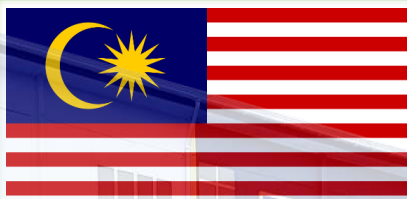


# e-PROCEEDING



THE 4<sup>th</sup> INTERNATIONAL  
MALAYSIA-INDONESIA-THAILAND  
SYMPOSIUM ON INNOVATION AND CREATIVITY, 2021

EXTENDED ABSTRACT  
24 AUGUST 2021



UNIVERSITI TEKNOLOGI MARA  
PAHANG BRANCH, MALAYSIA

*'Embracing  
Innovation & Creativity  
in  
Industrial Revolutions'*

**e-Proceeding**

**The 4<sup>th</sup> International Malaysia-Indonesia-Thailand**   
**Symposium On Innovation and Creativity 2021**  
*'Embracing Innovation & Creativity in Industrial Revolutions'*

Universiti Teknologi MARA  
Pahang Branch  
26400 Bandar Tun Abdul Razak, Jengka  
Pahang, Malaysia

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## WELCOMING REMARKS

Assalamualaikum wbt and greetings to all IMIT SIC 2021 participants.

It is a great pleasure to welcome all of you to the 4<sup>th</sup> International Malaysia-Indonesia-Thailand Symposium on Innovation and Creativity (IMIT SIC 2021). IMIT SIC is an annual program organized in shifts by universities' collaborators, as well as their strategic partners from Indonesia, Malaysia and Thailand. IMIT SIC was successfully organized by UiTM Perlis Branch in 2017, Universitas Riau (UNRI) in 2018 and Princess of Naradhiwas University (PNU) in 2019. Despite the strike of Covid-19 pandemic which has affected our academic institutions, UiTM Pahang branch has endeavoured the challenge by organizing this event via the virtual platform.



2020 and 2021 have been extremely challenging years for all of us. We struggled to keep up with the new norm caused by the pandemic, where the populations of the world were shaken, and still are. Although it has been a tough year, we must continuously move forward and face the obstacles that bring us to the adaptation of new practices.

Based on this creative adaptation approach, the ultimate objective of this symposium is to gather all researchers, scientists, experts and scholars from the Social Sciences, Business Administration, Engineering, as well as the Science Technology communities particularly in the Southeast Asian countries. Besides, it is hoped to be a channel to emphasize and empower the culture of innovation, to prepare a platform for ideas, information, and expertise as well as to expose innovators to potential investors through international partnership opportunities.

My deepest congratulations to the organizer of this important event, especially the Chairman, Associate Professor Dr Wan Mohd Nazri Bin Wan Abdul Rahman and his committee members, who have performed incredible tasks in organizing this event. Besides, I would like to convey my appreciation to all the strategic partners who have given their endless support throughout the process.

I would also like to express my gratitude to all keynote speakers and participants from Malaysia, Indonesia and Thailand. With the theme "*Embracing Innovation & Creativity in Industrial Revolution*", IMIT SIC 2021 could advance the latest developments in social sciences, science and technology, engineering, technology, art and civilization for a better future.

I hope everyone gains advantage from the abundance of knowledge and networking opportunities offered by IMIT SIC 2021. Thank you for your efforts and contributions in making this event a success. All the best, and may you have a fruitful symposium.

Thank you.

Prof. Ts. Dr Mohd Ilham Bin Adenan  
Rector  
Universiti Teknologi MARA Pahang Branch



## WELCOMING REMARKS



Praise and gratitude to Allah SWT for all his graces and blessings.

The 4<sup>th</sup> International Malaysia-Indonesia-Thailand Symposium on Innovation and Creativity (IMIT SIC 2021) will be held virtually on 24<sup>th</sup> August by Universiti Teknologi MARA Pahang Branch, Malaysia. This is the first time IMIT SIC is conducted virtually due to Covid-19 pandemic. Hence, it is such a great achievement to have 3 keynote speakers from our strategic partners, and more than 300 products, innovation, designs and idea contributions from all over Malaysia, Indonesia and Thailand.

With the theme “*Embracing Innovation & Creativity in Industrial Revolution*”, IMIT SIC 2021 aims to bring together researchers, scientists, scholars, practitioners, and industrialists to share, expose, communicate and commercialize new innovations, inventions, products and ideas as well as research findings in the areas of social sciences, science and technology, engineering, technology, art and civilization to neighbouring countries and also to the international platform.

As the chairperson of 4<sup>th</sup> IMIT SIC 2021, I would like to express my heartfelt gratitude to the organizing committee members for their unwavering commitment to ensure the success of this symposium. I would also like to convey my sincere appreciation and congratulations to Universiti Teknologi MARA Perlis Branch, Universiti Teknologi Johor Branch, Universiti Teknologi MARA Sarawak Branch, Universitas Islam Riau, Princess of Naradhiwas University, Yala Rajabhat University, Universitas Tanjungpura, Universitas Airlangga and Phuket Rajabhat University as our strategic partners and The Malaysia Solid State Science and Technology Society for supporting this symposium.

This symposium would also not be possible without the generous assistance from the management of Universiti Teknologi MARA Pahang Branch, strategic partners, moderators, judges who have selflessly contributed to the event. I hope everyone will enjoy the content, develop new research linkages and generate more ideas through the symposium. Besides, I hope IMIT SIC will serve as a platform for researchers, scientists, industrialists and scholars in cultivating research, innovation and creativity.

Your participation today will surely strengthen and play the most meaningful role in generating, publishing, and sharing new ideas and knowledge, as well as realizing the theme of IMIT SIC 2021. I am looking at the bright future of IMIT SIC in the years to come, to deliver better than its preceding years. I hope through IMIT SIC, we can continue to synergize, spread the benefits, and gain valuable experience.

Thank you.

Assoc. Prof. Dr. Wan Mohd Nazri Bin Wan Abdul Rahman  
Chairman IMITSIC 2021  
Universiti Teknologi MARA Pahang Branch

## **MESSAGE FROM THE EDITOR**

It is our pleasure to welcome you to the IMIT SIC 2021 extended abstract proceedings. The proceedings are collections of research reports contributed by researchers, academicians and students from Malaysia, Indonesia and Thailand.

My sincere gratitude goes to the authors, reviewers and technical program committee members for their contribution, hard work and support in promoting IMIT SIC 2021 in Malaysia, Indonesia and Thailand. More than 290 extended abstracts went through a peer review process and each was accepted based on its relevance, innovation and application to the respective field it represents.

The proceedings house a collection of extremely interesting and most current innovations, inventions and research findings, hence would be a valuable source of information and reference for researchers, academicians and students alike.

Thank you

Ruziana Mohamed  
Chief Editor

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

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## 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 0.00635 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

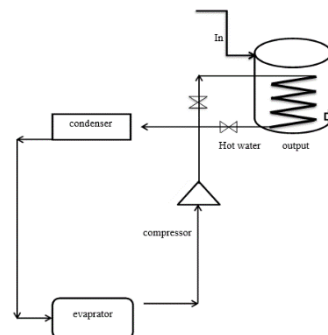


Figure 1. Schematic diagram of the experimental

## 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  $T_{\text{water in}} = 30^{\circ}\text{C}$  while the required temperature  $T_{\text{water out}} = 50^{\circ}\text{C}$  and the value of  $\Delta T = 50^{\circ}\text{C} - 30^{\circ}\text{C} = 20^{\circ}\text{C}$



**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 =  $60 \times 60 = 3600$  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 ( $d_i$ ) = 5,35 mm = 0,00535 m
- The outer diameter of the pipe ( $d_o$ ) = 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**

$$\begin{aligned} v &= \pi r^2 \cdot t \\ &= 3,14 \cdot 15 \text{ cm} \cdot 60 \text{ cm} \\ &= 42.390 \text{ cm}^3 \\ &= 42,39 \text{ L} \end{aligned}$$

**5. Heating Energy**

$$\begin{aligned} Q &= m_{\text{water}} \cdot C_{\text{water}} \cdot \Delta T \\ &= 42,39 \text{ Kg} \cdot 4200 \text{ J/kg } ^\circ\text{C} \cdot 20 \\ &= 3.560.760 \text{ J} \end{aligned}$$

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

$$\begin{aligned} h_o &= \frac{Q}{\pi \cdot d_o \cdot l \cdot \Delta T \cdot \Delta t} \\ h_o &= \frac{3.560.760 \text{ J}}{3,14 \times 0,00635 \text{ m} \times 8 \text{ m} \times 20^\circ\text{C} \times 3600 \text{ s}} = 300,51 \text{ J/m}^2 \text{ } ^\circ\text{C s} \end{aligned}$$

**7. Reynold's number calculation (Re)**

$$\begin{aligned} \text{Re} &= \frac{\rho \cdot v \cdot d_i}{\mu} \\ \text{Re} &= \frac{488,9 \frac{\text{kg}}{\text{m}^3} \times 0,06 \frac{\text{m}}{\text{s}} \times 0,00535 \text{ m}}{1,6 \times 10^{-5} \frac{\text{kg}}{\text{m} \cdot \text{s}}} \end{aligned}$$

$$\text{Re} = 9808,556 \quad (\text{Turbulent Flow})$$

**8. Calculation of the Nussel Number (Nu)**

$$\begin{aligned} \text{Nu} &= 0,023 \times \text{Re}^{0,85} \times \text{Pr}^{0,4} \\ &= 0,023 \times 9808,556 \frac{\text{kg}}{\text{m}} ^\circ\text{C}^{0,85} \times 2,4^{0,4} \\ &= 50,943 \end{aligned}$$

**9. Heat transfer coefficient on the inside of the pipe ( $h_i$ ):**

$$\begin{aligned} h_i &= \frac{\text{Nu} \cdot k}{d_i} \\ h_i &= \frac{5,943 \text{ W/m}^\circ\text{C} \times 0,07 \text{ W/m}^\circ\text{C}}{0,00535 \text{ m}} \\ h_i &= 666,554 \text{ W/m}^2 \text{ } ^\circ\text{C} \end{aligned}$$

**10. Number of turns (N)**

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

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

$$N = 10 \text{ turns}$$

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
<b>Average</b>		<b>45,2</b>	<b>4.3</b>

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

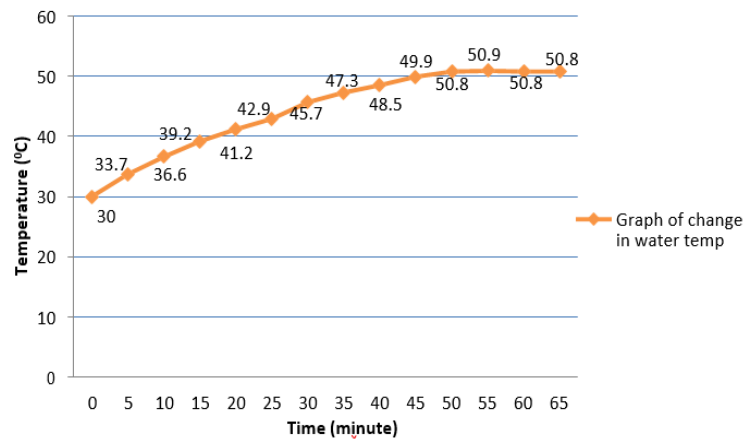


Figure 2. Graph of Increasing Water Temperature

**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 <sub>1</sub>	P <sub>2</sub>	P <sub>2'</sub>	P <sub>3</sub>	P <sub>4</sub>
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
<b>Average</b>		<b>103</b>	<b>337,83</b>	<b>311,17</b>	<b>278,67</b>	<b>169,33</b>
<b>Entalphi (kJ/kg)</b>		<b>120,6</b>	<b>123,16</b>	<b>123,17</b>	<b>47,1</b>	<b>33,8</b>

**1. Compressor Work (Wc)**

$$\begin{aligned}
 W_c &= h_2 - h_1 \text{ (kJ/kg)} \\
 &= 123,16 - 120,16 \\
 &= 2,56 \text{ kJ/kg}
 \end{aligned}$$

**2. Refrigeration Effect**

$$\begin{aligned}
 Q_r &= h_1 - h_4 \\
 &= 120,6 - 33,8 \\
 &= 86,8 \text{ kJ/kg}
 \end{aligned}$$

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

$$\text{COP} = \frac{q_r}{w_c} = \frac{h_1 - h_4}{h_2 - h_1}$$

$$\begin{aligned}
 &= \frac{120.6 \frac{kJ}{kg} - 33.8 \frac{kJ}{kg}}{123.16 \frac{kJ}{kg} - 120.6 \frac{kJ}{kg}} \\
 &= \frac{86.8 \frac{kJ}{kg}}{2.56 \frac{kJ}{kg}} \\
 &= 33.9
 \end{aligned}$$

#### 4. Actual Power

$$P_a = V \cdot I \cdot \cos \theta$$

$$= 220 \text{ volt} \cdot 4,4 \text{ A} \cdot 0,8$$

$$= 774,4 \text{ Watt.}$$

#### 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.

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#### 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.

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