Development of Refrigerator Cum Chill Water Dispenser System Using R134a, R600a & R290 Refrigerant :A Review

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Abstract- *Refrigerator is used to store food, vegetables, medicine and preserve them for long time at very low temperature. At the same time refrigerator is used to obtain cool water, for cool water users frequently opens the door of refrigerator so that load on the refrigerator increases, its directly affects the COP (coefficient of performance) or performance of the refrigerator. But now days people used separate water cooler dispenser to obtain cool water. So they buy separate water dispenser and Refrigerator so cost and size of devices increases. The aim of this work is to study different types of water dispenser available in market with different refrigerants used in it and the cost of this refrigerator cum water dispenser, and effect of ODP & GWP these refrigerants on environment and, it concludes that the cost of this water dispenser is very high which is not economically suitable for middle class family, the refrigerants used in this dispenser are very harmful for environment. There is provision of water cooler inside the refrigerator with small opening tap outside the refrigerator door. From literature survey it is found that this arrangement is very advantageous for the refrigeration COP of overall performance.*

Keywords- preserve ,COP, dispenser, overall performance, ODP,GWP.

I. INTRODUCTION

Today's, advanced technology implemented in the refrigeration industry, the main purpose this technology to reduce the energy consumption, increase the performance of the refrigerator and protect the environment. so refrigeration industry develop and uses various cheap, less harmful to environment, low energy consumption, low GDP and ODP alternative refrigerants to CFC refrigerants. Many restaurants, Many dairy mill, hotels, textile industries, Hospitals require both refrigeration, freezing, cooling, heating. In dairy mill dairy products are required to store at low temperature e.g butter or cooling of milks, curd. In case of restaurants food need store and preserve at low temperature, in hospitals many medicines are required to store and preserve at low temperature, in case of textile industry it requires central air conditioning plant which requires chilled water and hot water for steam generation and heating purpose. so that they uses separate units for heating, cooling and refrigeration or cooling purpose so that this device consumes more purchased electricity from grid and increases the cost of the devices. The performance of this device is calculated in terms of the COP (coefficient of performance). so that it is convenient to design the device such that combine effect will be obtained from the single unit. Hence cost, performance of the devices increases. also reduction in harmful gases to environments which cause to the ozone depletion potential (ODP), global warming potential(GWP) gases which is very harmful for environment. Because of compact construction of water dispenser and refrigerator the saving in ODP, GWP. There is also electricity consumption is decreases so that the performance of this system (combination of refrigerator and water cooler dispenser) increases, running cost is decreases.[2]

II. LITERATURE REVIEW

V Manoj et al [1] he studied different eco-friendly refrigerant alternate to R134a, by comparing the properties of the alternate eco-friendly refrigerants with R134a. Table no-1 shows the comparing the parameter of refrigerant with R134a. After study he conclude that R600 is best eco-friendly refrigerant to alter R134a.

Table 1. Comparison of Thermodynamic Properties of refrigerant properties at atm press. [11][12][13][14][15]

Refrigerant	Boiling temp.	Freezing temp.	Critical Temperature	Critical Pressure	COP	Energy consumption	GWP	ODP	Cooling capacity
Units	°C	°C	°C	bar		kw/TR			kw
R134a	-26.15	-101	101.06	40.56	4.61	0.762	1430	0	1.5
R600a	-11.73	-155	110	36.4	3.16	0.692	10	0	1.8
R290	-42.04	-189.9	369.7	42.5	3	0.6032	3	0	1.7

Table 2. Comparison of Thermophysical Properties of refrigerant properties at atm press.

Refrigerant	Thermal conductivity	$Density_{gas}$	$Density_{liq}$
		kg/m^3	kg/m^3
R134a	0.0970	14.35	1295.27
R600a	0.147	8.76	556.9
R290	0.153	4.8	500.1
R22 for AC	0.0748	3.5	1262.7

Table 1 and Table 2 shows the different properties of the refrigerant R134a, R600a and R22 at atm press.respectively from this table it is conclude that the R600a is the best alternate to existing refrigerant used in the water dispenser cum refrigerator, refrigerator, air conditioner etc.

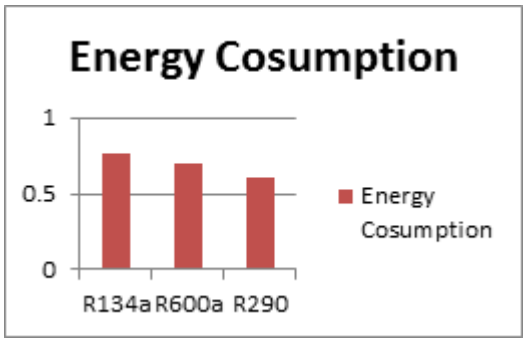

Figure 1. Graph no-1 Comparison of R134a,R600 and R290

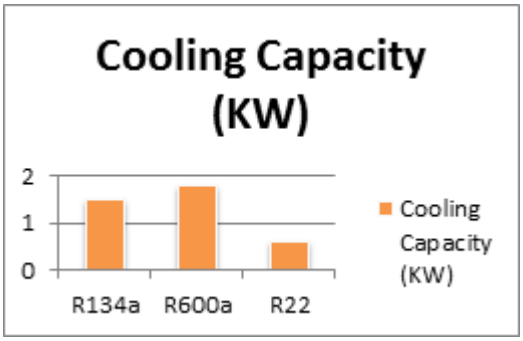

Figure 2. Graph no-2 Comparison of R134a, R600,R22

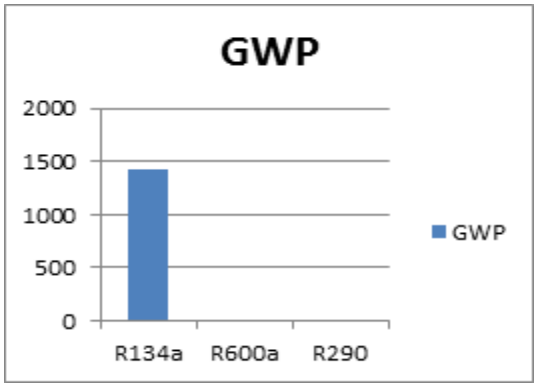

Figure 3. Graph no-3 Comparison of R134a, R600 and R290

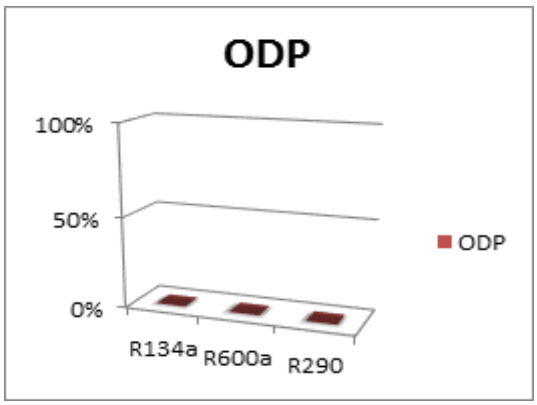

Figure 4. Graph no-4 Comparison of R134a, R600 and [11,12,13,14]& R290[11,12,13,14]

P.Dasthagiri et al. [1] has carried out the experimental investigation on Refrigerator Cum Chilled Water Dispenser. He designed Refrigerator cum chilled water dispenser not only provides cold storage for food, vegetables, medicines at low temperature and freeze some products like ice-cream inside the evaporator cabin but also provides the chilled water outside the refrigerator door by small tap by modifying exist refrigerator. He carried out experimental investigation by using refrigerant R-134a in his modified refrigerator.

A.S.Dhunde et al. [2] has published the paper on discussion of various research papers on power reduction for refrigerated cum air conditioner, air cooler and water cooler. He also discuss save water and forest which is are badly affects ecology system, awareness about environment impact, Global warming due to emission of the HFC, GWP,ODP etc and advantages and impact on environment due to energy saving, COP existing system quietly modified and acts as three in one system.

Table 3. Refrigerator Cum Water Dispenser Existing Setup With R134a[1]

Refrigerant	Capacity Of Ref.	Compressor capacity	Compressor		Evaporator		Capillary Tube	
			Length	Diameter	Length	Diameter	Length	Diameter
R134a	160	0.16 HP	8.5 m	6.4 cm	7.62m	6.4cm	2.42m	0.8mm

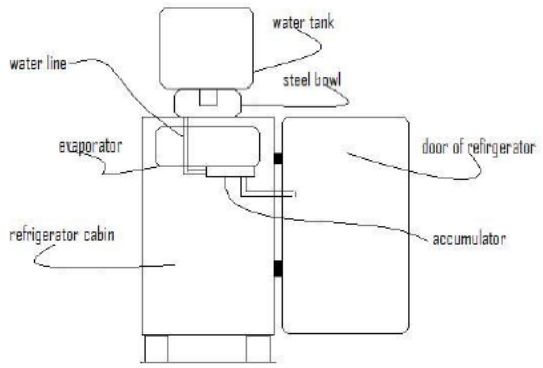

Figure 5. Experimental setup of Refrigerator cum chilled water dispenser [1]

Calculation Performance Parameters

1. Net Refrigerating Effect (NRE) = h1-h4 = in kJ/kg
2. Mass flow rate to obtain one TR, kg/min.
1. mr = 210/NRE = in kg/min.
2. Work of Compression = h2-h1 = in kJ/kg
3. Heat Equivalent of work of compression per TR
4. mr x (h2-h1) = kJ/min
5. Theoretical power(compressor)= in kW
6. Coefficient of Performance (COP) = h1-h4 / h2-h1
7. Heat to be rejected in condenser = h2-h3
8. Heat Rejection per TR = (210/NRE) x (h2-h3)
9. Compression Pressure Ratio = Discharge press./ Suction press. = Pd/Ps [1]

Table 4. Domestic Refrigerator With R134a Refrigerant[9]

Compressor Temperature in ^{0}c		Compressor Press. In bar		Evaporator ^{0}c		Mass Flow Rate kg/mi	R.E KJ/Kg	Work kw	COP	GWP	ODP
Suct.	Dis h.	Suction	Discha r	Temp.	Press						
10	53	0.68	12.4	-2	.8	1.555	135	0.61	5.70	1320	0

Table 5. Existing Refrigerator Water Cum Dispenser R134a Refrigerant[9]

Compressor Temperature in ^{0}c		Compressor Press. In bar		Evaporator ^{0}c		Mass Flow Rate kg/mi	R.E KJ/Kg	Work kw	COP	GWP	ODP
Suct.	Dis h.	Suction	Discha r	Temp.	Press						
13	58	0.75	14	2	0.9	1.6	133	0.61	5.72	1320	0

From calculation of performance by using parameter consist in table 3 and 4, we will get the overall information and performance of specific refrigerants for refrigerator cum water dispenser. We will replace the R134a by R600 and calculate the performance of that refrigerants.

M.P.Poonia et al. [3] has published paper on the Design and Development of Energy Efficient Multi-Utility Desert Cooler. He carried out the experimental investigation on his specially designed Desert water cooler by using evaporating principle for Rajasthan where high dry bulb temperature and low humidity is exist in summer season. His experimental setup is not only used for cooling of room, drinking cool water but also used for storing vegetables, medicines, foods for long time at low temperature than outside

temperature by separate attachment of G.I box and separate drinking water tank with Desert cooler .

Results from this testing shows that Performance of the cooler did not affected when other attachment with Desert Water Cooler, Rather the performance or effectiveness of water increases.

P.Tamil Selvam et al. [4] has published paper on the Design and Development of Modified Air Cooler cum Storage System. The main objectives of this experimental study is to provide air cooling as well as cold storage for foods, medicines, vegetables by modifying existing air cooler to air cooler cum storage system.

Table 6. Observation and Performance of Desert cooler [3]

Sr. No.	Time in min.	Air Temperature in °C		% Relative Humidity (RH)		Water Temp °C	WBT in °C (T_b)	Effectiveness %
		Outside Air Temp. (T_1)	Temp. after cooler (T_2)	Outside Air	After cooler			
1.	15	36.5	25.7	19	58	21.2	20.0	65.4
2.	15	36.0	25.8	20	54	20.8	20.0	63.75
3.	27	38.6	26.8	17	51	20.5	20.3	68.3
4.	25	37.5	25.8	18	55	20.0	20.0	68.57

Table 6. Observation and Performance of Desert cooler with Attachment [3]

Sr. No	Air temperature ^{0}C		Relative humidity (RH)		WBT	Effectiveness
	Ambient	After cooler	Ambient	From cooler		
1.	39.1	28	23%	58%	22.3	66.07%
2.	39.4	28	22%	56%	22	65.5%
3.	40	29	22%	56%	23	64.7%

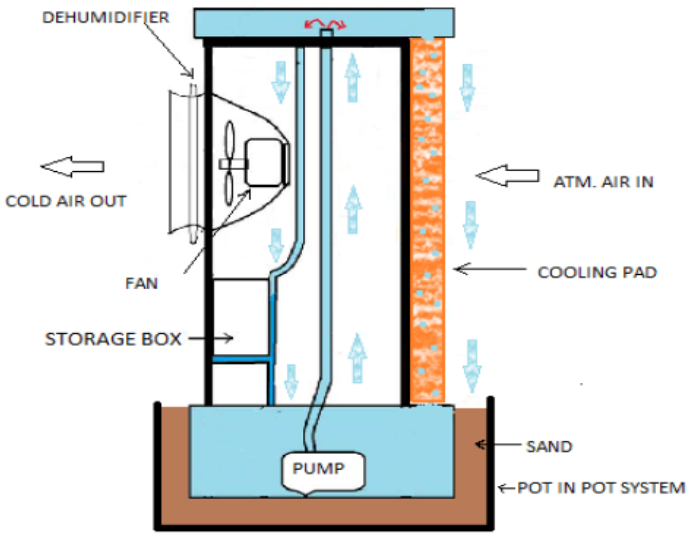

Figure 6. Experimental set up of modified air cooler cum storage system [4]

Vinay Vishwanath et al. [5] has carried out experimental investigation of Water Dispenser System Using Air Conditioning. The objective of this experiment is to provide hot water, cold water without affecting the performance of the Air conditioner by combining the water cycle and air cycle so that heat is transferred from closed space i.e room to the outside and this waste heat is used to heat the water outside the room. This system can be easily installed at official building, mall where the large numbers of air condition system used.

U.V.Kongre et al. [6] has published paper on Design Methodologies of Air-Conditioner cum water dispenser. This paper includes the design of evaporator, condenser, capillary tube to run on both cycle i.e air and water.

R.K.Singh et al. [7] has published paper on Design and Fabrication of Three in One Air Conditioning. This paper deals with human comfort conditions and designed the setup such that the air conditioner, water heater and water cooler are need for human comfort include in this single setup hence it is called Three in one Air conditionere.

S.C.Walawade et al. [8] has published a paper on Design and Development of Waste Heat Recovery System for Domestic Refrigerator. This paper includes the design waste heat recovery system for domestic refrigerator. Condenser rejects the heat to the atmosphere this heat has been utilized for the food warmer

S.B.Lokhande et al. [9] has published a paper on Design and Analysis of Waste Heat Recovery System for Domestic Refrigerator. The objectives of this paper to study the waste heat recovery from the condenser used in domestic refrigeration system. He concluded from his experiment that, as temperature difference decreased at evaporated section then the refrigerating effect is decreased.

III. CONCLUSION

By studying this research paper, It's observe that the waste heat recovery improves the overall performance of the refrigerator, air conditioner. By slightly modifying the existing refrigerator, air conditioner can increases the human comfort. Chilled water can be easily available without frequently opening the door of the refrigerator so that the performance of the refrigerator increases, consuming low electricity, decreases the GWP, ODP.

III. NOMENCLATURE

Symbol	Meaning
COP	Coefficient of performance
GWP	Global warming potential
ODP	Ozone depletion potential
R22	Monochlorodifluoromethane
R134a	Tetrafluoroethane
R600	Isobutane
R290	Propane

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