

## **PROTOTYPING OF NEW DOUBLE ROOF COOLING SYSTEM THROUGH THERMOFLUID CONCEPT FOR ENERGY OPTIMIZATION AND ENVIROMENTAL CONSERVATIONS**

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**ABSTRACT:** This new roof cooling system refers to the roof to be built into a closed system with specific water flow inside (natural + force). The new roof cooling system is designed to reduce inside temperature after the sun light hit the roof with the help of water flow inside the newly developed roof design (double roof). To build this cooling system, the gable roof design has been chosen as the main design for this system due to the frequent used designs in terraced houses for low development costs and Malaysia weather factor. The roof is designed with a Thermofluid concept that heat will be transferred through the water moving over the roofing material and the hot water will continue to be transferred to the cooling system. Therefore, water will be continued to recycle on the roof of the house (no water to be waste due to evaporation). Three steps water reservoir (water tank with specific minimum volume) will reduce water temperature to surrounding naturally. For the work, actual data obtained from this mini research are critical toward advanced technology that will be explored in energy harvesting and environmental concern for mankind and green world.

**KEYWORDS:** *Double Roof; Thermofluid; New Cooling System; Gable Design; Malaysia Weather.*

### **1.0 INTRODUCTION**

A cool roof is one that is designed to reflect more sunlight while absorbing less heat than a standard roof. According to Mohamed et al. [1], high reflective roof technology can improve the energy performance of residential buildings in very hot and dry climates. Reflective or cool roofs can reduce cooling load and electricity consumption in any home. According to Akbari et al. [2], a cool roof can be very reflective with the same protected properties and can be up to 10 °C cooler than the outdoor temperature, saving energy and reduced cost by using less air conditioning. A cool roof can be made of highly reflective paint, a sheet covering, or highly reflective tiles or shingles. The present invention relates to residential roof cooling systems that reduce the heat load on internal air conditioning equipment. Various designs and systems are used to introduce the roof cooling system. The roof is cooled by the roofing material used for cooling or heat conductivity.

Moreover, Roman et al. [3] investigated that three different types of effective roofs that can incorporate into today's technologies which are roof heat increase (TRHG), roof surface temperature, and heat-sensitive flux. Through the roof heat exchange of various roof cooling systems introduced, the first example of roofing or home cooling is through airflow that enters the roof of the house, under the house, or through the house windows, it will carry hot air directly through holes or open spaces like windows to produce hot air trapped out of the house, and the second example is through a system designed by humans with the help of water, roofing system of roofing houses, and roof laminations.

Roof cooling systems are almost always mounted on the roof of the house, and due to the extremely hot urban temperatures, most roof cooling systems can be found throughout Asia. Michael et al. [4], focused on the residential vernacular architecture in Cyprus by using natural ventilation, which aids in lowering the peak of indoor air temperature and improved indoor thermal condition during the day. Natural ventilation can be effective by lowering the daytime peak air temperature by up to 3 °C. On the other hand, without proper ventilation when building a home, hot temperatures can be trapped inside, resulting in stagnant air leading to bacteria and carbon build up, creating harmful indoor air for residents. Passive cooling techniques, according to Al-Obaidi et al. [5], are one of the innovative practices and technologies that provide the building with a comfortable state in a natural way.

Furthermore, Cengel et al. [6] investigated that thermofluid, also known as thermal liquids, which have three applications: thermodynamics, heat transfer, and fluid mechanics. The term heated refers to the mean of the heat, and fluid refers to liquids, gases, and vapours. Heat will be transferred through the movement of water as a fluid in the roof layer in the study of this cooling roof design. Temperature, fluid flow rate, and heat phase transition are also important in the context of thermal fluid because the changing temperature will be studied using the flow velocity of flowing water. Furthermore, they investigated the temperature difference between the driving force and the pull pressure for the fluid flow. The magnitude of the temperature gradient (temperature difference per unit length or rate of change of temperature) in that direction determines the rate of heat transfer in that direction.

For the review work, the study's goal is to use the thermofluid concept in order to create a new roof cooling system. Heat transfer, heat flows in the direction of decreasing temperature, and flow rate effects will be reviewed in the thermofluid application.

## 2.0 THE CONCEPT OF COOLING BY HEAT TRANSFER

According to Cengel et al. [7], heat transfer is a heat exchanger in which energy is transferred from one location to another based on the behaviour of the intervening medium. Heat can be transferred in three different ways in his study: conduction, convection, and radiation. All modes of heat transfer necessitate the presence of a temperature difference, and all modes transfer heat from a high-temperature medium to a lower temperature. Any exchange of energy between bodies takes place via one of these modes or a combination of them.

### 2.1 Conduction

Conduction is the transfer of energy from the more energetic particles of a substance to the adjacent less energetic ones as a result of interactions between the particles. Conduction can be placed in solid, liquid, or gases. In gases and liquid, conduction is due to collisions and diffusion of the molecules during their random motion. In solid, it is due to the combination of vibration of the molecules in a lattice and the energy transport by free electrons. The thermal conductivity of the material can be defined as the rate of heat transfer through a unit thickness of the material per unit area per unit temperature difference. The equation of conduction as shown in Equation 1.

$$\text{Rate of heat conduction} \propto \frac{(\text{Area})(\text{Temperature Hot} - \text{Temperature Cold})}{\text{Thickness}}$$

$$\dot{Q}_{cond} = \frac{kA(T_1 - T_2)}{\Delta x} = -kA \frac{\Delta T}{\Delta x} \quad (W)$$

$$\dot{Q}_{cond} = kA \frac{dT}{dx} \quad (W)$$

Equation 1

Where  $Q_{cond}$  the rate of heat transfer through the wall is doubled when the temperature is difference  $\Delta T$  across the wall or the area  $A$  normal to the direction of heat transfer is doubled,  $k$  is the thermal conductivity of material,  $\Delta x$  is the thickness equal to  $L$  and area  $A$ ,  $T_1$  and  $T_2$  is temperature difference and  $dT/dx$  is the temperature gradient.

## 2.2 Convection

Convection is a mode of energy transfer between a solid surface and a moving liquid or gas, involving the combined effects of conduction and fluid motion. The greater the convection heat transfer, the faster the fluid motion. Despite the complexities of convection, the rate of convection heat transfer is observed to be proportional to the temperature difference, as expressed by Newton's law of cooling. The convection equation, as shown in Equation 2.

$$Q_{conv} = hAs (Ts - T\infty) (W) \quad \text{Equation 2}$$

$Q_{conv}$  is rate of the heat convection transfer,  $h$  is convection heat transfer coefficient in  $W/m^2 \cdot K$ ,  $As$  is surface area through which convection heat transfer take place,  $Ts$  is the surface temperature and  $T\infty$  is the temperature of the fluid sufficiently far from the surface.

## 2.3 Radiation

Radiation is the energy emitted by matter in the form of electromagnetic waves (or photons) as a result of the changes in the electronic configurations of the atoms or molecules. Unlike conduction and convection, the transfer of heat by radiation does not require the presence of an intervening medium. In fact, heat transfer by radiation is fastest (at the speed of light) and it suffers no attenuation in a vacuum. This is how the energy of the sun reaches the earth. The maximum rate of radiation that can be emitted from a surface at a thermodynamic temperature  $Ts$  (in K or R) is given by Stefan-Boltzmann law. Equation of radiation as shown in Equation 3.

$$Q_{emit,max} = \sigma A_s T_s^4 (W) \quad \text{Equation 3}$$

Where  $Q_{emit,max}$  is indicates that net radiation heat transfer is from surface 2 to surface 1,  $\sigma$  is the Stefan-Boltzmann constant,  $A$  is surface area, and  $T$  is the temperature.

## 3.0 TYPE OF ROOF

The roof's purpose is to keep out bad weather and to provide shelter. Each country has its distinctive design. The influence of local culture is due to variations in each type of design. Figure 1 shows the different types and designs of roof houses. Design (a) the gable roof is popular due to the straightforward design of the roof timbers and the rectangular shape of the roof sections. Gable roof is a simple, triangular-shaped roof with downward slopes on either side of a ridge. This avoids details that take a lot of work or cost and are prone to damage. Design (b) hipped roof is a type of roof in which all the sides slope downward to the walls, usually with a fairly gentle slope, design (c) hip and valley roof, design (d) hipped roof with dutch gables, (e) skillion roof. According to Tominaga et al. [8], a roof's pitch has a major influence on the flow of the environment surrounding the building. Every one of these designs has its own set of benefits.

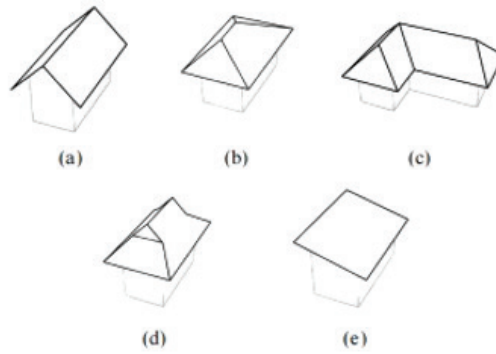


Figure 1: Type of roof (a) gable, (b) hipped, (c) hip and valley, (d) hipped with dutch gables (e) skillion [9]

#### 4.0 RELATED RESEARCH ON HOUSE COOLING SYSTEM

Various roof cooling processes have been built to meet the needs of every homeowner. According to Lien and Ahmad [10], they study on rooftop effects tend to airflow associated with wind turbine ventilators. They found this method is a cost-effectively and also environmental friendly due to natural ventilation tools. However, their findings still have lacking issues due to the using natural ventilation which depending to the air surrounding movements. Thus, this research will be introduced distilled water inside roof material.

According to Alvarado et al. [11] the main disadvantages of evaporation, skytherm, and evapo-reflective are the requirements for water, which can be a problematic in arid regions or other places where water is not available in sufficient quantities at any given time. Therefore, a close concept system is required to overcome the problem as highlighted due to lacks in open system condition. In this present research, a close system will be considered for the water flows inside the roof materials in order to control waste of water, sustainability and maintenance purposes.

There are many types of roof cooling system process such as water spray or moving water film over external shade cloth. Valiant [12] has been study a water spray cooling system for gable roofs that applied for external roof, however this still produced waste of water (mist) due to surrounding loses. Meanwhile, Ghosal et al. [13], conducted an experiment related to the water movement through the film or flowing on the shade that is laid out on the roof and walls of the house. Both of this research has proven negative impact by producing waste water to environment due to the open system applied in their research.

The gable roof type is the mostly used in Asia country like Malaysia because of simple design with low price of fabrication and extremely effective in controlling the hot urban temperature by natural air movement. According to Tominaga et al. [14], they have study different roof pitch by design of gable roof. The roof pitch that they experimented is 3:10, 5:10 and 7.5:10, with good findings at 5:10. The gable roof design is proven good for airflow and wind tunnel due to air circulation as stated in their findings. Therefore, this research will be considered the gable roof design for further investigation. Furthermore, there are similar design by Chong et al. [15], they created a smart roof system to reduce the heat gain of the building and enhance the resident's thermal comfort. This smart roof is composed of PVC tubes integrated with insulation material and assisted by fans and fans to be placed under the roof to act as air passage system. The new roof cooling system proposed will be the same design with smart roof, however the concept of cooling applied is totally different.

### 5.0 FUTURE POTENTIAL

This design will be formed as an equivalent matching roof of the water that will flow through it. The thermo-fluid cooling process is aided by a continuous flow of water fluid on the double roof. The selection of roof design and materials by using water fluid as a cooling system, a water pump for fluid to cycle for cooling process, and the process to fabricate the roof cooling system. The thermo-fluid concept is based on the exchange of heat from hot to cold water. Water will be recycled and reused in the system's cooling process. The water pump will aid in the flow of water through the roof and into the water-cooling process. Figure 2 depicts the expected double roof cooling system to prove working concept prototype.



Figure 2: Proposed future prototype of double roof cooling system concept

The cooling process will be used as a thermo-fluid system for water cycle in the roof cooling process are able to control the temperature from outside from entering inside the house or attic side as illustrated in Figure 3. The cool roof will provide a more comfortable and controlled indoor environment from hot temperatures. Scientific finding related to thermo-fluid effect (radiation-conduction-convection) on actual condition will be lead more understanding toward more exploration in this knowledge.

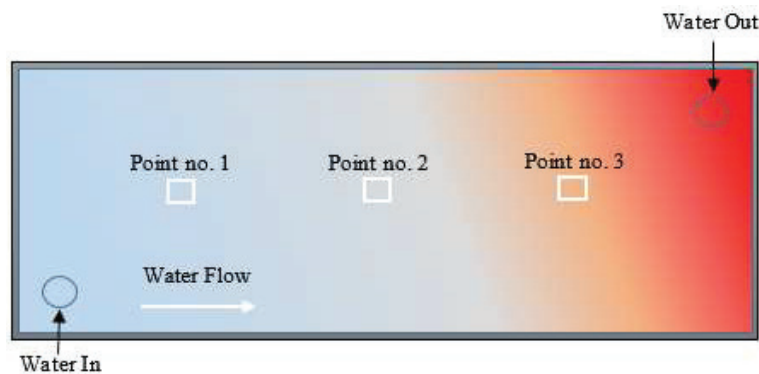


Figure 3: Illustration of expected hot water flow in roof

### 6.0 CONCLUSION

Based on a comprehensive literature review study shows that there are no concept like it has been used by adoption of drainage system via double roofs. This new concept will let the water flow in between two roofs freely but in controlled close system. Fluid will flow inside

the two layers of roofs then flow continuously into two separate tanks namely as cold and hot tank. This process is continuously recycling the water by applied the close system concept. This study will focus on lowering the temperature penetrated the house so that the home temperature will remain cool and not hot like the typical roof.

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