

Performance of Air Conditioning Water Heater with Trombone Coil Type as Dummy Condenser at Different Cooling Loads

Azridjal Aziz,^{a,*} and Arya Bhima Satria,^a

^aThermal Engineering Laboratory, Mechanical Engineering Department, University of Riau, Indonesia

*Corresponding author: azridjal@yahoo.com

Paper History

Received: 9-November-2014

Accepted: 15-November-2014

ABSTRACT

This paper presents the experimental performance study to observe the effect of changes in the cooling load of the combined air conditioning and water heating system with trombone coil type as dummy condenser using heat wasted from split type air conditioner. Effects of the following parameters to the system performance were examined: compressor power test chamber, test chamber temperature, condenser temperature, hot water temperature and Coefficient of Performance (COP). The results showed that the bigger the cooling load is given in the test chamber, the bigger the heat absorbed in the evaporator, so the higher the temperature of the hot water in a tank. COP increased with increasing of cooling loads. It was concluded that by combined air conditioning and water heating system so that space cooling and water heating can take place simultaneously, and the energy performance can be raised considerably.

KEY WORDS: *air conditioning, water heater, cooling load, COP, compressor power*

NOMENCLATURE

COP Coefficient of Performance
P Pressure
T Temperature
COP Coefficient of Performance
COP_R COP Refrigeration
COP_{R+HP} COP Refrigeration and Heat Pump

1.0 INTRODUCTION

The need of hot water is usually obtained from the electricity and gas that requires considerable energy, with energy recovery of waste heat from condenser in the air conditioning will be saving considerable energy. In thermodynamics terms of balance of energy, the waste energy from the condenser are combination of compressor energy and cooling effect energy in the evaporator, which means that energy wasted in the condenser is big enough, so that the potential of energy savings from condenser also big.

The electrical energy saving for water heating purposes by use the waste heat energy from the condenser also indirectly will save the use of fuel oil. The efficient uses of fuel as an energy source for the generation of electrical energy will have a positive impact on the environment, so that the recovery of energy from waste heat condenser using condenser dummy will give positive impact to the environment. The use of AC with the addition of a dummy condenser for water heating will save the cost of using electrical energy or gas because the cost of water heating from the condenser dummy obtained free of charge without increasing the cost of the use of AC. With the use of a dummy condenser at the AC will get two benefits at once that the rooms were comfortable and the hot water for various purposes.

Air conditioning water heater operates on an electrically driven vapor-compression cycle and pumps energy from the air in its surroundings to water in a storage tank, thus raising the temperature of the water. Air conditioning water heater are a promising technology in both residential and commercial applications due to both improved efficiency and air conditioning benefits. The super-heated refrigerant from compressor discharge of the air-conditioning system passes through a dummy condenser as trombone coil heat exchanger thereby transferring its heat to the cold inlet water within water heater tank. From this heat recovery technology, free hot water is produced in cooling operation, will achieve the highest COP. The temperature of the refrigerant is reduced, resulting in the two benefit of water heating and cooling. for higher air conditioning energy efficient.



Many researcher have been performed on heat pump water heaters (HPWHs), including structure, thermodynamics, working fluids, operation controlling, numerical simulation and economical analysis (Jie Ji et al. 2003, Fei Liu et al. 2008, M. M. Rahman et al. .2007, M. Joseph Stalin et al. 2012, Jie Ji et al. 2005, U. V. Kongre et al. 2013, Arif Hepbasli, 2009). Sreejith K, 2013 was investigated experimentally the effect of different types of compressor oil in a domestic refrigerator having water cooled condenser and the recovered heat from the condenser can be used for bathing, cleaning, laundry, dish washing etc. Yi Xiaowen and W.L. Lee, 2008 have been reported an experimental study on the performance of a domestic Water-cooled Air conditioner (WAC) using tube-in-tube helical heat Exchanger for preheating of domestic hot water. Mehmet Yilmaz, 2003 has been presented the performance analysis of an air-to-water vapor compression heat pump system using pure refrigerants and zeotropic refrigerant mixtures.

Main objectives of this study were to investigate experimentally the combined air conditioning and water heating system using R22 as working fluid. Effects of the following parameters to the system performance were examined: compressor power test chamber, test chamber temperature, condenser temperature, hot water temperature and Coefficient of Performance (COP).

2.0 EXPERIMENTS

2.1 Experimental Apparatus

In this study, performance investigation is conducted using the similar experimental apparatus as described in Azridjal et al, 2014. As seen in Figure 1, the apparatus has the air conditioning system with a nominal capacity 2.6 kW. and water cooled dummy condenser with trombone coil type heat exchanger (Figure 2). Since Azridjal et al. 2014 contains all the details of the test apparatus, measurements, test procedures, data verification etc., an interested reader is referred to Azridjal et al. 2014. In this paper test procedure will be described.

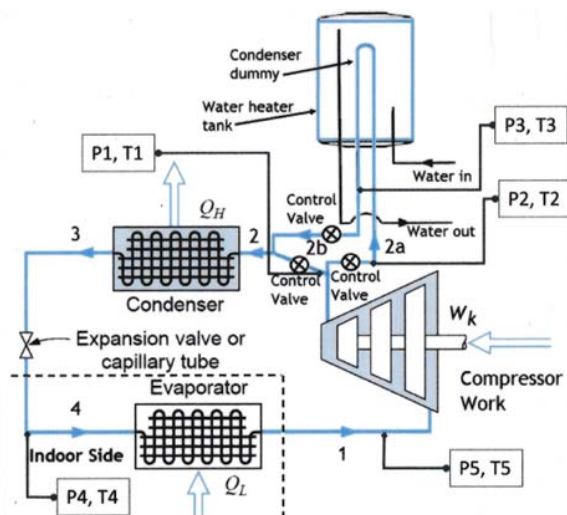


Figure 1: Schematic of Air Conditioning Water Heater (Sonntag, 2009, Azridjal et al.2014).

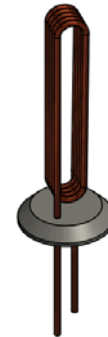


Figure 2: Condenser dummy trombone coil type

The schematic diagram of air conditioning water heater system is shown in Figure 1. The system can offer the following two operating modes. Mode 1 is only for space-cooling mode, this mode is like the common air-conditioning circles. Mode 2 can act as space-cooling and water heating mode. The switching among two modes is by means of on-off controls of the control valves valve. In this study, air conditioning water heater was operated in mode 2.

2.2 Test Procedure

Test procedure is as follows:

1. Ensure the apparatus is in good condition and there is no leakage of refrigerant.
2. Ensure that all test equipment is mounted properly.
3. The apparatus is turned on by connecting power cord to an electric current source and turn on the evaporator in a test chamber with set up temperature 16 °C.
4. Data were taken every 5 minutes for 120 minutes. Data collection depends on the parameters such as temperature, pressure, electric current, voltage in four condition: without load, and with load from electric bulb (1000 W, 2000 W and 3000 W)
5. When data recording were finished, turn off the apparatus in the test room and unplug the power cord from the current source.

3.0 RESULT AND DISCUSSION

Based on the design that has been done, the result of design the dummy condenser as heat exchanger is used type of trombone coil as shown in Figure 2. The trombone coil pipe was made of using a 3/8 inch diameter copper pipe, with 5 windings and 5,338 meters length. Then, the dummy condenser is placed in the water tank, which has a volume of 50 L that will be used for water heating. This heater is installed after the compressor and before the condenser, as shown in Figure 1.

Figure 3 shows the compressor power for two hours operation of system in different cooling load using dummy condenser. The testing of air conditioning water heater in mode 2, when the cooling load increase in the test room, the compressor power will increase too. This is because the heat that absorbed by the evaporator increase with increasing of cooling load and it will

cause compression power increase. It is affected by the heat which absorbed by the refrigerant in the evaporator increase, so compression power also increase. Compressor power average at loads of 3000 watts is 0,74526 kW, while without loads is 0,57635 kW, it appears that compressor power increasing that tends to occur linearly.

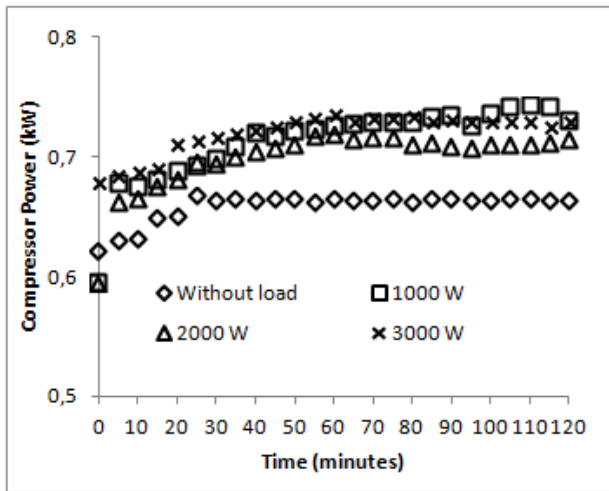


Figure 3: Compressor power vs. time at different cooling loads using dummy condenser

Figure 4 shows the distribution of water temperature in tank at different cooling load using dummy condenser. The higher cooling load is given in test chamber, the higher temperature of the water produced. This is because due to the heat generated by the condenser higher when the cooling load in the test room increase. The bigger cooling load given in the test room, the bigger heat absorbed in the evaporator, so the greater heat rejected in the dummy condenser that will heat the water in the tank. Where the highest water temperature at cooling loads 3000 W is 64.33 °C, while without load is 61.54 °C.

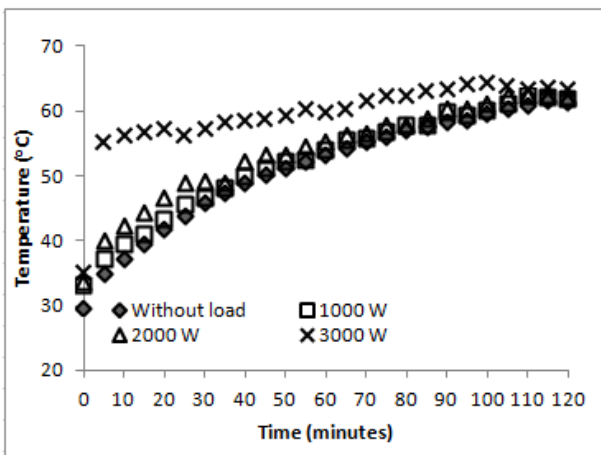


Figure 4: Water temperature in a tank vs. time at different

cooling loads using dummy condenser

Figure 5 shows condenser temperature and test room temperature at different cooling loads. At different cooling loads during 120 minutes of testing, it appears that the temperature of the condenser and temperature of test room tend toward steady condition after 30 minutes of testing. Condenser temperature and the temperature of the test room tend to rise with the increasing amount of cooling load, this is because the heat from the cooling load will be absorbed in the evaporator increase, so that the bigger the heat is removed in the condenser. The average temperature of the condenser at without load condition, 1000 W loads, 2000 W loads and 3000 W loads respectively are 72.66 °C, 70.07 °C, 76.72 °C and 78.12 °C. While the average temperature of the test room without load condition, 1000 W loads, 2000 W loads and 3000 W loads respectively are 20 °C, 18.03 °C, 22.57 °C and 26.09 °C.

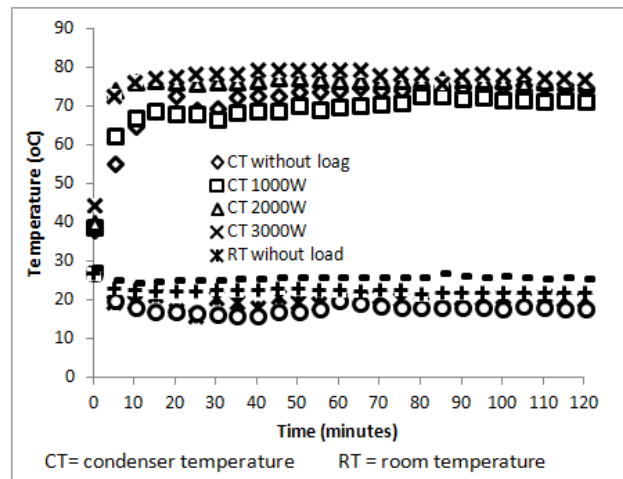


Figure 5: Condenser Temperature and test room temperature at different cooling loads

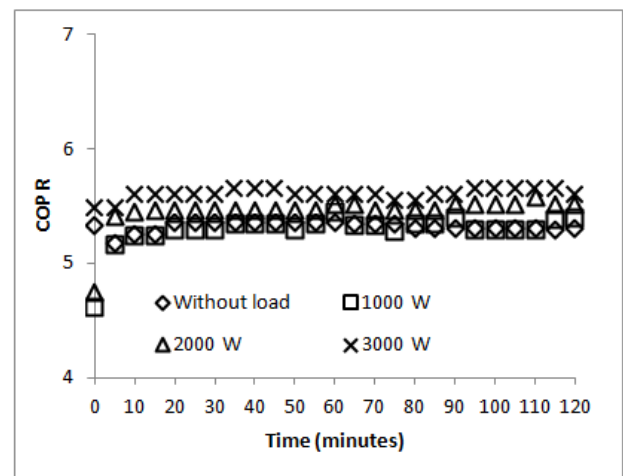


Figure 6: Coefficient of Performance Refrigeration (COP_R) vs. time at different cooling load using dummy condenser

Experimental results of Coefficient of Performance Refrigeration (COP_R) vs. time at different cooling load using dummy condenser is shown in Figure 6. As shown in Figure 6, the increase of cooling loads causes that the COP_R increases. The average COP_R of system without load condition, 1000 W loads, 2000 W loads and 3000 W loads respectively are 5.31, 5.33, 5.48 and 5.62. As seen in Figure 6, because compressor power increases with the rise of cooling load. Increasing the cooling load in the test room also will increase COP_R because the cooling power to be supplied at the evaporator increase too.

Coefficient Performance of Refrigeration and Heat Pump (COP_{R+HP}) as air conditioning and water heater at the different cooling load is shown in Figure 7. As the cooling load increases in the test room, COP_{R+HP} also increasing, although in cooling load 2000 W some time a little higher than 3000 W. The performance of COP_{R+HP} is bigger than COP_R because the benefits of cooling and heating are used simultaneously. Dummy condenser plays an important role in achieving higher system performance. Coefficient of Performance is higher for the combined system as air conditioning and water heater with dummy condenser. The use of dummy condenser as trombone heat exchanger affects the COP and the value of the optimum work compressor as shown in Figure 3.

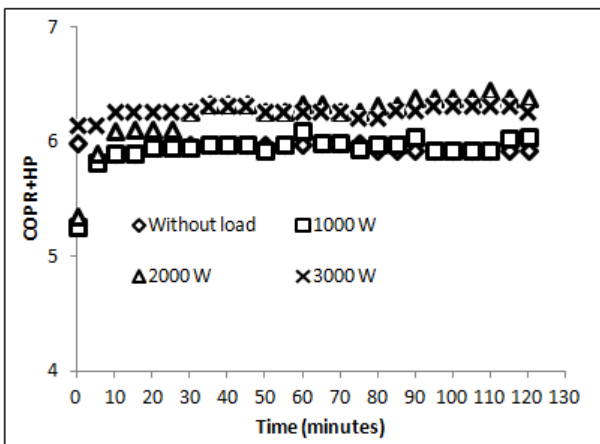


Figure 7: Coefficient of Performance Refrigeration and Heat Pump (COP_{R+HP}) vs. time at different cooling load using dummy condenser

4.0 CONCLUSION

The experimental performance study to observe the effect of changes in the cooling load of the combined air conditioning and water heating system using heat wasted from split type air conditioner are presented. The results indicate that the higher the cooling load is given in the test chamber, the greater the heat absorbed in the evaporator, so the higher the temperature of the hot water produced in the hot water tank. When the cooling load increase the COP_R and COP_{R+HP} also increasing too as the benefits of cooling and heating are used simultaneously. It was

concluded that by combined air conditioning and water heating system so that space cooling and water heating can take place simultaneously, the energy performance can be raised considerably.

ACKNOWLEDGEMENTS

This research work was funded by Research Institute of University of Riau Grants 2013 for Decentralization funding of Excellent Research Higher Education.

REFERENCE

1. Aziz, Azridjal., Kurniawan, Iwan., and Ginting, Hardianto., (2014). *Performance of Hybrid Air Conditioning Machine using Condenser Dummy For Water Heater*. Annual Seminar in Mechanical Engineering, Indonesian Society of Mechanical Engineering, SNTTM 13th University of Indonesia, paper no. 262. (in Indonesian).
2. Hepbasli, Arif., and Kalinci, Yildiz., (2009). *A review of heat pump water heating system*, Renewable and Sustainable Energy Reviews, Vols. 13, pp: 1211–1229.
3. Ji, Jie., Chow, Tin-tai., Pei, Gang., Dong, Jun., and He, Wei. (2003). *Performance of Multi-functional Domestic Heat-pump System*, Applied Thermal Engineering. Vols. 23, pp: 581-592.
4. Ji, Jie., Pei, Gang., Chow, Tin-Tai., He, Wei., Zhang, Aifeng., Dong, Jun., and Yi, Hua., (2005). *Performance of multi-functional domestic heat-pump system*. Applied Energy, Vols. 80, pp: 307-326.
5. Kongre, U. V. Chiddarwar, A. Dhumatkar , R. P. C. dan Ari S, A.B., (2013). *Testing and Performance Analysis on Air Conditioner cum Water Dispenser*, International Journal of Engineering Trends and Technology, Vols. 4, pp: 772-775.
6. Liu, Fei., Huang, Hui., Ma, Yingjiang., and Zhuang, Rong., (2008). *Research on The Air Conditioning Water Heater System*, International Refrigeration and Air Conditioning Conference, Purdue University, paper 893.
7. Rahman, M. M., Wai Meng, Chin., and Ng, Adrian., (2007) . *Air Conditioning and Water Heating-An Environmental Friendly and Cost Effective Way of Waste Heat Recovery*, Journal of Engineering Education, Vols.31, pp: 38-46.
8. Sonntag, Richard E., and Borgnakke, Claus., (2009). *Fundamentals of Thermodynamics*. John Wiley & Sonse, Inc.
9. Sreejith K., (2013). *Experimental Investigation of A Domestic Refrigerator Having Water-Cooled Condenser Using Various Compressor Oils*, International Journal of Engineering and Science, Vols. 2, pp: 27-31.
10. Stalin, M. Joseph., Krishnan, S. Mathana., and Kumar, G. Vinoth. (2012). *Efficient Usage of Waste Heat From Air Conditioner*, International Journal of Advances in Engineering & Technology , Vols. 4, pp: 414-423.
11. Yi, Xiaowen and W. L. Lee., (2009). *The Use of Helical Heat Exchanger for Heat Recovery Domestic Water-Cooled*

Air-Conditioners, Energy Conversion and Management, Vols. 50, pp: 240–246.

12. Yilmaz, Mehmet., (2003). *Performance Analysis of a Vapor Compression Heat Pump Using Zeotropic Refrigerant Mixtures*, Energy Conversion and Management, Vols. 44, pp: 267-282.

