PAPER NAME

IJLERA 2023 Djuanda.pdf

WORD COUNT	CHARACTER COUNT
3027 Words	**15799 Characters**
PAGE COUNT	FILE SIZE
6 Pages	**403.7KB**
SUBMISSION DATE	REPORT DATE
Jun 23, 2023 3:43 PM GMT+8	**Jun 23, 2023 3:43 PM GMT+8**

● 9% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 6% Publications database
- Crossref Posted Content database
- Crossref database
- 4% Submitted Works database

● Excluded from Similarity Report

- Internet database
- Quoted material
- Small Matches (Less then 10 words)
- Bibliographic material
- Cited material
- Manually excluded text blocks

Effect of Heat Input Condition on Evaporator to the Performance of High Temperature Heat Pump

Djuanda[1]

[1] *(Engineering Education Vocational, Makassar State University)*

Abstract: Condition of heat input in the evaporator is very influential on the performance of heat pumps. Analytical studies have been conducted with two main variables, namely temperature and load input to the evaporator. Refrigerant used in this study is isobutene (R-600a). This study is useful as a determination of the working conditions of the evaporator at a solar assisted high temperature heat pump. The results showed that for the compressor with a maximum working pressure of 25 bar the evaporator temperature maximum allowed for the pressure ratio PR = 3 should not exceed 60 °C, for PR = 2.5 may not exceed the temperature of 67 °C, for PR = 2 should not exceed 78 °C, and PR = 1.5 the maximum allowable evaporator temperature can reach 90 °C. The coefficient of performance (COP), heat pumps will be smaller if the evaporator temperature and pressure ratio increase. There is a polynomial relationship between the evaporator temperature, pressure ratio and COP of the heat pump.

Keywords: heat pump, high temperature, heat input, pressure ratio, performance, COP

I. INTRODUCTION

Heat flows naturally from a higher temperature to a lower temperature. By using a small amount of energy flow direction can be reversed by using heat pump technology. This technology is useful because it can move heat from natural sources such as air, water, soil, waste heat or solar energy into the room and used by industry.

There are two main types of heat pumps, the vapor compression heat pumps and absorption heat pumps. Theoretically, heat pumping can be achieved through a variety of thermodynamic cycles and processes such as the Stirling Cycle, Cycle Vuilleumier, solid-vapor sorbtion systems, hybrid systems, electromagnetic processes, and acoustic.

With a higher COP consideration, this study focused on the vapor compression heat pumps cycle. The theory of vapor compression heat pumps were developed in the late 19th century and began to be realized at the beginning of the 20th century. The main components of this cycle are the compressor, expansion device and two heat exchangers, each of which serves as the evaporator and condenser. Further development of high temperature heat pumps using a steam generator replaces the condenser function, as previously investigated [1]. The function of the condenser in the standard heat pump is replaced by a steam generator which is used to produce steam. The heat pump uses solar energy as a heat source in the evaporator. Hot water from the solar collector flows through the heat pump evaporator. The scheme of this system can be seen in Fig. 1, the system is divided into two parts, the sub-solar energy system that is used as a source of heat for heat pumps, and the second is a heat pump sub-system.

Heat from the source was transferred by evaporator to sub-system heat pump. The flow of refrigerant from the evaporator through an internal heat exchanger and then compressed in the compressor until it reaches pressure and high temperature. Refrigerant flowing through the steam generator and then move the heat into the flow of water through the steam generator that will turn it into vapor phase. Before entering the steam generator, water first flowed through pre-heater, which will increase the water temperature from the initial conditions.

Overall system efficiency is strongly influenced by the effectiveness of solar collectors and the performance of heat pumps. Effectiveness depends on the type of solar collector solar collector is used, while the performance of heat pumps in addition to depending on the design and construction of heat pumps is also strongly influenced by the type of refrigerant and heat input at the evaporator.

Some previous studies on heat pump combined with solar energy systems such as research conducted by Odeh et al [2]. Testing the heat pumps combined with solar energy using a double effect on the evaporator. Refrigerant used is R-134a. Double effect evaporator is obtained by combining the input of heat from the water evaporator and ambient air. Water flow rate is increased in the evaporator will increase the heat given off by the condenser as well as with increasing temperature of water entering the condenser would increase the heat pump COP.

Heat pump modeling is carried out by Akinsojiet al [3] for home heating purposes. An ordinary differential equation model is proposed for a wide range of solar heating systems that include a solar collector, a heat exchanger (HE), a boiler tank, a heat pump, and pipes, and pipe sections were employed to effectively simulate dynamics for solar thermal collectors and HE. The MATLAB/Simulink computation environment was used to model the hybrid system, and the yearly energy performance was simulated. The model was experimentally validated by comparing its results to the experimental database's instant thermal collector temperatures and hybrid system. The results demonstrate that the system coefficient of performance is higher than the conventional fossil fuel-based hot water-heating technique, and the hybrid system is the most cost-effective in terms of energy savings.

Combination of a solar collector with an air-source heat pump (ASHP) has been used in other studies [4].This study compared the winter work performance and economic benefits of three different heating forms: solar-air-source heat pump, air-source heat pump, and solar-electric auxiliary heating systems. Using the measurement data, a simulation model was created and examined. The results reveal that the temperature of the primary side water supply is consistent at around 60 C during the heating period, and the total operating hours of the solar collector period accounted for 26.9% of the total hours, of which 23.16% were independent working hours. The solar-air-source heat pump has a COPsys of 4.21, which significantly enhances work performance when compared to other systems.

With the aid of numerous models generated in the JAVA application, the Solar Energy Assisted Heat Pump (SAHP) system is modelled by constructing various processes [5]. In order to generate hot water using solar energy, the SAHP model was developed. The SAHP model was numerically examined with the inflow water temperature in the system taken as 10 °C in December and 20.5 °C in June.The Coefficient of Performance (COP) of the SAHP system for R134a and R404A was calculated in the heat pump modeling by using June 21, 12:00, the time when the spectrum energy is at its peak, as a reference.

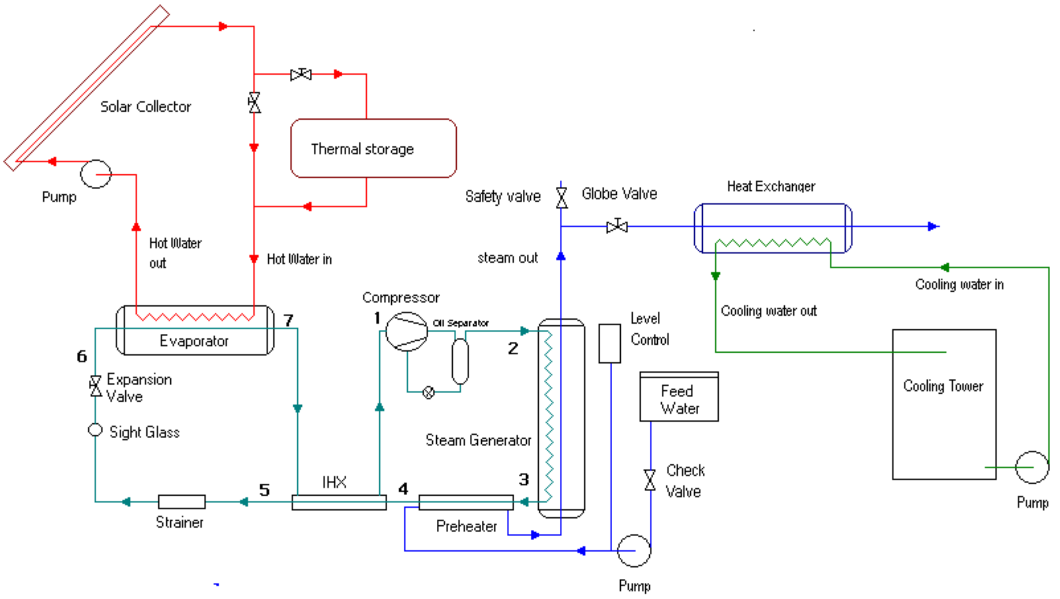

Figure 1 Solar assisted high temperature heat pump

The thermodynamic optimization of a solar heat pump powered by mechanical energy is described [6]. In order to characterize the best thermal performance under limited operating conditions while taking internal and external irreversibility into account during real operation, a novel formulation is developed. For the maximum heating load of the system, the coefficient of performance (COP) is determined by the ideal ratio between the condenser and collector-evaporator conductance (UA). The traditional performance characteristics (COP and second law efficiency) of an experimental air-R22 heat pump were determined, and the results were compared to those obtained using the expressions developed in this work. Results demonstrate how well the new model captures the functionality of actual systems.

The performance of the low GWP refrigerants R1336mzz (Z), R1224yd(Z), R1234ze(Z), and R1233zd(E) in typical one- and two-stage heat pump cycles (internal heat exchanger, economizer, flash tank, cascade) at various temperature levels is compared in the current study [7]. The thermodynamic simulations show that a trade-off between system complexity (such as control, number of components), efficiency, and volumetric heating capacity (VHC) has to be determined depending on the refrigerant and cycle. Depending on the refrigerant and the temperature of the heat exit, optimal COPs are attained.

A water vapor high temperature heat pump system can efficiently recover low-grade energy and is more environmentally friendly since it combines the benefits of a high temperature heat pump (HTHP) and a natural refrigerant [8]. In this work, a new water vapor HTHP system with waste heat recovery at 80–90 °C and hot water delivery at 120–130 °C is presented. The water vapor HTHP system model is created to examine the system's performance under various operational circumstances. To verify the modeling results, an experimental study of the HTHP system using water as the refrigerant is next conducted. The simulation results show that the compressor power ranges from 46.1 to 58.1 kW and the system COP ranges from 3.64 to 4.87 when the evaporation temperature is below 83-87 °C and the condensation temperature is between 120-128 °C. The simulation and experimental results are in good agreement with one another, proving the model developed in this study to be highly reliable and accurate for the water vapor HTHP system.

Pressure-enthalpy diagram of heat pump systems that operate at high temperatures for standard cycle is shown in Fig. 2.

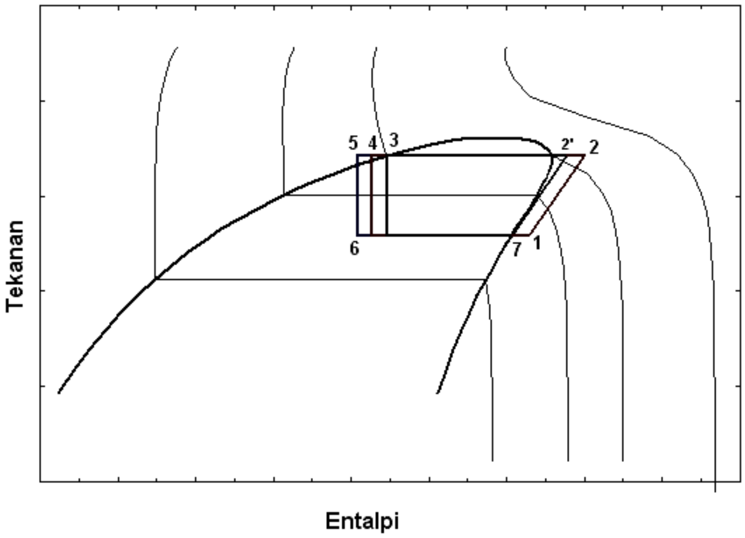

Figure 2 Pressure-enthalpy diagram of heat pump systems

The coefficient of performance, or COP, is a measure of system performance [9]. This parameter represents the ratio between the heat obtained in the steam generator and the energy supplied to the compressor. COP of heat pump is given in the equation:

$$COP = \frac{Q_{sg} + Q_{ph}}{W_{comp}} \quad (1)$$

As for the COP system as a whole is:

$$COP_{tot} = \frac{Q_{sg} + Q_{ph}}{W_{comp} + W_{pump}} \quad (2)$$

Where Q_{sg} and Q_{ph} is heat generated by the steam generator and pre-heater, W_{comp} and W_{pump} is supplied to the compressor and pump.

II. RESEARCH METHOD

The study was a simulation is the calculation of high temperature heat pumps. Heat pumps used are of the type using a refrigerant vapor compression isobutene (R-600a). Vapor compression type selection is based on the coefficient of performance (COP), which is higher than other types. A limitation is the availability of a compressor that can operate at high pressures.

The research began with studies of high temperature heat pumps heat pumps that produce specifications that will be used. Preparation of the equation and the simulation program is done with the components such as compressors, evaporators, steam generator, internal heat exchanger, pre-heater, and the expansion valve.

The variation of the evaporator input load becomes an important variable to investigate the characteristics and performance of heat pumps. With the obtained coefficient of variation of heat pump performance, entry and exit pressure compressor, condenser refrigerant temperature, and evaporator temperature. The results will be displayed in graphical form for each variable.

III. RESULT AND DISCUSSION

Two input variable heat pump is an important factor in the design of the system: evaporator temperature on heat pumps and heat pumps pressure ratio. Both of these variables will largely determine the design of heat pumps, especially in the use of compressor types.

Simulation of heat pump system using the operating conditions as in Table 1.

Table 1 Heat pump operating conditions

Refrigerant	R-600a
Evaporator temperature	30°C - 90°C
Pressure ratio	1,5 - 3
Compressor type	Open
Isentropic efficiency	0,7
Superheating Temperature	5°C
Sub cooling temperature	5°C
Heat Loss Factor	10%
Condenser load	7 kW

Simulations carried out by varying the evaporator temperature and pressure ratio of heat pumps. The simulation results suggest a link between the temperature of the evaporator and compressor pressure ratio as shown in Fig. 3 to Fig. 6.

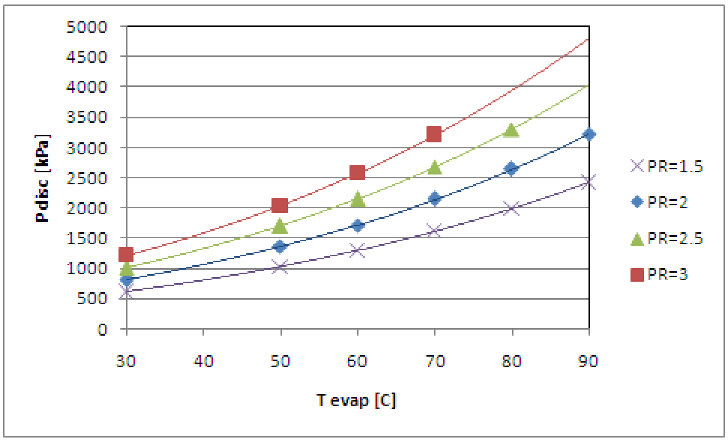

Figure 3 The relationship between the temperature of the evaporator and compressor discharge pressure

Fig. 3 shows the relationship between temperature of evaporator and compressor discharge pressure of heat pumps for various pressure ratios. The higher the temperature of the evaporator, the heat pump compressor discharge pressure is also greater. Similarly with the ratio the greater the pressure will increase the compressor discharge pressure. For the compressor with a maximum working pressure of 25 bar which is currently many outstanding then the evaporator temperature maximum allowed for the pressure ratio PR = 3 should not exceed 60 °C, for PR = 2.5 may not exceed the temperature of 67 °C, for PR = 2 should not exceed 78 °C, and PR = 1.5 the maximum allowable evaporator temperature can reach 90 °C. Some piston compressor designed specifically to work on the operating pressure of 40 bars. In this condition the maximum evaporator temperature is allowed to PR = 3 can reach 80 °C and for PR = 2.5 to 90 °C.

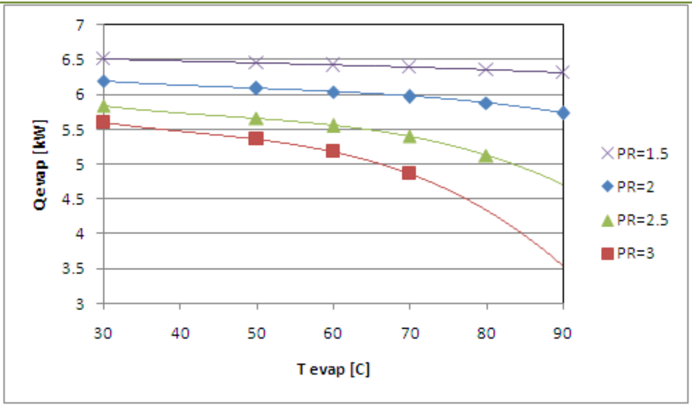

Figure 4 The relationship between heat input temperature evaporators and condensers load

Heat input to the evaporator which can be achieved for condenser 7 kW heat output and its relationship with the condenser temperature can be seen in Figure 4. Increasing evaporator temperature will reduce heat input evaporator. Achieved the biggest drop in pressure ratio PR = 3 and PR = 2.5. It can also be seen that the greatest heat input can be achieved at the smallest pressure ratio PR = 1.5.

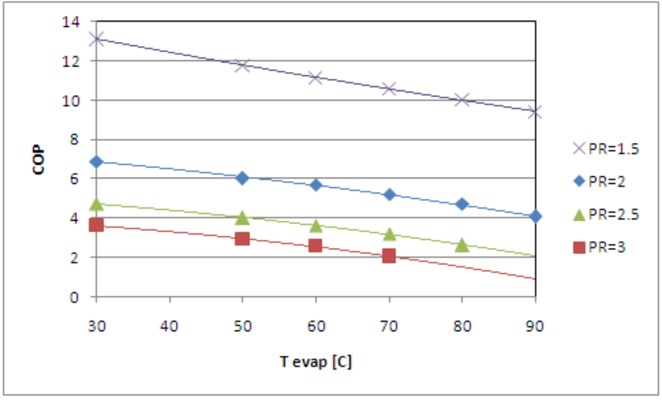

Figure 5 Effect of evaporator temperature and pressure ratio on the COP

The coefficient of heat pump performance is also influenced by input condition in the evaporator. As the evaporator temperature rise will reduce the coefficient of performance (COP) of heat pumps. Decrease in COP is influenced by the system's ability to absorb heat that is given from the outside, so that heat can be delivered to the condenser is also getting smaller. For the system to remain in a state of equilibrium, the lack of heat will result in higher compressor work. This is what spurred the decline COP heat pumps. Fig. 5 also shows the influence of pressure ratio on the heat pump COP. The higher the ratio of system pressure will only lead to lower the heat pump COP. With increasing pressure the low ratio of heat pumps will have an impact on the low compressor. The highest COP generated by heat pumps with pressure ratio of 1.5 is between 8.7 to 13, while the lowest COP generated by heat pumps that work on the pressure ratio of 3, i.e. between 2 to 3.6.

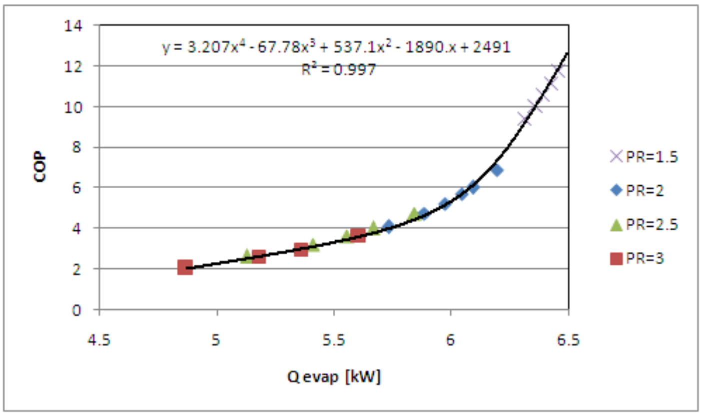

Figure 6 The relationship between heat input and COP

The relationship between heat input at the evaporator and the coefficient of performance of heat pumps is shown in Fig. 6. Plot evaporator Heat input to various pressure ratio in one area of the graph generates a unique trend, starting from the pressure ratio PR = 3 will produce the lowest COP, while the lowest pressure ratio PR = 1.5 will give the highest COP. General relationship between these variables can be obtained with a polynomial equation:

$$y = 3{,}207x^4 - 67{,}78x^3 + 537{,}1x^2 - 1890x + 2491 \tag{3}$$

With R = 0,997.

IV. CONCLUSION

From this research, the conclusion is:

1. Evaporator of the higher temperatures will increase the compressor discharge pressure. For the compressor with a maximum working pressure of 25 bar which is currently many outstanding then the evaporator temperature maximum allowed for the pressure ratio PR = 3 should not exceed 60 °C. As for PR = 2.5 may not exceed the temperature of 67 °C, for PR = 2 should not exceed 78 °C, and PR = 1.5 the maximum allowable evaporator temperature can reach 90 °C. Increasing evaporator temperature will reduce heat input evaporator. Achieved the biggest drop in pressure ratio PR = 3 and PR = 2.5. It can also be seen that the greatest heat input can be achieved at the smallest pressure ratio PR = 1.5.
2. Evaporator temperature and increasing pressure ratio will decrease the heat pump COP. The highest COP generated by heat pumps with pressure ratio of 1.5 is between 8.7 to 13, while the lowest COP generated by heat pumps that work on the pressure ratio of 3, i.e. between 2 to 3.6.
3. There is a polynomial relationship between the evaporator temperature, pressure ratio and heat pump COP.

REFERENCES

[1] Djuanda, A. Suwono, A.D. Pasek, N.P. Tandian, Experimental study on a-solar assisted high temperature, *Proc. The International Conference on Fluid and Thermal Energy Conversion*, 2009, the Korean Society of Heat & Cold Energy Engineers Gyeongsang National University, 190-198.

[2] Odeh, S., Salem N., Bilal A., Performance Evaluation of Solar-Assisted Double-Tube Evaporator Heat Pump System, *Int. Comm. Heat Mass Transfer, Vol. 31 No. 2*, 2004, 191 – 201.

[3] O. A. Akinsoji, O. A. Akpofure , G. Ofualagba , O. O. Patrick , and O. O. Olawale, Model-based simulation of a solar thermal heat pump hybrid system for a smart house, *Science Forum (Journal Of Pure And Applied Sciences) 21*, 2021, 119 – 129.

[4] J. Wu, M. Shen, J. Feng, The application of a solar-air-source heat pump dual supply heating system in a high-cold area in china, *Processes, 11 737,*2023, 1-15.

[5] D. Ozenen, M.T. Coban, Solar assisted heat pump modeling, *European Mechanical Science, 6(I),* 2022, 32-38

[6] E.T. Reyes, J.C de Gotari, Optimal performance of an irreversible solar-assisted heat pump, *Exergy, 1(2),* 2001, 107-111.

[7] C. Arpagaus, M. Prinzing, R. Kuster, F. Bless, M. Uhlman, J. Schiffmann, S. Bertsch, High temperature heat pumps-theoritical study on low GWF HFO and HCFO refrigerants, *Proc.25th IIR International Congress of Refrigeration (ICR)*, Montréal, Québec, Canada, 2019

[8] D. Wu, H. Yan, B. Hu, R.Z. Wang, Modelling and simulation on a water vapor high temperature heat pump system, *Energy (168)*, 2019, 1063-1072.

[9] Coelho, L.M.R, *Basics of Heat Pump Technology*, Workshop Groundhit, Brussel, 2006.

● **9% Overall Similarity**

Top sources found in the following databases:

- 6% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	**Di Wu, Hongzhi Yan, Bin Hu, R.Z. Wang. "Modeling and simulation on a ...** Crossref	2%
2	**School of Business and Management ITB on 2021-08-02** Submitted works	2%
3	**Jiarui Wu, Miao Shen, Junxiao Feng. "The Application of a Solar-Air-So...** Crossref	1%
4	**School of Business and Management ITB on 2021-08-04** Submitted works	1%
5	**University of Ulster on 2008-10-17** Submitted works	<1%
6	**Carlos Mateu-Royo, Joaquín Navarro-Esbrí, Adrián Mota-Babiloni, Áng...** Crossref	<1%
7	**De Montfort University on 2011-12-01** Submitted works	<1%
8	**A. Ucar, M. Inalli. "Exergoeconomic analysis and optimization of a sola...** Crossref	<1%
9	**D.A. Chwieduk. "Active solar space heating", Elsevier BV, 2016** Crossref	<1%

Excluded from Similarity Report

- Internet database
- Quoted material
- Small Matches (Less then 10 words)
- Bibliographic material
- Cited material
- Manually excluded text blocks

EXCLUDED TEXT BLOCKS

International Journal of Latest Engineering Research and Applications (IJLERA) IS...

Udayana University on 2019-05-09