Thermal insulation ceramic material by using coal combustion waste fly ash and waste glass with medicinal phytochemical repellent

Saroja Kumar Sahoo¹, Umakant Shrivastava¹ and Mohammad Ziyauddin Khan²

¹Research Scholar, Department of Physics, Dr. C. V. Raman University, Kota Bilaspur (C.G.) INDIA.
²Associate Professor, Department of Physics, Dr. C. V. Raman University, Kota Bilaspur (C.G.) INDIA.

Corresponding Author : E-mail: sarojkumar7690@gmail.com, mzkhan077@gmail.com

Abstract:
Toreduce in environmental load from pollution after primary using of various products (waste product), which is supporting to secondary utilization in preparation of thermal insulation materials using coal fly ash (40-60%), siliceous glass material (30-55%), some phytochemical medicinal additives and (2-8%) cellulose. We know that thermal energy is effective for nature. By the scientific ideas and methods ‘energy’ has been presenting a greatest continuous chain that frequently more economical to transforms the various form of ceramic materials. The capability of ceramic material such as “tiles”, cooking utensil, crucible etc chosen the better quality for treatment of heat insulation materials based on waste coal combustion of fly ash with waste glass and regular active form of adding medicinal organic adsorbates. In heretheorganic medicinal additives acts as reducing over materials from harmful diseases of microbial. It is favor for developing to high response to health care purposing. Over the materials, thermal activity depends on some factors such as chemical composition of substances. From this typical point, the Fly Ash and Waste Glass reduce the flow of heat. To testing after preparation of materials as water absorption in boiling and cold water acts with (4-5) days. By the thermal treatment, the material individually acts as (700-1000) °C. The mechanical durability with other physical and chemical properties for this material is supporting with environmental parameters.

Keywords:
Ceramic materials, Waste FA, Siliceous Materials, Cellulose, thermal insulation, medicinal Phytochemical.

1. Introduction
Ceramic materials are the abundance materials that used in various purposes. Its requisition by environ responding nature. For robust environment, we put the antibacterial ceramic materials, with thermally insulate, which is absolutely necessary in quality to dominate and annihilate the harmful microorganisms. In case of food, drink, water and other multifunctional concept of ceramic materials, the antibacterial material tends to obtaining the vast solutions to reduce the environmental harmful disease from microorganisms. In case of building materials of ceramic tiles, the antibacterial effect is the best concept for reducing harmful microbes over tiles surfaces. [1]. By sol-gel technique, the surface cleansing property of Titanium dioxide (TiO₂) in nanocomposites can be used[2]. By this application, it would be remove the harmful bacteria in daily useful material.
First of all thinking about, pathogenic microorganism attacking over several kinds of ceramic materials and damaging in ceramic materials (as the cause of diseases and pollution load in environment) [3].

1.1 About Pathogenic microorganism over damage ceramic materials:

The skin contact with the pathogenic microorganisms over daily use of ceramic materials in various area are considerable for increasing the rate of harmful diseases in environment. It is necessary to treat the materials in clinics, food industries and domestic spaces the vast utilization in antibacterial ceramic materials.

1.2 Phytochemicals:

Various types of phytochemical that reducing the harmful microorganism over ceramic materials. In India the medicinal plants as traditional medicine as date back to approx. 60,000 years ago [4]. In this paper, the medicinal plants could be used as well as harmful microorganism repellent.
1.3 Waste materials

The defective consumption material is known as waste materials. The production of waste materials has grown highly in amount with a lot of problem faces by environment. The higher harmful chemical and radiations corrupt our biodiversity. Now a days, the seriousness for attend to control the matter of waste material management is a global issue that remarkable for each and every humankind in our world. The heavy metal damage to the organ part of human that mixing with water from any chemical industries. The issues are avoiding by utilize the waste material to various purposes that includes designing & producing from waste materials to make up the good and healthy environment.
The paper is finding a solution for dealing with waste materials such as coal combust FA and WG. A large amount of fly ash produced from the raw material as coal in thermal Power plant using electrostatic precipitators (ESP) device that filter the fine particles. Both fly ash (FA)&waste glass (WG)are environmental meaningless materials but by scientific idea it has to be possible and showing the capacity which may be developed to lead the future success or usefulness resource material. Nowadays the FA is used in cement, concrete and other cement based applications in world. The interdisciplinary name of the garbage product ascribed to combustion of coal or lignite in the boiler of a thermal power plant is turned to dust as fine particles that carried in air, since the FA at bottom ash, pond ash or, mound ash. From the bottom of boilers by any acceptable procedure is termed as Bottom Ash. In here the terminology Pond Ash is used when FA or bottom ash or both mixed in any portion is transfer in the form of insoluble particles that suspension in water as deposited in pond. When the mixture of these in any portion is transferred or carried and deposited in dry form, then it is called as Mound Ash.

First of all, Scientist discovered the materials using waste FA i.e, cement specially requires for building bricks, concrete etc. The essential quality of FA in India uses in cement and concrete, which is managed by distribution of framing for fly ash to use of pozzolana (siliceous and aluminous compounds divided in the presence of alkali/water) and admixture. The major valuedifference in fly ash in India and elsewhere is in the glass(SiO\textsubscript{2}) content which described as a fine dust of mostly spherical glass particles having pozzolanic properties.

Nowadays the various use of fly ash that is gaining move faster scientific development for world[5]. It concerns to put fly ash for making disposal, which is increasing the list of research areas of application. In world, fly ash is not only being used in civil (building and roadconstruction) but also in, material science (ceramics, metallurgy), agriculture and environmental-related areas. There are common areas for using are cement, concrete, ready-mixed concrete, cement or lime-based fly ash bricks and blocks for walling prefabricated building elements, land reclamation, soil stabilization, road constructions, embankments, land fills etc and in case of Non-engineering applications such as in agriculture, plant nutrients, ceramics, neutralizing soil acidity, metal extraction etc.

The coal is mostly carbon which is formed by dead plants fossils with heat and pressure under soil. It is of four types mainly Peat, Lignite, Bituminous and Anthracite. And others are semi types of coal.

Peat - less than 60% carbon.
Lignite - (60 – 70) % carbon.
Sub-bituminous coal - (35 – 45)% carbon
Bituminous coal -85% carbon
Anthracite -87% carbon
Graphite - (95 - 99)% carbon
Cannel coal - lower than in fixed amount of carbon than Bituminous

Coal Fly Ash is classified in two types such as,

1) FA, which are obtained from bituminous coal with fractions of SiO\textsubscript{2}+ Al\textsubscript{2}O\textsubscript{3}+ Fe\textsubscript{2}O\textsubscript{3} greater than 70%.
2) FA, which are obtained from lignite coal with fractions of of SiO\textsubscript{2}+ Al\textsubscript{2}O\textsubscript{3}+ Fe\textsubscript{2}O\textsubscript{3} greater than 50%. The two kinds of Class C and Class F depending on the type of coal and the effective chemical analysis.
Class C FA is normally produced from the burning of lignite or sub bituminous coals, contains CaO higher than 10% and possesses cementations properties in addition to pozzolanic properties.

Class F FA is normally produced from the burning of bituminous or an anthracite coal contains CaO below 10% and possesses pozzolanic properties.

The classification, based on the boiler operations, which is classified with two distinct identities:

1. Low temperature (LT) fly ash, marked out of combustion temperature below 900°C.
2. High temperature (HT) fly ash, marked out of combustion temperature below 1000°C.

![Fig-1.3 Fly Ash (FA)](image)

Characteristics of FA are given as follows

1.3.1 Physical Characteristics

In general, the physical characteristics of fly ashes differ over a notable range correlate to their source. The fitness is likely effective more by features such as coal combustion and ash collection with classification than by the nature of the coal itself. Similarly, the type of fly ash exhibited no apparent influence on the specific surface as measured by the Blaine technique. Moreover, except in some cases, there was very little relationship between the specific surface as measured by the Blaine and the fineness as determined by percentage retained on a 45µm filter. It is a fine grained material consisting mostly of spherical, glassy particles containing irregular or angular particles. The Size and Shape of Fly Ash particle varies depending on the sources. It consists of silt sized particles as spherical and typically ranging in size between 10 to 100 micron.

1.3.2 The Color of FA

The color is grey, depending on its chemical and mineral constituents. Yellowish - Brown and light colors are typically associated with high lime content. A brownish color is commonly associated with the iron content. A dark grey to black color is typically assigned to upraised unburnt content. FA color is usually very consistent for each and individually power plant and coal source. The fineness of FA. Generally, FA is dry and wet filtering. Hence it is used to measure the fineness of fly ashes.
1.3.3 The specific surface of fly ash

The surface area of FA is the area of a unit of mass, can be measured by various techniques. There is a common skill as Blaine specific-surface method, which measures the resistance of compressed particles to air flow.

1.3.4 The Specific Gravity of FA

Specific heat capacity for different composition of fly ash is found as 0.753 J/g-°C. This is in the range of pure Cement Concrete. It can be observed that specific heat carrying capacity of composite is gradually increasing with increase in fly ash percentage. It is mainly because the fly ash particle exhibits higher specific heat capacity. The variation of specific heat with respect to fly ash grain size is higher for small sized particles. It is varied over a wide range.

Table 1.3 The Chemical Composition of Fly Ash

| COMPONENTS | PERCENTAGE % |
|------------|--------------|
| SiO₂       | 54.20        |
| Al₂O₃      | 25.13        |
| Fe₂O₃      | 11.72        |
| CaO        | 3.57         |
| MgO        | 1.2          |
| K₂O        | 0.76         |
| Na₂O       | 0.31         |
| TiO₂       | 1.1          |
| P₂O₅       | 0.6          |
| MnO₂       | 0.2          |
| SO₃        | 0.35         |
| LOI        | 0.86         |

It depends on the sources of coal and also on operating parameters of boilers that the various quality from source to source and within the source also. With the use of pulverized coal and systematic combustion system, LOI(Loss on ignition) is a measurement of unburned carbon remaining in the ash. Generally, the mineralogical Characteristic of FA of coal as a source and types of both influence on its mineralogical composition. It depends on the system of combustion and some unburnt coal may be collected with ash particles. In addition, the amount of glassy material, each fly ash may contain one or more of the four major crystalline phases: quartz, mullite, magnetite and hematite. In sub-bituminous fly ashes, the crystalline phases may include calcium sulphate and alkali sulphates. The reactivityfly ashes are related to the noncrystalline phase or glass for the high reactivity of high-calcium fly ashes may partially lie in the chemical composition of the glass.

Experiments are conducted to determine the thermal properties such as thermal conductivity, coefficient of thermal expansion, specific heat and thermal diffusivity. There is a decrease in thermal conductivity, increase in specific heat capacity and decrease in thermal expansion [4].
Many of the experiments which are conducted on fly ash based is mainly on the thermal conductivity and resistivity properties with WG is very less research has been conducted on its thermal properties. Thermal properties are very important factors of the fly ash based materials, because in real scenarios the structures undergo many physical and chemical changes due to the temperature effects. These temperature effects cause the thermal failure of the other materials and discharging the ion, protect the surface etc formation in the structure takes place. When there is a high heat of temperature, it puts in danger the ordinary materials like electronics appliances that the structures fails to withstand the high temperature and the structure collapses due to the overheating. The work presented in this paper reports an investigation on the behavior of best heat resistive materials produced from Fly Ash and WG. Attempts are made to study the effect of thermal properties on different composition of Fly ash and grain sizes of fly ash. Some of the earlier investigations showed that the thermal properties are enhanced with increase in fly ash percentage. With thermal property, thermal properties are also varying. In order to explore an interesting, useful engineering material and to check whether the Fly ash is able to withstand the change in temperature effects, with increase in percentage of Fly ash this study is carried out.

### 1.3.5 Thermal conductivity

It defined as the ability of material to conduct heat. The TC of pure concrete is around 1.38 W/m-K and the range 1.21.4 W/m-K of the Pure Cement Concrete. The greater are the porosity and pore size, the smaller is TC. That is for, if the porosity and pore size increased, the pores in concrete would be filled with more air, and the thermal conductivity of the gas is much smaller than the solid, compared to pure cement concrete, fly ash concrete has lower thermal conductivity.

### 1.3.6 Coefficient of thermal expansion

The ratio of change in length to product of temperature change and original length. For coefficient of thermal expansion by using digital Vernier caliper, the initial specimen length is measured, and then the specimen is kept inside the Oven for heating to get desired temperature. After the specimen attains the desired temperature the length of specimen is measured, this data used to find the Co efficient of thermal expansion.

### 1.3.7 Thermal diffusivity of the material

It is defined as the thermal conductivity divided by density and specific heat capacity at constant pressure. Thermal Diffusivity for different composition of fly ash. The thermal diffusivity is directly dependent on specific heat and thermal conductivity, the thermal diffusivity decreases with increase in the fly ash percentage this is because of the porosity and pore size of the fly ash. Also we can see that the diffusivity of the higher grain size is lesser than that of the smaller grain size because of the fine powder.

### 1.4 About waste glass (WG)

Glass is a product of supercooling melted liquid mixture that consists of sand, soda ash in which there is no crystallization and retains the organization for internal structure of melted liquid. After crushed the waste glass, it exhibits the particle size like sands.
The properties of waste glass (WG) materials are given as follows.

1.4.1 Physical properties of WG

WG with crushed particle are generally angular shape and contains some flat and elongated particles depend on degree of crushing. In here small particles exhibits less angularity and reduced the quantities of flat.

1.4.2 Chemical properties of WG

The elementary compounds of glass as Silicon when combined with Oxygen, silicon dioxide in the form of sand which is the most common glass former. It contains 68% silicon dioxide. As soda ash (anhydrous sodium carbonate) acts as the fluxing agent in melt. The limestone & dolomite are also used in lieu of soda ash. Types of glasses, such as made from soda lime glass, Lead alkali silicate glasses are used in manufacturing the light bulb, neon sign, optical fiber etc. Borosilicate glass having extra ordinary chemical resistances with high temperatures that used in research in laboratories.

1.4 The chemical compositions of glasses.

| Components | Value Percentage (%) |
|------------|----------------------|
| SiO₂       | 71.10 %              |
| Al₂O₃      | 01 %                 |
| CaO        | 9.2 %                |
| Fe₂O₃      | 0.29 %               |
| MgO        | 4.4 %                |
| Na₂O       | 12.6 %               |
| SO₃        | 0.5 %                |
| K₂O        | 0.81 %               |
| Loss of ignition | 0.04 % |
The glass is not chemically resisted to hydrofluoric acid and alkali. It is amorphous in nature.

1.4.3 Mechanical properties.

It is a brittle material that fractures from tensile stress. The internal friction angle or shear strength and bearing capacity of crushed blended aggregates high, its compatibility insensitive to moisture content. It’s having good soundness with frictional properties.

1.4.4 Thermal properties of WG

The glass having heat retention as low heat conductivity. Actually themixing of chemical composition in glass can help to decrease the depth of penetration.

The thermal conductivity of glass is not high. It is about $k = 1$ W/ m-K. Waste FA and WG are selecting for construct the heat resistive and conductive materials. As we know that heat resistive means thermal insulation and heat conductive means thermal conduction.

1.4.5 Thermal Insulation materials

It may be defined as a combination of materials that retard the flow of heat depending surface shape and size.

2. Advantages:

- To control the processing of temperature and protect the electronic wares.
- It prevents on cold surfaces and resulting corrosion.
- It provides the fire protection and absorbs vibration.

The materials which have basic requirement to dealing with heat transfer that the rate of heat flows in order to minimize the change of temperature[6]. It is very important to select right type of insulation materials considering temperature of system for the mode of heat transfer involved.

The thermal insulation materials like fibrous materials, building walls (paints, bricks wall), aluminum foil insulation etc. The metal foil which used to increase the insulating value of air spaces by reducing heat transfer by radiation. A film of paint is relatively thin that offers resistance to flow of heat conduction. The color of external paint the effect on absorption of heat from the sun, since the light-colored paint absorbs less heat from the sun which is the standpoint of insulation. The coating like paint contains metallic flakes i.e, aluminum paint.

The high temperature of heat resistant lightweight materials having high application in electronic appliances(battery electrode material, capacitors), furnaces, tunnel layers, anticorrosive materials (paint) etc[7]. The resistive material fully effective for high temperature that protect the devices and building structures.

For Environmental control; Focus is being continued on:

i) Development of new / incremental technologies, ii) Adaptation/large scale application of technologies, iii) Preparation of standards / specifications, iv) Support & facilitation to other Government Ministries / Department

The dumping of waste FA is one of the major concerns and challenge to the society, as the products are precarious as well as proper method is to be come after for the dumping of waste. By scientific ways, the waste product from the factory is one of the best solutions for dumping problems.
3. Research Methodology:

3.1 Materials

The actuality of which physical objects are unperturbed, in here the term is used notional. The word established some specific kind, quality, or quantity of matter, primarily as propose for use (cotton material, volatile materials), some materials are used for making this new thermal conductive & resistive material preparations are given below.

3.2 Waste glass

Waste glass which contains silica. The proportion of waste glass is 40-60%.

3.3 Fly ash

It is a waste material which is collected from NTPC SIPAT thermal power plant in Bilaspur of Chhattisgarh. The proportion of this material is (30-55)%.

3.4 Phytochemical repellent

A small quantity of percentage in Neem, Tulsi etc. pointing to medicinal phytochemicals for reducing the viral diseases from harmful diseases by microbes. It is added with preparation of ceramic materials that support to develop the intermolecular bonding character in substances. These are functioning for health care and response with ceramic materials.

3.5 Cellulose

The organic polymeric compound as Cellulose such as is used as binder, to bind the pattern of molecules by statistical thermodynamically arrangement. The proportion of cellulose is (2-8)%.

4. Manufacturing process:

4.1 Heat treating method

The material includes of the fine structure called “grains”. The nature of the grains (i.e. grain size and composition) is one of the most constructive factors. Hot plate provides an efficient way to manipulate the properties the rate of diffusion and the rate of cooling within the fine structure.

The structure consists of atoms that are grouped in a very specific arrangement, called a lattice. In most elements, this order will rearrange itself, depending on bonding factors like temperature and pressure[8]. This rearrangement may occur several times, at many different temperatures. In the soluble state, the process of diffusion causes the atoms of the dissolved element to spread out, attempting to form a homogenous distribution within the silica.

The heat resistive and conductive materials were made from waste fly ash, waste glass, organic additives and definite quantity of HF which prepared as following procedure.

In order to shaping the mixture of FA, WG finely by polymeric cellulose as binder with suitable compositions. The bonding between molecules depends upon reacting species for substances[9]. By the help of laboratory apparatus, the substance of definite amount of mixture initiating to pelletization by hydraulic pressure machine. And the pellets would be dry with temperature at 100°C for 5 hr by calibrator. After all, it is fired at muffle furnace at (1000-1300)°C.
4.2 Testing of material

4.2.1 Hot plate method

There are a number of chances to compute heat conductivity. It is verified in comparison with the thermal conductivity of nanofluid [10], each of them acceptable for restricted range of materials, depending on the thermal premises and the medium temperature. In general there are two basic mechanisms of computation:

5. Observation & Analysis:

Table 5.1 Raw Material composition

| Serial No. | Components                  | Sample No.1 | Sample No.2 | Sample No.3 |
|------------|-----------------------------|-------------|-------------|-------------|
| 1.         | WG (waste glass)            | (45 – 50)%  | (50 – 55)%  | (55 – 60)%  |
| 2.         | Coal FA (flyash)            | (35 - 39)%  | (35 - 39)%  | (28 - 32)%  |
| 3.         | Binder (Organic cellulose)  | (0 - 04)%   | (02 - 06)%  | (03 - 08)%  |

Mathematically, the thermal Conductivity of a material can be formulated.

\[
\lambda = \frac{q \times d}{T_1 - T_2}
\]

Whereas, ‘q’ quantity of heat passing through a unit area of the sample in unit time

\[
q = \frac{Q}{A}
\]

Where \( Q \) = Quantity of heat passing through a base area of sample in w.

\( A \) = Base area of the sample.

\( d \) = Distance between the two sides of sample.

\( T_1 \) = Temperature on warmer side of the sample.

\( T_2 \) = Temperature on colder side of the sample.
Table 5.2 Observation table for thermal conductivity and resistivity of materials

| Sample No. | Q in w | A in m² | q = \frac{Q}{A} in w/m² | T₁ in K | T₂ in K | T₁ – T₂ in K | d in m | λ. |
|------------|--------|---------|--------------------------|---------|---------|-------------|--------|----|
| S₁         | 10     | 1.5     | 6.67                     | 1373    | 1273    | 100         | 0.75   | 0.05 |
| S₂         | 12     | 2       | 6                        | 1423    | 1323    | 100         | 1      | 0.06 |
| S₃         | 11.5   | 0.5     | 23                       | 1473    | 1373    | 100         | 0.25   | 0.0575 |

The average thermal conductivity of this ceramic material is 0.0558.

6. Result

The thermal conductivity of this new thermal ceramic antibacterial insulation material is manufactured from waste glass and fly ash with medicinal phytochemical repellent is approximately 0.0558 W/mK.

7. Conclusion

Thermal insulation depends on preparation of particle size. And we know that the thermal insulation is the constant rate of reducing fluxion of heat from high to low temperature. In material the interatomic interactions develop the insulation rate in materials. In this paper, the coal FA, waste glass WG, organic medicinal additives are main component to prepare the materials. At (700-1000)°C, the physical parameters such as porosity, compressive strength, molecular size etc. to detect the advancing new materials.

To manage the waste materials which contributes in investigation of utilillization of waste material.

The main conclusion marked as,

a) The specimen that utilize mainly in building materials such as ceramic tiles materials, cooking utensil etc.

b) Thermal insulation depends upon particles size, absorption of water is mainly relative and supportive for environment.

The waste material utilising of FA & WG is the low cost effective material Production.

8. Suggestion
we suggest that the source of waste products represents increasingly the problem for human kind. As waste combustion coal fly ash and waste glass are the two basic ingredients and challenges for control the environmental pollution. The FlyAsh of oxide materials and WG as waste glass having siliceous compounds are the main selective components for making thermal insulation materials that contribute to minimize the negative impact of FA and WG for environment. In other hand, the production of heat insulation ceramic materials are selective usage for building materials such as tiles, cooking utensil etc to protect the environment. Mainly the harmful radiation and diseases will reduce by this ceramic material by the presence of oxide materials in FA and WG and phytochemical microorganism repellent from harmful microbial. It is balancing the both matter in case of FA & WG to protect the electronic and building materials. There is so cost effective by using in building materials.

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