Thermal Insulation of Building

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Abstract— Buildings are large consumers of energy in all countries. In harsh climatic conditions, a substantial share of energy goes to the air-conditioning of buildings. This air-conditioning load can be reduced through many means; notable among them is the proper design and selection of building envelope and its components. The use of thermal insulation in building walls and roof does not only contribute in reducing the required air-conditioning system size but also in reducing the annual energy cost. Additionally, it helps in extending the periods of thermal comfort without reliance on mechanical air-conditioning especially during inter seasons periods. Therefore, proper use of thermal insulation in buildings enhances thermal comfort at less operating cost. However, the magnitude of energy savings as a result of using thermal insulation vary according to the building type, the climatic conditions at which the building is located as well as the type, thickness, and location of the insulating material used. The project study includes literature survey covering importance of Thermal insulation, types of thermal insulation, thermal insulation methods, thermal insulation materials, advantages and disadvantages, and some other case study on thermal insulation. The detailed literature survey gave a better understanding to carry out the project work.

Key words: Building, Thermal Insulation

I. INTRODUCTION

The term thermal insulation can refer either to materials used to reduce the rate of heat transfer, or the methods and processes used to reduce heat transfer. Heat energy can be transferred by conduction, convection, radiation. Thermal insulation prevents heat from escaping a container or from entering a container. In other words, thermal insulation can keep an enclosed area such as a building warm, or it can keep the inside of a container cold. Insulators are used to minimize that transfer of heat energy. In home insulation, the R-value is an indication of how well a material insulates. The flow of heat can be reduced by addressing one or more of the three mechanisms of heat transfer and is dependent on the physical properties of the material employed to do this.

A. Insulation

Insulation is defined as a material or combination of materials, which retard the flow of heat. The materials can be adapted to any size, shape or surface. A variety of finishes are used to protect the insulation from mechanical and environmental damage, and to enhance appearance.

B. R – Value

"The R-value is the reciprocal of the amount of heat energy per area of material per degree difference between the outside and inside. The R-value is proportional to the thickness of the material. For example, if you doubled the thickness, the R-value doubles." It is also referred to as the thermal resistance or thermal rating of an insulating material. This is the parameter which is used to rate the thermal ability of an insulation. It determines the amount of resistance offered by the material to heat flow or transfer of heat energy. A higher R- value is usually preferred for better insulation.

R-value = $k.m^2$/watt or ft^2 °F.

C. Necessity of Thermal Insulation

Increasing energy costs and availability problems emphasize the need for immediate energy conservation even in the oil producing countries. An effective way of saving energy is to improve the thermal insulation of buildings. This is particularly important in hot climates where the energy demand for cooling by air conditioning is very high. In addition to the need for energy saving, high insulation standards are justified by improved comfort levels and increased building life. A well-insulated building will have a higher value. Developed by The Dow Chemical Company in 1947. Since then, advance processes, products and application research and development work has taken place in the U.S.A., Canada, Japan and Europe. Today, a variety of grades of Styrofoam to many applications and industries is available in various sizes and with various edge treatments. Extruded polystyrene foam is used in many parts of the world under widely differing climatic conditions.

D. Objective

A thermal insulator is a poor conductor of heat and has a low thermal conductivity. Insulation is used in buildings and in manufacturing processes to prevent heat loss or heat gain. Although its primary purpose is an economic one, it also provides more accurate control of process temperatures and protection of personnel. It prevents condensation on cold surfaces and the resulting corrosion. Such materials are porous, containing large number of dormant air cells. Thermal insulation delivers the following benefits:

- Reduces over-all energy consumption.
- Offers better process control by maintaining process temperature.
- Prevents corrosion by keeping the exposed surface of a refrigerated system above dew point.
- Provides fire protection to equipment Absorbs vibration.

II. MATERIALS

Various materials used in this study are cement sheet, fibreglass, cellulose, glass wool, rock wool, gypsum board and sheet of wooden ware and pulp. Cement sheet used as wall material and remaining as insulation material.

A. Cement Sheet

A cement board is a combination of cement and reinforcing fibres formed into 4 feet by 8 feet sheets (or 3 feet by 5 feet sheets), 1/4 to 1/2 inch thick that are typically used as a tile backing board. Cement board adds impact resistance and strength to the wall surface as compared to water

resistant gypsum boards. Cement board is also fabricated in thin sheets with polymer modified cements to allow bending for curved surfaces.

Fig. 1: Cement Sheet

B. Fiberglass

Fibreglass is the most common insulation used in modern times. Because of how it is made, by effectively weaving fine strands of glass into an insulation material, fibreglass is able to minimize heat transfer. The main downside of fibreglass is the danger of handling it. Since fibreglass is made out of finely woven silicon, glass powder and tiny shards of glass are formed. These can cause damage to the eyes, lungs, and even skin if the proper safety equipment isn't worn. Nevertheless, when the proper safety equipment is used, fibreglass installation can be performed without incident.

Fig. 2: Fibre Glass

C. Glass Wool

Glass Wool is widely used for insulation due to its thermal and acoustic insulation properties, tensile strength, light weight and exceptional resilience. Glass wool is an insulating material made from fibres of glass that is arranged using a binder into a texture similar to wool. Glass wool is produced in rolls or in slabs along with different thermal and mechanical properties.

Fig. 3: Glass Wool

D. Cellulose

Cellulose insulation is perhaps one of the most eco-friendly forms of insulation. Cellulose is made from recycled cardboard, paper, and other similar materials and comes in loose form.

Fig. 4: Cellulose

E. Rockwool

Mineral wool actually refers to several different types of insulation. First, it may refer to glass wool which is fibreglass manufactured from recycled glass. Second, it may refer to rock wool which is a type of insulation made from basalt. Finally, it may refer to slag wool which is produced from the slag from steel mills. The majority of mineral wool in the United States is actually slag wool.

Fig. 5: Rock Wool

F. Sheet Prepared by use of Woodenware & Pulp Material

Wood is not a fantastic insulator, but has a very advantageous blend of decent R value, high strength, light weight, and significant thermal mass. It's mainly a structural material of course, and its R value is actually much better than other structural things like concrete, steel, aluminum.

Pulp is a lingo cellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fibre crops, waste paper, or rags. Many kinds of paper are made from wood with nothing else mixed into them. This includes newspaper, magazines and even toilet paper. Pulp is one of the most abundant raw materials worldwide.

Fig. 6: Mixing Of Wooden Ware & Pulp

Sr. No	Material	R-Value
1	Cement sheet	0.005
2	Fibre Glass	2.9 to 3.8
3	Glass Wool	3
4	Cellulose	3.1 to 3.7
5	Rock wool	3.2
6	Wooden ware and pulp	1.0 to 1.5

Table 1: R-Value of Different Material

III. MODEL OF BUILDING

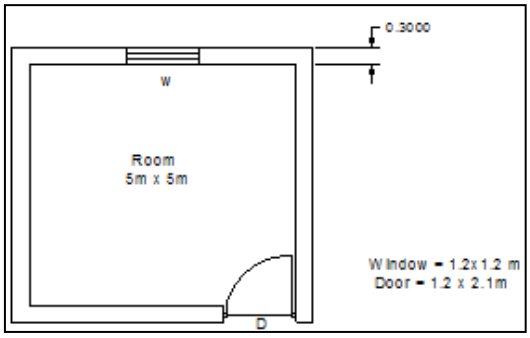

Fig. 7: Plan of Building

A. Model Wise Material

Building No	Wall Material	Ceiling Material	Paint
Building 1	Cement sheet	Cement sheet	Distemper
Building 2	Cement sheet, Fibre glass, Cellulose	Gypsum board	Distemper
Building 3	Cement sheet, Rock wool, Glass wool	Wooden ware and Pulp material	Distemper

Table 2: Model Wise Material

B. Material Property

1) Cement Sheet
- Size – 8 feet x 4 feet
- Price - Range Rs.925 to 1000
- Thickness – 6mm and 12mm
- Environmentally-friendly,
- Resistant to fire, water, vermin and fungus.

2) Fibre Glass
- Fibre Glass roll size – 1m x 3m
- Price – 950 per roll
- Thickness- 25 mm
- R-2.9 to R-3.8

3) Cellulose
- Price –Rs. 1000/ package
- R-value R-3.1 to R-3.7

4) Glass Wool
- Glass wool sheet size - 0.8 m x 1.2 m
- Rate of 1 sheet - Rs.200
- Thickness – 40mm
- R – Value R - 3.0

5) Rock Wool
- Rockwool roll Size – 1.22 m x 4 m
- Thickness – 50 mm
- Rate of 1 roll – Rs.1200
- R – Value R - 3.2

C. Sheet of Woodenware & Pulp Material
- Size – 50cm x 50cm
- Thickness – 12mm
- Price – Rs.5/kg
- High thermal storage capacity of wood

D. Model Installation

Fig. 8: Material Installation

IV. TEMPERATURE MEASUREMENT TEST

A. Methodology

Method consists following flow of work such as Design of model (i.e. width, length, thickness, height, Scale), Procurement of material, Model preparation, Installation of insulation material and paint the model. Dimension and scale of building model are shown as fig-7 and model consist 30mm wall thickness and 18mm ceiling thickness. There are number of insulation material applied to the model and its detail property given in article II.B. Here, total three models are made for the comparison of between them; one is made by only cement sheet, no insulation material used to it. And other remaining two models contain insulation material as given in table-2. During preparation of model cutting of cement sheet is done by steel cutting tool and material applied manually. Bond tide glue used for the adequate joint of cement board and its adhesive property is giving the good bond strength to the cement board. After the completion of model, distemper is made over its outer surface.

B. Instrument used for Test

Here, main two types of instrument exist one namely thermocouple censor and other PID controller.

1) K-type Thermocouple

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The voltage can then be interpreted using thermocouple reference tables to calculate the temperature.

There are many types of thermocouples, each with its own unique characteristics in terms of temperature range, durability, vibration resistance, chemical resistance, and

application compatibility. Type J, K, T, & E are "Base Metal" thermocouples, the most common types of thermocouples. Type R, S, and B thermocouples are "Noble Metal" thermocouples, which are used in high temperature applications.

Thermocouples are used in many industrial, scientific, and OEM applications. They can be found in nearly all industrial markets: Power Generation, Oil/Gas, Pharmaceutical, Biotech, Cement, Paper & Pulp, etc. Thermocouples are also used in everyday appliances like stoves, furnaces, and toasters.

Thermocouples are typically selected because of their low cost, high temperature limits, wide temperature ranges, and durable nature.

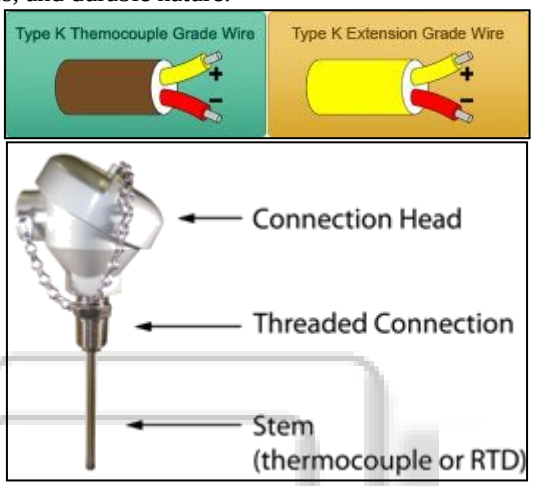

Fig. 9: Thermocouple

2) PID Controller

a) What is PID controller?

A PID (Proportional Integral Derivative) controller is a common instrument used in industrial control applications. A PID controller can be used for regulation of speed, temperature, flow, pressure and other process variables.

Fig. 10: PID Controller

b) How a PID Controller Works?

As discussed above that a PID controller uses the control algorithm as three modes, i.e., proportional + integration + derivative.

The proportional term applies appropriate proportional changes for error (which is the difference between the set point and process variable) to the control output. In fact, many control applications work quite well with only proportional control.

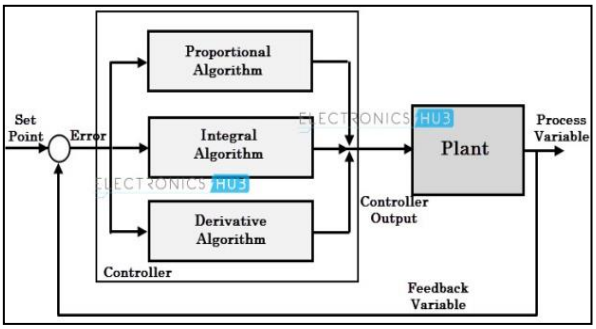

Fig. 11: Flow work of PID Controller

The integral term examines the process variable over time and offset of set point and then corrects the output if necessary. Derivative control monitors the rate of change of process variable and accordingly changes the output when there are unusual changes.

Each parameter of three control functions is adjusted by user to get the desired performance from the process. It measures the output of a process and controls the input by maintaining the output at a desired value (also called as set point). The most common example of PID controller is controlling temperature in many industrial applications.

C. Test Procedure

For the testing of temperature measurement, models are rest in atmospheric temperature for the 1hour. Thermocouple used for the temperature measurement. During the testing, first of all outside temperature is measured and then inside temperature is measured by the Thermocouple subsequently. Test result is given in table-3 below. Generally, the entire model giving positive reading. But it is shown that better performance given the model-III. As per the test result, Rockwool, Glass wool and sheet of wooden ware and pulp giving the better result as compared to other material.

In detailed, comparison and Temperature variation between them can be shown in Table-3.

Sr. No	Building No.	Time Duration	Outside Temp.	Inside Temp.	Difference in Temp.
1	Building 1	1 Hour	46˚c	44˚ c	2˚ c
2	Building 2	1 Hour	46˚c	40˚ c	6˚c
3	Building 3	1 Hour	46˚c	38˚ c	8˚ c

Table 3: Test Result

V. CONCLUSION

Looking at the analysis and results we can conclude that natural materials based on technical hemp obtained from agriculture can be used for the production of thermal insulation materials for wall construction and pitched roofs.

Among all the material used in this test, model made by rock wool, glass wool and sheet of wooden ware and pulp is giving the better result compare to other. We observed that this material can resist the heat sufficient way to provide comfort living in building.

As per analysis made the variations in the temperature of 30mm thick wall is about 6°C to 8°C. Looking at the results we can say that this difference could be much more in 30cm thick wall in actual building.

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