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AN INVESTIGATIONAL RESEARCH ON HEAT RESISTING ROOF SYSTEM BY USING SILICON AEROGEL

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ABSTRACT- *Roofing sheets are normally used in construction field. These are used in buildings such as restaurant, auditorium, factory, hotel, etc. Most commonly used roofing sheets are metal sheets, asbestos sheets, and plastic sheets, etc. These materials have high range of thermal conductivity, which allows the sunlight radiation to pass through the material, so the building which has these roofing systems will experience warm condition and normal room temperature. Aerogel is a component prepared by replacing liquid material with gaseous material in a gel. These materials have ultralow thermal conductivity; especially silicon aerogels have good strength and low thermal conductivity. The temperatures at top and bottom side of normal roofs are noted for a week. At the same time, the temperature study of heat resisting roof is also made. problems, a new concept for roofing sheets to resist the heat from the sunlight, is planned and implemented.*

1.1 General

Aerogel is a gel component in which the liquid molecules are removed in a convenient gel without damaging the structure of the gel through controlledprocess. These materials are extremely porous and have ultralow thermal conductivity. Aerogel was first created by Samuel Stephens Kistler in 1931, as a result of a bet with Charles Learned over who could replace the liquid in "jellies" with gas without causing shrinkage. Aerogels are produced by extracting the liquid component of a gel through supercritical drying. This allows the liquid to be slowly dried off without causing the solid matrix in the gel to collapse from capillary action, as would happen with conventional evaporation. The first aerogels were produced from silica gels. Kistler's later work involved aerogels based on alumina, chromiaand tin dioxide. Carbon aerogels were first developed in the late 1980s.

1.2 Knudsen Effect

Aerogels may have a thermal conductivity smaller than the gas contain. This is caused by the Knudsen effect. Knudsen effect is the reduction of thermal conductivity in gases when the size of the cavity encompassing the gas becomes comparable to the mean free path. Effectively, the cavity restricts the movement of the gas particles, decreasing the thermal conductivity in addition to eliminating convection.

1.3 Applications of Aerogel

1. In granular form to add insulation to skylights.
2. A chemical adsorber for cleaning up spills.
3. A catalyst or a catalyst carrier.
4. Thickening agents in some paints and cosmetics.
5. Laser targets for the National Ignition Facility.
6. Carbon aerogels are used in the construction of small electrochemical double layer super capacitors.
7. In water purification, chalcogels have shown promise in absorbing the heavy metal pollutants mercury, lead, and cadmium from water.

1.4 Aerogel Base Materials

The term aerogel does not refer to a particular substance, but rather to a geometry which a substance can take on the same way a sculpture can be made out of clay, plastic, papier-mâché, etc., aerogels can be made of a wide variety of substances, including

1. Silica
2. Most of the transition metal oxides (for example, iron oxide)
3. Most of the lanthanide and actinide metal oxides (for example, praseodymium oxide)
4.Several main group metal oxides (for example, tin oxide)
5.Organic polymers (such as resorcinol-formaldehyde, phenol-formaldehyde, polyacrylates, polystyrenes, polyurethanes, and epoxies)
6.Biological polymers (such as gelatin, pectin, and agar agar)
7.Semiconductor nanostructures (such as cadmium selenide quantum dots)
8.Carbon
9.Carbon nanotubes and
10.Metals (such as copper and gold)

1.5 SILICON AEROGEL

Silica aerogel is the most common type of aerogel, and the most extensively studied and used. Silicon aerogel is a nanostructured material with high specific surface area, high porosity, low density, low dielectric constant, and excellent heat insulating properties. The silica solids, three-dimensional, intertwined clusters that comprise only 3% of the volume. Conduction through the solid is therefore very low. The remaining 97% of the volume is composed of air in extremely small nanopores. The air has little room to move, inhibiting both convection and gas-phase conduction.

1.6 Properties of Silicon Aerogel

Despite their name, aerogels are solid, rigid, and dry materials that do not resemble a gel in their physical properties: The name comes from the fact that they are made from gels.

1. Low thermal conductivity
2. Material that is 98.2% air.
3. Rigid, friable
4. Extreme low density
5. Lowest dielectric constant
6. Lowest speed of sound through a material

1.7 Other Sheets

Certain other roofing sheets are also available in markets for their various properties. These roofing sheets are installed based on different requirements on different situations. Some of them are given below,

1. UPVC Roofing Sheet
2. Polycarbonate Roofing Sheets
3. Fibre glass Roofing Sheets
4. Aluminium roofing sheets
5. FRP roofing sheets

1.8 CHARACTERISTICS OF ROOFING SHEETS

The characteristics of a roof are dependent upon the purpose of the building that it covers, the available roofing materials and the local traditions of construction and wider concepts of architectural design and practice and may also be governed by local or national legislation.

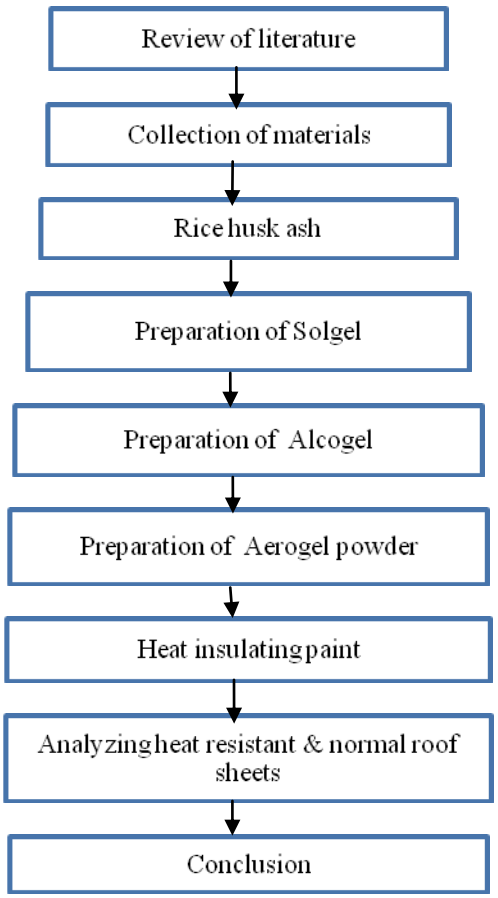


Figure 1.1 Methodology flow chart

2.1 RICE HUSK ASH

Rice husks are the hard protecting coverings of grains of rice. In addition to protecting rice during the growing season, rice hulls can be put to use as building material, fertilizer, insulation material, or fuel.Combustion of rice hulls affords rice husk ash. This ash is a potential source of amorphous reactive silica, which has a variety of applications in materials science.The ash is also a very good thermal insulation material.A number of possible uses for RHA include absorbents for oils and chemicals, soil ameliorants, a source of silicon, insulation powder in steel mills, as repellents in the form of "vinegar-tar" release agent in the ceramics industry, as an insulation material. In this project RHA is prepared by placing rice husk in silicon crucible and heated to 700oC for 6 hours in muffle furnace.

2.2 SODIUM HYDROXIDE AQUEOUS SOLUTION

Sodium hydroxide (NaOH), also known as lye and caustic soda, is an inorganic compound. It is a white solid and highly caustic metallic base and alkali salt which is available in pellets, flakes, granules, and as prepared solutions at a number of different concentrations. Sodium hydroxide forms an approximately 50% (by weight) saturated solution with water. Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in air. Sodium hydroxide is used in many industries, mostly as a strong chemical base in the manufacture of pulp and paper, textiles, drinking water, soaps and detergents and as a drain cleaner. Sodium hydroxide is industrially produced as a 50% solution by variations of the electrolytic chloralkali process. Chlorine gas is also produced in this process. Solid sodium hydroxide is obtained from this solution by the evaporation of water. Sodium hydroxide is a popular strong base used in the industry. Around 56% of sodium hydroxide produced is used by the industry, 25% of which is used in paper industry. Sodium hydroxide is also used in manufacturing of sodium salts and detergents, pH regulation, and organic synthesis. It is used in the Bayer process of aluminium production. In bulk, it is most often handled as an aqueous solution, since solutions are cheaper and easier to handle. In our project sodium hydroxide aqueous solution is prepared by dissolving 10g of sodium hydroxide pellets in 250 ml of distilled water so that sodium hydroxide aqueous solution of normality1 mol per litre can be prepared.

2.3 NITRIC ACID

Nitric acid (HNO3), also known as aqua fortis and spirit of niter, is a highly corrosive mineral acid. The pure compound is colorless, but older samples tend to acquire a yellow cast due to decomposition into oxides of nitrogen and water. Most commercially available nitric acid has a concentration of 68%. When the solution contains more than 86% HNO3, it is referred to as fuming nitric acid. Depending on the amount of nitrogen dioxide present, fuming nitric acid is further characterized as white fuming nitric acid or red fuming nitric acid, at concentrations above 95%.Nitric acid is the primary reagent used for nitration - the addition of a nitro group, typically to an organic molecule. While some resulting nitro compounds are shock- and thermally-sensitive explosives, a few are stable enough to be used in munitions and demolition, while others are still more stable and used as pigments in inks and dyes. Nitric acid is also commonly used as a strong oxidizing agent.

2.4 SOLGEL

In materials science, the sol-gel process is a method for producing solid materials from small molecules. The method is used for the fabrication of metal oxides, especially the oxides of silicon and titanium. The process involves conversion of monomers into a colloidal solution that acts as the precursor for an integrated network of either discrete particles or network polymers. The simplest method is to allow time for sedimentation to occur, and then pour off the remaining liquid. Centrifugation can also be used to accelerate the process of phase separation.

Fig no 1.2 : Aerogel

2.5 ALCOGEL

At the gel point, the mixture forms a rigid substance called an alcogel. The alcogel can be removed from its original container and can stand on its own. An alcogel consists of two parts, a solid part and a liquid part. The solid part is formed by the three-dimensional network of linked oxide particles. The liquid part (the original solvent of the Sol) fills the free space surrounding the solid part. The liquid and solid parts of an alcogel occupy the same apparent volume.

2.6 AEROGEL GRANULES

Known as frozen smoke, solid smoke, solid air or blue smoke, aerogel is the best thermal insulator and the lightest solid of any present-known substance in that over 90% of its volume is constituted of air in extremely tiny nano-pores and the rest is composed of clusters intertwined with three-dimensional, small silica solids

2.7 PROPERTIES OF AEROGEL GRANULES

1. Unsurpassed Insulation Performance
2. Excellent Light Diffusion
3. Excellent Physical Stability
4. High Porosity and Specific Surface Area
5. Extremely Low Density and Nanopores.

2.8 APPLICATIONS OF AEROGEL GRANULES

Aerogel granules are suitable for a wide range of applications where super insulation is required and there are suitable size and weight constraints. In particular, these granules are ideal for insulating double glazing and skylights due to their excellent light diffusing properties.

2.9 PREPARATION METHOD

Aerogels can be prepared from more than one method based on different requirements of properties of aerogels. For our project granular aerogel powder is required.

Step1: The rice husk ash is properly weighed and 20g of ash is mixed with 250ml of sodium hydroxide aqueous solution. The solution heated at 90oC for 1 hour with reflux. This process is known as hydrolysis.

Step 2: The solution is filtered and then it is neutralized by adding nitric acid to it. The pH of the resulting solution from step 1 will be nearer to 14. The pH value should be reduced to 7 by adding nitric acid. This process is known as condensation. The resulting solution is known as sol gel.

Step 3: The sol gel was aged to 24 hour with room temperature. A soft jelly substance will be formed which is known as alcogel.

Step 4: The alcogel was dipped into ethanol for 1 week with replacement of fresh ethanol for every 24 hours.

Step 5: The resultant gel was aged at room temperature for 48 hours. Granular aerogel powder will be formed. And then it is heated at 100oC for two hours. The resultant molecule is known as granular aerogel powder.

By completion of step 3 a soft jelly substance will be obtained and by step 6 a fine granular silicon aerogel powder will be obtained. These granules can be used as paint additives which will act as insulation for sunlight.

RESULT AND DISCUSSION

3.1 TEMPERATURE READINGS

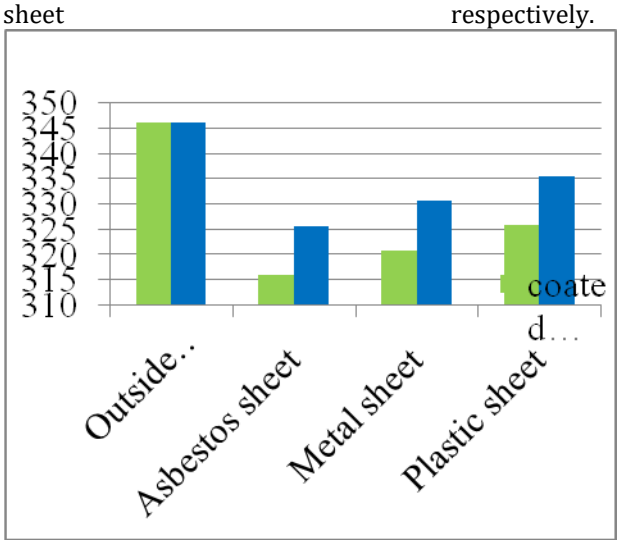
The sheets were tested in sunlight during day hours and temperature readings were taken. The sheets were tested for seven days and analysis was done for average of seven days.

Day Result :

The temperature readings from 09.00 am to 05.00 pm from our observstions.

COMPARISONS OF NORMAL SHEETS

The temperature readings of all normal sheets for a week was added and the compression graph was drawn between outside temperature, temperature of normal asbestos sheet, temperature of normal metal sheet, and the temperature of normal plastic sheet respectively.



ECONOMICAL FEASIBILITY

Economical feasibility is the analysis whether the product is economically possible to implement or not. Normally aerogels require much amount for production since base component is costly. But, in this project rice husk is the base material which gives silicon. Hence the production of silicon aerogel does not cost much. The overall cost required is given below from which the economical feasibility calculations can be made

MATERIALS	QUANTITY	PRICE
1.Rice husk	1 kg ----	Rs. 10
2.Sodium hydroxide pellets		100Kg-- Rs. 300
3.Nitric acid	50 ml---	Rs. 15
4.Paint	2 litre---	Rs. 400
5.Electric current	10 units ---	Rs. 75
Total		Rs. 800

Approximately Rs. 800 is needed to prepare 2 litre of insulating painting. This paint can be applied up to 240 square feet in single coating. For double

coating, it can be applied up to 120 square feet. The cost per square feet is given by,

240 square feet = 800Rs
1 square feet = 800/240
= 3.34 Rs

The cost of the insulating paint is Rs. 3.34 per square feet. 50 % of the cost is for paint. The paint additive cost is only Rs. 1.17 per square feet. Hence the product is economically possible to implement.

CONCLUSION

A detailed study on heat insulating paint using silicon aerogel granules has been made and results has been obtained. The test on asbestos sheet, metal sheet, and plastic sheet shows various results and following conclusions were made.

- The use of granular aerogel powder as paint additive effectively acts as thermal insulator for sunlight.
- The economical means of aerogel powder can be made using rice husk, which is practically possible to implement.
- It is obtained that metal sheets conducts more heat than asbestos sheet and plastic sheet conducts more heat than metal sheet.

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