The pilot study of sustainable renewable heat energy which generated from an active compressor in a pest control industrial company

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Abstract. Energy recovery is one of methods to minimize carbon foot print. In addition to that, the increase of the price of energy is unavoidable, these days, including in industrial sectors which makes renewable energy, that offers a friendly price-performance issue, is now taken into consideration. Furthermore, the using of energy recovery is beneficial as it not only reduces energy consumption, but also gives cost saving for the product that are made. In this case, heat energy which generated by the lubrication process of the compressor system was studied to determine how this heat can be captured and be used for heating process. Firstly, the heat from lubrication process is contacted with water through a heat exchanger and connected through piping system as a continuous heating process to increase the temperature of water in a test bath. Secondly, if this idea of energy conservation works, the estimated average energy saving is equal to 33.1% (19.4 kWh). Temperature, time, actual wattage, and the size of the products which are directly affected by the process were collected to determine the best possible way to harvest this heating energy.

Keywords: heat recovery, compressor, renewable energy

1. INTRODUCTION

Reduce energy usage is, at all times, the best way to improve plant efficiency. The main objective of this journal is to determine the amount of heat energy that could be harvested in a heat recovery system to heat up water in a specific production process, the test bath. Furthermore, the total energy, then, is calculated and converted to a specific saving which is helpful to determine the effectiveness of the heat recovery process. According to figures from the Carbon Trust, over 90% of the electrical energy used by a typical air compressor is lost as heat. Being able to capture and reuse this energy for space heating, water heating or for other process that requires heating therefore offers real benefits for businesses and is in step with the view being taken across industry that a broader, more holistic view must be taken when it comes to energy efficiency. The increase of the price of energy is unneglectable, including in industrial sectors, as it is required to ensure fiscal revenue of the countries as well as to maintain the efficiency of the resource [1]. The Office of Gas and Electricity Markets, The United Kingdom, also stated that by the 2017, the energy consumption strategy is adapting to the consuming less behaviour, reducing emission project, and applying for the new sources of power [2]. As stated for the "adapting to the new sources of power", utilizing heat which generated by the compressor is one of the new simple application which related to the energy saving through consuming less energy, reducing emission, as well as its renewable energy properties which is applicable in industrial sectors. Thus, the importance of this study is related to the attempts of using the eco-friendlier technology while in the same time reducing the production cost with a more sustainable energy source. Carbon Trust UK (2011), also conducted several applications of heat recovery system which generated from boilers as well as compressors. The wide range of applications of heat recovery, in that case, was utilized by harvesting the heat from compressors and boilers to heat up the building air conditioners as well as the hot water provided to the domestic area [3].

2. MATERIAL AND METHOD

In this energy reduction exploration, a pilot scale system of heat recovery was configured. The pilot scale system consists of (1) Compressor (90 kWh), (2) Heat Exchanger, (3) water storage tank, (4) Production unit - test bath, and electrical panel. The looping tubular system was utilized between the (1) compressors and (2) heat exchanger, and (3) water storage tank, as well as a production unit – test bath [4].

The detail of the figures is shown in **Figure 1**.

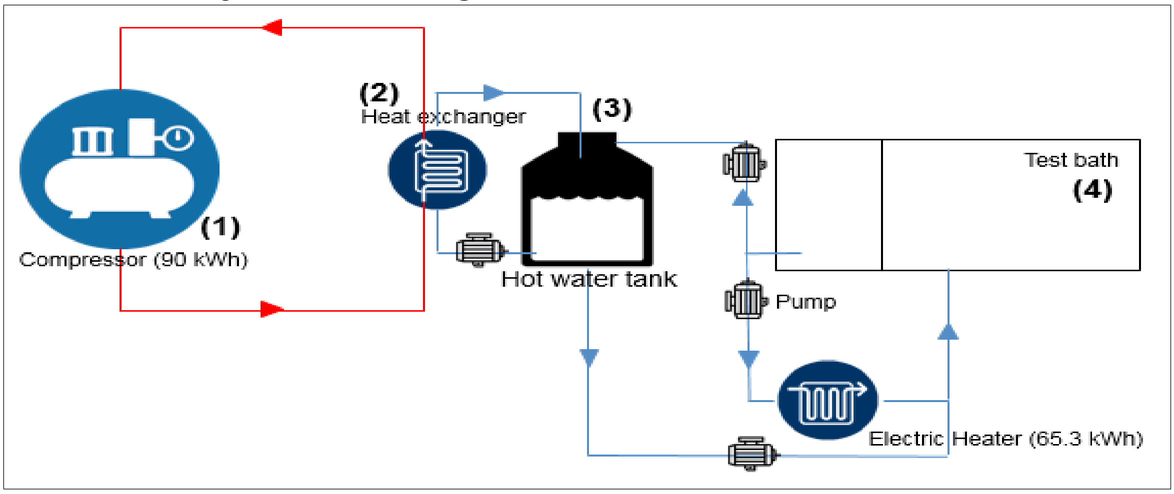

Figure 1. Flow Diagram of The Installed Heat Recovery System

Furthermore, the idea of the research was to reduce the energy consumption in the test bath (require operating temp [5]. at 53-55^{0}C) that comes from the electrical heater (max P = 200kWh) by supplying hot water (70-90^{0}C) by using alternative heating from a heat exchanger that utilizing hot oil that is coming from the compressor [6].
Basically, as shown in **Figure 1**, the energy recovery system works by utilizing the heat which produces from the compressors. The compressors working at below parameters:

1. Stalled power : 90 kW
2. Shaft power : 86 kW
3. Cold water inlet to pre-heat system (from test bath) : 52^{0}C
4. Hot water produced from energy recovery : 60^{0}C
5. Flow of water (constantly) : 65 liter/minute ≈ 1.083 liter/second

The energy recovery works by bypassing the hot oil to the heat exchanger, in where the heat exchanger acting as an alternative heating system. The temperature of the oil before entering the heat exchanger was as at 93^{0}c. With the total amount of oil within the system is equal to 75 liters, the flow of oil is 1.8 liter/second.

Below is the flow process of the research methodology.

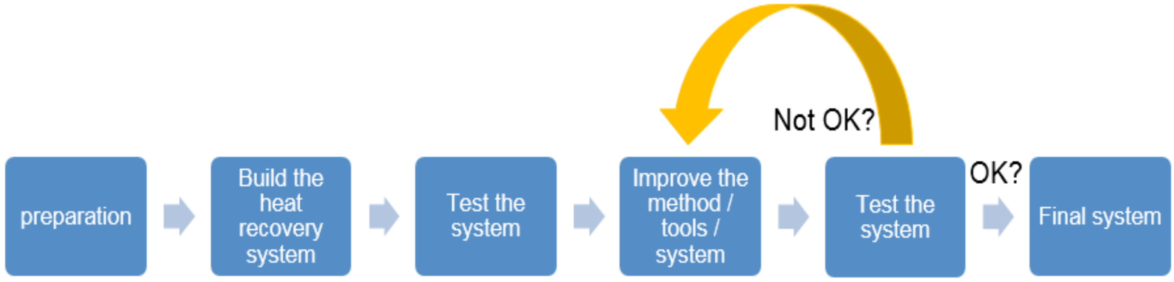

Figure 2. Research Method for The Heat Recovery System

3. RESULTS and DISCUSSION

Before the heat exchanger was installed, the data for existing condition (electrical consumption) was captured. The test bath tested 3 type tins volume, 275, 600, 720 ml, those data were collected for each sample to determine the difference between those tins. The result is shown in **Figure 3**.

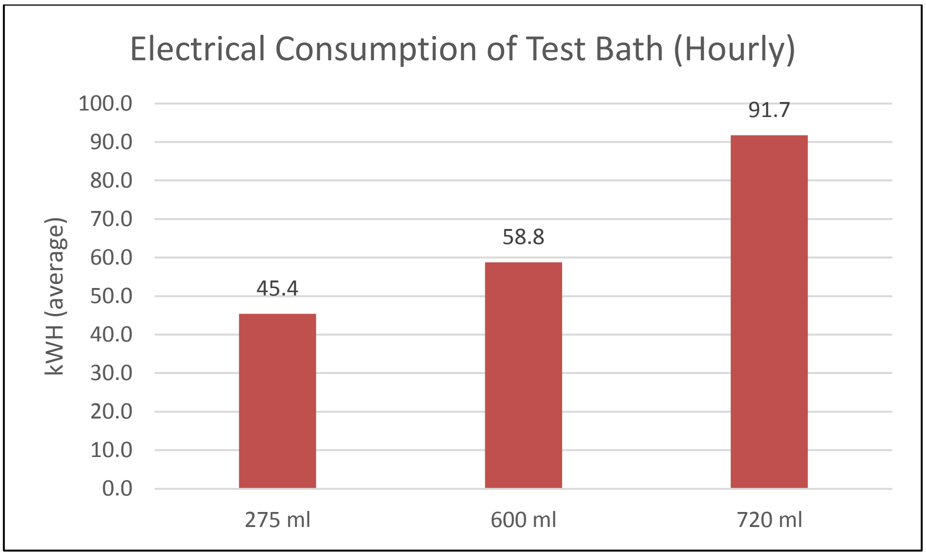

Figure 3. Electrical Consumption of Test Bath with Conventional Electrical Heater

Below equation is estimated energy required to heat the water in the test bath:

$$\text{Recovered energy (kW)}=4.2 \text{ x water flow } \left(\frac{l}{s}\right) \text{ x water temperature rise } (0_C)$$

$$\text{Recovered energy (kW)}=4.2 \text{ x } 1.083 \text{ x } 10^0\text{C}=45.486 \text{ kW}$$

The comparison between single heat supply and with additional heat supply was studied.

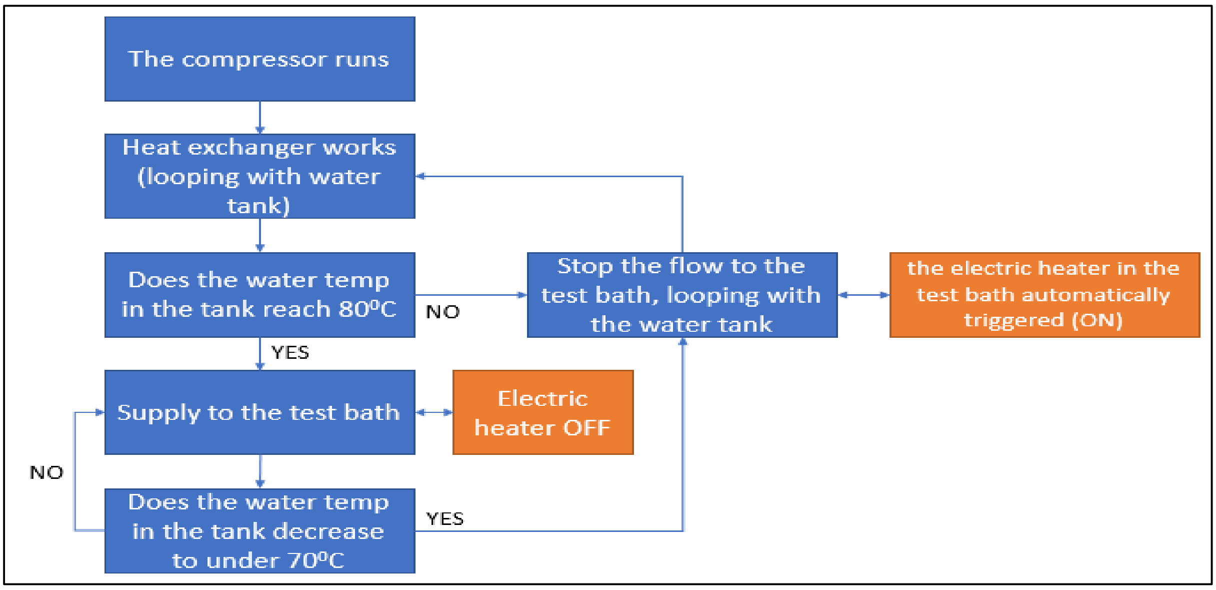

Figure 4. Logical Flow Chart of Programmed Heat Recovery System

To see how the system with additional heat system work please refer to **Figure 4** (Flow control of the heating system). As can be seen from **Figure 4**, there are 2 system which works sequentially, the electric heater and the heat exchanger from the pre-heat system. If the desired temperature of water in the water tank is not reached, then it will automatically trigger the electric heater to heat up the water in the test bath. Once the temperature reaches 80^{0}C, the heat exchanger system automatically connects to the test bath and the electrical heater in the test bath goes off. Once it reaches the 70^{0}C or lower, the connection will be closed and it triggers the electrical heater in the test bath to support the heating process. As the system works based on this logical flow chart without any external intervention, at least 50% of the running time is possibly supported by the renewable energy from energy recovery system.
Furthermore, the ineffectiveness of heat recovery (heat exchanger) occurred under 70^{0}C as the heat could not support the need of test bath and resulting on the conventional heater triggered to run [7]. On the other hand, the shorter the gap of temperature, the quickest the heat recovery system to achieve a certain temperature (in this case 80^{0}c). Furthermore, the higher the set point of the heat inside of the energy recovery, the longer the ER operate to generate heat to the set point which was equal to 55 minutes to 65 minutes. The comparison of electrical usage between the conventional electric heater and heat recovery processes is shown in **Figure 5**. On the left-hand side, the process of the heating and cooling of the test bath require 4 minutes and 8 minutes, consecutively. The process of cooling of the test bath occurred as the material and tins absorb the heat from the water through times.

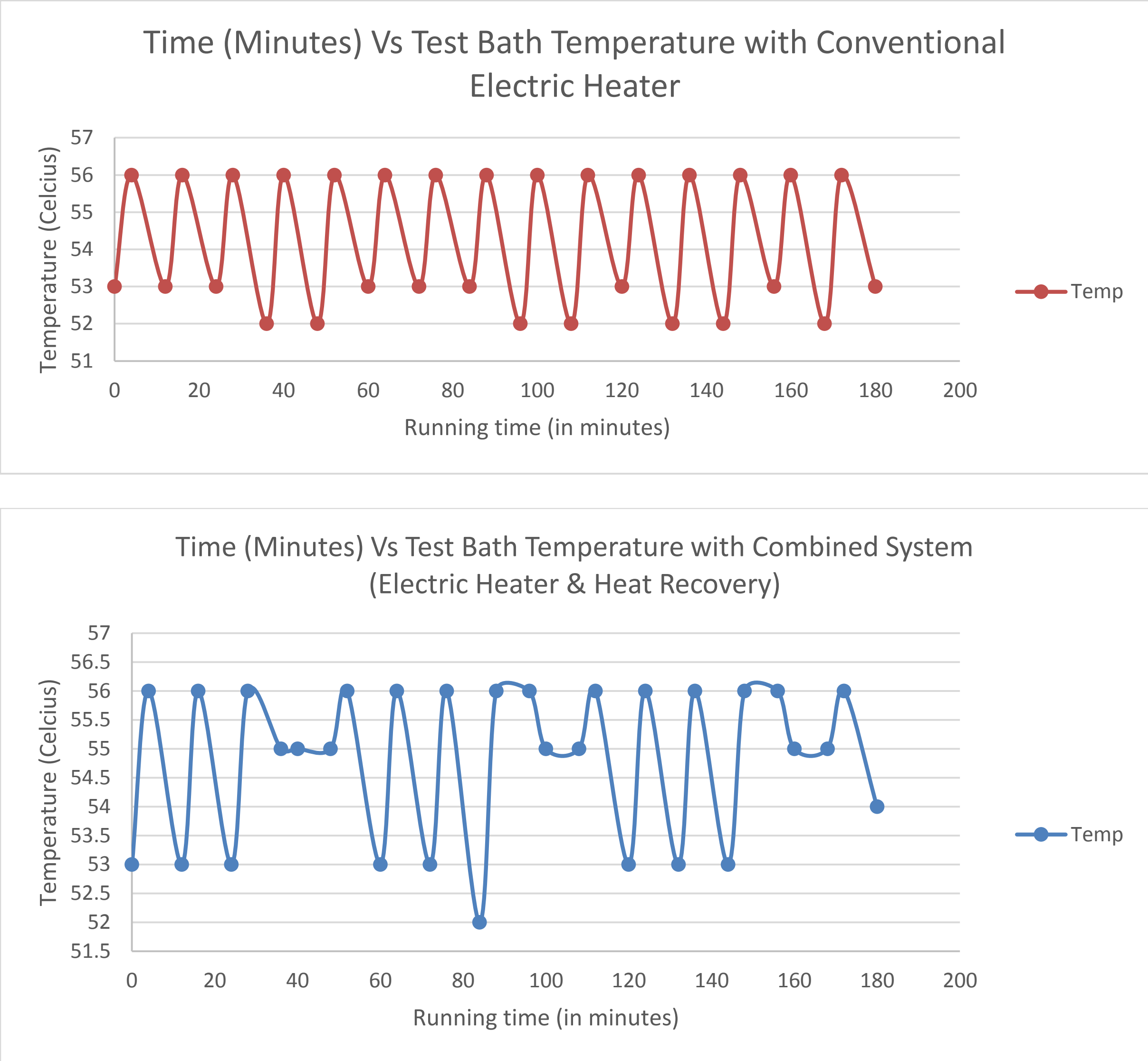

Figure 5. Recorded Temperature; with Combine Electrical Heater and Additional Heat Recovery System.

By installing the heat recovery system, from 1 hour of monitoring, 32 minutes of the process is fully supported by the free energy from heat recovery while the other 28 minutes is handled by the conventional electric heater. With this condition, the saving occurred through the first 30 minutes comes from utilizing the free energy while the other 30 minutes, the heat recovery regenerate the heat in the closed cycle tank to desired temperature (80C). While the heat recovery system heating the water in the tank in a closed loop, the system is automatically separated with the test bath which resulting on the self-heating occurred by the electric heater. By stating that, means that even after the process of renewable energy takes place, the conventional electric heater is still required to maintain the desired temperature for at least 45% of the running time.

Based on some certain consideration, the shortest and most effective running operation temperature was the 80^0C-70^0C. The results for each tin for that operation temperature points are shown in **Figure 5**.

It was shown that, from **Figure 6**, the highest consumption came from the test bath of 720 ml tins while the lowest one came from the 275 ml. Furthermore, the energy saving was also higher with the smaller volume of tins (720 ml < 600 ml < 275 ml) with the saving was 17.4%, 38.7%, and 43.1% consecutively.

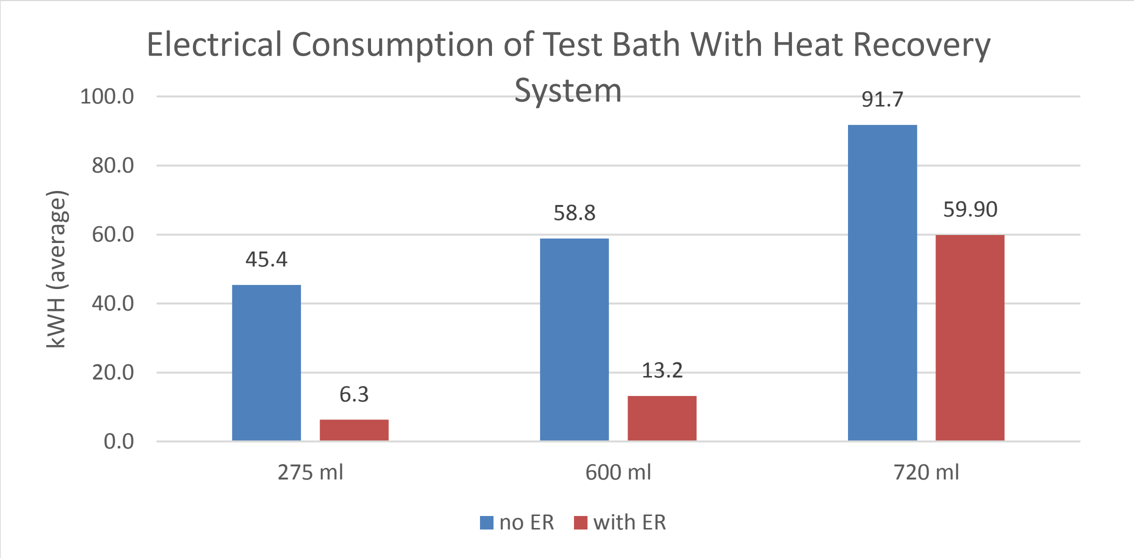

Figure 6. Electrical Consumption of Test Bath with Heat Recovery System.

4. Conclusion

All things considered, the heat energy required in test bath was supported by heat recovery system by the average of 33.1% or equal to 19.4 kwh. Furthermore, the exact saving was 17.4%, 38.7%, and 43.1% for 720 ml, 600 ml, and 275 ml consecutively. While the saving was achieved, there are several things to consider into the account; the pressure load of the compressor, the tins which tested inside of the test bath, the temperature points where the heat recovery operates, and the required water temperature inside of the test bath. Thus, the implication toward the practical areas can be drawn as it is a sustainable option to reduce the cost of utilizing the heat energy and the system itself is easy to understand and re-applicable for other type of processes which required high water temperature.

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