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YOGESH K. MHATRE
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai., yogeshmhatre.k@gmail.com

GANESH V. JADHAV
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai., ganeshjadhav.17@rediffmail.com

YOGESH R. JAGTAP
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai., yogeshjagtap.15@rediffmail.com

SANKET A. BHANDARKAR
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai., sanketbhandarkar123@gmail.com

T. Z. QUAZI.
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai., kazitaqui@rediff.com

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A CASE STUDY ON GAS RECOVERY UNIT FOR R-22

YOGESH K. MHATRE, GANESH V. JADHAV, YOGESH R. JAGTAP, SANKET A. BHANDARKAR, AND T. Z. QUAZI.

Department Of Mechanical Engineering,
Saraswati College of Engineering, Sector-5, Kharghar, Navi Mumbai – 410210, University of Mumbai.
Email: yogeshmhatre.k@gmail.com; ganeshjadhav.17@rediffmail.com; yogeshjagtap.15@rediffmail.com
sanketbhandarkar123@gmail.com; kazitaqui@rediff.com

Abstract:- The present research is concerned with proper recovery of the R-22 [1] gas, which is widely used in various R.A.C. fields on the system failure and reusing these recovered gases again for the future use. It is well known that various cooling units are widely spread in their applications and are circulating R-22 as a refrigerant. It is intended to recover this type of refrigerant by any means preventing its ill effects on environment. The time required for recovering is less, hence the system requires less time. The recovery rate of the unit ranges between 1 to 2 kg/min for 1 ton capacity of the system. We can use the unit for any ton capacity of the breakdown system refrigeration and air conditioning system to recover the gas. The. Global warming [2] is the process wherein the average temperature of the Earth's near surface air increases, owing largely to various man-made activities. Though there are some natural causes for this rise in temperature, they stand to be insignificant when compared to the man-made causes. Understanding global warming & green house gas causes and effects can give us a brief idea of the dreadful phenomena our future generations may have to face. There are some of the prominent global warming causes and effects.

Keywords: *R-22, recovery rate, global warming, energy consumption.*

1. INTRODUCTION

Refrigeration and Air conditioning system are used worldwide for various applications like Air conditions, Refrigerators etc.They are commonly used in food industry, homes, automobiles and glass industries etc.The Refrigerants are used to produce cooling effect as per requirement. But if any component or element of system fails we have to extract the refrigerant from system or released it into atmosphere. But some of these refrigerant are harmful to the environment they are responsible for O.D.P & G.W.P. Hence to release this refrigerant in atmosphere is not desirable, so they must be stored or recovered by some means. As we are using R.A.C systems its maintenance is also an important factor. It is done periodically. The care of the breakdown maintenance is manly the leakage of the refrigerant gases in the system. The leakage is found by various methods of detecting leaks [3]. Sometimes the compressors fails, at that time the gas is trapped in the system. In such cases we cannot do the maintenance work by keeping the gas in the system. Hence either the gas in the system was released in the atmosphere and then the new compressor was installed in the system or the compressor maintenance was done by restarting the system and again filling the fresh refrigerant gas in it and then system was started. But by the use of Gas Recovery Unit we can recover the gas in the system i.e. we can extract the gas from the system and store in the cylinder which could be further used according to the requirement.

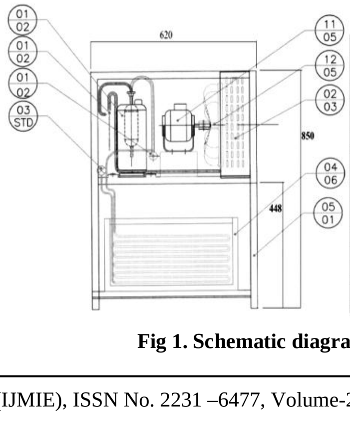
By this means we can firstly recover the gas which was released into the atmosphere because of the breakdown repairs and secondly we can reduce the percentage of the gas released into the atmosphere which is harmful for ozone layer by being the genuine reason for Global Warming effects. So this unit is helpful for the environment and it reduces the costs of recovering and reusing the same recovered gas. VCRS [4] system is used in the unit where the compression is done by the 1 ton capacity compressor and the expansion is done by the capillary tube. The condensation done by the condenser and for evaporation copper tube is surrounded inside the tray.

2. EXPERIMENTAL WORK

2.1 Apparatus Description

A gas recovery unit of 1 ton of the refrigeration capacity was selected for experimental testing. The overall physical external dimensions of the recovery unit are (620 x480 x850) mm and 15 kg weight. The figure (a) shows a schematic diagram of the unit and manifests the instrumentation and measurement tools. The unit is powered by a single electricity phase at (49.36) cc/rev speed rotary vane compressor.

The unit utilizes (*R-22*) as a circulating refrigerant. The expansion is controlled by copper capillary tube of 450 mm length and 1mm diameter. All components of the unit are connected by copper tubing with brazed connection.



ASSEMBLY DETAILS

Sr.No.	DESCRIPTION	QTY.	MTL.	PLANNED SIZE
16	GAS CYLINDER (2 kg)	2	STD	-
15	CHARGING LINE	2	STD	-
14	DISCHARGE FAN	01	STD	ø300X90L
13	OIL SEPERATOR	01	Cu	ø30X100L
12	HEAT EXCHENGER	01	Cu	ø7/8"X260L
11	FAN MOTOR	01	STD	ø112X120L
10	COPPER TUBE (7/8")1 feet	01	STD	-
09	A/c FILTER (3/8")	01	STD	3/8" TWO WAY
08	NRV WITH PIPE	01	STD	¼"
07	THERMOSTAT	01	STD	POSITIVE TEMP.
06	COPPER TUBE ¼"	01	Cu	¼"
05	FRAME	01	M.S.	620X480X850
04	PLASTIC TRAY	01	STD	500X440X260
03	EXPANSION VALVE	01	STD	1/60"
02	CONDENSER	01	STD	380X380X110
01	COMPRESSOR	01	STD	ø110X260L

Fig 1. Schematic diagram of unit

2.2 Refrigeration System Testing Methods

2.2.1 Pressure test

The pressure test is carried out by using dry nitrogen gas at pressure of 300 psi. This test held for 24hrs & the leakages are checked by soap tests

2.2.2 Evacuation test

The system is dehydrated by the means of high vacuum pumps up to pressure of 30 Hg for 24 hrs and the whole system was heated by the torch flame.

2.2.3 Charging test

After the evacuation is carried out the vacuum is broken by addition of refrigerant to the pressurized system at suction pressure of 50-55 psi and discharge pressure of 230 psi. The system is filled with 200-400 grams of R-22.

Table 1. Comparative Refrigerant Performance per Ton of Refrigeration [2]

Sr. no.	Properties	R-22
1.	Evaporator pressure (Mpa)	0.296
2.	Condenser pressure (Mpa)	1.192
3.	Compression ratio	4.03
4.	Refrigeration effect (kj/kg)	162.46
5.	Refrigerant flow rate (kg/s)	0.00616
6.	Sp. Vol. of suction gas	0.0774
7.	Compressor disp.	0.476
8.	Compressor power (kw)	0.210
9.	COP	4.75
10.	Compressor discharge temp (^{o}K)	326
11.	O.D.P	0.055
12.	G.W.P	1810

2.3 Methodology

Process 1-2: Isentropic compression of saturated vapour in compression.

Process 2-3: Isobaric heat rejection in condenser

Process 3-4: Isenthalpic expansion of saturated liquid in expansion device

Process 4-1: Isobaric heat extraction in the evaporator

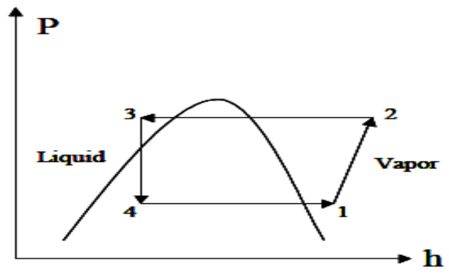


Fig 2. Pressure-enthalpy diagram

2.4 Analysis of The Cycle

2.4.1 Refrigerating Effect

The refrigerating effect accomplished by evaporator can be stated as:

$q_{evap} = (h_1 - h_4)$

2.4.2 Evaporator Capacity

The evaporator capacity can be calculated from the air side process by:

$Q_{evap} = m_a(h_{ai} - h_{ao})$

Mass of the refrigerant $(m_r) = Q_{evap} / q_{evap}$

2.4.3 Condenser Capacity

The condenser capacity = $Q_{cond} = m_{r*}(h_2 - h_3)$

2.4.4 Useful Work

This work used by the refrigerant can be expressed as:

$W = m_r(h_2 - h_1)$

3. WORKING

We used two cylinders one as failed system and another for recovery purpose. The failed system is connected to the compressor by using hand operated valve. At first R-22 was allowed to circulate in the system to achieve the temp. of the water placed in plastic tray upto 16-18 ^{o}C and s.p. upto 45-55 psi. Once the steady state was achieved thermostat was cut off & compressor stopped automatically. During this process the discharge valve was closed and the R-22 flows through the circuit indicated by black linings as shown in the figure.

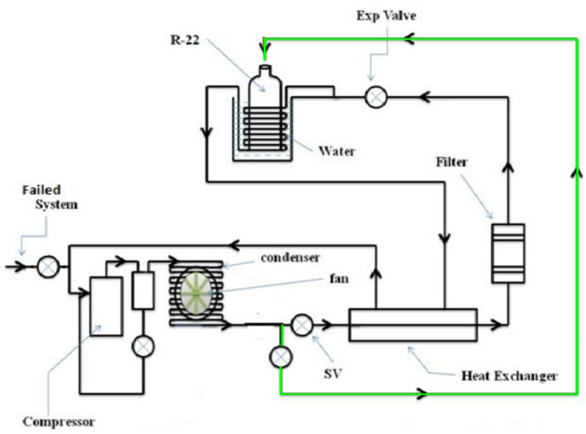


Fig.3 Line diagram of refrigerant gas recovery unit

After maintaining suitable pressure limit, the R-22 from the failed system flows through the compressor, condenser and circuit shown by the green line during this process charging line was closed and discharge valve was opened which is connected to the recovery cylinder placed in the water tray. During this recovery process weight of the cylinder was measured for every 10 pulses and the time required was noted.

4. OBSERVATION TABLE

Table 2. The table shows sample readings.

Sr. No.	Input (Gas from the failed system)	Gas recovered by the system (in grams)	Time required (in seconds)	No. of pulses
1.	210	120	10.34	10
2.	250	250	9.93	10
3.	210	340	8.89	10
4.	230	350	8.72	10

5. CALCULATIONS

5.1 Recovery Rate

Weight of each cylinder = 1380 grams

Weight of each charging line = 100 grams

$$\text{Recovery rate} = \left\{ \frac{\sum \text{Gas recovered}}{\sum \text{Total time taken}} \right\}$$

Gas in the system = 600 grams

Gas in failed cylinder = 1440 grams

Gas in the empty cylinder = 170 grams

Recovery rate = (1060/37.26)

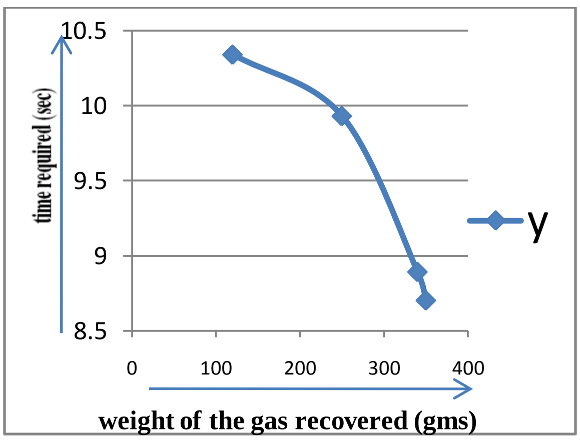
= 28 grams/sec

= 1.67 kg/min

Graph 1: For the weight of the gas recovered (grams) to the time required (sec) to recover the gas.

Scale: On X– axis 1 unit = 100 grams

On Y – axis 1 unit = 0.2 sec



5.2 Energy calculations

$$\text{Energy required} = \frac{\text{No. of pulses (for 10) * 3600}}{\text{EMC * time reqd. for no. of pulses}}$$

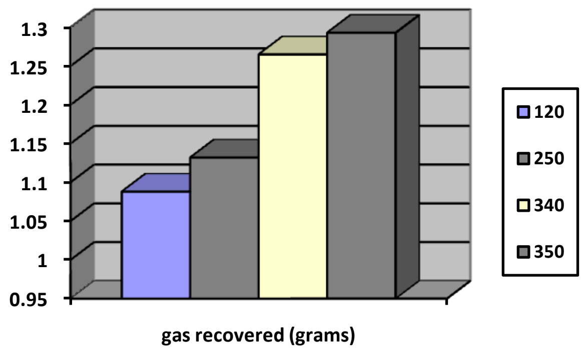
where ,

E.M.C = Energy Meter Constant for 10 pulses
= 3200

Table 3. Energy calculations

1	Gas recovered (gms)	Time reqd. (sec)	Energy reqd. (W)
1.	120	10.34	1.088
2.	250	9.93	1.133
3.	340	8.89	1.265
4.	350	8.7	1.293

Graph 2: For the weight of the gas recovered (grams) to the energy required (Watts).



6. CONCLUSION

From the above discussion we conclude that

(i) Performance of VCRS decreases with increase in outdoor temp.

(ii) When we circulated the R-22 in the system to achieve the temp of the water up to 16-18 °C this is because temp. of the water reduces more gas will be recovered.

(iii) The time required for recovering is less, hence the system requires less time.

(iv) The recovery rate of the unit ranges between 1 to 2 kg/min for 1 ton capacity of the system.

(v) We can use the unit for any ton capacity of the breakdown system refrigeration and air conditioning system to recover the gas

(vi) We can store the recovered gas and can use for another or same system in the future.

(vii) The money wastage for the new gas is reduced due to usage of the old gas, hence it is money saving project.

(viii) It minimizes the global warming effect and the ozone depletion potential due to the release of the gases in the atmosphere.

7. NOMENCLATURE

Temp : Temperature

ODP: Ozone Depletion Potential

GWP: Global Warming Potential

Reqd. :Required

W: Watts

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