Technical performance for heat storage of solar cooker using vegetable oil as working gluid

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Abstract

The purposes of the study are to design the solar cooker which used vegetable oil as a heat transfer medium. From the technical performance for heat storage of solar cooker using vegetable oil as working fluid, equipped with evacuating tube of collector an absorber-plate, the palm oils acting as fluid for heat. The design of the system allows its benefits of fixed position on during all of the year. The various foods test the real climatic conditions of Phitsanulok, Thailand showing the solar cookers effectiveness to cook two meals per day. Condition during the cooker works on flow rate of palm oil per day was 0.0025 kg/s and specific heat capacity of palm oil was 2.19 kJ/kg °C, the collector area was 0.78 m^2 and given average of solar radiation per day were 668.43 W/m^2. The maximum and minimum temperature of vessel was 95.94 °C and 57.82 °C respectively that enable to boiled water up to 86 °C, efficiency was at 40.06%. This system can be applied to a kitchen wall of a building. It could be then made use for no sunshine. The result of experiment showed that the solar cooker in this study is usable, there are some factor which can increase its heat efficiency. A solar cooker is used in summer with high temperature and high solar radiation, there is increased and quick heat capacity produced by the solar cooker.

Keywords:

Solar cooker, vegetable oil, evacuate tube

1. Introduction

Thailand's recent interest in the development of renewable energy from the current reliance on imported energy that is derived from fossil fuels and oil from other countries is almost 50% of the country's energy demand. The energy demands of the country are increasing every year, the production cannot meet the rising need of energy demanded, therefore an alternative solution is required.

Renewable energy development would reduce the current demand for imported energy and won't spread the risk of relying on a singular source of energy by using alternative sources of energy. The options available are the development of solar energy, wind energy, hydroelectricity, biogas and garbage. It is possible to lower the cost of renewable energy production, then it might gain increasing acceptance and might be used as a primary source of energy production in the future.

Solar energy is the one renewable energy that can be used as direct and indirect energy. Current research is focused on various ways of developing and improving the efficiency of solar energy production to protect our environment, economy and society. This technology has applications for boiling water, drying, desalination, cooking, electricity production, cooling and pumping.

Solar cooking uses solar energy to cook. It requires locations that have consistent sunlight with applicable areas without relying on any other kinds of energy. The main advantage of utilizing solar energy is that it is completely natural. Moreover, it does not produce any pollutants in the nvironment. The two main methods of solar energy cooking utilize direct and indirect solar radiation cookers [1].

Direct solar radiation can cook food in a pot by letting solar radiation have direct contact with the pot in order to use the potential for harnessing solar radiation. This kind of oven is called a box solar cooker, it works by forcing solar radiation to reflect on a square box that has a lid covering the top of the box [2-5]. The lid can be constructed from glass or plastic plate. The inside is painted black to absorb the heat and transfer it to the food.

Another method is capturing solar radiation using a parabolic plate [6,7] which will provide a higher temperature than a normal box oven. The solar radiation will be gathered a singular point of focus on the pot to increase its temperature and spread heat all over the container. The indirect solar cooker provides heat by using an instrument called a "collector" to produce the heat. The function of the collector is to collect the heat of solar radiation and apply it in heat production. There are three kinds of collectors: flat collectors, vacuum tube collectors and radiation gathering collectors. These collectors will absorb thermal energy and use an intermediary to conduct the heat; for example, water, oil, or other liquids that can conduct the heat [8].

In this study, a solar cooker is designed and fabricated by using a vacuum tube collector. This solar cooker needs to use a liquid to transfer heat and cook food. The liquid that has been chosen for this study is vegetable oil and has a higher rate of heat transfer compared to water which allows faster heat production. Water has a higher capacity for containing heat, but the cooking containers require a higher rate of heat 120 °C beyond water's boiling point of 99.8 °C.

Water is said to have a higher heat capacity compared to vegetable oil. However, this capacity is unsuitable for this study because of its temperature. The high heat of 120 °C through the cooking container needs to be transferred beyond water's boiling point 99.8 °C [9].

Furthermore, vegetable oils are used, they are safe for consumption they are directly extracted from vegetable production. According to industrial production standards, we can ensure that vegetable oil will not have a negative impact on consumers or the environment. This study is original research, there was not any research that used vegetable oil as an intermediary to transfer heat in a solar cooker before.

The solar cooker that used vegetable oils as a media had three main components. The first component is a vacuum tube collector that produces heat from solar radiation that is incident on the collector.

The second component is vegetable oil used to contain and transfer heat to the food container.

The third component is the pail containing heat used to collect heat of vegetable oil. used to contain the heated

The heat of the vegetable oil will be kept inside the well-designed pail. The top of the pail has a concave gap leading inside to place food. Solar radiation makes contact with the vacuum tube collector, it will collect heat before being transferred to the vegetable oil. As the vegetable oil gets hotter; it will flow as referred to the fluid theory of different temperatures.

High temperature hot oil causes floating at its surface, the lower temperature hot oil goes down the storage tank at the bottom and moves up to the heat collector to produce heat again and goes around in circle.

The cooking process has reaches a required temperature; food container can be placed at the top of the storage tank.

The heat of the storage tank will be transferred high temperature to the lower temperature areas by means of conduction according to the difference in temperature and mass. The container then immediately provides heat that is suitable for cooking.

2. Experimental Procedure and Measurements

This experimental research is an efficiency of solar cooker uses vegetable oil as working fluid to designs and structures directly for testing.

This solar cooker was taken to testing for SGtech, Naresuan University, Phitsanulok, Thailand. The collector of solar cooker was the southern part in maximum of solar radiation.

2.1 Study of the heat transfer fluid for solar cooker

In this section, the objective is to select the suitable heat transfer media for the solar cooker system. There were 4 mains properties of the heat transfer media for the solar cooker as follows;

Non-toxic and friendly to the environment; the comparison of emission factors of cooking fuel and vegetable oil. The emission factor of palm oil is 2.2894 kgCO_2eq, which is lower than the emission factor of other cooking fuel.

The vegetables oils have higher heat capacities than water; palm oil is 235 °C a higher smoking point than coconut oils 117 °C and sunflower oil is 227 °C and water is 100 °C.

Higher heat transfer rate than water; the heat rates coefficient of vegetable oils. The palm oil and sunflower oil have higher heat transfer rates than other vegetable oils and water.

Low cost; comparing the cost of vegetable oils for cooking, the cost of palm oil is the lowest 42 Baht/Unit.

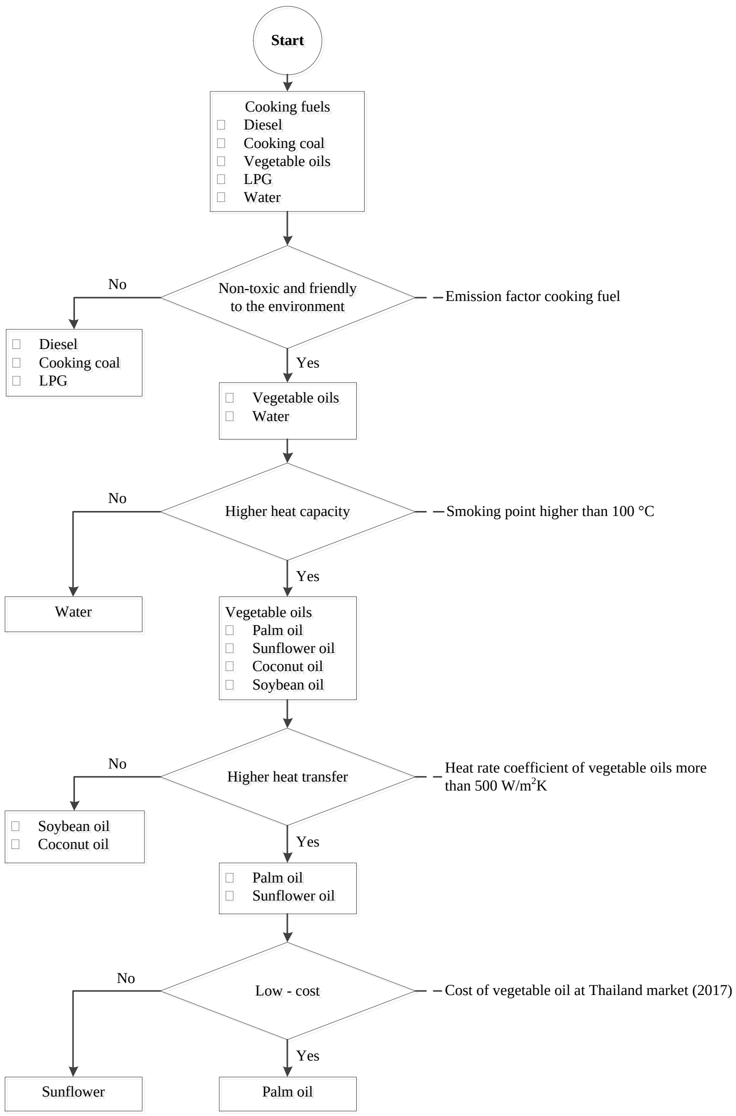

Fig. 1 Flow charted to step of selection the heat transferred fluid for solar cooker.

2.2 Design a primary evaluation of the solar cooker with vegetable oil as the working fluid

The calculation for demand energy to heat up the food is preparation of raw material that is suitable for solar cooking. List of ingredients included vegetables, meat, fish, fruits are cut into small pieces and cooked without adding water. For beans, soak them overnight and cover with water when cooking. Be careful with too much water, it slows downed cooking process. For rice and lentils, cook with water just covering the food.

There are six mains steps for this part as shows in fig. 2

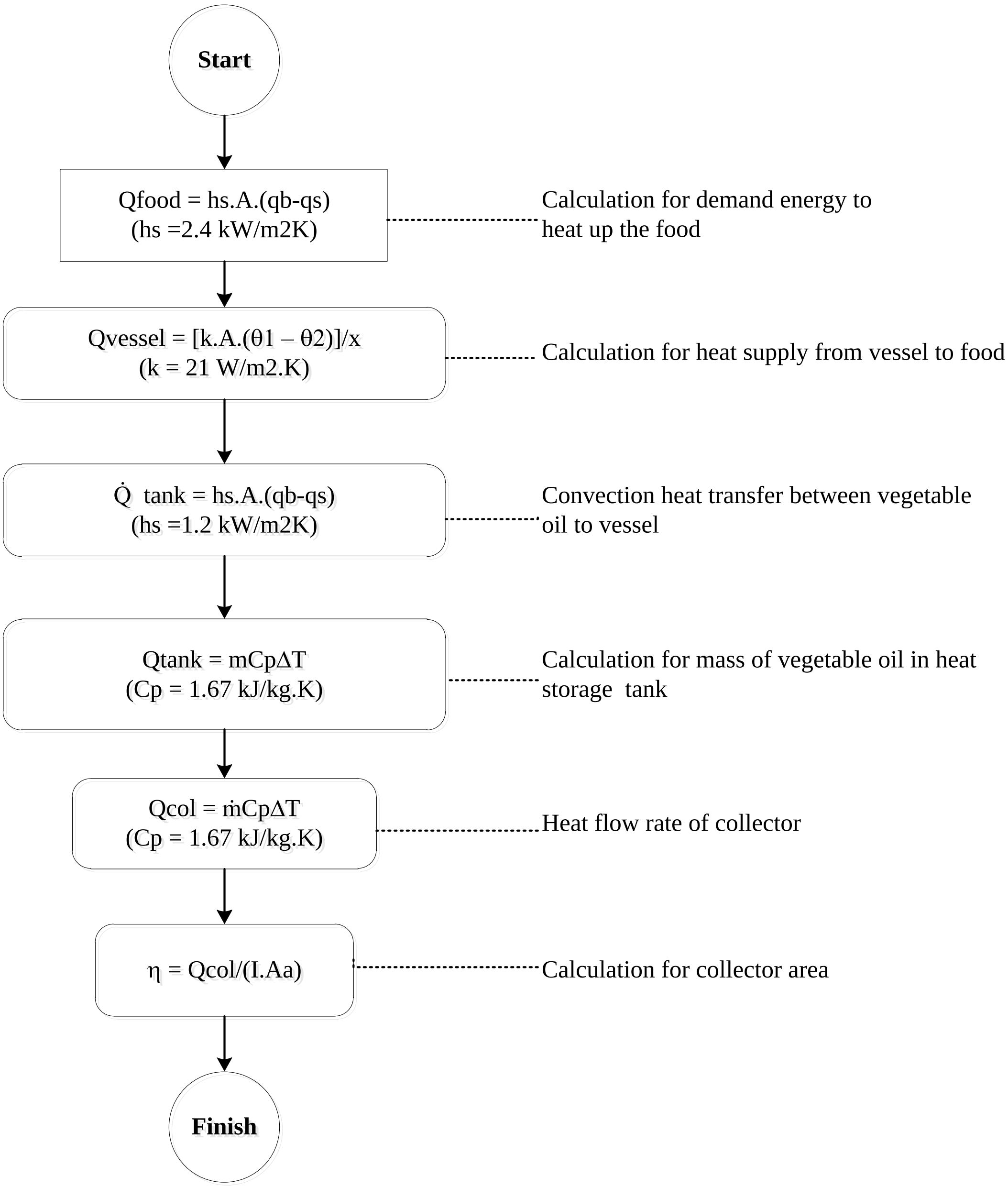

Fig. 2 Solar cooker system sizing flowchart.

2.3 The evaluation of solar cooker

The data recorded should comply with input factor, the measuring data and current meteorological data of the solar radiation such as inclination of the solar radiation, ambient temperature, input and output oil temperature and the flow rate of the vegetable oil. All data was recorded every single minute. As showed in table 1

Table 1 Measuring Data of the Solar Cooker System.

Measuring Parameter	Symbol	Average	Unit	Note
Inclined Irradiance	I	1 min	W/m^2	Pyranometer
Ambient temperature	T_a	1 min	°C	Data recorder
Oil temperature Input	T_{in}	1 min	°C	Data recorder
Oil temperature to reduce	T_{oil}	1 min	°C	Data recorder
Oil temperature in tank Water	T_{tank}	1 min	°C	Data recorder
temperature	T_{water}	1 min	°C	Data recorder
Temperature in vessel	$T_{mean\ 1\text{-}9}$	1 min	°C	Data recorder

The tools of this experimental research were T-type thermocouples/digital thermometer connection, a weather station/data logger connection. Five T-type thermocouples were used to measure mean temperatures of the different components in the bottom vessel for cooking on storage tank. Four T-type thermocouples were used to measure the mean temperature of the different components of the wall of the hole for cooking. Two T-type thermocouples were used to measure the temperature of the different components of palm oil in the storage tank. One thermocouple is used to measure the temperature of the hot oil in the upper portion of the storage tank and one in the lower portion. All thermocouples were connected to the data logger. The weather station/data logger connection was used to measurements the solar irradiance and ambient temperature.

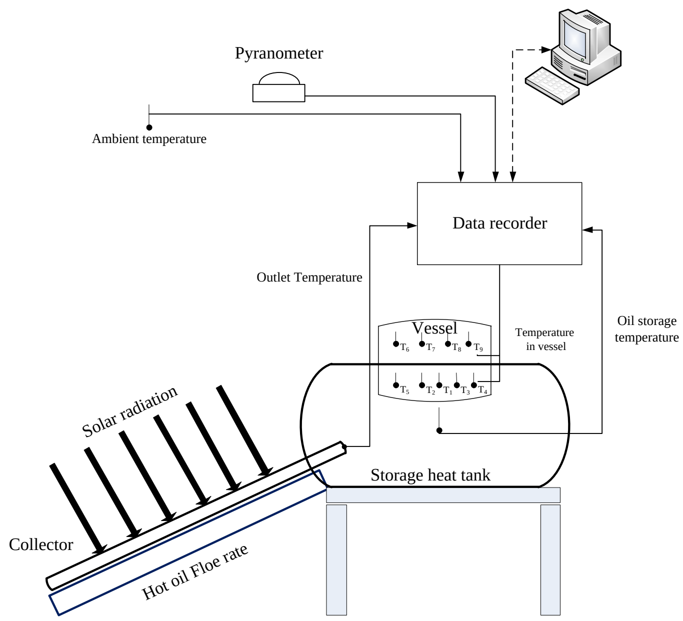

Fig. 3 Measuring positions of the solar cooker.

These experiments on the solar cooker using vegetable oil as the working fluid were conducted with no loads and with different loads and loading times under the actual field conditions of the SGtech, Naresuan University, Phitsanulok, Thailand.

- A set of experiments with no load in the cooking vessel of the solar cooker. This set was conducted to investigate the effectiveness of the evacuating tube collector and to investigate the thermal capability of the heat in the storage tank.
- A set of experiments with cooking loads in water were performed to confirm the results of the experiments with heat transfer of the load and the performance of the heat in the solar cooker using vegetable oil as the working fluid at different cooking times.

Collector efficiency can be calculated by equation 1, η_{col} is collector efficiency, $\dot{m}$ is mass flow rate of the vegetable oil which is equal to the mass of vegetable oil (m)/time of heat storage in the tank. ΔT is the difference in temperature between the vegetable oil and outlet temperature of the solar collector. C_p is specific heat of vegetable oil (W/m^2C). I is irradiation (W/m^2). A_a is surface area (m^2)

$$\eta_{col} = \dot{m} . C_p . (Tout – Tin) / I .A_a \quad (1)$$

Heat efficiency of the solar cooker system can be calculated by equation 2, η_{sys} is collector system efficiency, m is mass of vegetable oil (kg), ρ is density of vegetable oil (kg/m^3), V is total volume of vegetable oil (m^3), C_p is specific heat of vegetable oil (kJ/kg °C), T_f is final temperature of vegetable oil (°C), T_i is internal temperature of vegetable oil (°C), I is incident solar radiation on collector (kJ/m^2) and A_a is Surface area (m^2).

$$Efficiency = \eta_{sys} = (Heat Energy Out/Heat Energy In) = (m.C_p.(T_f – T_i))/I.A_a \quad (2)$$

3. Results and Discussion

3.1Vegetable Oil

Vegetable oil is used in the experiment; it has a higher heat transfer rate compared to water. The heat transfers coefficient of vegetable oil from 300 W/m^2K to 1,000 W/m^2K.

Table 2 Properties Comparison between Various Oils and Water.

Vegetable oil	Density (kg/m^3)	Specific gravity	Thermal conductivity (W/m.C)	Heat transfer coefficient (W/m^{2}K)	Specific heat (kJ/kg.K)	Cost (bath/liter)
Palm	851	0.924	0.16	998	2.19	42
Sunflower	920	0.919	0.17	876	2.15	76
Coconut	924	0.925	0.15	325	2.10	159
Soybean	928	0.966	0.15	469	2.64	53
Water	1,000	1	0.598	100	4.18	-

From table 2, palm oil is the best vegetable oil. The heat transfer coefficients between 300 W/m^2K and 1,000 W/m^2K. It can be concluded that palm oil is getting the best heat transfer rate compared to other vegetable oils. Also it is the lowest priced and can be bought at the local market.

3.2 Design and a primary evaluation of solar cooker

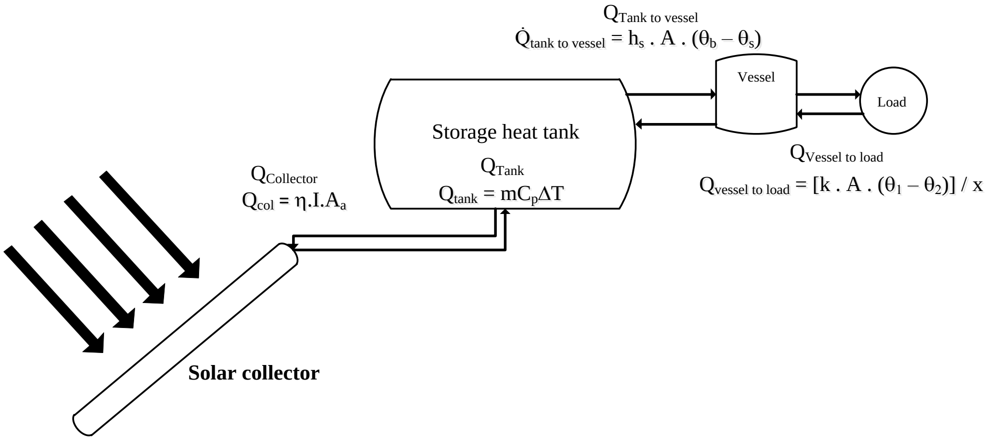

Fig. 4 Performance of the solar cooker using vegetable oil as working fluid.

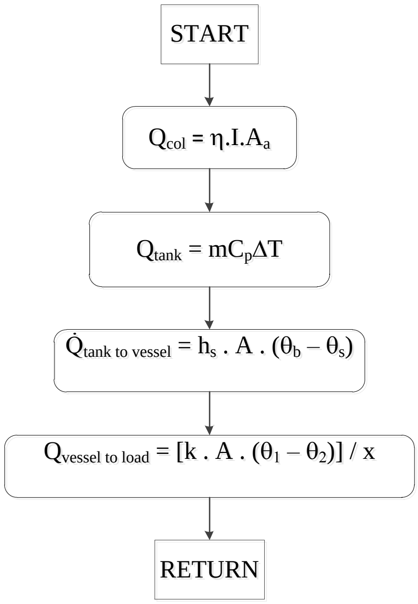

Fig. 5 Flow diagram of the solar cooker using vegetable oil as the working fluid performance calculation.

Performance for heat transfer of the solar cooker using vegetable oil as working fluid

Calculation for heat value of the solar collector

Where $\eta_{Collector}$ is the efficiency of solar collector = 0.28, I is the incident solar radiation on collector plate (W/m^2) = 0.668 kW/m^2, and A_a is the surface area of solar collector (m^2) = 0.78 m^2 , and $Q_{Collector}$ is heat value of solar collector.

$$Q_{Collector} = \eta_{Collector}\ .\ I\ .\ A_a$$
$$= 145 \text{ kJ/s}$$

Calculation for heat value of oil on in tank

Where T_{in} and T_{out} are the temperature of vegetable oil that enters and leaves the tank = 95.9 and 57.8 °C, m is mass of vegetable oil = 46 kg (1 liter = 0.92 kg palm oil), Cp is specific heat of vegetable oil = 2.19 kJ/kg.°C and $Q_{Oil\ on\ tank}$ is heat value of vegetable oil (kJ)

$$Q_{Oil\ on\ tank} = m\ .\ C_p\ .\ (T_{out} - T_{in})$$
$$= 3{,}838.2 \text{ kJ}$$

Calculation for heat value of oil on tank to vessel

Where Q (J/s) is the rate of heat transfer, A(m^2) is the surface area = 0.006 m^2, θ_s is the object's surface temperature = 25°C , θ_b is the bulk fluid = 95.94 °C , and h_s is the surface heat transfer coefficient = 1,200 (W/m^2 °C)

$$Q_{Oil\ on\ tank\ to\ vessel} = h_s\ .\ A\ .\ (\theta_b - \theta_s)$$
$$= 510.5 \text{ J/s}$$

Calculation for heat value of vessel to load

Where Q (J/s) is the rate of heat transfer, k is the thermal conductivity = 0.021 kW/m^2, A is the surface area = 0.006 m^2, $\theta_1 - \theta_2$ is the difference of temperature = (95.9 – 25) °C, and x is the object thickness = 0.0015 m.

$$Q_{\text{Vessel to load}} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 5.96 \text{ kJ/ms °C}$$

Heat production was done using 10 tubes. Each tube has diameter 50.8 mm. length 1.5 m. to parallel in area 0.78 m^2 in the end of tubes sticks to base and inclined at 17 degrees for receiving for receiving vertical solar radiation.

The heat storage system was made from stainless sheet 0.2 mm thick. They were rolled to form a cylinder in horizon two overlap each other. The inner tank has a diameter of 350 mm and the outer tank has a diameter of 450 mm. Inner tank has a capacity of 50 liters. The upper cooked inlet of tank has performed the vessel for cooking. Diameter of the vessel is 20 cm and its height is 20 cm, punch at the upper, the side of tank is used to add and fill the storage tank as in figure 5.

Fig. 5 Solar cooker using vegetable oil as working fluid.

Table 3 Technical Specification of Solar Cooker Uses Vegetable Oil as the Working Fluid.

Material	specification
Dimensions of storage tank	
Inner storage tank	ϕ 350 mm ×572 mm
Overall dimension	ϕ 450 mm ×672 mm
Dimension of collector	
Evacuate tube	ϕ 50.8 mm × 1500 mm × 10 tubes
Collector area	520 mm × 1500 mm
Overall dimension	620 mm × 1500 mm
Dimension of structure	573 mm × 600 mm × 1780 mm
Wheel	ϕ 300 × 6 wheels
Material for structure cooker system	
Storage tank	Stainless sheet0.2 mm thickness
Vessel	Stainless sheet 0.2 mm thickness
Structure	Carbon steel square tube
Wheel	Extrusion plastic film
Insulation	Glass mineral wool
Spacing between inner and outer storage tank	50 mm
Specific heat of palm oil	2.19 kJ/kg.K

3.3 The evaluation of solar cooker

The experiment was conducted on the cooker without a load. The experiment was started on the solar cooker in ambient temperature. Figure 6 shows the variation and incident of the total solar radiation on the collector. Solar radiation in the experiment was higher than 1,000 W/m^2 in the afternoon.

The result measurement of the hot oil temperature. The heat produced a tube from solar collector with an area of 0.78 m^2 can produce heat averaging 64.9 °C and a maximum heat of 75 °C in the afternoon. The hot oil production would be stored in the heat tank on vessel. The hot oil it produced averaged 86.7 °C per day and the maximum heat was 100.4 °C in the afternoon at the ambient temperature 33.8°C.

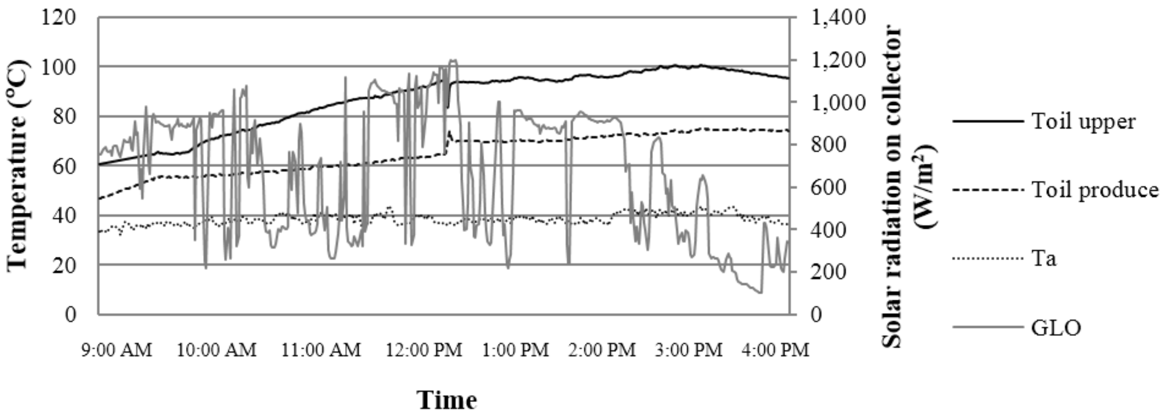

Fig. 6 Temperature of oil in the storage tank.

The results of the temperature in the vessel are divided into two measurements of different temperatures in the vessel which have a little change in temperature. The average temperature at the bottom of the vessel was 82.75 °C and 78.9 °C inside the vessel as showed in figure 7-9

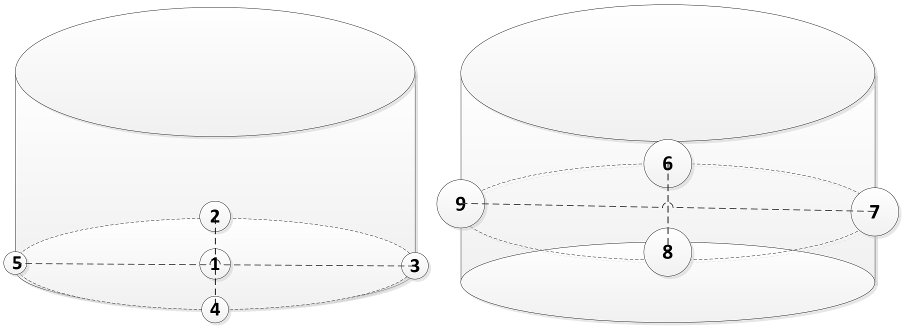

Fig. 7 Temperature point measurement in vessel.

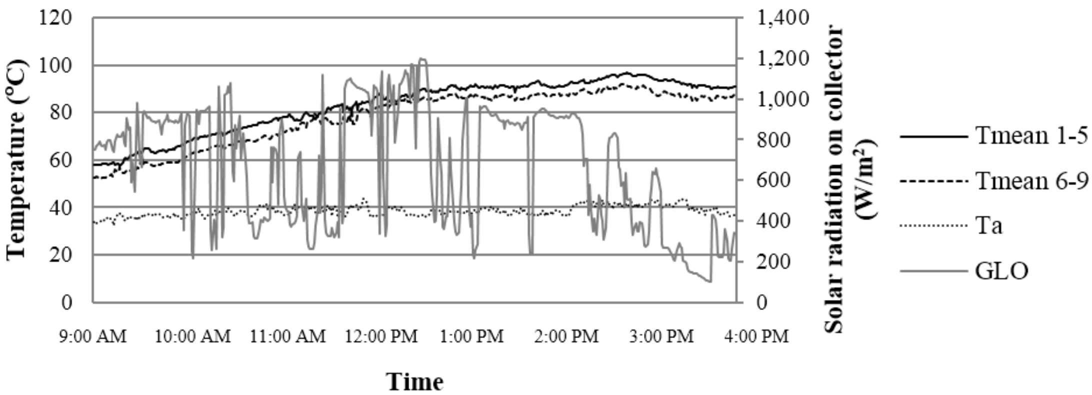

Fig. 8 Average temperature in vessel.

The result measurement of water temperature in vessel to average per day was 71.43 °C and maximum temperature was 86 °C in the afternoon, compared to different temperature of oil in storage tank and temperature in vessel.
It was found that the heat loss was so little that it caused high temperatures water in vessel. In figure 9, the heated oil in the storage tank can accumulate heat and can be used to cooked or warm in the evening.

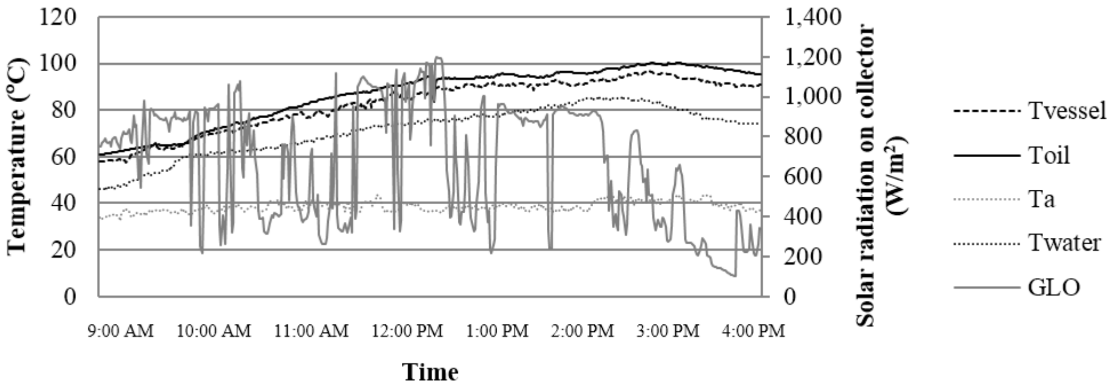

Fig. 9 Differences of palm oil, water and vessel temperature.

Calculation of the efficiency of the evacuated tube solar collector of system

$$\eta_{collector} = \dot{m} \cdot C_p \cdot \Delta T \, / \, (I \cdot A_a)$$
$$= [0.0025 \text{ kg/s} \times 2.19 \text{ kJ/kg °C} \times (57.8 - 31) \text{ °C}] \, / \, (0.668 \text{ kW/m}^2 \times 0.78 \text{ m}^2)$$
$$= 0.282$$

The efficiency of the solar collector system was 28.2 % of the flow rate of palm oils in system per day. It was 0.0025 kg/s and the specific heat capacity of palm oil was 2.19 kJ/kg °C.
The maximum temperature produce in the collector and oil inlet was 57.8 °C and 31 °C respectively. The collector area was 0.78 m^2 and the average solar radiation per day was 668 W/m^2 Calculation of the efficiency assessment of the solar cooker that used vegetable oil as the working fluid

The flow rate of palm oil in the system per day was 0.0025 kg/s, the specific heat capacity of the palm oil was 2.19 kJ/kg °C.

The maximum heat produced in collector and oil temperature inlet was 95.9 °C and 57.8 °C respectively. The collector area was 0.78 m^2 and the average of solar radiation per day were 668 kW/m^2

$$\eta_{collector} = \dot{m} \cdot C_p \cdot \Delta T \, / \, (I \cdot A_a)$$
$$= [0.0025 \text{ kg/s} \times 2.19 \text{ kJ/kg °C} \times (95.9 - 57.8) \text{ °C}] \, / \, (0.668 \text{ kW/m}^2 \times 0.78 \text{ m}^2)$$
$$= 0.4006$$

The efficiency assessment of the solar cooker used vegetable oils as the working fluid in this research and found that the flow rate of the palm oil in the system per day was 0.0025 kg/s and the specific heat capacity of palm oil was 2.19 kJ/kg °C.

The maximum and minimum temperatures produced in the vessel was 95.9 °C and 57.8 °C respectively. The collector area was 0.78 m^2 and the average of solar radiation per day was 668.43 W/m^2. The calculated efficiency of the solar cooker in this study was 40.06%

Table 4 Result for Parameters of Solar Cooker Use Vegetable Oil as Working Fluid.

Collector area	0.78 m^2
Collector efficiency	0.28
Number of parallel collector	8
Solar cooker system efficiency	0.4
Tank volume	50 L
Tank height	350 mm
Set point temperature	90 °C
Tank model	Horizontal cylinder tank
Orientation/tilt angle	South-facing/17°

3.4 Cooking tests

The results of experiments of cooking tests have been conducted on the vessel of solar cooker using vegetable oil as working fluid with different cooking loads.
The experiments found that; the maximum instantaneous and daily enhancements of total solar radiation incident on the collector.

The cooking loaded with actual two cook meals per day. Table 5 shows the first meal was prepared for lunch at 10:30 and the second meal was prepared for dinner at 13:00. The first meal was 6 eggs (360 g) + 1,000 ml water or 240 g rice + 420 g water loaded in cooking pot. The second meals are 244 g chicken + 1,000 g waters or 316 g pork + 800 ml water or 500 g black bean + 1,500 g water loaded in the cooking pot. The rice, eggs or vegetables (cabbage and long beans --- lentils) are added to make the first meal, the meals are completely cooked after 1 hour, the chicken and pork is also completely cooked after 1 hour.

(a)

(b)

(c)

(d)

(e)

Fig. 10 Pictorial view of meals cooked in the solar cooker using vegetable oil as the working fluid.

Table 5 Cooking Tests of Various Foods with the Solar Cooker Using Vegetable Oil as the Working Fluid.

first meal (09:30 - 12:30)			Second meal (12:30 - 16:30)		
Loading time	Food items	Cooking time	Loading time	Food items	Cooking time
10:30	Egg: 1360 g 360 g: Egg; 1,000 g: water	0h40 (63 °C)	13:30	Chicken: 1244 g 244 g: Chicken; 1000 g: Water	1h44 (74 °C)
11:30	Rice: 660 g 240 g: Rice; 420 g: Water	0h50 (74 °C)	13:50	Pork: 1116 g 316 g: Pork; 800 g: Water	1h09 (71 °C)
11.50	Vegetable: 2073 g 322 g: Cabbage; 101 g: Lentils; 1,650 g: Water	0h54 (80 °C)			

Calculation of the rate of heat transfers in food items

Egg: 1,360 g

Where Q (J/s) is the rate of heat transfer of egg, k is the thermal conductivity of water at 60 °C = 0.654 W/m^2, A is the surface area of vessel = 0.006 m^2, $\theta_1 - \theta_2$ is the different of temperature = (63 – 25) °C, and x is the object thickness of egg = 0.02 m

$$Q_{Egg} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 18 \text{ kJ (0h40)}$$

Rice: 660 g

Where Q (J/s) is the rate of heat transfer of rice, k is the thermal conductivity of water at 70 °C = 0.663 W/m^2, A is the surface area of vessel = 0.006 m^2, $\theta_1 - \theta_2$ is the different of temperature = (74 – 25) °C, and x is the object thickness of rice = 0.05 m

$$Q_{Rice} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 11.7 \text{ kJ (0h50)}$$

Vegetable: 2,073 g

Where Q (J/s) is the rate of heat transfer of vegetable, k is the thermal conductivity of water at 80 °C = 0.670 W/m^2, A is the surface area of vessel = 0.006 m^2, $\theta_1 - \theta_2$ is the different of temperature = (80 – 25) °C, and x is the object thickness of vegetable = 0.02 m

$$Q_{Vegetable} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 35.96 \text{ kJ (0h54)}$$

Chicken: 1,244 g

Where Q (J/s) is the rate of heat transfer of chicken, k is the thermal conductivity of water at 70 °C = 0.663 W/m^2, A is the surface area of the vessel = 0.006 m^2, $\theta_1 - \theta_2$ is the different of temperature = (74 – 25) °C, and x is the object thickness of chicken = 0.02 m

$$Q_{Chicken} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 60.5 \text{ kJ (1h44)}$$

Pork: 1,116 g

Where Q (J/s) is the rate of heat transfer of pork, k is the thermal conductivity of water at 70 °C = 0.663 W/m^2, A is the surface area of vessel = 0.006 m^2, $\theta_1 - \theta_2$ is the different of temperature = (71 – 25) °C, and x is the object thickness of chicken = 0.02 m

$$Q_{Pork} = k \cdot A \cdot (\theta_1 - \theta_2) / x$$
$$= 38.1 \text{ kJ (1h09)}$$

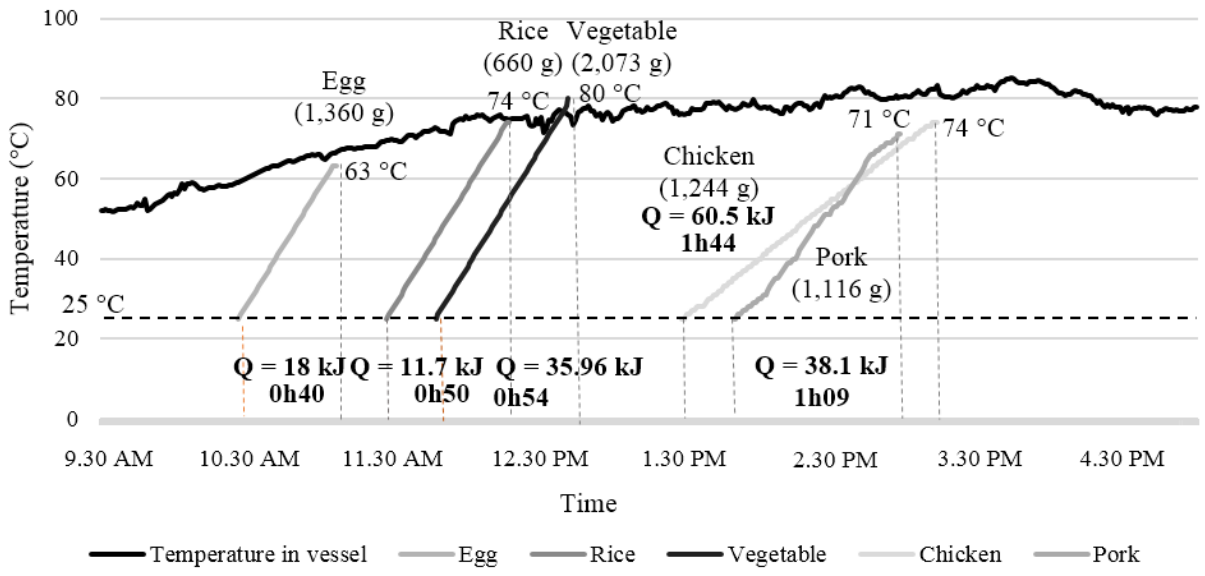

Fig. 11 Graph shows the cooking tests of various foods with the solar cooker using vegetable oil as the working fluid.

The cooking tests of various foods with the solar cooker using vegetable oil as the working fluid. Based on the results of the experiments that had been conducted on the cooker with different actual cooking loads, the experiments are maximum instantaneous and Daily Enhancements in the total solar radiation are incident on the collector. The cooking was done using two loads per day. The first were 6 eggs (360 g) + 1,000 ml water or 240 g rice + 420 g water loaded in cooking pot. The second meal was 244 g chicken + 1,000 g waters or 316 g pork + 800 ml water or 500 g black bean + 1,500 g water loaded in the cooking pot. The rice, eggs and vegetables (cabbage and lentils) are added to first meal, the meals were completely cooked after 1 hour.

4. Conclusions

The technical performance of heat storage in a solar cooker using vegetable oils as the working fluid. It is equipped with evacuating tube of collector an absorber-plate, and palm oil as the heat transfer media. The prototype was constructed by simple means and locally available materials. The design of the system allows the benefits of a fixed position all year round. The various foods tested the real climatic conditions of Phitsanulok,

Thailand which showed its effectiveness by cooking two meals per day. In addition, it can be used as a heat storage device for cooking and warming even without sun light. This system can be applied in the kitchen wall of a building. It could be then make use of no sunshine.

This study has chosen only vegetable oil as working in collector and heat storage tank of the solar cooker system.

The system could heat the oils up to 90 degrees Celsius, higher than water in glass tubes of the solar radiation panels [12]. The heat from the oil in the storage tank is transferred to the cooking vessel where it can be used for boiling water to cook food.

It not necessary to cooking with outdoor same as other solar cooker [2,6], and can also accumulate heat of cook at evening times.

This solar cooker could be used for cooking in a kitchen with the collector outside of the building. It can also produce foods that meet food safety standards as well [16].

The results of this experiment showed that the solar cooker in this study is usable, and there are some factors which can increase its heat efficiency. There is increased and quick heat capacity produced by the solar cooker.

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