



The Green Logistics Idea using Vacuum Insulation Panels (VIPs)

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ABSTRACT

This research aims to reduce fuel consumption in transportation systems using vacuum insulation panels (VIPs) for cold storage trucks. The material was vacuum Insulation Panels (VIPs) is a custom-made insulator using glass fibers pressed at 10 tons per square meter and the thermal conductivity conditions of the selected materials ranged between 0.0028 and 0.007 W/mK and has a size of 12 mm comparative experiment method of cold storage trucks equipped with VIPs and without VIPs of 4 model frozen cars. Which has Model 1 (4 Wheels Truck), Model 2 (4 Wheels large Truck), Model 3 (6 Wheels Truck), and Model 4 (10 Wheels Truck). The sensor installation in the cold room is distributed in every wall to achieve differentiation and distribution of cold temperatures. The results are calculated as the energy saving result, it was found Model 1 (4 Wheels Truck) have best fuel savings. This research can apply other types of cold storage trucks or research in the same way as the air wall by inserting VIPs insulation inside the external insulation to reduce heat transfer.

1. Introduction

Logistics costs are still a business concern and national development. Especially the cost of inland transportation, which includes refrigerated and frozen vehicles. The cold supply chain management, cold supply chain management Maintaining product quality from upstream and midstream to downstream is a challenge in achieving optimal quality control and cost effectiveness [1]. Therefore, most of the costs come from the use of engine power by oil for produce cooling to maintain the product temperature. From Figure 1 overview of heat loads of cold storage, 51% heat load form through walls, 23 % heat load form heaters and fans, 12% heat load form gasket area, 6% heat load form gasket area from food and 2% heat load form door openings [2]. This means that reducing the heat load that passes through the walls of the cold room is the best reduction in energy consumption [3].

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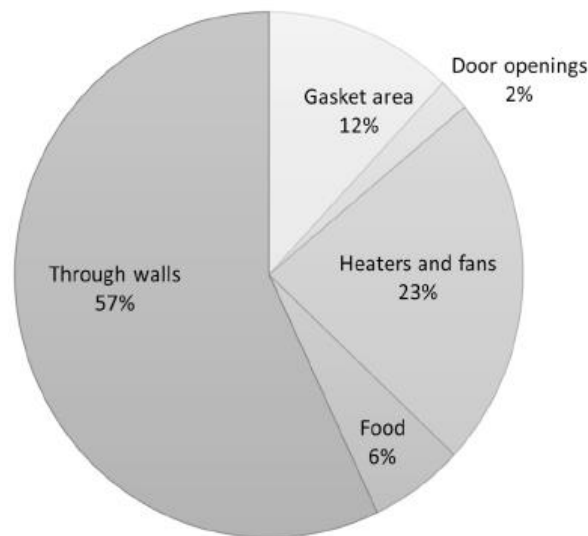


Fig. 1. Overview of heat loads of cold storage [1]

Cold storage insulators have been continuously developed from the past to the present. The progressing of cold room insulators, as shown in Figure 2 [4]. Found that, the best heat transfer coefficient (U value) value is vacuum insulated panels (VIPs) [5] and smallest size [6]. Therefore, VIPs is appropriate to be used in this research to reduce the heat load, reduce energy consumption and maintain the quality of the product [7].

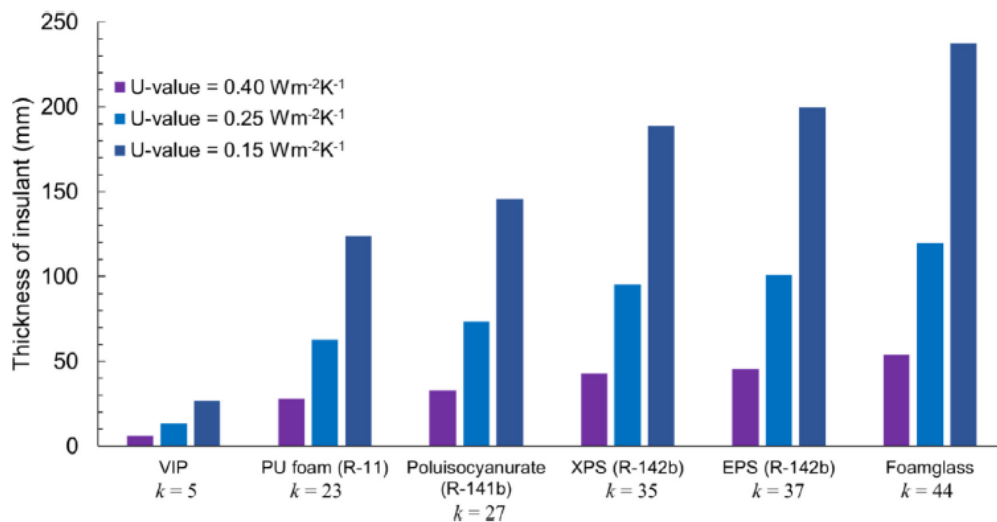


Fig. 2. The progressing of cold room insulators [4]

The logistics model uses a frozen truck with the temperature at -25 to -23 degrees Celsius, chiller trucks 0 to -2 degrees from the factory to the distribution center, and end-user. The type and size of rucks in this model will differ from length to the destination or product type. When using many types or many trucks, the cost will be high and difficult to control. The green logistics model happens to solve the effect of environmental from logistics, such as fuel in logistics and carbon dioxide from engines. This research will present the idea of the green logistics using vacuum insulation panels (VIPs) that u-value better than polyurethane foam [8].

2. Materials and Methods

The material, VIPs is a custom-made insulator using glass fibers pressed at 10 tons per square meter, then vacuumed and foil wrapped. The limitations of VIPs are currently not available in a wide variety of applications [9], as they must be prevented from impacting or kinking resulting in loss of insulation due to vacuum loss [10]. The vacuum insulated panels (VIPs), as shown in Figure 3 [11]. The thermal conductivity conditions of the selected materials ranged between 0.0028 and 0.007 W/m K and has a size of 12 mm [12].

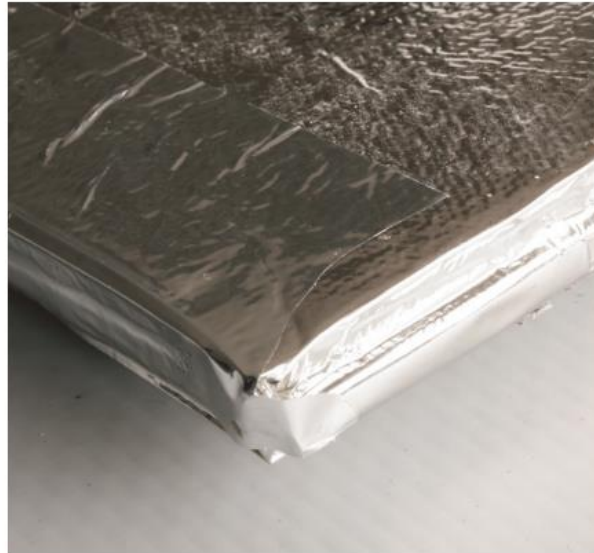


Fig. 3. The vacuum insulated panels (VIPs) [11]

The methods, Comparative experiment method of cold storage trucks equipped with VIPs and without VIPs [13] of 4 model frozen cars, as shown in Figure 4. Which has Model 1 (4 Wheels Truck), Model 2 (4 Wheels large Truck), Model 3 (6 Wheels Truck) and Model 4 (10 Wheels Truck). All 4 models of the frozen cars will have the machine specification as shown in Table 1 [14]. There are 7 temperature measurement points, consisting of 6 temperature points inside the cold room and 1 outside temperature in model 1,4. There are 6 temperature measurement points, consisting of 5 temperature points inside the cold room and 1 outside temperature in model 3. There are 5 temperature measurement points, consisting of 4 temperature points inside the cold room and 1 outside temperature in model 2. The sensor installation in the cold room is distributed in every wall to achieve differentiation and distribution of cold temperatures. The installation of the sensor outside the cold storage is installed behind the cold storage trucks to prevent wind and pressure coming into contact with the sensor, resulting in inaccurate measurements. The Temperature measurement location, as shown in Figure 5 [15] and how to install an additional VIPs in a cold room, as shown in Figure 6 [16].



Fig. 4. Frozen cars 4 models

Table 1
 Spec cars 4 model

| Item / Model | Model 1 | Model 2 | Model 3 | Model 4 |
|-------------------------------|------------|--------------|------------|------------|
| 1. Compressor | | | | |
| 1.1 Model | SD5H14 | SD-709/TM-16 | DKS-32 | DKS-32 |
| 1.2 CC | 138 | 163 | 313 | 313 |
| 2. Motor 380V | - | - | - | 7.5 hp |
| 3. Refrigerant Types | R 404A | R 404A | R 404A | R 404A |
| 4. Application Range | | | | |
| 4.1 Truck Type (Wheels) | 4 | 4 | 6 | 10 |
| 4.2 Cabinet Dimension (m) | | | | |
| - W | 1.66 | 1.72 | 2.16 | 2.30 |
| - L | 2.41 | 3.38 | 6.50 | 7.10 |
| - H | 1.60 | 1.60 | 2.15 | 2.30 |
| 4.3 Room Temp. (c) | 0 or -25 C | 0 or -25 C | 0 or -25 C | 0 or -25 C |
| 5. Truck detail (Isuzu Truck) | | | | |
| - CC | 1900 CC | 3000 CC | 5200 CC | 7790 CC |
| - hp | 150 hp | 130 hp | 150 hp | 300 hp |
| 6. Fuel | Diesel | Diesel | Diesel | Diesel |

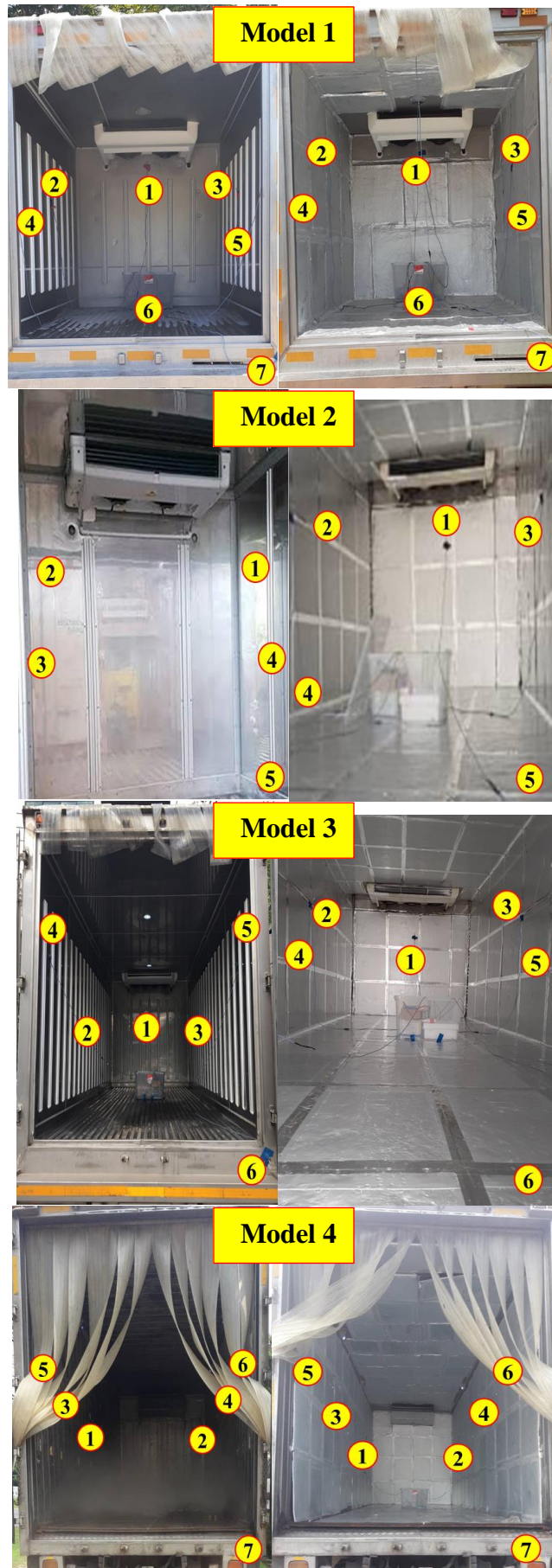


Fig. 5. The Temperature measurement location

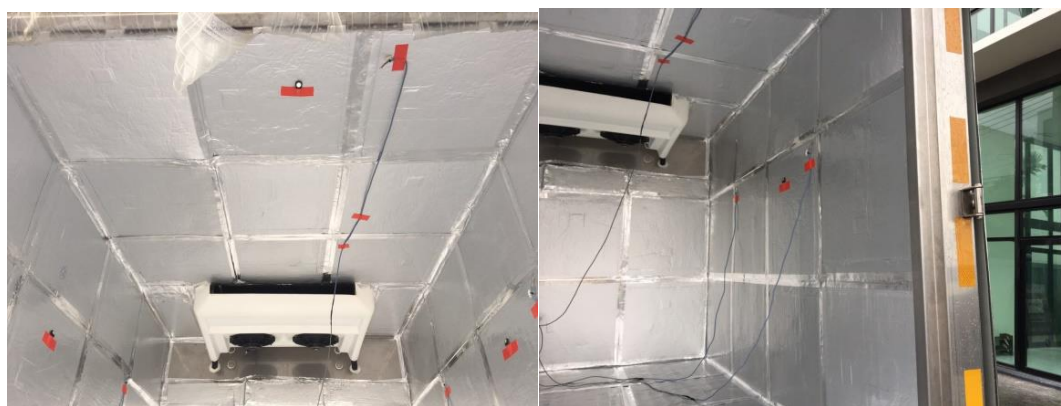


Fig. 6. How to install an additional VIP in a cold room [16]

3. Results and Discussion

3.1 Model 1 - 4 Wheels Truck

As a result of the temperature results prior to installation of VIPs, as shown in Figure 7, it was found that the refrigerated cars were controlled an average of -12 degrees and defrosted 6 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -8 degrees due to the defrosting with heater. The average temperature along the route was 944 kilometers, averaging 26 degrees. The compressor takes 5 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 5 minutes. The compressor cut in - cut off time before install VIPs, as shown in Figure 8.

As a result of the temperature results rear to installation of VIPs, as shown in Figure 9, it was found that the refrigerated cars were controlled an average of -12 degrees and defrosted 6 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -8 degrees due to the defrosting with heater. The average temperature along the route was 944 kilometers, averaging 26 degrees. The compressor takes 10 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 10 minutes. The compressor cut in – cut off time after install VIPs, as shown in Figure 10.

Test results show that VIPs insulation can maintain the same temperature as without VIPs insulation but the time required for cut in cut off is better to install VIPs insulation. The energy saving effect comes from the moment when the compressor is stopped, which means saving fuel to be used in cooling as a result of VIPs insulation. When all the results are calculated as the energy saving result, it is obtained that over a distance of 944 km, the fuel price is 26.39 baht / liter. It was found that the fuel consumption rate before VIPs installation was 7.12 km / liter, and compared with the after VIPs installation at 8.33 km / liter, the fuel savings was 17.06%.

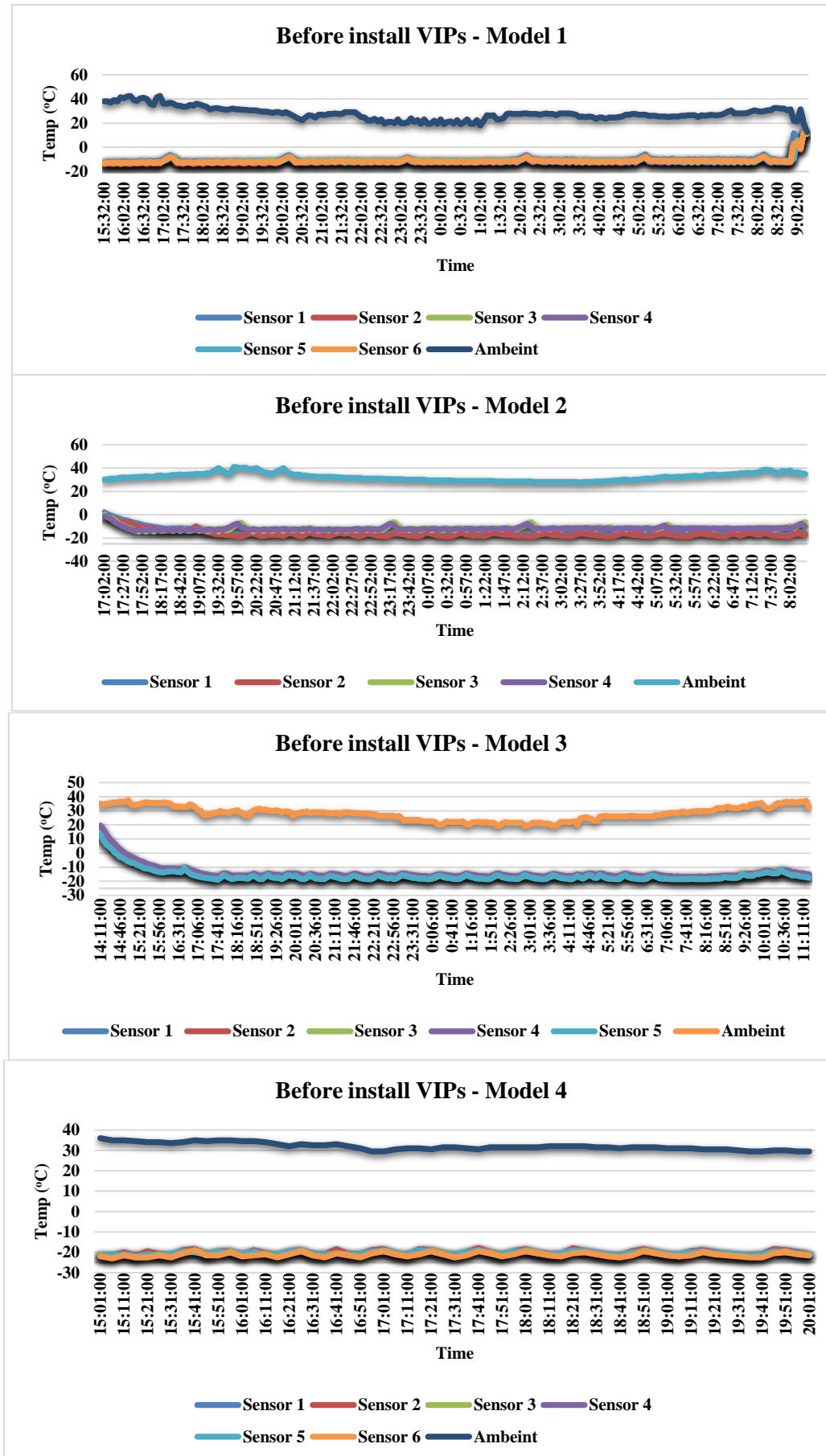


Fig. 7. Temperature results before install VIPs

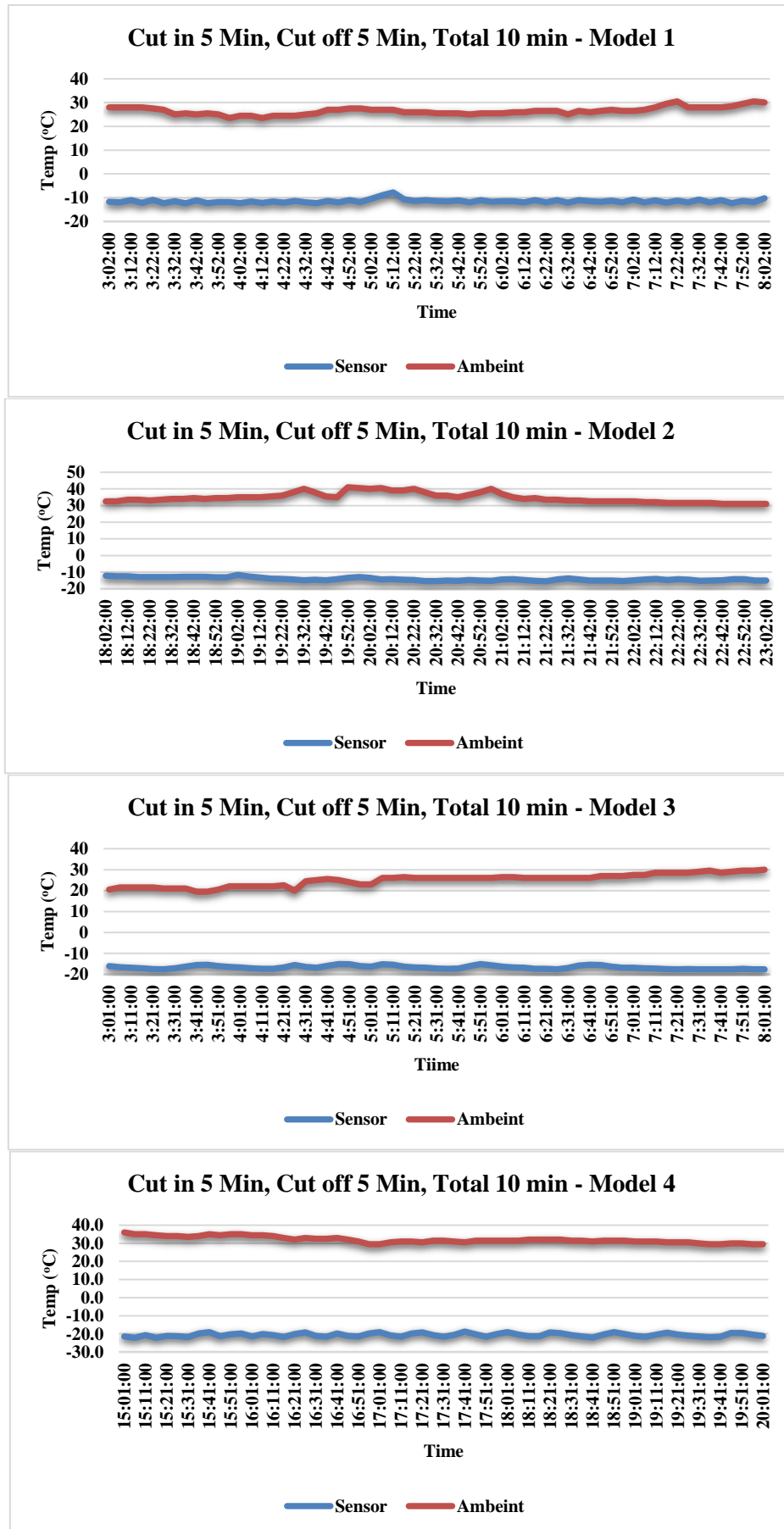


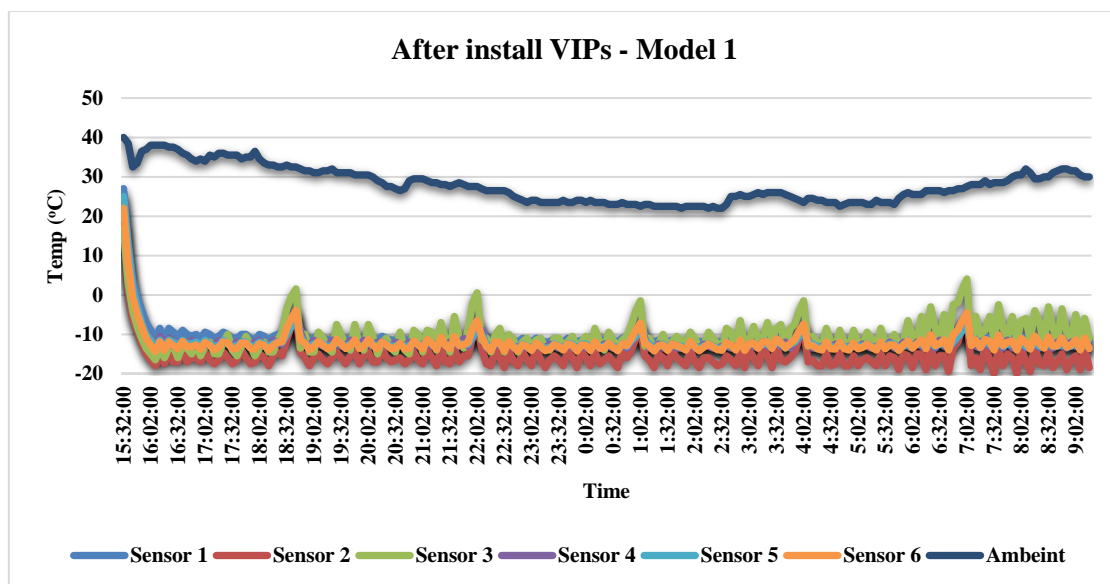
Fig. 8. The compressor cut in – cut off time before install VIPs

3.2 Model 2 - 4 Wheels large Truck

As a result of the temperature results prior to installation of VIPs, as shown in Figure 7, it was found that the refrigerated cars were controlled an average of -14 degrees and defrosted 5 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -12 degrees due to the defrosting with heater. The average temperature along the route was 976 kilometers, averaging 34 degrees. The compressor takes 5 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 5 minutes. The compressor cut in - cut off time before install VIPs, as shown in Figure 8.

As a result of the temperature results rear to installation of VIPs, as shown in Figure 9, it was found that the refrigerated cars were controlled an average of -14 degrees and defrosted 5 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -8 degrees due to the defrosting with heater. The average temperature along the route was 976 kilometers, averaging 33 degrees. The compressor takes 5 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 10 minutes. The compressor cut in – cut off time after install VIPs, as shown in Figure 10.

Test results show that VIPs insulation can maintain the same temperature as without VIPs insulation but the time required for cut in cut off is better to install VIPs insulation. The energy saving effect comes from the moment when the compressor is stopped, which means saving fuel to be used in cooling as a result of VIPs insulation. When all the results are calculated as the energy saving result, it is obtained that over a distance of 976 km, the fuel price is 25.79 baht / liter. It was found that the fuel consumption rate before VIPs installation was 12.91 km / liter, and compared with the after VIPs installation at 13.32 km / liter, the fuel savings was 3.17%.



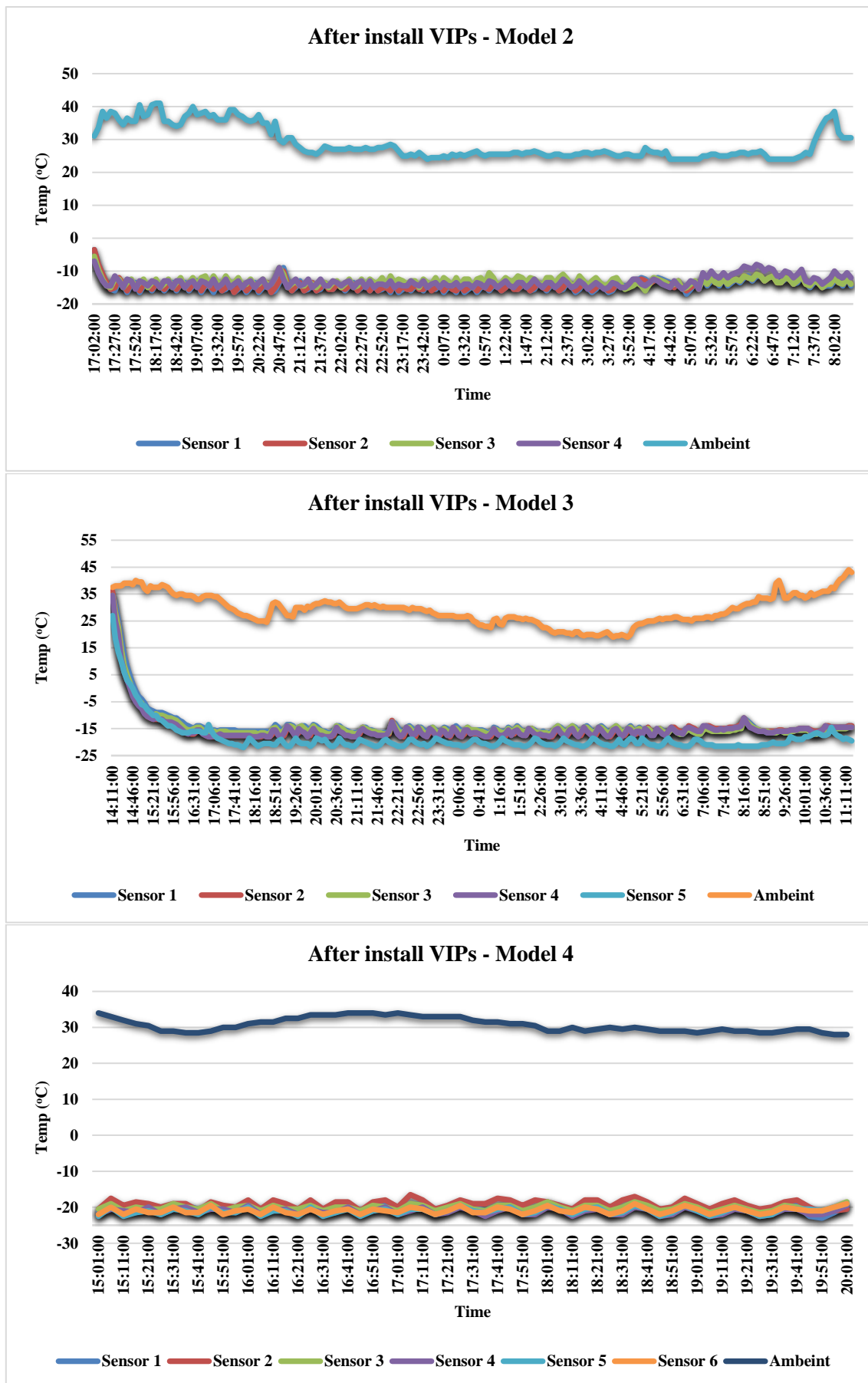


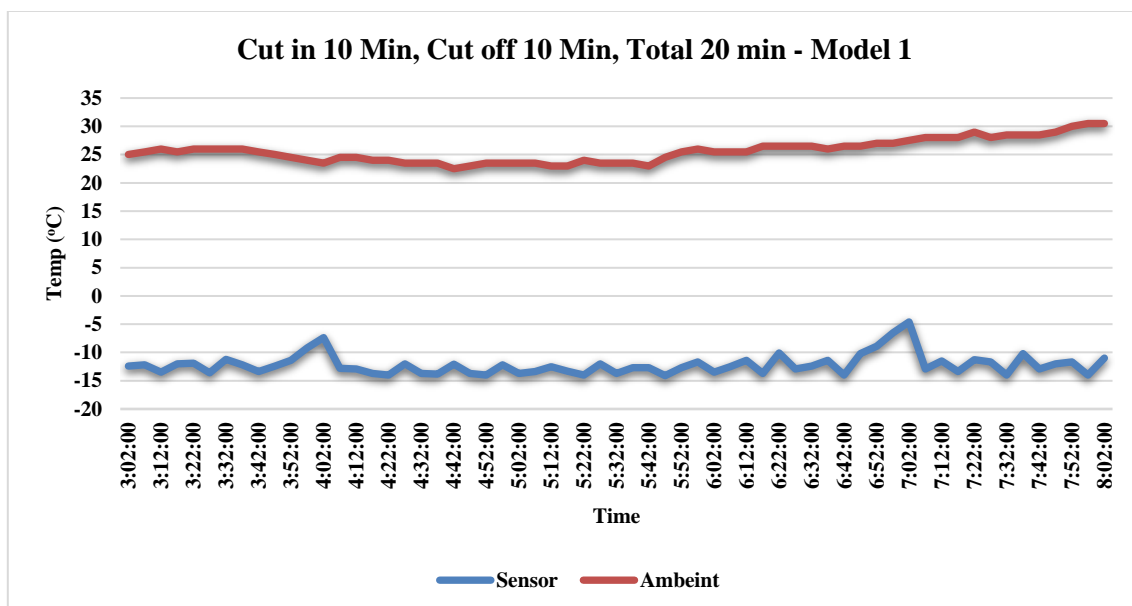
Fig. 9. Temperature results after install VIPs

3.3 Model 3 - 6 Wheels Truck

As a result of the temperature results prior to installation of VIPs, as shown in Figure 7, it was found that the refrigerated cars were controlled an average of -16 degrees and defrosted 22 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -15 degrees due to the defrosting with heater. The average temperature along the route was 1,025 kilometers, averaging 25 degrees. The compressor takes 5 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 5 minutes. The compressor cut in - cut off time before install VIPs, as shown in Figure 8.

As a result of the temperature results rear to installation of VIPs, as shown in Figure 9, it was found that the refrigerated cars were controlled an average of -16 degrees and defrosted 27 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -15 degrees due to the defrosting with heater. The average temperature along the route was 1,025 kilometers, averaging 24 degrees. The compressor takes 10 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 15 minutes. The compressor cut in – cut off time after install VIPs, as shown in Figure 10.

Test results show that VIPs insulation can maintain the same temperature as without VIPs insulation but the time required for cut in cut off is better to install VIPs insulation. The energy saving effect comes from the moment when the compressor is stopped, which means saving fuel to be used in cooling as a result of VIPs insulation. When all the results are calculated as the energy saving result, it is obtained that over a distance of 1,025 km, the fuel price is 26.09 baht / liter. It was found that the fuel consumption rate before VIPs installation was 4.88 km / liter, and compared with the after VIPs installation at 5.07 km / liter, the fuel savings was 3.98%.



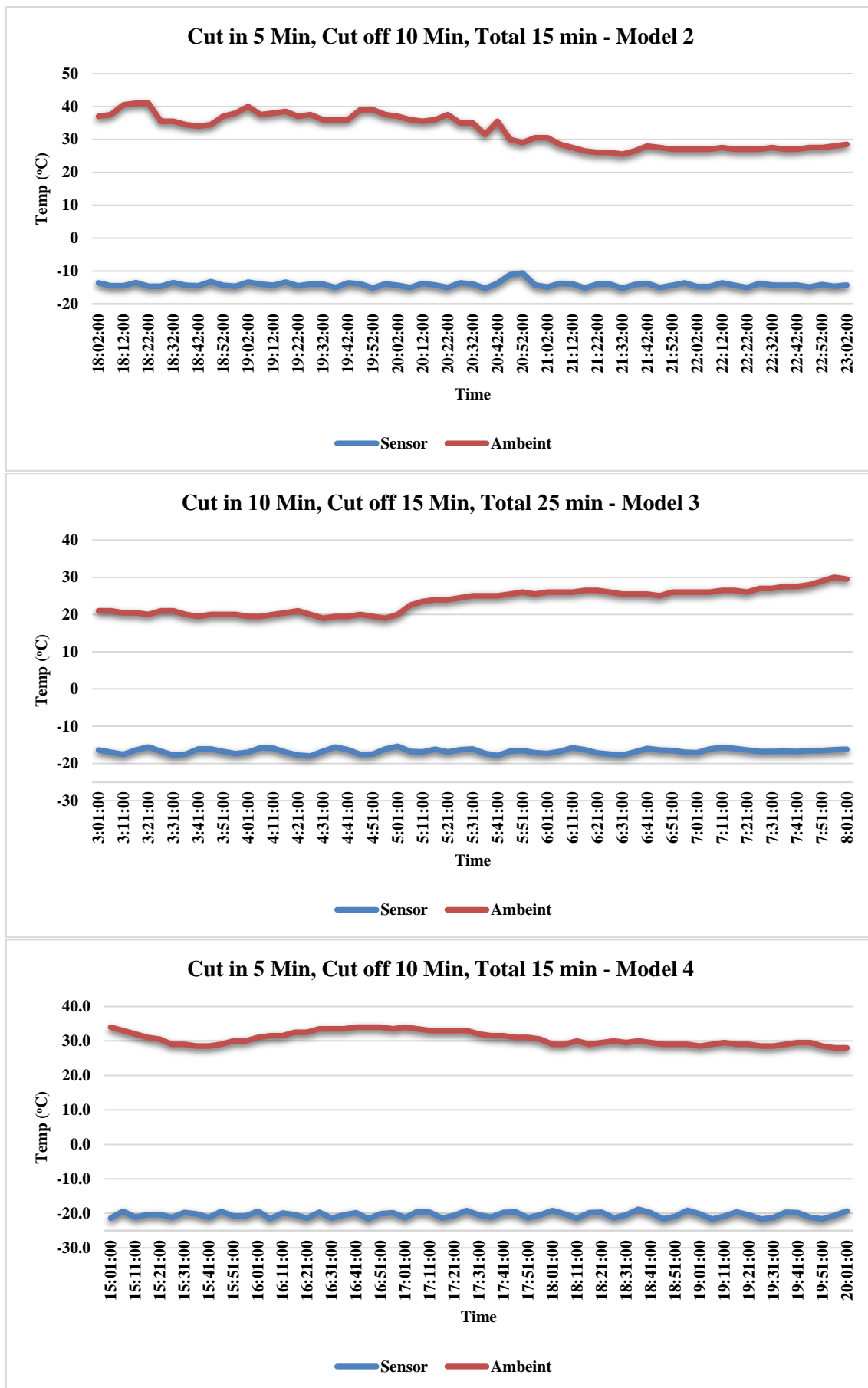


Fig. 10. The compressor cut in – cut off time after install VIPs

3.4 Model 4 - 10 Wheels Truck

As a result of the temperature results prior to installation of VIPs, as shown in Figure 7, it was found that the refrigerated cars were controlled an average of -20 degrees and defrosted 15 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -18 degrees due to the defrosting with heater. The average temperature along the route was 1,036 kilometers, averaging 32 degrees. The compressor takes 5 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 5 minutes. The compressor cut in - cut off time before install VIPs, as shown in Figure 8.

As a result of the temperature results rear to installation of VIPs, as shown in Figure 9, it was found that the refrigerated cars were controlled an average of -20 degrees and defrosted 18 times a day due to the compressor operating at -25 degrees for evaporator temperature in low temperature condition. During the defrosting time, the temperature of the freezer room will rise to a maximum of -18 degrees due to the defrosting with heater. The average temperature along the route was 1,036 kilometers, averaging 31 degrees. The compressor takes 10 minutes to reach the set temperature, and it rises when the compressor stops running to the point where it starts up again in 15 minutes. The compressor cut in – cut off time after install VIPs, as shown in Figure 10.

Test results show that VIPs insulation can maintain the same temperature as without VIPs insulation but the time required for cut in cut off is better to install VIPs insulation. The energy saving effect comes from the moment when the compressor is stopped, which means saving fuel to be used in cooling as a result of VIPs insulation. When all the results are calculated as the energy saving result, it is obtained that over a distance of 1,036 km, the fuel price is 25.79 baht / liter. It was found that the fuel consumption rate before VIPs installation was 2.40 km / liter, and compared with the after VIPs installation at 2.67 km / liter, the fuel savings was 11.33%. The results of all 4 models, as shown in Table 2, it was found Model 1 (4 Wheels Truck) have best fuel savings followed by the Model 4 (10 Wheels Truck), Model 3 (6 Wheels Truck), and Model 2 (4 Wheels large Truck) respectively.

Table 2
Summary fuel savings

| Model | Type | Condition | Compressor Operating Time (Min) | | | fuel consumption rate (km / liter) | |
|-------|-------------------------------|---------------|---------------------------------|---------|-------|------------------------------------|------|
| | | | Cut In | Cut Out | Total | | |
| 1 | 4 Wheels Truck | Chiller | With Out VIPs | 10 | 5 | 15 | 20.0 |
| | | | With VIPs | 10 | 10 | 20 | 24.0 |
| | Freezer | With Out VIPs | 5 | 5 | 10 | 7.1 | |
| | | With VIPs | 10 | 10 | 20 | 8.3 | |
| 2 | 4 Wheels large Truck | Chiller | With Out VIPs | 5 | 5 | 10 | 15.1 |
| | | | With VIPs | 5 | 10 | 15 | 16.3 |
| | Freezer | With Out VIPs | 5 | 5 | 10 | 13.0 | |
| | | With VIPs | 5 | 10 | 15 | 13.3 | |
| 3 | 6 Wheels Truck | Chiller | With Out VIPs | 5 | 5 | 10 | 5.3 |
| | | | With VIPs | 5 | 10 | 15 | 5.5 |
| | Freezer | With Out VIPs | 5 | 5 | 10 | 4.9 | |
| | | With VIPs | 10 | 15 | 25 | 5.1 | |
| 4 | 10 Wheels Truck | Chiller | With Out VIPs | 5 | 5 | 10 | 2.3 |
| | | | With VIPs | 5 | 10 | 15 | 2.4 |
| | Freezer | With Out VIPs | 5 | 5 | 10 | 2.4 | |
| | | With VIPs | 5 | 10 | 15 | 2.7 | |

4. Conclusions

In many countries, land transportation is still used as the primary transportation and cold storage trucks are used to distribute products to different locations. VIPs insulation is an alternative that can reduce the cooling energy consumption of oil-driven compressors. Demonstrates the potential to reduce energy consumption that can still be achieved in the future, people should research other types of cold storage trucks or research in the same way as the air wall by inserting VIPs insulation inside the external insulation to reduce heat transfer.

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