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Redesign 3 R Machine as a Refrigerant Waste Treatment Alternative in Environmental Rescue

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Abstract. Cooling machine technologies really affect nowadays' modern life, not only limited in enhancement of life quality and comfort, but it has also reached the essential things of humans' life supporter (Arora, 2001). Cooling machine technologies have direct contribution toward environmental damage such as depletion of ozone layer and global warming through synthetic refrigerant waste and leakage (CFC and HFC) to environment. The refrigerant release to the environment is 60% of the service sector. Destructive characteristics of ozone possessed by CFC were first proposed by Rowland and Molina which were then supported by yard measurement. It is estimated that ozone layer damage occurs for about 3% every decade. The ozone layer located in the stratosphere is functioned to prevent ultraviolet-B ray from entering into earth surface. This Ultraviolet-B is suspected to be the cause of health problem for humans and disorder for plants on earth. As for the purpose of this research is to obtain a product design of refrigerant waste processing system (recovery and recycle refrigerant) as well as to acknowledge the work method (COP) of cooling machines that use CFC refrigerant (R-12) as the result of recovery and recycle compared to CFC refrigerant (R-12)/ pure R134a. One method that can be used is by redesigning existing equipment namely 3R machine that cannot be used anymore thus it can be reused. This research will be conducted through modifying the existing 3R machine therefore it can be reused and be easily operated as well as doing the maintenance, after that the refrigerant as the result of recovery will be tried on a refrigeration system and a test of refrigeration system work method will be conducted by using the refrigerant recycle product which is obtained and compared with the work method of the one with pure refrigeration. The result has been achieved that the redesign product of refrigerant waste processing equipment can be reused and able to perform the recovery, recycle and recharging process, although using semi-automatic control system. So the use of car air conditioning refrigerant can be more efficient. With the functioning of 3R mesu is expected wastes refrigerant is not wasted which is one of the efforts to save the environment.

Key word: Redesign, 3R Machine, Environment rescue

1. INTRODUCTION

Cooling machine technologies really affect nowadays' modern life, not only limited in enhancement of life quality and comfort, but it has also reached the essential things of humans' life supporter (Arora, 2001) [1]. This technology is required to prepare foodstuff, food storage and distribution, chemical process which needs refrigeration, air conditioning for the sake of room comfort either industries, offices, transportations, as well as households and hospitality operations.



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The impacts of air conditioning and refrigeration systems on stratospheric ozone are primarily linked to release of ozone-depleting refrigerants. Their contributions to global warming stem both from release of refrigerants and from emission of greenhouse gases (GHGs) for associated energy use [2]. Scientists and Geographers (especially climatologists) have provided scientific and meteorological evidence of the patterns of change in the climatic conditions of the world with the resultant conclusion that global warming is rapidly occurring and the on-going global warming is anthropogenic [3]

Cooling machine technologies have direct contribution toward environmental damage such as depletion of ozone layer and global warming through synthetic refrigerant waste and leakage (CFC and HFC) to environment, there for A computer model has been written to predict the consumption of refrigerants for vehicle air conditioning in China, India, South Korea and South-East Asia, their effect on ozone depletion and global warming, and their costs . The refrigerant release to the environment is 60% of the service sector [4].

Destructive characteristics of ozone possessed by CFC were first proposed, which were then supported by yard measurement. It is estimated that ozone layer damage occurs for about 3% every decade. The halogenated refrigerants have adverse environmental impacts such as ozone depletion potential (ODP) and global warming potential (GWP) [5]. The ozone layer located in stratosphere is functioned to prevent ultraviolet-B ray from entering into earth surface [6]. This Ultraviolet-B is suspected to be the cause of health problem for humans and disorder for plants on earth, The school having none of such equipment, prompted the professors of the Refrigeration and Air conditioning Department to innovate equipment that would recover and recycle refrigerant so that unnecessary venting could be prevented [7].

Association Heating Refrigeration and Air Conditioning Engineer (ASHRAE, 2005) defines refrigerant as flowing substance in a cooling machine (refrigeration machine or air conditioner/ AC). Refrigerant is the most essential component in refrigeration cycle since it causes cooling and heating effect on cooling machine. Commercial replacement of fluorocarbons in mobile air conditioning systems (MACS) with typically HC-290/600a[60/40] and minimal precautions began in Idaho in 1993. R290/600a has low environmental impact but mixed with air is flammable and frequencies for fire, injury and cabin overpressure were predicted [8]. The refrigerant R12 consumed slightly more energy than R134a at higher evaporating temperatures and The refrigerant R134a showed slightly lower coefficient of performance than R12 [9]. R134a having a better COP than CO₂ with the COP disparity being dependent on compressor speed (system capacity) and ambient temperature [10]. Many papers have been published on R134a within the last four years, beginning from the point when it became apparent that R134a would be the favorite for replacing the most important fully halogenated refrigerant worldwide [11]

These substance functions on absorbing heat from objects/media desired and take it, later disposing heat into the air or the atmosphere. Classifies kinds of refrigerant into synthetic and natural refrigerant.

Currently the handling of refrigerant disposal into the environment in a number of cooling machine service companies/workshops is using 3R machine (Recovery, Recycle, and Recharging), in which this 3R machine is a donation from the World Bank through KLH. 3R machine can only be given to several cooling machine services companies/workshops in order to conduct an environmentally friendly cooling machine service.

According to the field observation this 3R machine cannot be well used, since most of the machines are broken moreover from financial point of view the machine procurement needs much money, thus the cooling machine service companies/workshops are reluctant to use it, therefore they return to their old method namely disposing it into the environment. One method that can be used is by redesigning the existing 3R machine thus it can be reused for cheap and efficient CFC and HFC refrigerant management, therefore the refrigerant waste will not be disposed into the environment. There is a widespread belief that the only viable refrigerants in most applications are new fluorocarbon chemicals. This trend will result in continued emissions of several hundred thousand tonnes of alien

chemicals to the atmosphere each year, involving the potential risk of unforeseen environmental effects [12]. Furthermore the management product can be reused or recycled.

a. Statements of Problem

The problem discussed by writer is how to redesign 3R machine (Recovery, Recycle, and Recharging) to be operated for processing refrigerant waste thus it will not be disposed into the environment.

b. Objectives of Study

The purpose of this study is to obtain the result of redesigned refrigerant waste 3R (Recovery, Recycle, and Recharging) machine thus it can be reoperated for processing the refrigerant waste so it will not be disposed into the environment.

c. Significance of Study

There are some benefits expected from this study, namely:

1. By reoperation a not-functioning 3R machine, therefore the used refrigerant can be reused after undergoing recovery and recycle process of 3R machine
2. Preventing CFC and HFC from disposing into the atmosphere, thus the depletion of ozone layer can be prevented as well as global warming by HFC when servicing.
3. Increasing society's awareness and active participation in ozone layer protection programme and global warming prevention, many peoples confuse the causes and consequences of global warming with those of ozone layer depletion [13].

2. METHODOLOGY

a. Research Development Methodology

The method used in this study is research and development method which is a method used for producing certain product and testing the product's affectivity (Sugiyono, 2008). A design development model used is by doing efforts for searching a breakthrough in waste recycling system therefore it will become a beneficial product.

b. Research Design

This research will be conducted by redesigning the existing 3R machine that does not work anymore thus it can be reuse. The redesigned system in the existing 3R machine is the automatic control system that will be changed into semi-automatic system. Where control system which cannot function for a long time will be able to damage the mechanic system of 3R machine. After the machine redesign results are completed then the process of testing process about the workings of the machine results redesign recovery process, resecley, and richarging.

c. The Measured Variable

The measured variable in this research to know that the system is working properly is pressure in which the measured ones are compressor's high pressure, compressor's low pressure, and recovery tube pressure.

d. Variable Measuring Methodology

Low pressure is measured through compressor's absorbing side controlled with low pressure switch and the high pressure is measured through compressor's output side which is also controlled by high pressure switch and the pressure of recovery tube is measured with pressure gauge connected with compressor's high tap side.

3. RESULT AND DISCUSSION

a. Control System before Redesigning

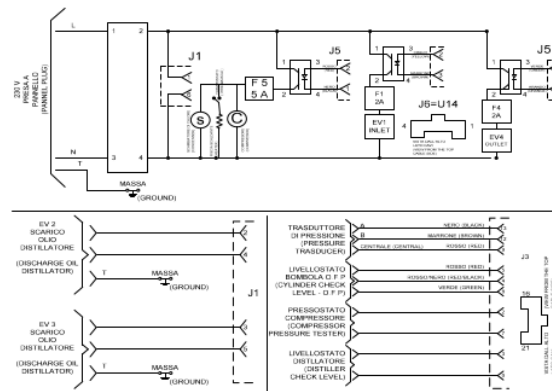


Figure 1. 3R Machine Control Systems before Redesigning

This 3R machine control system uses automatic system for all operational starts from recovery, recycle, recharge, as well as oil and refrigerant separation, in which by using start menu system will work automatically. This control system is a module and is not repaired in each components and if a damage happens it must be replaced with one module. This module is not available in domestic market, thus most of these machines located in Bali cannot be operated.

b. Control System as Redesigning Product

The design of manual control of 3R machine is done as redesigning product. The components used in this circuit namely, contactor, relay, time delay relay as timer, push button no (start), push button nc (stop), high low pressure switch as pressure pacifier on system controlling the compressor's on and off, solenoid valve to control the refrigerant's in and out current from the component, switch as an on off solenoid switch that manages the oil return compressor and oil recovery as well as mode choice, in which mode 1 is especially for recycling and mode 2 is for *recovery*, *recharging*, vacuum process, next there are several lamps functioned as indicator for each process, the last one is a motor as system activator.

c. The Working Procedure of Redesigned 3R Machine

3R machine is a machine used for collecting used refrigerant for later to be recycled therefore can be reused in cooling system. There are three work principles own by 3R machine namely *recovery*, *recycle*, and *recharge*. On recovery system the refrigerant located in cooling system is absorbed by 3R machine until the system's pressure is less than 10 Psi, in this mode the refrigerant is directly recycled and then is stored in a refrigerant storage tube as the result of recovery. In recovery system the on-going cycle is a closed cycle, it means the refrigerant only circulates in 3R machine itself and the occurrence of oil, dust, dirt, air filtering process was taking part in refrigerant circulation. The operation procedure of 3R machine after being modified will be explained as follows:

- 1) Connect 3R machine to the voltage resource; push on off switch located in machine's side body. If there is voltage resource entering machine, the indicator lamp around the switch will turn on.
- 2) There are several buttons on the machine's front side for choosing mode, start and stop mode, and on off switch for oil return compressor and oil recovery. Control is divided into 2 modes namely special mode for *recycle*, and vacuum mode, *recovery*, *recharging*. The classification of those 2

modes is based on the solenoid valve's function which manages the closed and opened refrigerant's current to system. This mode actually disconnects the connection between solenoid 1 and 2, where solenoid 1 and 2 must be active at the same time when *recycle* mode and solenoid 1 is active by itself when *recovery* mode, solenoid 2 is active by itself when *recharging*. If the solenoids are active in all modes at the same time thus the refrigerant current will be random or not in accordance with the path we desire. The following is the front side of control machine buttons. In special mode recycle the red lamp will turn on and green indicator lamp on recycle mode if the start button is pressed. The following is the picture of recycle mode. (PICT)



Figure 2. Special Mode Recycle

- 3) To operate machine for the first time please check whether the hpls indicator is on, if yes it means that there must be pressure entering the system, if there is no mode pressure indeed it can be started but the compressor will not work since there is no refrigerant pressure entering the system. This aims to keep the system from being excess and lack of pressure. The set pressure is 10 Psi for low pressure and 400 Psi for high pressure.



Figure 3. High Low Pressure Switch and Indicator

- 4) For recovering or absorbing refrigerant from cooling system to 3R machine foremost connect the manifold gauge to cooling system and 3R machine as shown in the following picture. After connecting press button start *recovery*, slowly open valve located in the place where the manifold gauge is connected and wait until the compressor works and absorb the refrigerant in the system. Compressor works after the hpls is in normal pressure and the indicator lamp on hpls is off, that means the compressor works.



Figure 4. Display Control Recovery

- 5) For *recycle* system choose special mode for *recycle*, because this process is a closed cycle make sure that there is no outside valve opened thus the refrigerant will not come out through the *in out refrigerant*. By pressing start *recycle* button this mode will work without time limitation, it would be better this mode is run less than 10 minutes therefore the solenoid will not be hot for being opened too long.
- 6) On *recharging* mode or reloading refrigerant from 3R machine to the cooling system first connect the manifold gauge to the cooling system and 3R machine as the following picture. After connecting make sure that the cooling system is also working and press start *recharging* button, open the valve where the manifold gauge and 3R machine are connected slowly and wait until the cooling system compressor works and absorbs the refrigerant collected by 3R machine. Cooling system is incapable to absorb all refrigerant collected by 3R machine since the machine pressure is limited to minimum 10 Psi remaining. After the compressor on 3R machine stops working but the mode is still on, stop the mode immediately therefore the pressure inside machine is not subsiding because solenoid will shut the refrigerant current.
- 7) For vacuuming cooling system using 3R machine, first connect the manifold gauge to cooling system and 3R machine as shown in the picture below.
- 8) After connecting press the start vacuum button, open the valve in a place where the manifold gauge is connected and vacuum machine will work on vacuuming cooling system. Vacuuming is managed by a timer which works for 30 minutes. The reason for choosing 30 minutes vacuuming is based on cars AC workshops' experiences which are used to do the vacuum process for about 30 minutes to make sure that air, water vapour, and dirt inside the system are clean.

4. CONCLUSION

A test is done in order to acknowledge the ability of 3R machine in recovery, recycle, and recharge process. After conducting a test the system can operate optimally, this is shown in recovery process of refrigerant taken from car's AC if the refrigerant runs out then the compressor will be off because of being controlled by low pressure switch. In this process the lowest pressure set is 10 Psig and high pressure does not surpass 400 Psig. If high pressure has reached 400 Psig, this shows the recovery tube is full and the compressor will be off automatically.

Recycling for 3R machine in this testing runs well in which low pressure is not less than 10 Psig and high pressure does not surpass 400 Psig.

Recharging can run normally proven by heating with a heater on a recycling product storage tube, can change refrigerant in liquid form into gas form thus recharging can run automatically to the system that will be given refrigerant as recycle product.

5. ACKNOWLEDGMENT

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