Design and build a water heating system using a helical type heat exchanger by utilizing the exhaust heat of the air conditioner condenser

by Dedikarni Panuh

Submission date: 17-Jan-2023 03:48PM (UTC+0700)
Submission ID: 1994037916
File name: Prosiding_IMITSIC_2021_full.pdf (316.3K)
Word count: 2161
Character count: 9469

e-ISBN:9789833289 Proceeding of iMIT SIC 2021

Design and Build a Water Heating System Using a Helical Type Heat Exchanger by Utilizing the Exhaust Heat of The Air Conditioner Condenser

Dedikarni[1]*, Shandy Kurniadi[1], Trimon P Sinaga[1], Dody Yulianto[1], Eddy Elfiano`[1]
[1]*Department of Mechanical Engineering, Islamic University of Riau, Indonesia*
Corresponding authors: dedikarni@eng.uir.ac.id

ABSTRACT

To take advantage of the heat energy wasted from the Air Conditioning (AC) system so that it is not wasted and does not cause global warming, a heat exchanger (water heater) is designed. An Air Conditioner Water Heater tube installed in the AC system functions as a heat exchanger to absorb heat from the refrigerant pipe out to the compressor so that the water becomes hot and stored for later use. The heat exchanger planning for heating water in the helical type air conditioning system is carried out to plan the heating material, the length of the heating pipe, the cross-sectional area, and the number of turns of the helical type heat exchanger. From the planning results obtained copper pipe heating material with a diameter of 0.01635 m, a pipe length of 8 m, and several turns of 10, with a tank capacity of 42 liters of water. From the results of the trial planning a heat exchanger (water heater) with an increase In temperature of 42 liters of water by 50°C in 60 minutes.

Keywords: *Energy, Air Conditioner, Water Heating System, Helical Pipes, Temperature*

1. INTRODUCTION

The use of air conditioning is often used in tropical areas, which are known for their hot summer, so the air conditioner is used to lower the temperature and provide thermal comfort. However, the use of air conditioning can have a harmful impact environment. One of the negative impacts of using AC is an increase in environmental temperature resulting from the exhaust heat of the air conditioner just dumped into the environment. The heat energy generated from the air conditioning system can be utilized as new energy so that it is not wasted. One of the utilizations of waste heat the resulting AC condenser is deep heating water. With utilization This means that the application of energy conservation to the AC system can be applied so that the AC is not only used as an air conditioner but also can be used as a water heater, namely the Air Conditioner Water Heater (ACWH) (Aziz et al., 2014).

ACWH is used by utilizing the condenser for exhaust heat heating water that can be used for bathing and other purposes that need warm water. This system uses a heat exchanger connected to the AC system so that in use it does not need additional energy. In this system, there are two advantages at once, namely as air conditioning and as a water heater so that it will save usage energy (Pusponegoro & Putra, 2020)

Looking at the prospects generated from this system, the author wants to use the ACWH system as a water heater can be developed in the community. This is because the costs required are very small and can reduce usage electrical energy so that it has an impact on saving energy

use and can reduce the effect of increased ambient temperature caused by exhaust heat AC condenser.

2. EXPERIMENTAL

This research was conducted at the Mechanical Engineering Laboratory, Faculty of Engineering, the design of the Riau Islamic University was carried out in September 2019. The research methodology was carried out, namely first by conducting a literature study, then conducting a survey and problem identification, then calculating the dimensions of the heat exchanger, which consisted of pipe length, pipe dimensions and a number of pipes to be used, then make a water heater, then if the appliance is functioning, the final step is to conclude from the results of the research that has been successfully carried out. In designing a heat exchanger, it requires several stages in the manufacturing process, so that a desired finished model is produced steam compression cycle with water heater.

2.1 Tools and Materials used

The tools and materials used in this study are one unit of AC Split, Flaring Tool, Tang Ampere, Tube Cutter, Pressure Gauge, Welding of Copper Pipe, Refrigerant R410A, Copper Pipe, Water Storage Tank, Perforated Elbow Iron.

2.2 Sketch Tools

This tool sketch is a form of the tool design process that will be carried out

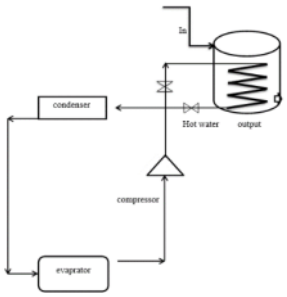

Figure 1. Schematic diagram of the experimental

3. RESULTS AND DISCUSSION

This water heater utilizes the exhaust heat from the 1 PK AC compressor has a high temperature which will experience heat transfer with a deepwater tank that has a low temperature. So that the exhaust heat from the condenser Air conditioning is not wasted and can be reused for heating water.

3.1 Calculation data and manufacture of refrigeration systems using a water heater.

1. Determine the temperature of the hot water used

For the use of water in this heat exchanger using ordinary water, which is the average temperature of the water $T_{water\ in} = 30°C$ while the required temperature $T_{water\ out} = 50°C$ and the value of $\Delta T = 50°C - 30°C = 20°C$

2. Determination of the length of time heating water (t)

For the time to be used in planning the heat exchanger is assumed to be 60 minutes = 60 × 60 = 3600 second

3. Design and Calculation of Heat Exchanger.

The pipe used as a heat exchanger in the water heater from the heat output of the condenser is used as the following pipe.

- Brand: Hoda
- Inner diameter of the pipe (d_1) = 5,35 mm = 0,00535 m
- The outer diameter of the pipe (d_0) = 6,35 mm = 0,00635 m
- Pipe thickness = 0,5 mm = 0,0005 m
- Long pipe (L) = 8 m
- Helix diameter (D) = 0,25 m

4. Water capacity

$v = \pi r2.\ t$

= 3,14. 15 cm. 60 cm

= 42.390 cm^3

= 42,39 L

5. Heating Energy

$Q = m_{water}.\ C_{water}.\ \Delta T$

= 42,39 Kg . 4200 J/kg °C . 20

= 3.560.760 J

6. Heat transfer coefficient on the outer side of the pipe (h_o)

$$ho = \frac{Q}{\pi.do.l.\Delta T.\Delta t}$$

$$ho = \frac{3.560.760\ J}{3.14 \text{ x } 0.00635 \text{ m x } 8 \text{ m x } 20°C \text{ x } 3600 \text{ s}} = 300{,}51 \text{ J/m2 °C s}$$

7. Reynold's number calculation (Re)

$$Re = \frac{p.v.di}{\mu}$$

$$Re = \frac{488.9\frac{kg}{m^3}\ x\ 0.06\frac{m}{s}\ x\ 0.00535\ m}{1.6\ x\frac{10^{-5}kg}{m}.s}$$

Re = 9808.556 (Turbulent Flow)

8. Calculation of the Nussel Number (Nu)

Nu = 0,023 x $Re^{0.85}$ x $Pr^{0.4}$

= 0,023 x 9808.556$\frac{kg}{m}$ $°C^{0.85}$ x $2.4^{0.4}$

= 50,943

9. Heat transfer coefficient on the inside of the pipe (hi):

$$Hi = \frac{Nu.k}{di}$$

$$Hi = \frac{5.943\ W/m^{\circ}C\ \ x\ 0.07\ W/m^{\circ}C}{0.00535\ m}$$

Hi = 666,554 W/m^2 °C

10. Number of turns (N)

$$N = \frac{L}{\pi.D}$$

$$N = \frac{8\ m}{3.14 \text{ x } 0.25 \text{ m}}$$

N = 10 turns

From the results of the above analysis, the data obtained: The length of the APK pipe is 8 m with the number of turns 10 which is inserted into a tube with a volume of 42 L with a diameter of 30 cm and a height of 60 cm. To form a straight copper pipe into a helical shape, use a wooden cylinder with a diameter of D = 25 cm. The heat exchanger that has been made is then installed at the bottom of the water storage tank. This tank is tubular with a diameter of 30 cm and a height of 60 cm so that it can hold 42 liters of water. Then done installation of water heater with the compressor unit.

The step that must be done is to open the compressor casing and measure the required pipe length from the compressor to the inlet side of the heating coil and from the exit side of the heating coil to the inlet of the condenser. This is done because this water heater utilizes the exhaust heat from the condenser, the heat flow from the compressor is deflected first into the tank containing water before it enters the condenser, resulting in heat transfer from the AC pipe with the water in the tank.

Before being connected to the heating coil, the pipe from the compressor to the condenser is cut using a tube cutter. Then the pipe connection from the compressor to the inlet side of the heating coil is made and the exit side of the heating coil to the condenser is done by welding.

1. The process of collecting data on testing tools

To get hot water with a capacity of 42 liters, the temperature rise in the water tank is following the table below.

Table 1. Increased Water Temperature

No	Minute	Temperature °C	Ampere
1	5	33,7	4
2	10	36,6	4.2
3	15	39,2	4.4
4	20	41,2	4.6
5	25	42,9	4.2
6	30	45,7	4,3
7	35	47,3	4,4
8	40	48,5	4,3
9	45	49,9	4,2
10	50	50,8	4,4
11	55	50,9	4
12	60	50,8	4,2
13	65	50,8	4,4
Average		**45,2**	**4.3**

According to the table above, a graphic diagram of the increase in water temperature with time is obtained as follows:

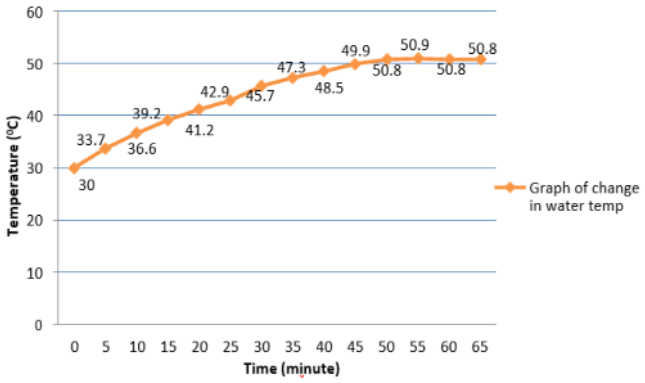

Figure 2. Graph of Increasing Water Temperature

3.2 Calculation Data of Research Results The performance of refrigeration in the water heater

Table 2. AC performance data retrieval

No	Time	Evap/ Komp (Psi)	Komp/ Cond 1 (Psi)	Cond 1/ Cond 2 (Psi)	Cond 2/ Kapiler (Psi)	capillary / Evap (Psi)
	Minute	P_1	P_2	$P_{2'}$	P_3	P_4
1	5	100	337	310	295	165
2	15	100	335	310	297	165
3	25	105	342	315	200	173
4	35	105	342	315	295	165
5	45	100	340	310	290	175
6	60	110	337	310	295	173
Average		**103**	**337,83**	**311,17**	**278,67**	**169,33**
Entalphi (kj/kg)		**120,6**	**123,16**	**123,17**	**47,1**	**33,8**

1. **Compressor Work (Wc)**

   Wc = h_2 - h_1 (kJ/kg)

   = 123,16 - 120,16

   = 2,56 kJ/kg

2. **Refrigeration Effect**

   Qr = h_1 - h_4

   = 120,6 -33,8

   = 86,8 kJ/kg

3. **Coefficient of Performance (COP)**

   $$COP = \frac{qr}{wc} = \frac{h1-h4}{h2-h1}$$

$$= \frac{120.6\frac{kj}{kg} - 33.8\frac{kj}{kg}}{123.16\frac{kj}{kg} - 120.6\frac{kj}{kg}}$$

$$= \frac{86.8\frac{kj}{kg}}{2.56\frac{kj}{kg}}$$

$$= 33.9$$

4. Actual Power

Pa = V. I. Cos θ

= 220 volt. 4,4 A. 0,8

= 774,4 Watt.

4. CONCLUSION

Based on research on the design and manufacture of a water heater system using a hot air conditioner condenser, the following conclusions can be drawn.

1. A helical type water heater has been designed by utilizing the 1 pk AC condenser exhaust heat to get hot water.
2. The water heater tank is made of HDPE (high-density poly Ethylene) which has a capacity of 42 L with dimensions of 60 cm tank height and 30 cm tank diameter. The designed water heater is made of copper pipe with a diameter of 6.35 mm and a length of 8 m which is formed into a helix with a diameter of 25 cm (10 turns).
3. The water temperature that can be used to heat 42 liters of water with a heating time of 60 minutes is 50 °C.

5. ACKNOWLEDGMENTS

I was a writer, would like to express my deepest gratitude to Universiti Teknologi Mara (UiTM), Cawangan Negeri Sembilan, Kuala Pilah Campus, and the Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for providing facilities and financial support for this research. And also, my deepest gratitude to the Institute for Research and Community Service (LPPM) of the Islamic University of Riau (UIR) for the facilities and financial support for this research.

6. AUTHOR CONTRIBUTION

Shandy Kurniadi, Trimon P Sinaga conceived of the presented idea and developed the theory and performed the computations. Dedikarni and Dody Yulianto verified the analytical methods. Eddy Elfiano encouraged Shandy Kurniadi to investigate a specific aspect and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

7. REFERENCES

Aziz, A., Ginting, H., Hatorangan, N., & Rahman, W. (2014). *Analisis Kinerja Air Conditioning Sekaligus Sebagai Water Heater (ACWH). June 2014*, 1–6.

https://doi.org/10.13140/RG.2.1.2396.5840/1
Pusponegoro, F., & Putra, N. (2020). Manufacturing and performance testing of hybrid air conditioner water heater (H-ACWH). *AIP Conference Proceedings*, *2255*(September). https://doi.org/10.1063/5.0014136

Design and build a water heating system using a helical type heat exchanger by utilizing the exhaust heat of the air conditioner condenser

ORIGINALITY REPORT

11%	11%	0%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.researchgate.net Internet Source	10%
2	repository.nwu.ac.za Internet Source	2%

Exclude quotes	On	Exclude matches	< 2%
Exclude bibliography	On		