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Thermosyphon Application for Temperature Distribution of Vegetable Oil in Vacuum Fryer

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Abstract

This research was to investigate thermosyphon application for temperature distribution of vegetable oil in vacuum fryer. Thermosyphon is made from stainless tube with inner diameter of 2 cm and length of 40 cm. The working fluid was distilled water. The volume of pot fryer was 0.12 m³. The temperature for testing was 80, 90 and 100 °C. The air pressure in a vacuum frying pot for testing was 0.6, 0.8 and 1 bar. It was found that thermosyphon can distribute the temperature of vegetable oil in a vacuum frying pot. When thermosyphon was installed to a vacuum fryer, the average difference of vegetable oil temperature was ± 1 °C.

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Keywords: Thermosyphon; Vacuum fryer; Heat Pipe

1. Introduction

Thailand is the agricultural country. Thailand has many fruits and many vegetables. The problem of many types of agricultural products was the inability to keep the products over season and also low price problem. To solve this problem, agricultural products were transformed and kept for using over season. Frying fruits and vegetables is a way to keep them. Fried fruits and vegetables are more costly than common ones.

Vacuum frying is an efficient method of reducing the oil content in fried snacks, maintaining product's nutritional quality, and reducing oil deterioration. It is a technology that can be used to produce fruits and vegetables with the necessary degree of dehydration without excessive darkening or scorching of the product. In vacuum frying operations, food is heated under reduced pressure [<60 Torr ≈ 8 kPa] causing a reduction in the boiling points of the oil and the moisture in the foods [4]. There are many high nutritious vegetables and fruits that could be vacuum-fried. In Thailand this technology is used to produce highly nutritious snacks.

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Heat pipe exchanger is equipment in many industries. The effectiveness of heat pipe depended on material of tube and working fluid in tube. Heat pipe consists of three sections – condenser, adiabatic and evaporator sections. The thermosyphon is a type of the heat pipe.

Thermosyphon transfers heat in exactly the same way as the heat pipe, which is evaporation and then condensation. Thermosyphon is a passive heat transfer device with high effective thermal conductivity. Thermosyphon is similar to a heat pipe. Thermal input at the evaporator region vaporizes the working fluid and this vapor travels to the condenser section. At the condenser region, the vapor of the working fluid condenses, and the latent heat is rejected via condensation. As result of heat pipe and thermosyphon advantages, it was applied to exchange heat and studied to improve the effective heat pipe [1-3,5].

As a result, at a bottom of vacuum pot fryer the temperature of vegetable oil is higher than upper level. Therefore, in this research the thermosyphon was applied to distribute temperature of vegetable oil in vacuum fryer.

2. Experimental setup and procedure

2.1 Thermosyphon Heat Exchanger

Thermosyphon as shown in Figure 1 was made from stainless steel tube number 304 with inner diameter of 25 mm. The length of thermosyphon was 400 mm. The distilled water was used as working fluid. The ten thermosyphons were set up to stand, then set up the stand with ten thermosyphons to vacuum frying pot.



Fig. 1. Thermosyphons

2.2 The Vacuum Fryer

The vacuum fryer in this research, Figure 2, was divided into four parts: the vacuum frying pot, the electric heater, the vacuum pump and the air filter. The vacuum frying pot for frying was made from stainless steel number 304 of 2 mm (thickness), and the volume of pot fryer was 0.12 m³, then the pot fryer was covered by thermal insulator. The electric heater (3,000 W) was set up at the bottom of pot fryer for heating vegetable oil. The vacuum pump (20 L/minute) was used to suck the air from inner frying pot. The air filter was used for catching oil and water vapours; the air was passed through before it enters the vacuum pump.

2.3 Operating conditions

The vegetable oil was palm oil. The palm oil of 70 L was filled into frying pot. The temperature difference of palm oil was determined by setting vegetable oil temperature in frying pot of 80, 90 and 100 °C. When the palm oil temperature was up to equilibrium temperature, the temperatures of palm oil were measured and recorded every five minutes until 1 hour by testo 177-t4 v01.10, the positions for temperature measurement are showed in figure 4. The pressure for testing was 0.6, 0.8 and 1 bars.

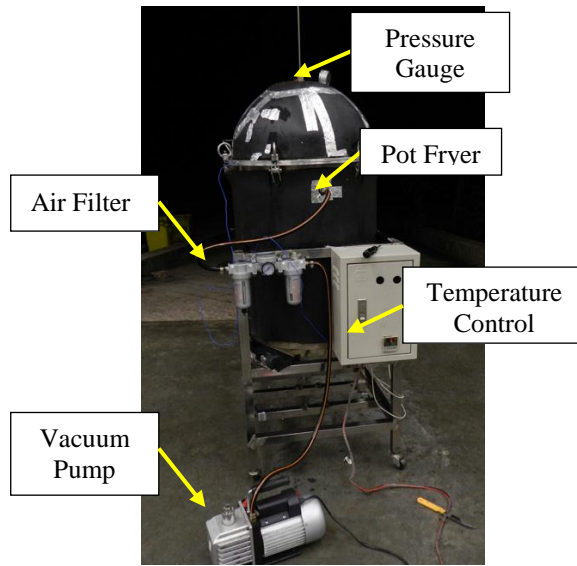


Fig. 2. The vacuum fryer

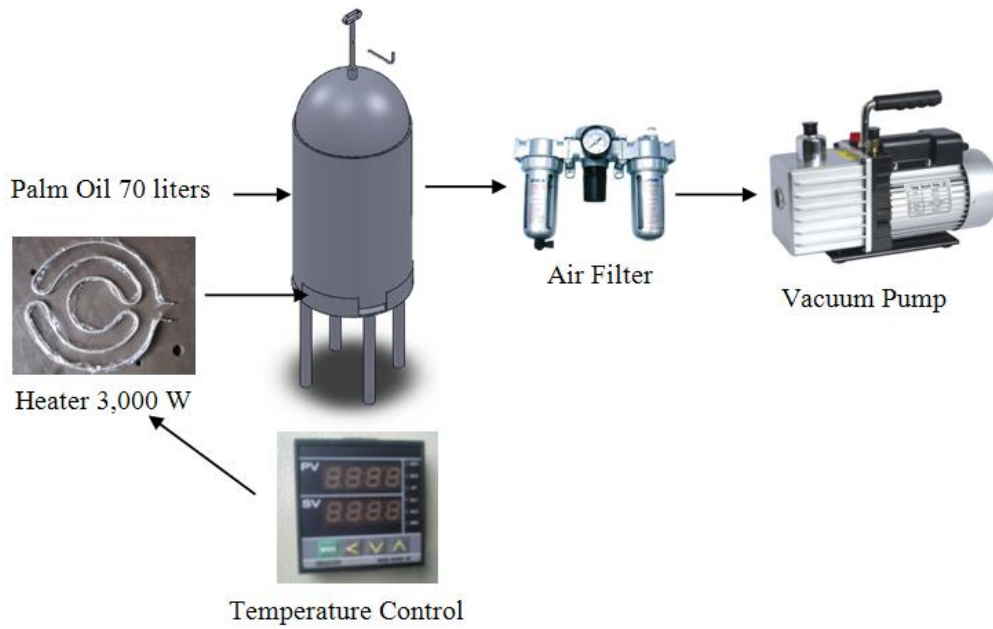


Fig. 3. The schematic diagram of the vacuum fryer

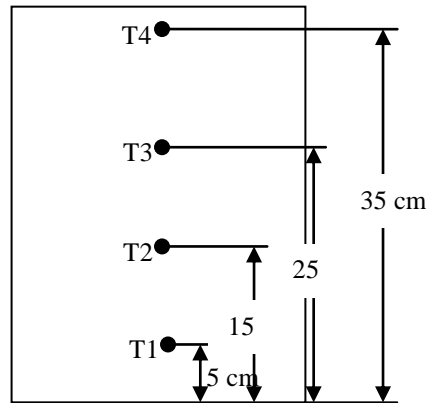
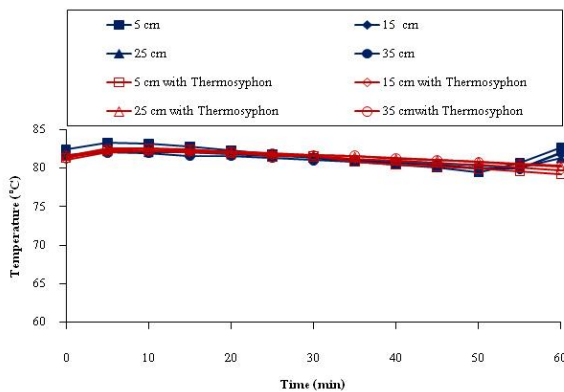


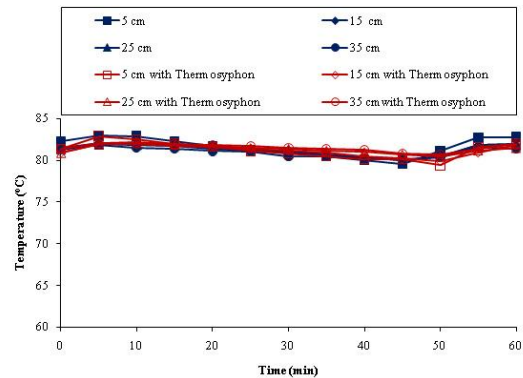
Fig. 4. The positions for temperature measurement

3. Results and discussions

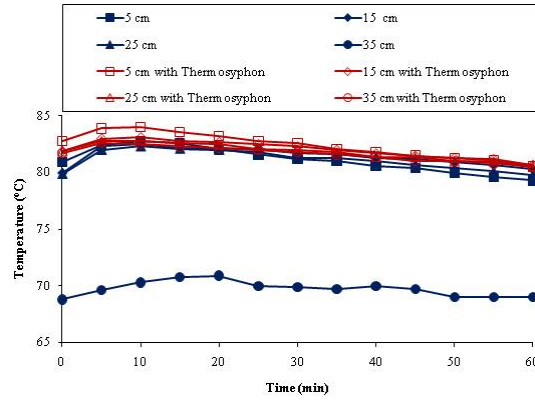
In Figure 5-7 it shows the result of temperature at any positions. It was found that thermosyphon can be distributed the oil palm temperature in any inner pot air pressure and any oil palm temperature. The oil palm temperature difference in vacuum frying pot with thermosyphon was lower than the oil palm temperature difference in vacuum frying pot without thermosyphon. The average temperature at 35 cm without setting up thermosyphon as shown in figure 5 (C) was lower than other results because in case of air pressure of 1 bar at 80 °C, palm oil boiling was turbulence less than in case of air pressure of 0.6 and 0.8 bar. When thermosyphons were set up in vacuum frying pot, the average of temperature difference interval in any point was ± 1 °C. Because the thermosyphon can transfer heat from bottom level of oil palm in vacuum frying pot (high temperature) to upper level of oil palm in vacuum frying pot at the same oil palm temperature and air pressure in vacuum frying pot, the oil palm temperature difference in vacuum frying pot with thermosyphon was lower than the oil palm temperature difference in vacuum frying pot without thermosyphon.



(a) 0.6 bars

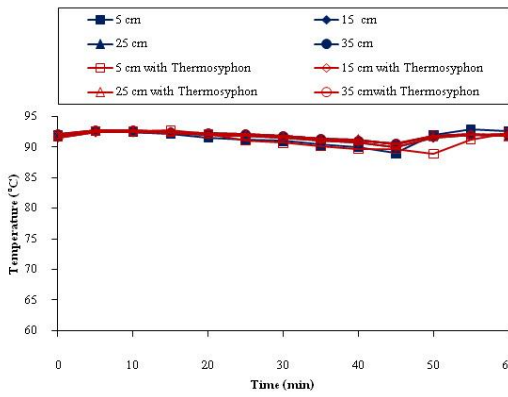


(b) 0.8 bars

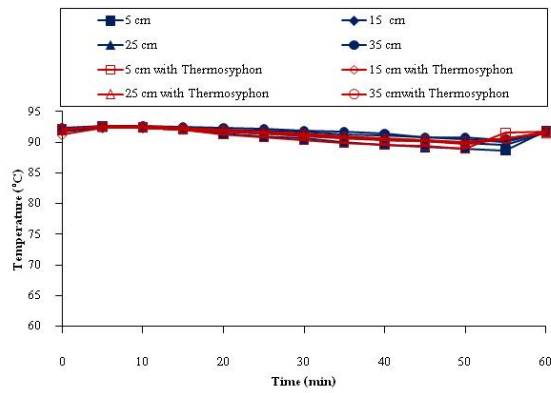


(c) 1.0 bar

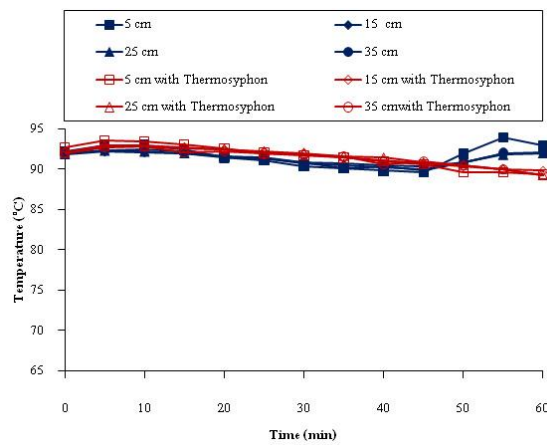
Fig. 5. The temperature difference results of palm oil at 80 °C



(a) 0.6 bars

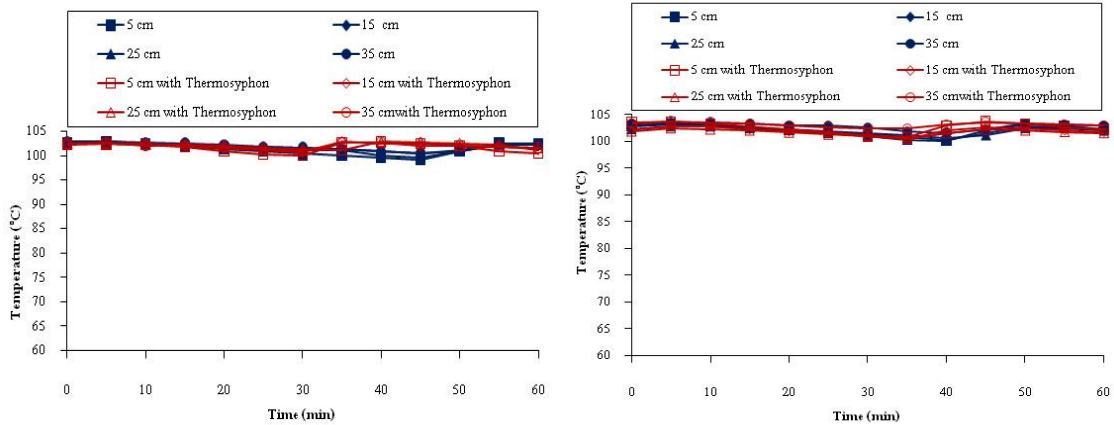


(b) 0.8 bars



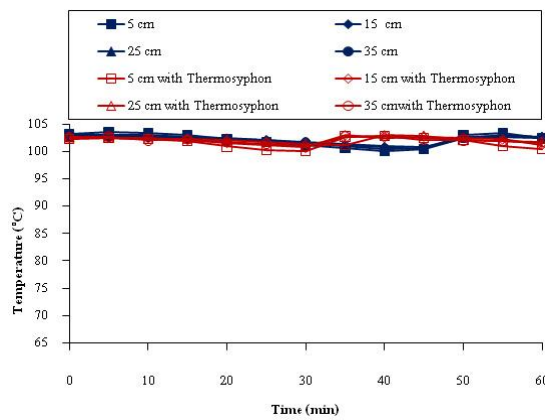
(c) 1.0 bar

Fig. 6. The temperature difference results of palm oil at 90 °C



(a) 0.6 bars

(b) 0.8 bars



(c) 1.0 bar

Fig. 7. The temperature difference results of palm oil at 100 °C

4. Conclusions

Thermosyphon can distribute the oil palm temperature in any inner pot air pressure and any oil palm temperature. The oil palm temperature difference in vacuum frying pot with thermosyphon was lower than the oil palm temperature difference in vacuum frying pot without thermosyphon.

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