



ALTERNATIVE COOLING SYSTEM OF ZINC ROOFED FOOD STALL USING RIVER WATER RESOURCES

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ABSTRACT

Most personal rural stalls in towns or small cities are using zinc roofs as the top shelter. The material properties itself influence the rate of temperature changes during the afternoon that typically as the peak of daily temperature. Zinc, which is the material of the roof, is a type of good absorbent and heat releasing material. The purpose of this study was to create an alternative system to cool down the area under the roof of zinc-roofed stalls in order to reduce the heat and discomfort during peak temperature periods that believed contributing in customer's satisfaction. An alternative method proposed is the use of corrugated booth cooling system using water resources. This system use natural water resources or the river water as a major resource to cool down the zinc roof which then the space under the stall. The use of river water is natural water gushing and will prevent water shortages. The system sprinkle water on the zinc roof using water sprinkler. This study will analyze two types of data measuring the effectiveness of this system by temperature difference, which is in the space under the stall's roof temperature. Two analyzed spaces divided which are installed system area and space that not installed with the cooling system. The purpose of this two separation data is to compare the temperature differences in the studied area. The system is environmentally friendly and has aesthetic value to afford comfort for the customers.

Keywords: cooling system, natural resources, water, rural, zinc roof.

INTRODUCTION

Various types of stalls that use different roof type materials such as zinc, tiles, polycarbonate roofing, and others. However, the lunch period with sunny and hot weather in the afternoon causing inconvenience to customers especially the stalls using zinc roof. The system also does not require a high cost as it uses natural water resources (Rosdi *et al.*, 2014). Results from this project will help trader's stalls that use corrugated iron as stated in Table-1 to use this system to help cool and provide more comfort to the visitors.

Thatched roofs of zinc are indeed hot especially in the afternoon. Scorching hot weather conditions coupled with rising global temperatures will greatly felt and this causes inconvenience to customers of zinc-roofed stalls because they had to eat in the heat and warm conditions. Therefore, this project is using river water as a coolant to their zinc roof. A zinc roof cooling can reduce the internal temperature under the booth and solve problems of overheating and heat as well as providing more convenience environment for customers.

This research is purposely to implementing the natural resources cooling system to the rural food stall in Batu Pahat Johor Malaysia. The analyses involved are measuring the effectiveness of the cooling system considering the natural river water as the cooling medium. The sample case study been done at the food stall name Warung Asam Pedas-Pakat Pakat in Sri Gading. The food stalls in Sri Gading chosen as the next to the river.

The impact of this project is it indirectly helps cooling zinc roof, thereby lowering the temperature in the booth and give more comfort to the visitors. Results from this project will help trader's zinc-roofed stalls to attract more customers and provide comfort for them to eat in the booth.

SOURCES OF HEATING

Direct sun radiated heat

Global warming is a phenomenon of entrainment gas that known as the greenhouse gas where the gas blocked and trapped the earth's heat from escaping into space. The nature of the gas is allowing sun radiation to pass through but prevent the release of radiation of the earth into the atmosphere. Global warming also affects the temperature and air environment where the temperature and the surrounding air to heat up. It causes people to carry on their daily activities with less comfortable conditions.

Table-1. Approximate weight of different roof types.

Type of food stalls	Number
Zinc Roof Food Stalls	64
Not Roof Zinc Food Stalls	20
Type of Food Stalls	small stalls



Zinc roofed

Roof or the roof is a major component of a building. The roof plays an important role in the structure of a building. Apart from being a protector of the warm weather and rain, the roof shape gives the aesthetics of a building. A building is not complete if no roof constructed. Constructions of the roof are dependent on the climate of an area. The slope of the roof alienated into three types of gradient namely mild slope, moderate slopes and steep slopes. The roof is a roof of a steep slope more than 10° from the horizontal line. For a gradient of 70° upwards categorized as a wall (Mahmod Abd Hakim *et al.*, 2014). For countries that experience snowy winter, the roof used was a steep slope roofs in order to facilitate snow to prevent snow retained and adding load on the roof. Zinc roof is one of the roof coverings on the market (Masiri *et al.*, 2013). In addition, there are also varieties of other materials used for roofing, including concrete tiles, asbestos and clay tiles. The pieces of the roof have its own weight varying between one another. Table-2 shows the approximate weight of the roofs of the self.

Table-2. Approximate weight of different roof types.

Material	Weight (kN/m ²)
Zinc	0.05
Asbestos	0.25
Concrete	0.40 - 0.50

COOLING AGENT MEDIUM

River

The river is a large natural water channels. The source of the river may be from the lake, springs or creeks. Rainwater that falls on the land will usually fall into the ocean or large body of water such as lakes. River end is called the estuary river, while the cause is called upstream (Jackman, 1977). The river usually confined to a channel, made up of the riverbed between two cliffs on either side. Most of the rainfall in the ground would be through the river on its way to the sea. A river usually consists of several streams that merge. Always flowing is the properties that make the river are an ideal source as a cooling agent or medium as shown in Figure-1.



Figure-1. River beside the sample's stall.

COOLING SYSTEM PROCESSES

Heat absorption cycle

A cooling system has developed which using water as the cooling medium to absorb the heat from the source or the zinc roof. The system consider about re-cooling the heated water to start over the cooling cycle. The heated water needs a re-cooling process because it will be used again for another cooling cycle (Rosdi *et al.*, 2015).

Cooling medium temperature dropdown is a way to maintain the temperature gap between the source and the sink. The total net heat been transferred is Q_{net} (Boyd and Kasper, 2003).

$$Q_{net} = \sum_{materials} mc \frac{dT}{dt} \quad (1)$$

m = mass of the medium contacted

c = specific heat

dT/dt = temperature change (with time)

Referring to the equation, it shows that by manipulating the temperature differences will contribute to the heat absorbed by time. Considering river is a flow channel that is always change over time then the medium or heat absorber will always changeable and do not need re-cooling process (Dobrzański, 2009).

Processes flow

The processes flow shown in Figure-2 develop a cycle of resources update and ensure there are no wastage of resources and environmentally friendly. Heated water used will be flow back to the river and replaced (Mahmod *et al.*, 2014).

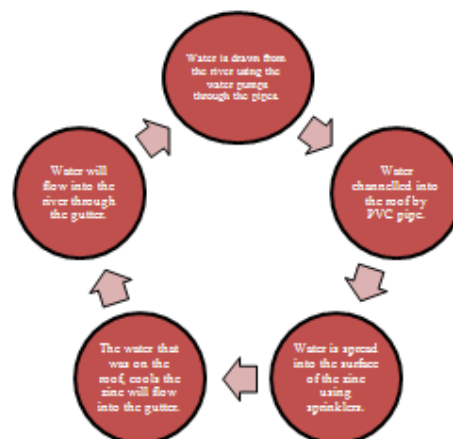


Figure-2. Processes flow.



SYSTEM INSTALLATION

Installation layout

A rural food stall chosen with the owner cooperation to install the system with all the modifications. The stall has the required criteria of zinc roofed and beside a small river to be tested. The critical elements have been identified are the water intake and water outlet. Figure-3 shows the layout of overall system that been installed with the sample stall.

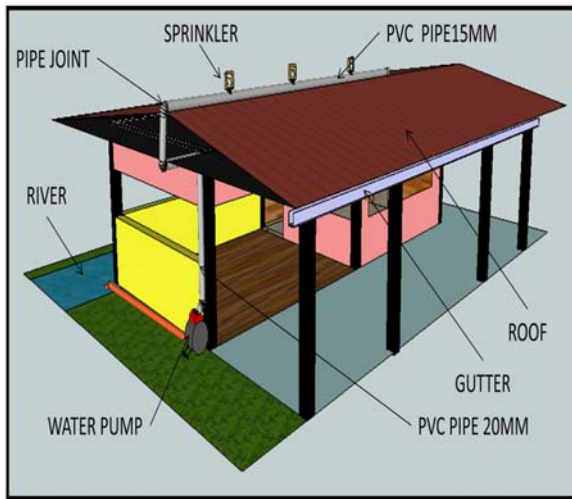


Figure-3. System components installation structure.

Cooling water intake

The cooling water intake is using pipe that immerse into the river beside the stall connected with the water pump which transfer water to the top section. The depth of the input suction also been considered to get the lowest temperature water. Referring to equation (1), the temperature difference between the water and the zinc roof will affect the total net heat transfer.

Heat flux, H that determined, as the rate of heat energy transfer through a given surface, per unit surface is proportional related to the depth of the water, Y (Caissie, 2006).

$$\frac{\partial T}{\partial t} + V \frac{\partial T}{\partial x} = \frac{H}{\rho C_p Y} \quad (2)$$

C_p = specific heat of water

ρ = density of water

Cooling water distribution

Water sucked from the river transferred to the top section that will equally disperse. Component used to transfer the water to the zinc roof is water sprinkler. The sprinkler was purposely to distribute the water equally to the zinc roof covered area and which will undergo the heat

transfer convection cooling also by the increasing droplets surface area (Lee *et al.*, 2007). Meanwhile, the sprinkled water as shown in Figure-4 will enhance the top appearance of the stall that ideally will contribute in business commercialization. The contact area of zinc and cooling water will also contribute in the total net heat transfer in equation (1).

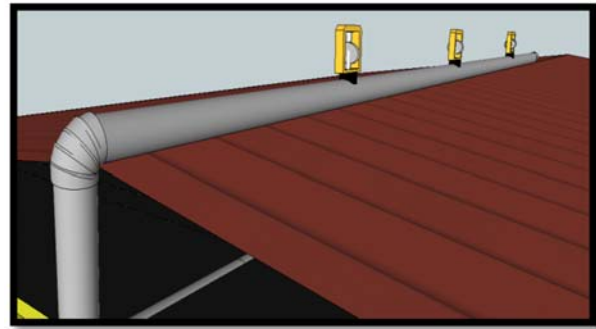


Figure-4. Top section sprinkler.

Heated water dismissal

Heated water that occurs by heat absorption after zinc roof contact will be dismissing back to the river without any recovery processes. Flowing open water channel is a good solution to dismiss the heated water that will cool down the heated water temperature back to original temperature.

TEMPERATURE MEASUREMENTS

Area of study

For the result analysis, four parameters been picked to relate the contribution to the temperature distribution. Referring to Figure-2, the cooling system been installed on half-length of the top section roof to separate the areas under of study. These areas considering just area for customers sitting space to neglect the heat source form other source as kitchen and else. The selection made to compare the temperature just at the customer's area and the airflow velocity within both experimented area assumed as equal.

River water and ambient temperature been considered to be measured to analyze the differences (Beyer, 1983). The ambient temperature measured to see the difference of the temperature outside and inside the stall then paraphrased by cooled and non-cooled area under the stall.

Measurement's procedures

Temperature readings has been measured using four thermometers that statically placed at four places beside the intake hose for the river water temperature, center of both experimented areas under the roof and outside the stall for the ambient temperature. For better



precision, the temperature readings were ran for four days ongoing.

The peak hour for maximum temperature has been identified to be at the range of 1200 until 1400 in noon (Rosdi *et al.*, 2015). The maximum temperature measured at the ambient temperature outside the experimented stall.

DATA COLLECTING AND ANALYSIS

Temperature readings

Temperature readings have been collect at all four areas from 1100 until 1500. All the temperature readings have been ran for four days ongoing for the concept of data precision and accuracy. From Figure-5 shown below, the temperature distributed along the period do shows gap between the areas with cooling system and without cooling system area measured.

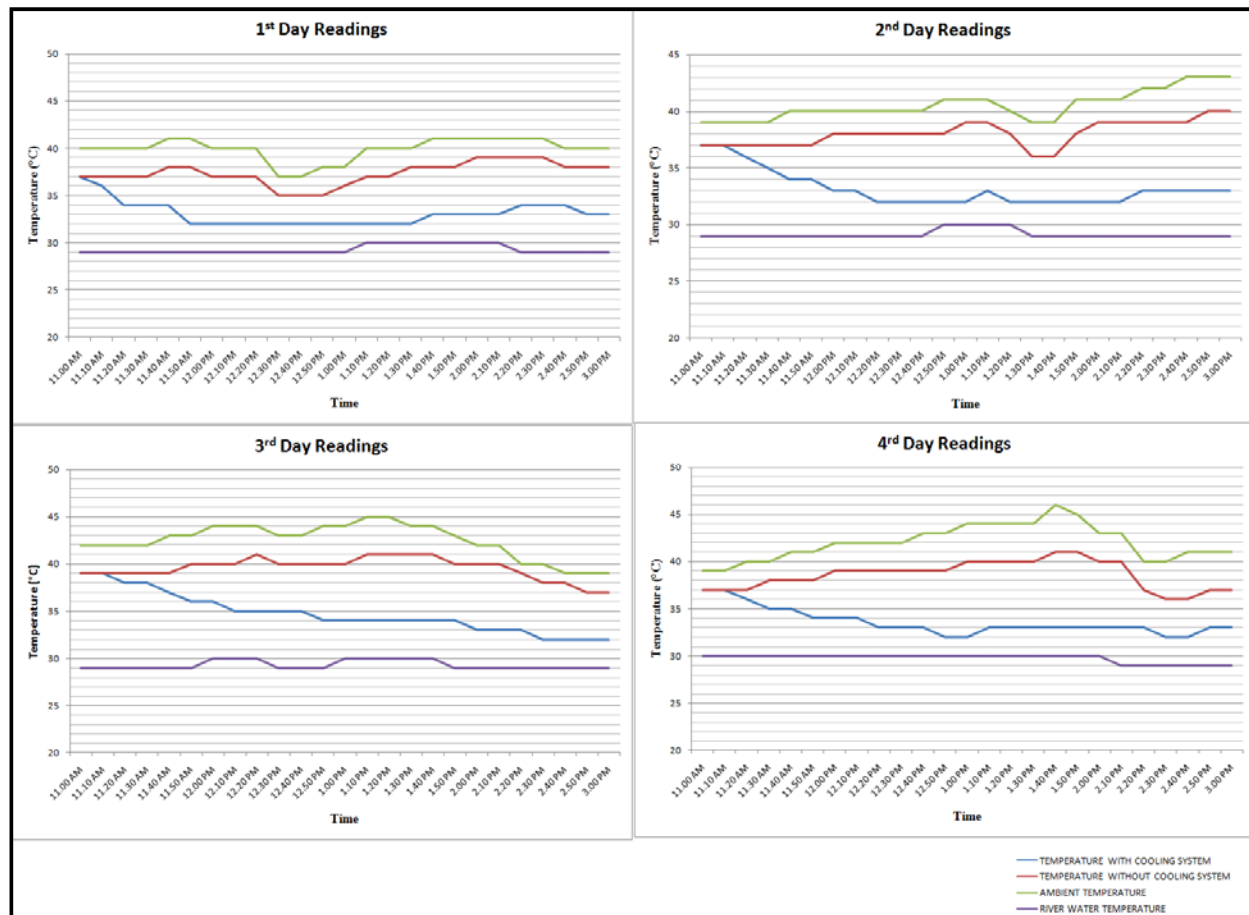


Figure-5. Temperature distribution.

Comparing four areas that been measured from Figure-5 above, directly shows the ambient temperature was always higher than the zinc covered area. This result concludes that zinc roof does contribute in providing lower temperature area compare to open sun expose areas. Second highest temperature was the area without the cooling system and followed by the area with the cooling system. The river water temperature used as the cooling medium was always is the lowest temperature between all four measured temperatures.

Temperature dropdown

Temperature dropdown is the main objective of the study. The temperature dropdown been analyzed to find the maximum temperature drop between two tested spaces. Table-3 shows the maximum temperature gap between the studied areas.

**Table-3.** Maximum temperature drop

Day	Max. temp. difference (°C)
1	6
2	7
3	7
4	8

Heat transfer analysis

From detail view, the cooling system had occurs heat transfer processes that capable of drop down the space temperature installed system. The heat transfer processes have been identify to be conduction with the contact surface of water and zinc roof and convection with the flow of cooling medium water n the zinc roof surface. Indirectly some heat transfer maybe occurs under the roof with airflow heat convection. Total processes experimented to provide 6 °C to 8 °C temperature drop comparing installed and uninstalled space.

CONCLUSIONS

Firstly, the alternative cooling system using water applied on zinc roofed stall had proven that the stall temperature can be cool down using natural resources provided by a river. The water used will be unlimited resources for the system that free of charges. Result in table 3 shows that the system capable to drop down the temperature until maximum 8 °C. The average temperature of cooled space is 35 °C that is 5 °C lower than the average temperature un-cooled space.

From the scope of appearance, the sprinkler in the system provides the look of fountain that is good for customer attraction with the natural look. The system believed to be an affordable and commercial system that can be implementing by the rural zinc roofed stall owner. Some modifications maybe applied regarding the constraints of the rural zinc roofed stall.

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