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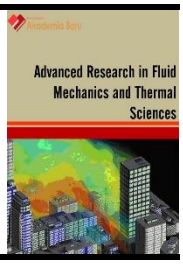

The Improvement of Energy Efficiency for Refrigeration System in Thailand Convenience Store by Digital Scroll Compressor

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ABSTRACT

In this research will present energy saving of R448A refrigeration system in convenience stores 150 m^2 by digital scroll compressor that energy used 40,997 kWh/Year/Store replaced for fix speed scroll compressor that energy used 62,364 kWh/Year/Store. The digital scroll compressor can operated in unload status and full load status that controlled by evaporator temperature (Tev) set point at -10 degree and condenser temperature (Tcd) set point at 38 degree and superheat temperature (Tsh) at 10 degree, in unload status the power consumption for digital scroll compressor will decreased 50% that impact for energy saving and important for night time when low requested cooling load because compressor started–stopped many time. The methodology was measured power consumption (W), voltage (V), current (I), power factor (PF), frequency (Hz), evaporator temperature (Tev), condenser temperature (Tcd), liquid temperature (Tlq), sub cool temperature (Tsc), gas temperature (Tg), superheat temperature (Tsh) by power meter data logger and temperature data logger. The result summarized relation of all parameter and showed energy saving 34%, 21,367 kWh/Year/Store of compressor.

1. Introduction

1.1 Convenience Store in Thailand

The energy saving was important for decreased energy used of business section in Thailand because the energy used of business section in Thailand was second energy used of overall energy used in Thailand [18]. The convenience store in Thailand was more than 20,000 in 2019 and will has trends to increase every year and opened 24 hours that energy used more than resident and energy

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used of convenience store that part of retail business was fourth energy used of business section in Thailand [1].

1.2 Convenience Store Power Consumptions

The ratio of energy used of convenience store in Thailand that first was refrigeration system, second was air condition system [16], third was electrical equipment, fourth was lighting as ratio convenience store in Taiwan as shown in Figure 1 below [2].

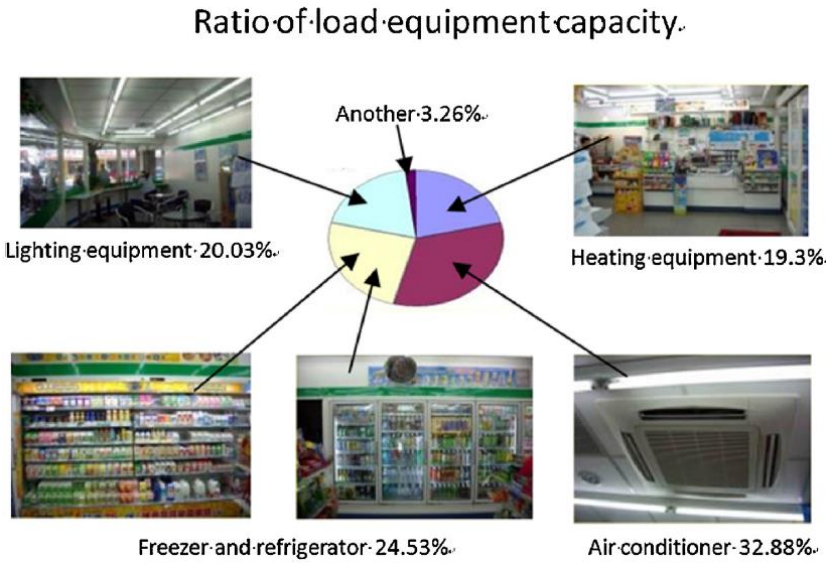

Fig. 1. The energy used ratio of convenience store in Taiwan [2]

The best two way for decreased energy used of convenience store in Thailand was used high energy efficiency and used energy management system and the example for energy saving in refrigeration system as shown in Figure 2 below [3]. The most of example for energy saving in refrigeration system that need to decrease compressor power consumption because compressor power consumption was most energy used of refrigeration system. In this research will present digital scroll compressor that energy saving 34% that widely used in residential heat pumps and air conditioners [9].

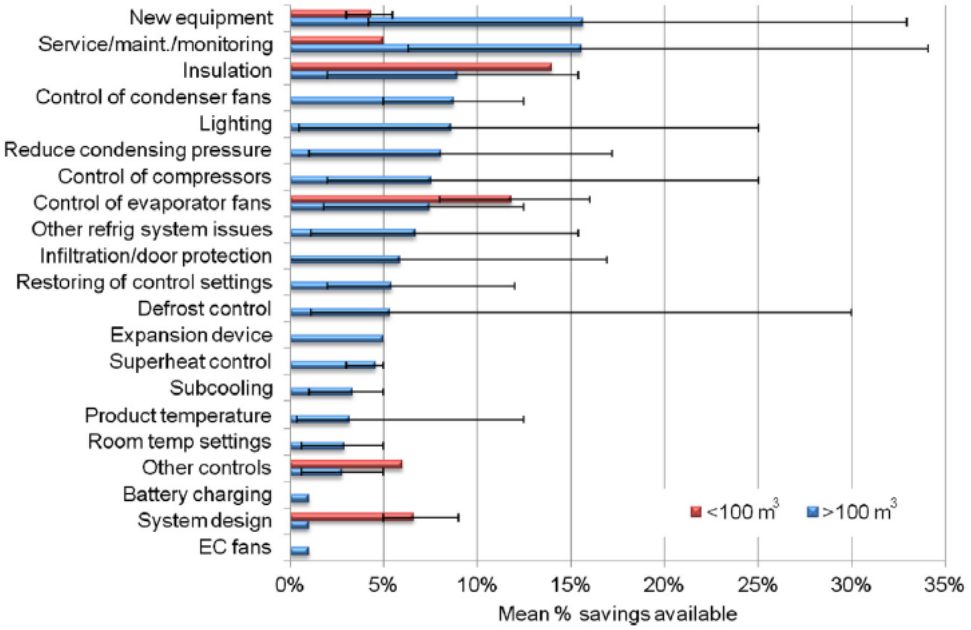

Fig. 2. The example for energy saving in refrigeration system [3]

1.3 R448A Refrigerant

The trend of refrigerant in Thailand was increases energy efficiency and decreases global warming [17] as shown in Figure 3 below [10,11]. The R448A refrigerant was develop for retrofit to R404A. The hydrofluorocarbons/hydrofluoroolefins (HFCs/HFOs) R448A (GWP=1390) was azeotropic mixture of R32 (26%), R125 (26%), R1234yf (20%), R134a (21%) and R1234ze (E) (7%) could retrofit in the refrigeration system using R404A. The hydrofluorocarbons (HFCs) R404A (GWP=3735) was azeotropic mixture of R125 (26%), R143A (52%), R134A (4%) [13]. Bolt refrigerants are no frame propagation and lower toxicity and used polyol ester oil (POE). The R448A had higher cooling capacity (Qe) than R404A by hydrofluorocarbons (HFCs) R32 in component [14] and lower global warming potentials (GWP) than R404A by hydrofluoroolefins (HFOs) by R1234yf and R1234ze (E) in component [15]. The result showed global warming potentials decrease 70% and COP higher than R404A [12].

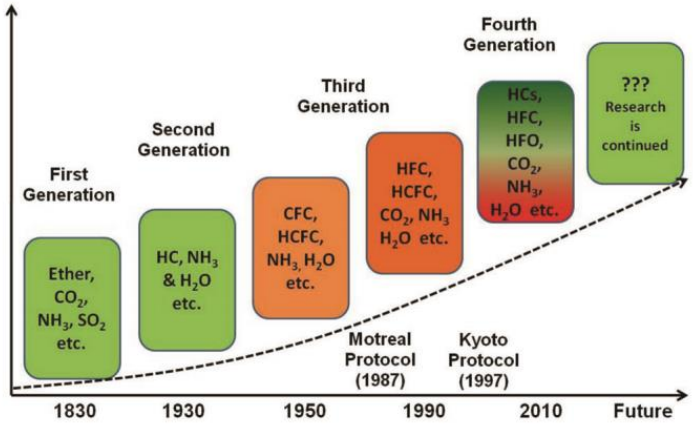

Fig. 3. Trend of refrigerant [10,11]

1.4 Digital Scroll Compressor

The digital scroll compressor can operated in unload status and full load status as shown in Figure 4 below that controlled by evaporator temperature (Tev) set point at -10 degree and condenser temperature (Tcd) set point at 38 degree and superheat temperature (Tsh) at 10 degree, in unload status the power consumption for digital scroll compressor will decreased 50% that impact for energy saving and important for night time when low requested cooling load because compressor started–stopped many time [5].

Fig. 4. How digital scroll compressor operated

2. Methodology

The methodology was measured power consumption (W), voltage (V), current (I), power factor (PF), frequency (Hz), evaporator temperature (Tev), condenser temperature (Tcd), liquid temperature (Tlq), sub cool temperature (Tsc), gas temperature (Tg), superheat temperature (Tsh) by power meter data logger and temperature data logger [4].

3. Results

3.1 Temperature Analysis

When fix speed compressor scroll compressor operated by evaporator temperature higher than set point at -10 degree as shown in Figure 5 below. And cut off when evaporator temperature lower than set point at -10 degree. When the compressor cut off at evaporator temperature lower than set point at -10 degree, Compressor will operate at evaporator temperature until -20 degree because compressor cannot cut off immediately by compressor pump down that unnecessary and impact to energy used of compressor.

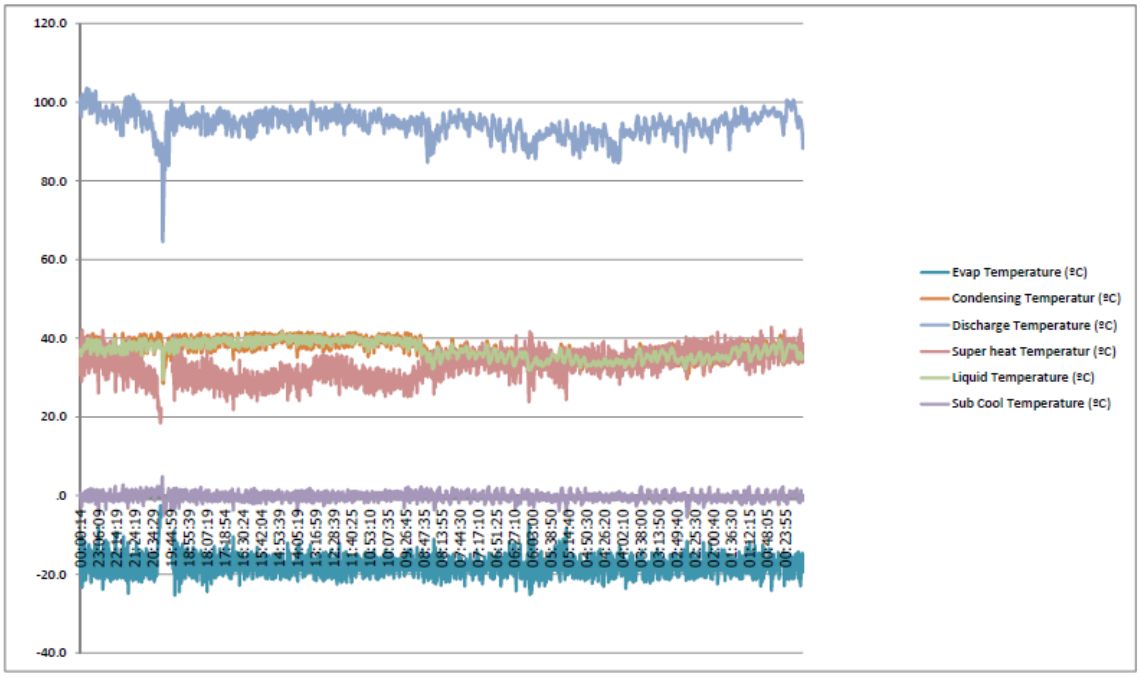

Fig. 5. Fix Speed Scroll Compressor Temperature Analysis

When digital scroll compressor operated by evaporator temperature higher than set point at -10 degree as shown in Figure 6 below and cut off when evaporator temperature lower than set point at -10 degree. When the digital scroll compressor operated at evaporator temperature lower than set point at -10 degree the digital scroll compressor will not cut off and operated in unload status, in unload status evaporator temperature will high because mechanical of digital scroll compressor not operated [7] but operated only motor of digital scroll compressor that energy used 50% of overall energy used of compressor and digital scroll compressor will continuous to operate in unload status and full load again [8].

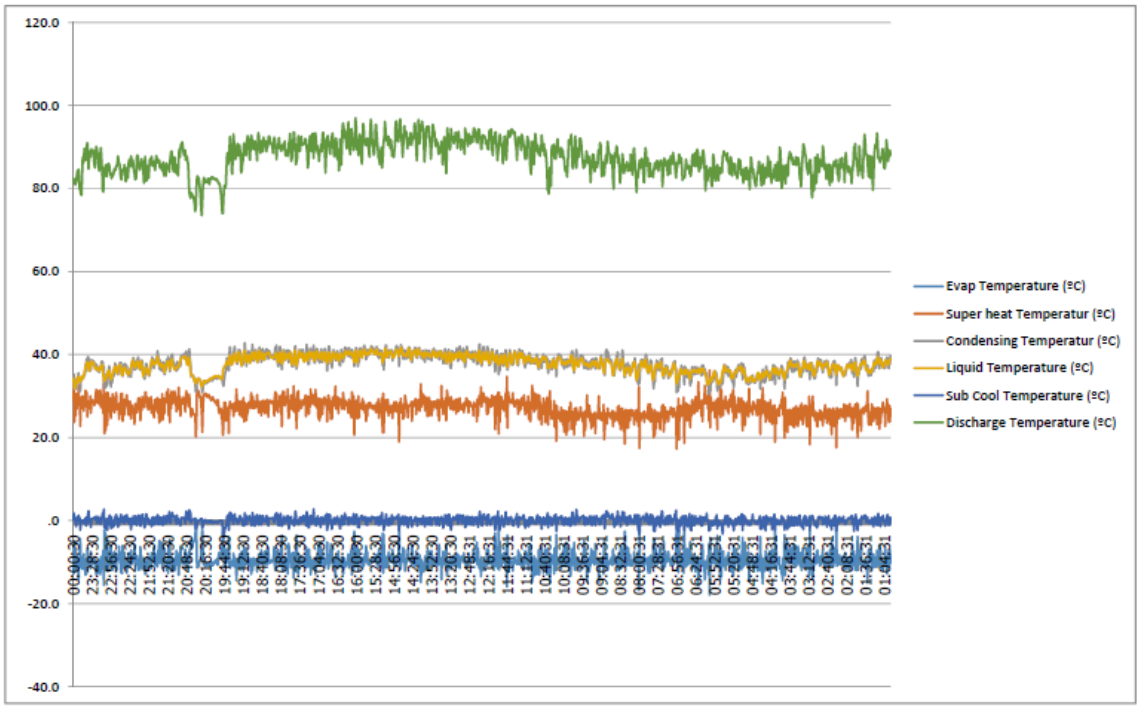

Fig. 6 Fix Speed Scroll Compressor Temperature Analysis

3.2 Power Consumption Analysis

The energy used of fix speed scroll compressor was 62,364 kWh/Year/Store and energy used of digital scroll compressor was 40,997 kWh/Year/Store that energy saving 34%, 21,367 kWh/Year/Store of compressor in Figure 7 below. In day time, the average energy used of fix speed scroll compressor was 14.9 kWh/Hour and the average energy used of digital speed scroll compressor was 12.1 kWh/Hour and energy saving 19%. In night time, the average energy used of fix speed scroll compressor was 13.5 kWh/Hour and the average energy used of digital speed scroll compressor was 11.1 kWh/Hour and energy saving 18%. The energy saving in nigh time is lower than day time because in night time that request cooling load and run time of compressor lower than day time that mean the energy use of compressor in nigh time is lower than day time too [6].

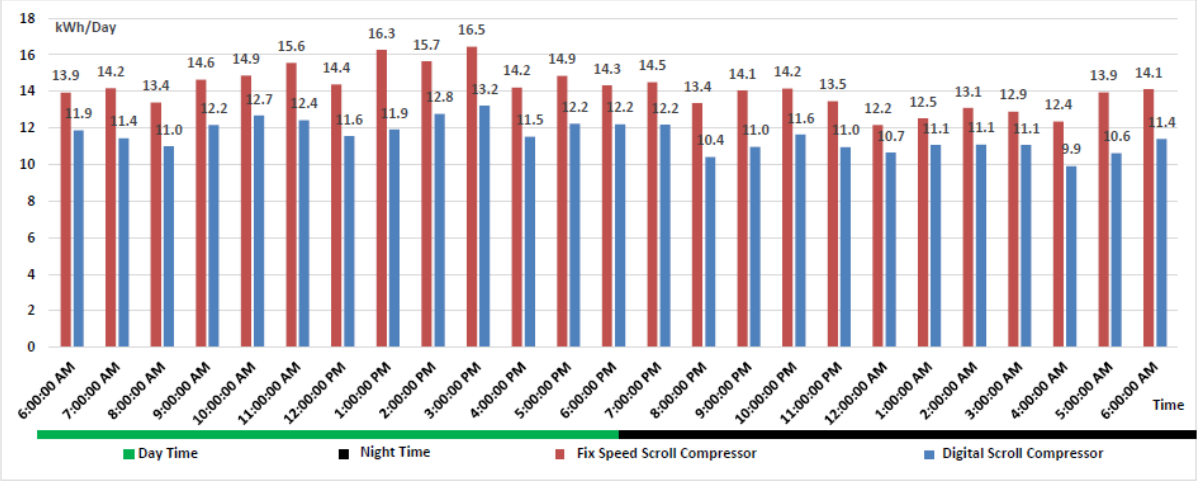

Fig. 7. Power Consumption for Fix Speed and Digital Scroll Compressor

4. Conclusions

The digital scroll compressor can operate in full load and unload status that controlled by evaporator temperature at -10 degree and could decrease over operated when compressor pump down and continuous to operated. The result showed energy saving 34% that energy saving 19% in night time and energy saving 18% in day time.

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