain as raw material. The characterization requires of this work was successful to get an optimum ceramic sponge. From this experiment, the application of the ceramic sponge method, the ceramic sponge can withstand the temperature until 1250℃ as optimum temperature. Based from the result, density of solid loading will affect the mechanical properties of ceramic sponge. The ceramic sponge cartridge is designed to remove suspended matter from muddy water using sedimentation and filtration via ceramic sponge in order to produce clear water.

Acknowledgment

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