

The analysis of cooling system working performance by using pure R 410a refrigerant with the results of R 410a recycle

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Abstract. Cooling machines have a direct contribution to environmental damage including depletion of ozone layer and global warming caused by the leakage and discharge of synthetic refrigerants (HCFC and HFC) into environment. The discharge of refrigerant into the environment is 60 percent of service sector. Some obstacles found when making a model of a refrigerant waste treatment system since it could only be used for CFC (R-12)/ R-134a refrigerants. This research aims at redesigning a machine made beforehand thus it can process various refrigerant wastes used in hospitality industries which involved several components such as compressors, oil separators, filters and distillers for recycling R410A refrigerants. By having this ability, all refrigerant waste can be recycled. Result shows that the redesigned machine can recycle refrigerant waste and the signal can be reused. Calculation results on COP cooling system using pure R 410A showed 4.5, whereas by using recycled R 410A refrigerant 4.3 was obtained. COP using recycled refrigerants was lower than the one using pure refrigerants due to contamination of dirt, oil and other elements. However, with COP value of 4.3 the system performance is still good, therefore the recycled R410A refrigerant can be reused.

1. Introduction

The development of the hotel industry in Bali is increasing along with the development of the tourism industry. The tourism industry in Bali is a leading industrial sector. According to the data obtained from the Badan Pusat Statistik (BPS) (Central Statistics Agency) of Bali states that the amount of star and non-star hotels in Bali reached 2,079 hotels. LG Bali Branch Manager Anton Fatoni said that every month around 3,000–4,000 units of air conditioning machines are absorbed by the market in Bali, 20% of which serve hotels and villa needs. "the demand from tourism properties is quite high, it is due to the large amount of hotel, villas, and condotels development spread in various tourist areas.

Current cooling machine technology greatly influences the life of the modern world, not only limited to improving the quality and comfort of life, but also has touched the essential things that support human life [1]. This technology is needed for the preparation of food materials, food storage and distribution, chemical processes that require cooling, air conditioning for the comfort of the room in industry, offices, transportation and household and hotel operations. At the present time, the most widely used cooling machine technology is from the type of vapor compression cycle [2]. Most of these machines use HCFC and HFC refrigerants. HCFCs and HFCs refrigerant are the cause of global warming and ozone layer damage [3].

Cooling machine technology has a direct contribution to the damage of environment including depletion of the ozone layer and global warming through leakage and discharge of synthetic refrigerants



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(HCFC and HFC) into the environment [3]. The discharged of refrigerant into the environment is 60 percent of the service sector [4]. In response to the damage of the ozone layer in the stratosphere, began the negotiation process of the development of international measures to protect the ozone layer through Vienna Convention which was passed in [5], it was followed up with the ratification of the Montreal Protocol which contained regulations on production supervision, consumption and trade in ozone-depleting substances [5].

Indonesian government has ratified Vienna Convention, Montreal Protocol and London Amendment through Presidential Decree No. 23 of 1992. Furthermore, the implementation of the ozone layer protection program in Indonesia is facilitated by the State Ministry of Environment as a controlling institution in environmental conservation efforts [6].

Nowadays the management of refrigerant waste in the hospitality industry is still not handled properly, in which from the results of our interviews with several hotel technicians the refrigerants in refrigeration machines is still managed by disposing it of into the environment, thus it will have negative impacts on environment. Based on the results of the previous research, there is a model of refrigerant waste management systems made yet many obstacles are still faced, such as the unoptimal evaporation process of refrigerants in the system, and CFC refrigerants R-12/ R-134 a as the limited type of refrigerants used, whereas the refrigerant waste currently used in hotel industry has a variety of types. By redesigning the refrigerant waste processing, hopefully the refrigerant waste management machine in the hotel industry will be handled, therefore it can reduce air pollution caused by the hospitality industry's refrigerant waste.

1.1. Problem

Environmental problems do not stand alone, but are always closely interrelated. The relationship between problems is caused by one factor leading to various problems, a factor which has different influences, and the cumulative interaction between various problems and the caused effects. The waste management system model made in previous research still faced many obstacles such as the unoptimal evaporation process of refrigerants within the system, and the limited refrigerant type to CFC (R-12) / R-134a, meanwhile the current refrigerant waste in the hospitality industry comes in various types.

1.2. Aim

The purpose of this research is to get an efficient and environment friendly hotel waste management system design product.

2. Literature review

2.1. Refrigerant

Association Heating Refrigeration and Air Conditioning Engineers [6] defines refrigerants as substances that flow in refrigeration machines (refrigeration machines or air conditioning / air conditioning machines). Refrigerant is the most important component of the refrigeration cycle since it is the one that causes cooling and heating effects on the cooling machine. This substance serves to absorb heat from the cooled objects/medias and carry them, then throw the heat into the air or into the atmosphere. classified types of refrigerants into synthetic refrigerants and natural refrigerants [5].

2.2. 3R engine (recovery, recycle and recharging)

3R engine refrigerant is a machine used for the process of sucking (recovery), recycling (recycling), and recharging (recharging) refrigerant after being removed from the car's air conditioning system. Refrigerant expenditures are performed due to various things, including repairing, maintaining, and reducing refrigerant quality due to contamination of lubrication oil when circulating in an AC system. Throwing refrigerant containing chlorine gas (CFC) into free air without storing it in recovery machines (3R) will cause environmental pollution and damage the ozone layer (O3). The use of R-134a is very beneficial, especially when refilling, since there is no need to spend more money on buying new

refrigerants. The equipments used in the refilling process are a 3R engine, charging manifold, and leak detection device.

3. Research methods

3.1. *The method of research development*

The research method used in this study is a research and development method which is used to produce certain products and to test their effectiveness [5]. The applied development design model is to make efforts to find a breakthrough in waste recycling systems in order to turn waste into useful products.

3.2. *Research design*

This research will be conducted by designing an existing 3R engine that can only recycle CFC (R-12)/R-134a refrigerants and cannot be used for R 410A refrigerants. Redesigning is performed to improve the work of the compressor by replacing it with a larger capacity therefore higher working pressure is obtained. By replacing the compressor, other supporting components have also to be adjusted such as oil filters, oil separators, distillers, and refrigerant heaters. After the redesigned engine is completed then do the recycling process of R 410A refrigerant waste so that it can be recovered and further testing to determine the obtained performance of the system refrigerant by using recycled refrigerant and later to be compared with the performance of the refrigeration system by using pure refrigerant. This performance is tested on split AC system.

3.3. *Measured variables*

In this study the measured variable in order to know whether the system can optimally operate is pressure. In which the measured pressures are compressor high pressure, compressor low pressure and recovery tube pressure.

3.4. *How to measure variables*

Low pressure is measured through the suction side of the compressor which is controlled by a low pressure switch, whereas high pressure is measured through the compressor output side which is also controlled by high pressure switch and tube pressure recovery. The pressure is measured by pressure gauge connected to the compressor's high pressure side.

4. Results and discussion

4.1. *Refrigeration effect*

The refrigeration effect of the Split AC system using pure refrigerant produces a higher value reaching 84 Btu/lb, while systems using recycled refrigerants produce a refrigeration effect of 77 Btu/lb. The effect of system refrigeration using pure R 410A is greater than the one using R 410A recycle results since the recycle refrigerant in the system still contains elements such as dirt and oil. This occurs because when refrigerant is recycled on a machine which makes the ability of components, filters for instance, cannot filter the refrigerant into 100% pure refrigerant, so that the recycled refrigerant still contains elements, i.e. dirt and oil.

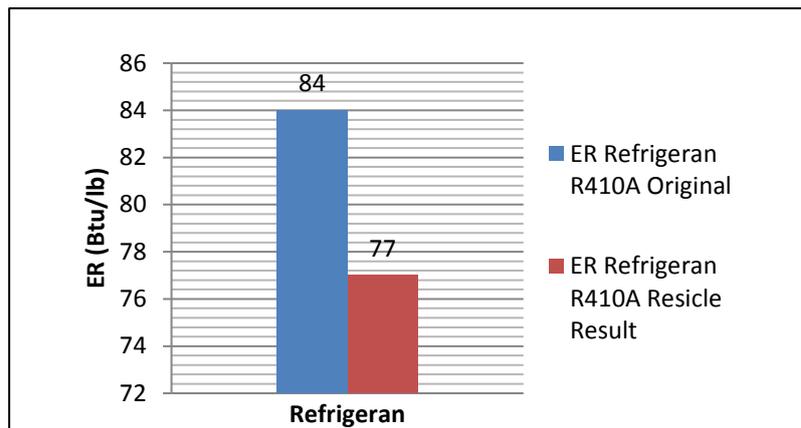


Figure 1. The graph of comparison of the value of refrigeration effects (ER) systems using pure R 410A refrigerants with recycle R 410A refrigerants.

4.2. Compressor performance

By looking at the compressor, it is inversely proportional to the cooling effect resulting from a system which uses pure R 410A refrigerant and recycled R 410A refrigerant, where the compressor using R 410A refrigerant recycle result is greater than the one using pure R 410A. This happens due to the presence of elements such as dirt and oil in the recycled refrigerant which results in harder work of the compressor.

4.3. System performance

The performance of the system can be seen from the value of COP as the result of system testing. Based on the value of the COP system, the system using pure R 410A refrigerant is greater than the one using recycled R 410A refrigerant. With the great effect of refrigeration and slight performance of the compressor will result in greater system performance and vice versa if the work of a large compressor with a small refrigeration effect will result in smaller system performance. From the results of the testing and subsequent calculation of COP, the COP system using pure R 410A refrigerant reached 4.9 while the COP system using the recycled refrigerant is 4.3. By looking at the decline in system performance, the system using R 410A reflex transmission results decreased by 13.95% compared to the one using pure R 410A refrigerant.

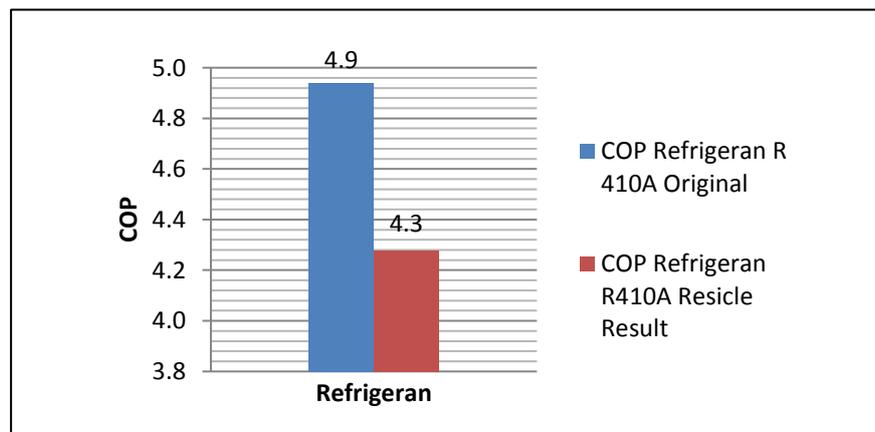


Figure 2. Graph of comparison of COP system values using pure R 410A refrigerant with resicle R 410A Refrigerant.

5. Conclusions

From the results obtained, the performance of the system using recycled R 410A refrigerant is lower than the system using pure R 410A refrigerant, with a decrease of 13.5%. The decrease in the performance of this system is due to the heavier work of the compressor system using recycled R 410A refrigerant than the system using pure R 410A refrigerant. The amount of compressor work is due to other elements such as dirt and oil on the recycled R 410A refrigerant. Although the performance of the system using recycled R 410A refrigerant is lower than the one with pure R 410A refrigerant, the performance of the system that uses recycled R 410A refrigerant can still be and is feasible to use, so that the refrigerant waste can be useful for tourism industry parties and not damage the environment.

6. References

- [1] Arora C P 2011 *Refrigeration and Air Conditioning* (Singapore: Mc.GrawHill inc)
- [2] Chaiwongsa P and Wongwises S 2007 *International Journal of Refrigeration* **30** 601-608
- [3] Wuebbles D J 1994 *International Journal of Refrigeration* **17** 7-17
- [4] Calm J M 2002 *International Journal of Refrigeration* **25** 293-305
- [5] Kruse H 2000 *ASHRAE Jurnal* 16-24
- [6] Calm J M 2012 *International Journal of Refrigeration* **25** 705-715