Value Addition of Nagar Parker Kaolin as Porous Ceramic Bodies for Metallurgical Industry

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Naveed Ali*, Suhail A. Soomro*, Ahsan Ali*, Sanwal Hussain*, Muhammad Shoaib Qureshi*

Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan

Abstract: Kaolin is one of the most significant and valued products which is developed under hot weathering rocks and slightly wet climate tropical rain forest is example of that kind of climate. The most important mineral in kaolin are kaolinite and halloysite which has the composition $Al_2Si_2O_5(OH)_4$ while halloysite has the similar composition but excess molecule of water $Al_2Si_2O_5(OH)_4 \bullet 2H_2O$. Due to increase in demand of filtration in molten metal industry, the demand of filters has been increased. Due to tremendous increase, many industries pay heavy taxes and money to buy equipment's and material from other countries that had additional finical burden on country economy. Preparation of indigenous porous body will help to support the economy of Pakistan. This study has been focused on preparation and characterization of porous indigenous material from Nagarparker Kaolin. Kaolin samples were collected from Nagarparker mining sites. Chemical analysis were carried out of indigenous kaolin, porous ceramic bodies; using kaolin, saw-dust, charcoal, millet and poppy seeds (khas khas) as pore former. Batch formulation of kaolin samples were formed into green bodies and fired at 1150°C at controlled rate. The samples with Millet exhibit surface cracks and low thermal shock after firing. A control batch process using Saw-dust, charcoal and poppy seeds (khas khas) showed uniform surface characteristics with pores, high strength, thermal stability and no surface cracks thereby confirming the viability of process module. Apparent porosity as high as 20%-41% has been calculated. It was concluded that the porous ceramic body is environment friendly and advantage of the material availability indigenously.

Keywords: *Filtration, Kaolin, Pore formers, Porous body, molten metal, sustainability, environmental friendly*.

1. Introduction

Porous bulk ceramics are broadly utilized for mechanical application such as fluid or gas filters, catalysis underpins, gas wholesalers, performs for metal-impregnated ceramic–metal composites, plus implantable bone platforms. Permeable ceramic bodies have both higher fluid penetrability and higher mechanical quality.[1] Indeed predominant Osteen conductivity and higher mechanical quality would be anticipated for calcium phosphates due to a tall degree of uniform pore measure and connect association. Porous ceramics are broadly utilized in different shapes and compositions in filtration and division, dissemination, warm confinement, sound retention, chemical filling, bio ceramics, chemical sensors, etc. [2] The advancement of absorbent ceramic body appealing since absorbent ceramic objects extra stable at extreme situations they be able to construct to fulfil particular prerequisites owing to their exterior characteristics. An assortment of permeable medium counting steel, wood, wire screens, woven fiber glass textures, reinforced total, squeezed ceramic strainers and ceramic froths are accessible [3]. In any case, the tall temperature steadiness of permeable ceramic objects capacity adapt the hole size designed for particular operation had expanded request for permeable ceramic objects in mechanical uses. within metallurgical casting, earthenware base filters be utilized isolated strong particle as of liquid metals also strong particle be capture in filter (permeable ceramic body) permitting the fluid stage get ahead of non-metallic incorporations be negative natural physical property, outside finish casting items because consequence give metals extended scrap rate [4]. Within the range of separator, permeable ceramics gives a implies for vitality reserve funds or warm misfortune minimization, improved heat manage had ability oppose the destructive character of slag's in refining operation[5]. Permeable ceramic bodies are as a rule made from aluminosilicates and a few technologies are accessible for their generation the nature of raw materials be that as it may influences porosity (pore estimate), outside, chemical dormancy and warm stun resistance of permeable ceramic materials nagar parker is capable with large deposit of ceramic raw material such as pegmatite, mica, clay, feldspar, quartz and bauxite. Clay mineral deposit would have found in all the area of Nagar parker and are mostly high-grade clays contain kaolinite $Al_2Si_2O_5(OH)_4$. With rising demand for porous ceramic in industrial application, a number of technology had industrial intended for fabricate material while attempt manage pore characteristics as well as properties [6]. Investigational examination consequently aims build up earthenware bodies as of kaolin deposit situated at Nagar parker thar. Kaolin, a main soil material by means of slight plasticity, had sample from Nagar parker and process for create earthenware body by means of additives so as to be on fire out throughout firing of porous bodies (flammable

Corresponding author Email address: *engr.naveedlarik@gmail.com*

pore formers) reveal possibility produce permeable ceramic material as of clay deposit.

Kaolin stores found in Nagar parker lie parallel to Run of Kutch range, the propel ponder inspects the physico-chemical attributes of the crude and washed Nagar Parker kaolin stores.[7].

Nagar Parker kaolin mineralogy and genesis and told about the quality of Nagar Parker kaolin increases towards the top and declines descending recommending that extreme compound weathering is in charge of the cause of these stores.[8].

Swat kaolin stores have categorized, assessed to their potential like industrial raw materials. Their elements size, color measurements, consistency, plastic limit, fluid breaking points, drying, firing shrinkage, water absorption, oil absorption, pH, water dissolvable issue, dampness and huge thickness has been checked.[9]

This study concerns the preparing and characterization of permeable ceramics based on low cost mineral raw materials for environmental applications.[10]

In our research work porous ceramic bodies are made successfully by using charcoal, sawdust, poppy seeds, millet and kaolin with varying ratios. The porous ceramic bodies are effective in metallurgical industry for filtration of molten metal.

2. Experimental Methods

2.1 Raw Material Beneficiation and powder Preparation

First of all the kaolin is washed, sieved and dried in the plaster of Paris. For washing purpose water is added into the sample of kaolin and stirred to get slurry which have specific gravity about 1.23, for sieving slurry is then passed through 350 µm for impurities removal. Then water is removed from viscous medium. Then introduce the material in an electric oven for further dried, up to 200 degree for 7 hr and dried out material will be feed interested in sledge hammer Mill, to shatter into small particles. The particle density and particle ranges for the properties of raw material will be determined by 4cablenetfilter, the sizes are 250, 180, 150 and 125 micro meters. For the purpose of reducing mesh dimension govern elements size sharing. For each batch we use 5kg kaolin for analysis and then sieves are mechanically agitated for duration of 60 minutes. After that process we measure particle size and characterized it. By using Litzen berger, we determine the mean particle density.

2.2 Chemical Analysis by XRF

Chemical analysis kaolin powder is gotten through a Spectro XLab 2000 X-Ray Fluorescence (XRF) spectrometer tests gotten from Nagar parker. 4 gm each test sieve throughout a 106 µm sifter were blended by 1 gm Licowax fine particles serve as a folio. Blend be at that point processed intended for 3 min in Retsch processing machine (demonstrate MM 301) and squeezed inside XRF pellet press. Powder tests be at that point stacked into the Spectro XLab2000 test holders for the XRF examination. The most composition of kaolin tests are oxides of Si and Al. The Si/Al proportion is found to be 1.43. The kaolin contains mineral pollutions of press, calcium, magnesium, etc.

2.3 Analysis by XRD and crystallinity index

XRD fine particles design are primarily utilized intended for assurance of the basic property plus the distinguishing proof of mineral in strong condition in mineral science. This work the earlier to the estimation, each test was arranged employing a standard strategy for powder test planning. kaolinite characterization will be done through Hinckley List (Hinckley 1963). In this work the utilizing a Philips PW1820 Modified Powder Diffractometer and CuKα radiation at 40 kV and 30 mA plus step gauge of 0.05° 2θ at a checking occasion of ten seconds. Estimations be conduct on subjectively organized fine particles courses of action. Diffraction plans be facilitated next to the ICSD's PDF database inspected utilizing the X'pert Highscore plan (panalytical, Netherlands). Quality (order–disorder) of the kaolinite tests be characterized utili`zing the Hinckley record (Hinckley, 1963). The Hinckley Record standards of kaolinites be measured because extent entirety of stature over establishment of the 110 and 111 peaks next to band covering peaks happening among 20 degree and 23 degree, 2θ and at that point compared to the complete stature of the 110peak over the establishment. The ordinary crystallite size of kaolinite tests be measured by the Scherrer broadening technique utilizing basal 002 reflection by means of beat point at (26.80, 2Ɵ) (Scherrer, 1918).

2.4 Formation of porous body

By using Equation (1) or determination of specific sizes like; (kaolin, pore formers) in batch samples.

$$\text{Weight \%} = \frac{\text{Weight of component}}{\text{Total weight}} \times 100 \quad (1)$$

Formulated samples of different sets of batch are made of Nagar Parker kaolin with pore formers (charcoal, millet, sawdust poppy seeds) had been blended with water and afterward worked to take out irregularities, caught air foams and to guarantee uniformity. Source, trade and several physical property pore formers used during research be listed in Table 2.1.

Table 2.1: Characteristics of the formulation components.

Formulation Components	Sources	Trade name	Physical properties
Charcoal	Wood	Charcoal	Low moisture content Light weight Less fire resistance
Millet	Millet plant	Millet	High level of heat tolerance
Sawdust	Wood shavings	Sawdust	Light weight Less fire resistance Low moisture content Higher water transmission rate
Poppy seeds	Poppy flower	Poppy seeds	Light weight Less fire resistance

The blend of pore formers and kaolin was at that point full into shape plus hand squeezed about twenty seconds. shape be totally occupied on top of every portions to similar equal for extent uniformity and guarantee that powders had very

much squeezed and minimized. Squeezed test then expelled as of the form and dry on room temperature (ca. 25°C) on sheets intended for duration of 4 days subsequent to that had been additionally dry at 105°C. In CSIR manufactured gas furnace, the dried bunch figured green bodies was let go to 1150°C and splashed for 2 hours. At 573 degree Celsius, heating rate of 4°C/min were decreased to 2°C/min to evade devastating and crash beginning propagation that could cause as of volume vary because of alteration down quartz to high quartz (Heaney et al., 1994, Rykart 1995).using saw dust, charcoal and poppy seeds were also prepared for the second batch formulations. The sawdust having low heat attributes has utilized as the source of perspective pore former. The procedure succession defined already had repetitive for this kind of set making also. The seeming absorbency (measure of holes inside the area of absorbent rock-solid) of the Saw dust created clay frames had figured utilizing Eq. (2): weightiness dehydrated absorbent sample (Wd), weightiness of dehydrated absorbent example absorbed water to empower holes loaded with water (Ws), weightiness of absorbed sample absorbed in water again Wsi.

$$\text{Apparent porosity} = \frac{W_s - W_d}{W_{si}} \quad (2)$$

2.5 Drop Test

It is very important to determine the mechanical damage quantity of material during the handling, transportation and storage. However one of the useful methods is the Drop tests that can be used in different engineering disciplines to simulate the behaviour of material under defined boundary condition. In the drop test, mechanical properties of the samples observed. Drop test has been done according to the standard procedure the maximum height for drop test is 5 feet from the ground we usually drop the sample and check the strength of the material whether its weak or have good strength.(Onder et al., 2015)

3. Results and discussion

3.1 Chemical composition of the kaolin sample by XRF

Chemical composition of kaolin test collected from Nagar parker decided by X-ray Fluorescence as shown in table 3.1. Most composition of kaolin tests be oxides of Si plus Al. The Si/Al proportion is originated to be 1.43. Normal Si/Al proportion is the sign of normal SiO_2 substance as confirmed by XRF. The kaolin contains mineral debasements of press, calcium, magnesium and antacids etc. Kaolin mineral is classified as either requested or disarranged with relative degree of crystallinity.

Table 3.1: Chemical composition of the kaolin sample.

Compounds	SiO_2	Al_2O_3	Fe_2O_3	Mgo	Cao	SO_3	Na_2O	K_2O	Cl	LOI	Total
Kaolin (%)	51.43	35.96	0.65	0.90	0.27	0.10	1.44	0.40	0.16	8.50	99.85

Composition of group detailing and the reasonableness of permeable ceramic material intended used to possible utilize during mechanical filtration plus liquid metal filtration be clarified via high volume of porosity plus exterior range in addition to physical, chemical plus warm properties ceramic material in Table 3.2. These properties in order are inherently connected with nature of crude materials (kaolin) the pore formers utilized. Molecule measure range of the tests after molecule estimate examination is appeared in Table 3.3. There's broad extending of element sizes within tests which be fundamental near pressing configuration (Kingery et al., 1976; Richerson, 2006).

Table 3.2: Composition of Batch Formulation of Different samples

Sample	Composition (%)					
	Nagar Parker Kaolin	Pore Formers				Water
		Sawdust	Charcoal	Millet	Poppy Seeds	
1a	74	6	_	_	_	20
1b	62	18	_	_	_	20
2a	74	_	6	_	_	20
2b	62	_	18	_	_	20
3a	74	_	_	6	_	20
3b	62	_	_	18	_	20
4a	74	_	_	_	6	20
4b	62	_	_	_	18	20

Table 3.3: Particle Size Distribution of Kaolin

Experiment	Sample Weight (g)	Size Range (µm)	Weight Retained	%Weight Retained
1	1500	+350µm	590	39.3
		+250µm	345	23
		+150µm	165	11
		-150µm	400	26.6
2	1500	+350µm	575	38.3
		+250µm	360	24
		+150µm	135	9
		-150µm	430	28.6
3	1500	+350µm	686	45.7
		+250µm	470	31.3
		+150µm	240	16
		-150µm	104	6.9
4	500	+350µm	350	70
		+250µm	50	10
		+150µm	30	6
		-150µm	70	14

3.2 XRD analysis and crystallinity index

In Fig. 3.1 appear the powder XRD designs of the beginning Nagar parker kaolinite among 20 degree and 40 degree 2θ. The limit plus strongly crest confirm so as to kaolinites well-crystallized. Howdy calculation, 0.8 for Nagar parker demonstrates that the Nagar parker kaolin is well crystallized. Howdy relate to physical property of kaolin, especially molecule estimate (Hinckley, 1963).

Experimentally watched that the Nagar parker is additional plastic and this perception is credited to the molecule sizes of the test utilized: Nagar parker kaolin is generally finer. This is often bolstered by crystallite estimate 368.7 Å calculated for Nagar parker separately utilizing Scherrer broadening strategy. In common, requested kaolin be extra coarse than clutter kaolinites which tend to be less coarse and contain a better outside zone along extra noteworthy versatility strength (Whittaker, 1939). Fig. 3.2, 3.3, 3.4, appears compacted pictures dried green body prepared firing. Green body quality be very important since a frail green body be probable to smash within course of sintering. After exposure to air phase, it be watch so as to tests by tall rate of pore formers (charcoal, millet, poppy seeds and saw dust) moreover split or else twisted (turn or else bowed out). This perception be ascribed nature of pore formers

utilized. After firing, millet, pore shaped tests had expansive surface splits, caught pore formers, tall porosity and rough cleavages inside broken tests, stain and mutilated measurement (Fig. 3.5). Uniqueness be credited nature of pore formers utilized. Millet plus saw dust the truth that response discharges more CO2 than response clarifies why objective problems within structure of permeable ceramic material through charcoal pore formers be negligible in association by means of millet plus sawdust.

$$(C_6H_{10}O_5)\ n(S) + 6O\ (g) \rightarrow 6CO_2 + 5H_2O$$

It was moreover watched that tests with no plasticizer their structure be totally crumbled while those by means of plasticizer have as it were little splits. a large amount of permeable ceramics moreover appeared discoloration since of the discharge expansive volume CO as combustible pore formers. Figure 3.6, 3.7 appears tests of a controlled clump handle with Saw dust, poppy seeds, Charcoal as pore formers. Controlled tests later than firing displayed homogeneous pore dispersion, warm solidness plus compactness with no signs exterior splits or else mutilations. This can be credited toward lower softening temperature of Saw tidy, poppy seeds the quicker softening rate plus non attendance of implosion. uniqueness of tests after firing be summarize Tables 3.4 for group definition. In expansion, the clear porosity of ceramic material improved with expanding sum Pore formers within tests. Clear porosity as 41% is calculate confirming potential of kaolin deposits in develop porous material used for engineering application.

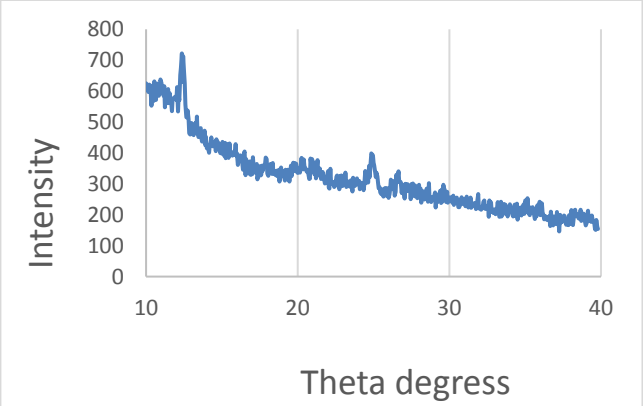

Fig. 3.1: XRD patterns of Nagar parker kaolin sample

Fig. 3.2: Ceramic bodies after drying (Saw dust and Charcoal)

Fig. 3.3: Ceramic bodies after drying (Millet)

Fig. 3.4: Ceramic bodies after drying (Poppy seeds)

Fig. 3.5: Porous ceramic bodies with (Millet) after firing

Fig. 3.6: Porous ceramic bodies with Saw dust and Charcoal after firing

Fig. 3.7: Porous ceramic bodies with Poppy seeds after firing

Table 3.4: Summary of results of fired bodies at 1150°C for batch formulation

Sample ID	Pore former	Fired samples characteristics upon visual inspection				
		Cracks	Trapped pore former	Glassy phase	Cleavage	Porosity
1a	Sawdust	Minor surface cracks	Not visible	Visible	Uneven	High
1b	Sawdust	Minor surface cracks	Not visible	Visible	Uneven	High
2a	Millet	Large Surface Cracks	Not visible	Visible	Uneven	High
2b	Millet	Large Surface Cracks	Not visible	Visible	Uneven	High
3a	Charcoal	Few Surface Cracks	Visible	Visible	Uneven	Low
3b	Charcoal	Few Surface Cracks	Visible	Visible	Uneven	Low
4a	Poppy Seed	No Surface Cracks	Not Visible	Not Visible	No	Very Low
4b	Poppy Seed	No Surface Cracks	Not Visible	Not Visible	No	Very Low

Fig. 3.8: Sawdust Porous ceramic body drop test

Fig. 3.9: Poppy seed porous ceramic body drop test

Fig. 3.10: Millet porous ceramic body drop test

Fig. 3.11: Charcoal porous ceramic bodies drop test

4. Conclusion

Probability of produce porous ceramic material intended of engineering application on or after kaolin deposit have effectively explore during investigation. HI calculation base on XRD investigation exposed Nagar parker kaolin be well crystallized plus prearranged Uniform compact green bodies produced happen to distorted plus structural defect be observed after firing at 1150 degree Celsius.

While combustible pore formers are used. A controlled process using Saw dust, Charcoal, poppy seeds since pore former resulted within standardized porous material, with no discoloration of medium confirming choice plus size of pore formers is significant within achieve porous ceramic material. Formulations contain 60% kaolin used manufacture of ceramics by means of porosities as high as 41% if right pore formers are used the current study appears Nagar parker kaolin have appropriate chemical composition plus be able to utilized as potential crude material intended for generation of ceramic bodies and distinctive other sorts of permeable bodies.

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About the authors

Naveed Ali got his Bachelor of Engineering in chemical from Mehran UET Jamshoro in 2016. He is enrolled as ME student in chemical department MUET Jamshoro. His research interests in coal, textile chemicals, kaolin, soil.

Dr. Suhail A. Soomro is Prof at Department of Chemical engineering, Mehran University of Engineering and Technology Jamshoro Sindh Pakistan. He has pursued his Bachelor of engineering from Mehran UET Jamshoro Sindh Pakistan in 1989. He completed his MSc in Advanced Chemical engineering from University of Bradford, Bradford U.K in 1992. He awarded his PhD Degree in Chemical engineering from Mehran UET Jamshoro Sindh Pakistan. Prof Suhail awarded Earned British Government Foreign & Commonwealth Office Scholarship 1992 for Doing M Sc in U.K. Earned Gold Medal for securing First Class First Position in Undergraduate Chemical Engineering. His research interest are Drilling fluid system, transmission of heavy oils, Waste Treatment & Management, Bioprocess Engineering & Bioremediation, Polymer Processing & characterization, Clean coal technology, Catalysis & catalyst synthesis and characterization.

Sanwal Hussain has received his Bachelor of Engineering degree in Petroleum and Natural Gas from Mehran University of Engineering and Technology Jamshoro Sindh Pakistan in 2015. Currently he is doing his Master of Engineering in Chemical from the same university. His research interest includes crude oil processing, natural gas processing, coal treatment and simulation.

Ahsan Ali completed his BE in Petroleum and natural gas from Mehran UET Khairpur campus in 2015. He is currently ME student at Mehran UET Jamshoro in Chemical department. His research interest includes crude oil refining, gas treatment, drilling fluids, kaolin.