Low Cost Refrigerant (R12/R-22) Recovery Equipment

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Abstract

The destruction of the ozone layer is one of the major issues of the world today. One of the gasses that contributes to the ozone depletion is a refrigerant gas containing chlorofluorocarbon (CFC). Refrigerator and air conditioning unit use this kind of gas. Refrigerator is one of the most important domestic appliances used in the preservation of food. Recent studies show that 30 percent of all CFCs released into the atmosphere comes from air conditioning units, some of refrigerant leak out. But the majority of CFC release occurs during air conditioning service repair. In order to prevent the release of these refrigerant gasses when conducting a repair, it needs to recover the gas and reuse it using a recovery machine. This improvised refrigerant recovery equipment can recover 76.97% refrigerant gas, and consumes only 0.074 Kwh of 230 VAC, class T, Sanyo Refrigerator Unit (110g). This recovery equipment can be made up from a recycled component of a refrigeration unit and locally available materials, and it only cost PhP 12,630.00.

Keywords: Refrigerant recovery, R-12/R-22, Low cost refrigerant recovery

I. INTRODUCTION

Refrigerant (R-22) has been widely used for many years. It possesses many desirable physical and thermodynamic properties and employs in a wide range of applications and temperatures with good system performance (Prapainop, R., Suen, K. O., 2012). R22, as the last remaining ozone-depleting HCFC, will face the eventual phase-out in probably less than five years time (UNEP, 2006).
One of the gasses that contributes to the ozone depletion is a refrigerant gas (R-22) which been used in air conditioning unit, and even in any cooling system. Antartic ozone hole discovered the full extent of anthropogenic ozone destruction (Farman et al., 1985). Subsequently, it explained as caused by ozone-depleting substances (ODS) including CFCs or refrigerant gasses and halons. Their degradation products and complex chemistry involving heterogeneous reactions on the cold surfaces of polar stratospheric clouds and aerosols (Solomon et al., 1987; Peter, 1997; Solomon, 1999). Many further studies confirmed a significant decrease in the thickness of the extratropical ozone layer (Staehelin et al., 2001, 2002; Fioletov et al., 2002; WMO, 2007).

All Refrigerant (R22) released into the atmosphere comes from Air conditioning units, some of refrigerant leak out, but the majority of CFC release occur during air conditioning service repair. Based on observation in Air conditioning Service

Center and Shop in Samar, Philippines. It is a common practice venting refrigerant gas particularly R22 while conducting a repair because refrigerant (R22) is cheap, and no one realizes that it contributes to ozone depletion.

Choosing an alternative refrigerant gas is very difficult. Even though there are numerous alternative refrigerants introduced today as a replacement for R22 and other phased out refrigerant gasses, we have to consider also the energy performance than those being phased out.

Recovering Refrigerant (R22) is important to those existing air conditioning systems using R22 and reusing the recovered gas during system charging. The commercial available commercial refrigerant gas is very much expensive, and some ordinary technicians cannot afford to have one. The purpose of the Study is to develop an R22 recovery apparatus made from locally available materials.

II. METHODOLOGY

A. Project Development

The refrigerant recovery equipment plan shall be prepared to determine the needed materials and equipment. The equipment used in terms of the structure, motor capacity, and the materials are to be considered.

Project total cost is about PhP 12,630.00 (US$281.6). The machines are available in the local market making it possible for mass production.

The system uses magnetic contactor (10A) and push button switches so that it will be easy to operate. The yellow button indicates "off" and green for "on". The electrical system uses neon lamp as indicator.

The green lamp indicates while in the operated system. While, in yellow lamp, it indicates that the system has power but not yet operated or in standby mode. It utilizes; 2 HP motor compressor, OLP that protects the motor from excessive amperage. The electrical wiring connection of a developed recovery equipment is illustrated in figure 2.

B. System Process Operation

The refrigerant recovery process in Figure 2 from a disabled unit (air conditioning unit) will flow through the first stage oil separator. The contaminated oil separated from the refrigerant gas will go through the different port to drainage system collected in a different container.

The refrigerant gas will continue flowing from the 1st stage oil separator to filter drier in which it filters small foreign particles and remove moisture. And then the gas goes through the accumulator receives liquid refrigerant from a filter drier and prevents liquid refrigerant from flowing into the suction line and compressor.

The refrigerant gas will pass through the compressor in the form of low-pressure vapor due to its suction pressure (all pressures will be monitored by a pressure gauge). And then, it will turn into a high-pressure gas (because of the discharge pressure of the compressor) to the 2nd oil separator in which the excess oil from the compressor will go back to the compressor.

The refrigerant will separate from the oil and go to the filter drier, and then; it will move to the condenser mechanism in which, it cools high-pressure refrigerant gas until it transforms into a liquid state. After, the purification process the refrigerant gas will be stored in a labeled recovery tank.

The recovery system is installed with

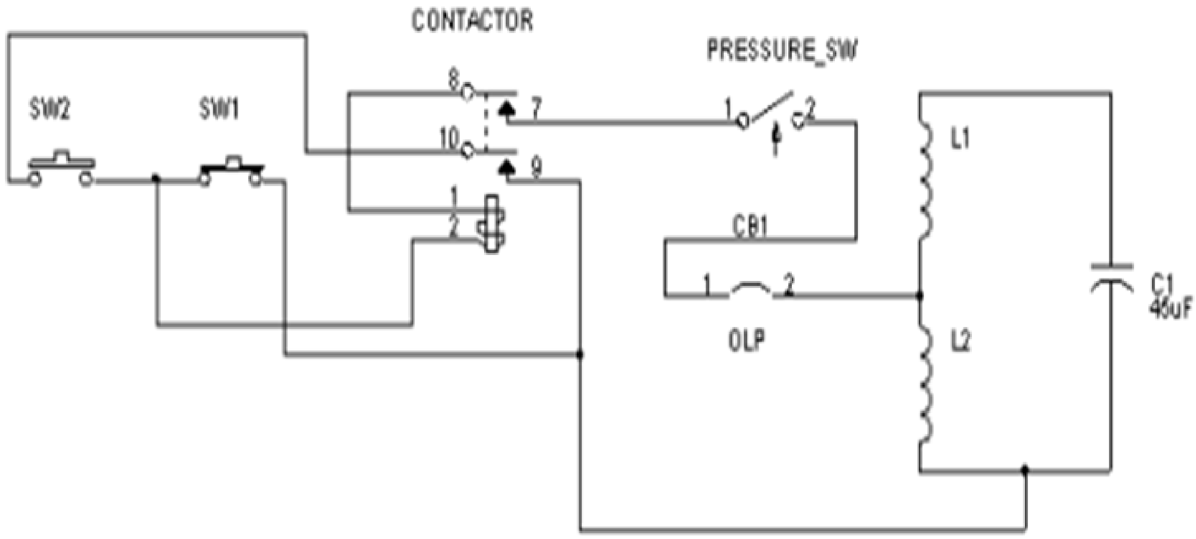

Figure 1. Schematic Wiring Design

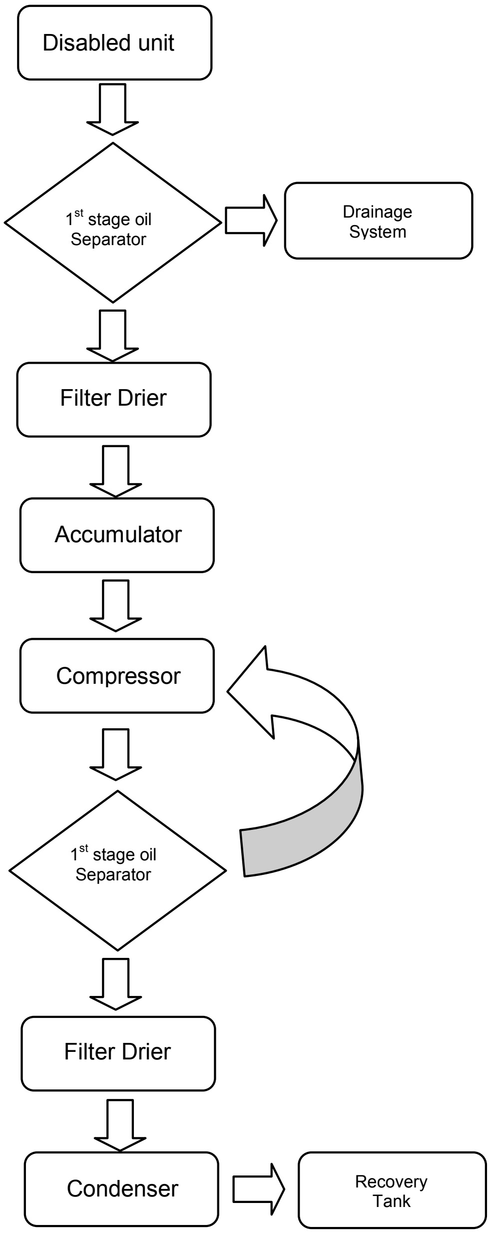

Figure 2: System Operation Flow

different purifying devices such as the following:

Accumulator. The function of the accumulator is to store refrigerant, filter particles, absorb moisture and separate vaporous refrigerant from a liquid refrigerant. In which the process of the accumulator is that when refrigerant leaves the evaporator coil as a mixture of vapor and liquid. The liquid that enters the accumulator will falls to the bottom. The vapor rises to the top and goes to the compressor. The liquid refrigerant at the bottom of the accumulator (Figure 1) gradually vaporizes off, and then the gas will go to the compressor.

Filter-Drier or Strainer Drier. The function of a refrigerant filter-drier is to remove harmful contaminants that exist in a refrigerant system. Moisture and foreign substances are the most common contaminants that exist in a refrigeration system.

The contaminant that receives the most attention is moisture. Inadequate equipment during system installation or service is a potential cause of excess moisture.

This additional moisture causes chemical reactions between the lubricant and

Table 1.
The result of the evaluation of power consumption

Trials	Time (t) (hr)	Voltage (E)	Current (I)	Power (kW)	Energy Consumption
1	.05 (3 mins)	230 V	6.78 A	1.559 kW	0.078 kWh
2	.05 (3 mins)	219 V	6.59 A	1.443 kW	0.072 kWh
3	.05 (3 mins)	215 V	6.61 A	1.421 kW	0.071 kWh
Total Average (power consumption)					0.074 kWh

refrigerant (forming acid), ice formation in the metering device, corrosion of metals, copper plating and chemical changes to motor insulation and other system materials.

Oil Separator. This device is used to separate the contaminated oil from the refrigerant gas. The oil has a different port for drainage, and it will not go to the recovery tank. The oil stored in a different container and used for other purposes.

The testing is only limited on the power consumption of the develop R22 recovery equipment and the percentage of recovery. Power consumption is computed using the formula:

$$P = E(1) / 1{,}000$$

Where, P is the Power consumption (Kw), E is the actual voltage (V), 1 is the actual current (A) and 1,000 is a constant conversion factor.

$$W = P(t)$$

Where, W is the Work (Kwh), P is the Power Consumption (Kw), and t is the time of operation expressed in hours.

Recovery percentage is computed using the formula:

$$P = \text{(Recovered Gas)/(Gas from the unit)} \times 100$$

Where, P is the percentage of recovered refrigerant, recovered gas is expressed in grams as well as recovered gas from the disabled unit. 100 is a constant number in converting the result into percentage.

The refrigerant recovery equipment has two (2) gauges in order to monitor the condition of each mechanism. Likewise, it allows you to see if there is a refrigerant gas from a disabled unit. When the compound gauges reading turns into bellow psi reading, it means that the refrigerant gas from the disabled unit is now fully recovered.

RESULTS AND DISCUSSION

Power Consumption

The testing and evaluation of power consumption of a developed recovery equipment uses an ammeter to get the actual current of the operation of the develop equipment during the recovery process. It also utilizes a voltmeter to get the actual voltage during the testing of the gadget. Using a power on delay timer, it will be set for three minutes at the start of the operation in order to have a uniform time in testing the consumption of the gadget. Total energy used in recovering refrigerant is 0.074 kWh as reflected on table 1.

Table 2 presents the result of the evaluation of the gadget. The 1st trial recovered 77.36% of refrigerant gas. The second trial has 76.55% recovered and the 3rd trial recovers 77% of refrigerant gas. The average percentage of refrigerant recovered of developed equipment is 76.97 %.

Table 2.
Results of the evaluation of recovery percentage

Trials	Refrigerant Code	Time Consumed (mins)	Disabled Unit	Recovered Gas	Energy Consumption
1	R 22	3	110	85.1	77.36
2	R 22	3	110	84.2	76.55
3	R 22	3	110	84.7	77.00
Total Average (power consumption)					76.97%

IV. CONCLUSIONS AND RECOMMENDATIONS

Findings revealed that the developed refrigerant recovery equipment has the capability to recover an average of 76.97 % of gas from a 110 g refrigerant from a disabled unit within 3 minutes. And based on the result, the developed refrigerant recovery equipment consumes only 0.074 Kwh during the recovery of a 110 g of refrigerant gas from a disabled unit. These indicate that the equipment consumes little energy during the recovery.

And the developed refrigerant recovery equipment has a total cost of P 12,630 which is relatively cheap compared to an existing refrigerant recovery machine and has the capability to recover 76.97 % of refrigerant gas.

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