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Performance analysis of heat pump by retrofitting of HFC refrigerants

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Abstract
To meet the need of quality of life and solve consumption of energy, highly efficient, energy-saving and environment-friendly water heaters in our daily life are required to use and air source heat pump water heater works on heat pump principle which makes low-grade thermal energy transfer from air to water by the cycle of heat pump. Compared to gas water heater, electric water heater and solar water heater, air source heat pump water heater is highly efficient, energy-saving and environment friendly and it is well-received by customers. Air Water Heater can generate less CO_2 than Conventional heating systems; as it uses a renewable, natural source of heat (i.e. Air).due to this it affect less on environment. Also we can use low ODP refrigerant rather than R22.In this experiment COP of heat pump is calculated and compared for refrigerants R22, R410a and R134a. It is observed that the COP of R410a is higher compared to other two refrigerants. High energy efficiency (reduced energy consumption) up to 60% reduction in energy costs compared with traditional heating technologies.

Keywords: energy, environment friendly, energy efficiency, heat pump, refrigerants

1. Introduction
An air source heat pump (ASHP) is space-conditioning appliances that can provide both heating and cooling, although models exist that only provide one or the other. In heating mode, the heat pump uses electricity to extract heat from the outside air and transfers it to the home's interior. While it may seem counterintuitive that a winter atmosphere can provide heat, the outdoor air does indeed contain heat. An ASHP uses a refrigeration cycle to "step up" the heat to a temperature suitable for space heating. In cooling mode, the heat pump works like a refrigerator, removing heat from the interior of a house and moving it outside.

To meet the need of quality of life and solve consumption of energy, highly efficient, energy-saving and environment-friendly water heaters in our daily life are required to use and air source heat pump water heater works on heat pump principle which makes low-grade thermal energy transfer from air to water by the cycle of heat pump. Compared to gas water heater, electric water heater and solar water heater, air source heat pump water heater is highly efficient, energy-saving and environment friendly and it is well-received by customers.

Table 1

Sr. No	Author	Refrig-erant	Findings
1	J.H. Lee *et al* (2002)	R22 and R407	R22 & R407C refrigerant to evaluate the heat transfer capacity of the condenser and to validate the simulation results.
2	James M. Calm (2002)	R11, R12, R22 and R500	Most of the current anxiety with refrigerant selections is unwarranted. Engineers, building owners, and others involved in chiller decisions should revert to traditional chiller specifications based on cost
3	R. Cabello *et al* (2004)	R134, R407C and R22	R134a, R407C and R22 have been the refrigerants used as working fluids.
4	B. Saleh, M. Wendland (2006)	R11, R12 and R22	R245fa for R11 R245ca and RE245 for the intermediate refrigerants R123 and R141b, RE170, R152a, and RC270 for R12 propane and propylene for R22
5	Ching-Song Jwo (2008)	R290, R600 and R134a	Measurements of refrigerating effect for home refrigerator by using R12, R134a, and hydrocarbon refrigerant (R290/R600a) are carried out.
6	Vincenzo La Rocca, Giuseppe Panno (2011)	R22	The refrigerator used at DREAM to test the behavior of the R22 substitutive fluids, having a semi-hermetic compressor
7	Bartosz Gila, Jacek Kasperskia (2013)	R601 and R602	For best simulation conditions, the values of COP max were about 0.422 and 0.385, for n-pentane (R601) and n-hexane (R602), respectively

8	Jacek Kasperski, Bartosz Gil (2014)	R152A, R290, R600a and R717	There is no hydrocarbon enabling a high value of entrainment ratio in a wide range of generator temperature.
9	Vaibhav Jain *et al*	R22/ R134a/R410A/R407C/M20	Performance of parameters it can be concluded that R407C is a potential HFC refrigerant replacement for new and existing systems presently using R22 with minimum investment and efforts.
10	ABHISHEK TIWARI, R.C.GUPTA (2011)	R404a, R134a	R404a is a refrigerant which provides better cooling capacity than the R134a
11	Charbel Rahhal, Denis Clodic (2006)	R290,R32 and R-152a	significant COP increase with mixtures mainly composed of R32 and R152a
12	Sungjin In *Et al* (2015)	R410A, R32 and R446	The optimal refrigerant charges for R32 and R446A were 20% and 10%lower, respectively, than that for R410A.
13	A. Kundu *et al* (2014)	HCFC22, R407C and R410A	Both pressure gradients of refrigerant blends R407C falls behind R410A.

2. Potential Studies of R407C, R410A and R134a

2.1 R407C

It is a non-ozone depleting blend of three HFC refrigerants (R32, R125, and R134a). It gives performance as close as R22.

Advantages

- Less harmful influence on the environment than R22. Value of GWP is same as that of R22 but ODP is zero.
- Negligible alteration required while shifting from R22 to R407C. An R22 system and an R407C system use many of the exact same components

Disadvantages

- Multiple significant leaks (50 wt. %), and recharges leads to impact on energy efficiency and heat transfer conditions.

2.2 R410A

It is a non-ozone depleting blend of two HFC refrigerants (R32, R125). It provides benefits in efficiency and system size. It exhibits higher pressures and refrigeration capacity than R22.

Advantages

- Less harmful influence on the environment than R22. Value of GWP is same as that of R22 but ODP is zero.
- It provides benefits in efficiency and system size.

Disadvantages

- Higher operating pressure than R22 requires well built system, which is generally expensive.
- Complete redesign of system requires while shifting from R22 to R410A.

2.3 Freon R134a

It is a new refrigerant which is hydrogen fluoride hydrocarbons (referred to as HFC).

Advantages

- It does not contain chlorine and its ODP is zero.
- It is safe, non-flammable, non-toxic, and non-explosive.

Disadvantages

- Having higher GWP, contribute significantly in greenhouse effect.
- It has a poorer performance when evaporating below 0°C.

3. Experimental Setup

Experiment set up is as shown in fig. It is consisting of water tank of capacity 100 liters, hermetically sealed compressor, evaporator and expansion device, pressure gauges, thermometer and energy meter.

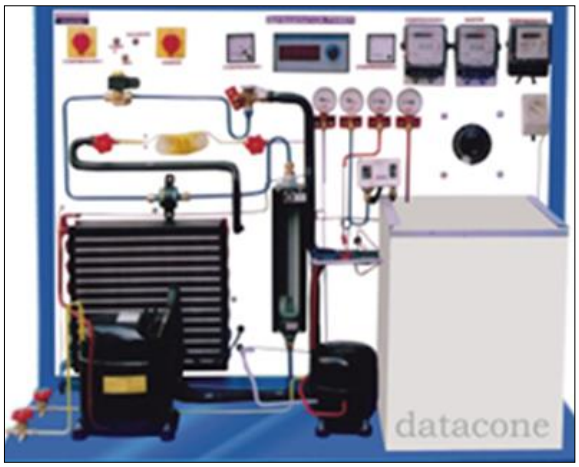

Fig. 1: Conceptual view of experimental setup

4. Calculations

$$S_1 = S_{f1} + x.S_{fg1}$$

Where x is dryness fraction of
$S_2 = S_2' + 2.3\ C_{pv} \times \log (T_2/T_2')$
$h_1 = h_{f1} + x\ (h_{g1} - h_{f1})$
$h_2 = h_2' + C_{pv}\ (T_2 - T_2')$
$h_{f3} = h_{f3}' - C_{pl}$ x degree of under cooling
Assume degree of under cooling = 5°C

Table 2: Observations for R134a

Time Durati-on (min)	Water Temp. (°C)	Cond. Temp. (°C)	Evapo Temp. (°C)	Suc. Press (PSI)	Disc. Press. (PSI)
Initial	28	28	25	100	100
10	35.7	68	8	40	180
20	45.2	70	12	50	200
30	50.3	72	13.5	50	200
40	55	75	16	50	250

Table 3: Observations for R22

Time Durati-on (min)	Water Temp. (°C)	Cond. Temp. (°C)	Evapo Temp. (°C)	Suc. Press (PSI)	Disc. Press. (PSI)
Initial	28	28	28	150	150
10	43	50	12	350	75
20	50.3	65	14	350	75
30	55.8	70	16.5	375	65
40	63	75	18	410	85

Table 4: Observations for R410A

Time Durati-on (min)	Water Temp. (°C)	Cond. Temp. (°C)	Evapo Temp. (°C)	Suc. Press (PSI)	Disc. Press. (PSI)
Initial	28	28	28	120	120
10	37	50	8	40	200
20	50	55	12	50	200
30	56	59	14	50	200
40	60	64	16	75	250

5. Results & Discussion

Table 5: Results for R134a

Time Durati-on (min)	Water Temp. (°C)	Condenser Temp. (°C)	Evapora-tor Temp. (°C)	COP
Initial	28	28	25	--
10	35.7	68	8	3.17
20	45.2	70	12	3.21
30	50.3	72	13.5	3.16
40	55	75	16	3.09

Table 6: Results for R22

Time Dura. (min)	Water Temp. (°C)	Condenser Temp. (°C)	Evaporator Temp. (°C)	COP
Initial	28	28	28	--
10	43	50	12	6.12
20	50.3	65	14	4.04
30	55.8	70	16.5	3.64
40	63	75	18	2.16

Table 7: Results for R410A

Time Dura. (min)	Water Temp. (°C)	Condenser Temp. (°C)	Evaporator Temp. (°C)	COP
Initial	28	28	28	--
10	37	50	8	4.80
20	50	55	12	4.49
30	56	59	14	4.04
40	60	64	16	3.37

6. Conclusion

From the results we can conclude that the coefficient of performance of R22 is greater compared to R134a and R410A. But R22 is environmentally dangerous to use. COP of refrigerant R410a is higher compared to R134a. It's observed that the COP decreases with rise in temperature**.**

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