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Experimental Investigation on Linde-Hampson Refrigerating System Operating with Different Blends of Hydro-Carbons as Alternate Refrigerants

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ABSTRACT

Refrigerants are the basic working fluids in refrigeration, air conditioning and heat pumping systems. The development of refrigeration and air conditioning industry depends to a large extent on the development of refrigerants to suit various applications and the development of various system components. At present the industry is dominated by the Vapour compression refrigeration systems, even though the Vapour absorption refrigeration systems have also been developed commercially. A number of climate-friendly alternatives to CFC/HCFC/ HFC refrigerants are, or will become, available for use in commercial refrigeration applications. Alternatives available today include hydrocarbons-isobutene (R-600a), propane (R-290), and propylene (R-1270) -ammonia (R-717), and carbon dioxide (R-744) respectively. This research focused to develop a strategy of refrigerants to improve the efficiency of the refrigeration system. The proposed methodology consists of Linde-Hampson refrigeration system operated with blends of hydrocarbons propane (R290) and butane (R600) as the low-temperature working fluid. To improve the efficiency of the system an evolutionary machine learning hybrid lightning search algorithm-simplex method (LSA-SM) is proposed in the study to forecast the refrigerant temperature and pressure at different ambient temperatures and loading conditions. LSA-SM has higher computational accuracy, faster convergence rate, and stronger stability than other algorithms and can effectively solve the problem of constrained nonlinear optimization in reality. The proposed methodology is mathematically modelled and executed in the running platform of Mat Lab and executed as performance charts.

Keywords: Linde- Hampson refrigeration system; Vapour absorption refrigeration systems; Hybrid lightning search algorithm-simplex method (LSA-SM); Mat Lab.

1. INTRODUCTION

Evolution of fast growing population, urbanization, a need to even out seasonal variations in production, sales, and food industry that needs to produce in locations distant from the consumers are all factors that create a large demand for refrigerated storage space. Hence, refrigeration as a food preservation technology has become an important industry over the last century by Prabha. Refrigeration system's energy consumption and costs are among the most important items on the agenda of future strategy for some industries and a number of commercial sectors, such as food, drink and chemicals. By contrast with these high demands and costs, even a small optimization in the system performance can offer significant cost savings, resulting in increased profits by Palanisamy (2017). Therefore, depending on the system requirements, various configurations can be made in refrigeration systems considering the conditions of the environment and energy savings by Bolaji (2014). For instance, some commercial refrigeration systems use one compressor and multi evaporator because of their ability to meet various refrigerating loads at different temperatures in different zones within the same system, such as large office buildings and hotels, food preservation industries, supermarkets, etc. The rapid industrialization has led to unprecedented growth, development and technological advancement across the globe by Bolaji and Huan (2014). Today, global warming and ozone layer depletion on the one hand and spiraling oil prices on the other hand have become main challenges. Excessive use of fossil fuels is leading to their sharp diminution and nuclear energy is not out of harm's way. In the face of imminent energy resource crunch there is need for developing thermal systems which are energy efficient by Sathish (2017).

Evaporating heat transfer is very important in the refrigeration and air-conditioning systems. HFCs such as R134a, R404Al and R407C have dominated the replacement of CFCs and HCFCs, mainly because they broadly possess similar chemical, thermodynamic and flammability/toxicity characteristics as well as having been extensively marketed by manufactures by Joudi (2014). However HFCs are more difficult to apply because of poor compatibility with construction materials and in particular mineral oils, which has meant that certain synthetic lubricants, typically polyesters (POEs) and polyalkylglycols (PAGs) have to be used instead. Moreover, they are less tolerant to contaminants within the system by Sanz (2014). HFCs tend to have low toxicity and are largely non-flammable, although a couple of fluids, such as R32 and R152a that are used in several blends are flammable. In terms of environmental impacts, although HFCs have a negligible ODP they do retain the high GWP characteristic of most fluorinated refrigerants, hence the introduction of certain legislation. There are a number of available mixtures that may contain various components including HFCs, HCFCs, HCs, FICs, HFO, and PFCs by Chayhan (2015). These mixtures are generally produced for the purpose of drop-in or retrofit refrigerants. The inclusion of HCFCs or HCs is to provide some solubility with the mineral oils that are used in existing CFC (or) HCFC systems. In other cases, such mixtures are developed to match particular characteristics of a specific refrigerant that it is intended to replace, or to achieve an improvement in cycle efficiency by Kumar (2014). HFC is the mostly widely used alternative refrigerant in refrigeration equipment such as domestic refrigerators and air conditioners. Though the global warming up potential of HFC is relatively high, it is affirmed that it is a long term alternative refrigerants in lots of countries.

Thermal systems like refrigerators and air conditioners consume large amount of electric power. It is essential to developing energy efficient refrigeration and air conditioning systems with nature friendly refrigerants by Jerald (2014). Exergy analysis of a thermal system can be performed by analyzing the components of the system separately. Identifying the major components of exergy loss gives the solution for the improvement of a system efficiency. Exergy analysis is a useful way for determining the real thermodynamic losses and optimizing environmental and economic performance in the systems such as vapour compression refrigeration systems by Natarajan (2015). The rapid advances in nanotechnology have led to emerging of new generation heat transfer fluids called nano-fluid. By addition of nanoparticles to the refrigerant results in improvements in the thermo-physical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system by Yataganbaba (2015). In this manner, this research motivates to find the optimal energy saving refrigeration system by proposing a blended mixture of refrigerant and nano material to optimize the efficiency of the system by Muruganandam (2017).

The research paper is organized in the following ways. The literature survey on recent research is elaborated in the section 2, the proposed methodology of refrigeration system is elaborated in the section 3 and experimentation and result discussion of the proposed method is explained in the section 4 and the conclusion of the research is elaborated in the section 5 respectively.

2. LITERATURE SURVEY

Ozone depleting and global warming issues are recognized as critical aspects of the most serious global environmental problems. They have become the most important criteria in the development of new refrigerants. In this study, Bolaji and Huan (2014) analyze the performances of R152a, R161, and R1234yf with very low global warming potential were investigated theoretically as alternatives to R134a in vapor compression refrigeration systems. Many efforts have been paid for replacement of CFCs and HCFCs, so it is considered that a certain solution has been found to solve the ozone-depletion issue. Many refrigerants containing CFCs and HCFCs were increasingly replaced with hydro-fluorocarbons (HFCs), which have zero ozone depletion potential. Hydro fluorocarbons [HFC's] and Hydrocarbons [HC's] are an alternate for CFC's and HCFC's in which there are no chlorine atoms and not participate in destroying ozone layer. R134a and R152a belongs to the family of HFC's and R290, R600, R600a belongs to the family of HC's. Hydrocarbons have earlier been used as refrigerants, and with increasing awareness of environmental impact, their use has been considered again recently. Rahman (2014) evaluate the Performance of a domestic split type air conditioner using two different refrigerants, i.e., R22 and R290. Major hydrocarbons under consideration are propane, isobutene, n-butane, perfluorocyclobutane, cyclo-propane, propylene, etc. Among these refrigerants, R290 is considered as a replacement for R22 in conventional operation. These natural refrigerants are environmentally friendly, non-toxic, chemically stable, compatible with many materials and miscible with mineral oils. Hydrocarbons have extensively been used in the early years of refrigeration but a number of technical and safety issues caused them to be abandoned when CFC refrigerants became available. They are compatible with the materials and lubricating oils used in conventional refrigeration systems. The results revealed that R290 refrigerant has better performance compared to R22 refrigerant.

Vapor compression Refrigeration system is an improved type of Mechanical refrigeration system.

The ability of certain liquids to absorb enormous quantities of heat as they vaporize is the basis of this system. Compared to melting solids (say ice) to obtain refrigeration effect, vaporizing liquid refrigerant has more advantages. Boorneni (2014) focused on alternative refrigerant to conventional CFC refrigerant, CFC like R12, R22, R134a, etc are not eco-friendly. The emission of these refrigerants causes the depletion of ozone layer etc. In the present work, the performance of the domestic refrigerator is determined using R600a (Isobutene) and comparison with R134a (Tetrafluoride-ethane). The present work an attempt has been made to improve the coefficient of performance (cop) of the system, by incorporating a heat exchanger before admitting refrigerant into the compressor. Thus the compressor work reduces and it may results increase the performance of the refrigeration system. Refrigeration is concerned with the absorption of heat from where it is objectionable plus its transfer to and rejection at a place where it is unobjectionable. Nagalakshmi (2014) investigate behavior of R134a refrigerant. R134a refrigerant is non-toxic and does not flare up within the whole range of operational temperatures. Srinivasan (2017) studied and analysed about the missile with grid fins and the effect on flow drag using ANSYS. Godwin (2017) and Lakshmanan (2017) investigated about the optimum parameters for obtaining the best performance using alternate fuels of IC engines working under the current cooling system using Nanofluids.

Liu (2015) made an objective to explore the possibility of using the modified cycle in a domestic refrigerator with R290/R600a for improving the performance of domestic refrigerators. In this work, the energy and exergy analysis is applied to investigate the performance of the modified cycle with R290/R600a. Many studies have been carried out for reducing energy consumption on refrigeration cycles. Cimsit (2015) presents the thermo-economic optimization of LiBr/H2O-R134a compression-absorption cascade refrigeration cycle. The detailed exergy-based thermo-economic analyses, thermo-economic evaluation with exergoeconomic variables, and thermo-economic optimization by using non-linear simplex direct search method have been performed for the cascade refrigeration cycle. In recent decades, energy savings have become increasingly important in various fields. As one of most common household appliances, domestic refrigerators and freezers are significant users of electricity. Therefore, improving their energy efficiency is of paramount importance. In particular, natural refrigerants such as hydrocarbons (propane, butane and isobutene) have revived interest in small heat pump and refrigeration systems due to low global warming potential (GWP). Yan (2015) presents a modified vapour compression refrigeration cycle (MVRC) for applications in domestic refrigerator/freezers using zeotropic mixture R290/R600a. The results show that the MVRC cycle outperforms the TVRC cycle under all given operating conditions and the advantage is more obvious at lower evaporating temperature, lower sub cooling temperature and higher condensing temperature. Domestic refrigerators are major energy consuming appliance in household environment. R134a is the most widely used refrigerant in domestic refrigerators, due to its excellent thermodynamics and thermo physical properties. Saravanakumar (2014) investigate the energy analysis on the hydrocarbon refrigerant mixture of R290/R600a as an alternative to R134a on the performance of a domestic refrigerator which is originally designed to work with R134a. Thus, it can be concluded that R290/R600a mixture could be an ozone-friendly, energy efficient, and safe viable alternative to R134a for domestic refrigeration systems.

Evaporating heat transfer is very important in the refrigeration and air-conditioning systems. HFC 134a is the mostly widely used alternative refrigerant in refrigeration equipment such as domestic refrigerators and air conditioners. Coumaressin (2014) investigated the effect of using CuO-R134a in the vapour compression system on the evaporating heat transfer coefficient. Based on the applications, nanoparticles are currently made out of a very wide variety of materials, the most common of the new generation of nanoparticles being ceramics, which are best split into metal oxide ceramics, such as titanium, zinc, aluminium and iron oxides, to name a prominent few and silicate nanoparticles, generally in the form of Nano scale flakes of clay. Nano refrigerant is nothing but the combination of Nano particle to the refrigerant for the sake of better refrigeration process. By addition of nanoparticles to the refrigerant results in improvements in the thermo physical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system. CuO nanoparticle with R134a refrigerant can be used as an excellent refrigerant to improve the heat transfer characteristics in a refrigeration system. The obtained evaporating heat transfer coefficient result with increases with the usage of Nano CuO. The Nano particles like AL_2O_3, CuO and TiO_2. Now can be form some other Nano refrigerant by combining the different Nano particles of same size. The most common refrigerant in current time is R132a in all the refrigeration systems like vapour compression refrigeration system, domestic refrigerators and air conditioners. But the only problem with this type of refrigerant is they need the large amount of electric power. Singh (2015) made a review based on the nanotechnologies used in present time in refrigeration system like vapour compression refrigeration system, domestic refrigerator and air conditioner etc. Nano refrigerant is nothing but the combination of Nano particle to the refrigerant for the sake of better refrigeration process. As compared to alternative refrigerant the Nano refrigerant has better heat transfer.

3. INVESTIGATION ON LINDE-HAMPSON REFRIGERATING SYSTEM

Refrigerants are the basic working fluids in refrigeration, air conditioning and heat pumping systems. They absorb heat from one area such as an air-conditioned space and reject it into another system such as outdoors usually through evaporation and condensation processes respectively. The development of refrigeration and air conditioning industry depends to a large extent on the development of refrigerants to suit various applications and the development of various system components. At present the industry is dominated by the vapour compression refrigeration systems, even though the vapour absorption refrigeration systems have also been developed commercially. Numerous substances have been tried and used as refrigerants. However, choosing a refrigerant has become more complex in recent years. Blends are made up of two or more single-component refrigerants. Each single-component refrigerant has its own pressure-temperature relationship and unique physical properties, such as density, heat of vaporization and heat transfer coefficient. Many design strategies exist today to reduce the amount of refrigerant needed while at the same time reducing the probability of leakages and moderating risks if using a flammable or toxic refrigerant. Although most of these advanced refrigeration systems still rely on HFC refrigerants, they have great potential for drastically reducing HFC consumption in multiplex rack commercial refrigeration systems. In addition, a number of climate-friendly alternatives to CFC/HCFC/ HFC refrigerants are, or will become, available for use in commercial refrigeration applications. Alternatives available today include hydrocarbons-isobutene (R-600a), propane (R-290), and propylene (R-1270) - ammonia (R-717), and carbon dioxide (R-744) respectively.

This research focused to develop a strategy of refrigerants to improve the efficiency of the refrigeration system. The proposed methodology consists of Linde-Hampson refrigeration system operated with blends of hydrocarbons propane (R290) and butane (R600) as the low-temperature working fluid. The proposed methodology comprises with the addition of hydrocarbon mixtures to the refrigerants. The performance of the hydrocarbon mixture is analyzed by validating the temperature and pressure of the compressor at inlet and outlet distributions. The experiment is conducted at an ambient temperature of 303 K and noted. To improve the efficiency of the system an evolutionary machine learning algorithm is proposed in the research to forecast the refrigerant temperature and pressure at different ambient temperatures and loading conditions. The algorithm comprises of hybrid lightning search algorithm-simplex method (LSA-SM) for low computational accuracy and it is applied to function optimization and constrained engineering design optimization problems. Simplex method (SM) iteratively optimizes the current worst step leaders to avoid the population searching at the edge, thus improving the convergence accuracy and rate of the algorithm. The proposed methodology is mathematically modelled and executed in the running platform of Mat Lab and executed as performance charts. LSA-SM has higher computational accuracy, faster convergence rate, and stronger stability than other algorithms and can effectively solve the problem of constrained nonlinear optimization in reality.

3.1 Experimental Setup of Refrigeration System

The performance of the considered alternative refrigerant mixtures is experimentally studied in comparison with R290/R600a mixture in the visi cooler of conventional R134a system operating at medium temperature application.

A conventional visi cooler has a compatibility of having a low temperature refrigeration usage and normally used for refrigerating beverage bottles and storage of liquids. The liquid is maintained at a temperature of 2^{o}C to 4^{o}C. Temperature for evaporation of the refrigeration system is -7°C to -10°C.Generally visi cooler uses both R12 (and) R134a as refrigerants. The condenser in this cooler is of air cooled type which appears like plate fin type. The capillary tube in this device is set as an expansion device with a particular evaporator coil and a hermetically sealed compressor. On R134 visi cooler circuit the current researches were carried out. With the mixtures of hydrocarbon refrigerants the circuit is charged. The hydrocarbon refrigerants are (a) R290/R600a (50/50), (b) R290/R600a (60/40), (c) R290/R600a (70/30) and (d) R290/R600a (80/20) these refrigerants are charge one at a particular time.

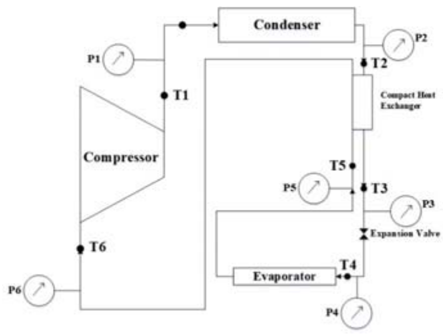

Fig. 1. Circuit Flow of Refrigeration System

To record the necessary data necessary apparatuses are placed at all essential locations. At the exit to the evaporator and inlet to the condenser pressure gauges with ±0.5% accuracy are fixed. PT100 RTD temperature sensors are used to measure the temperature at the required points with ±0.250C accuracy were placed at all the necessary state points. The flow rate of the refrigerant is evaluated by coupling a flow meter to the circuit and the energy consumption of compressor can be evaluated by attaching the compressor module with the accuracy of ±1W to a watt meter respectively. The evaporator coil is present in the calorimeter's brine solution (ethylene glycol). The size of calorimeter is of 223 mm in diameter and 223mm of height insulated with PUF and thermo-rex in the wall exterior to reduce the heat leakage.

To vary the temperature of the brine solution a heater is placed suitably inside the calorimeter and Stirrer was used to stabilize the temperature. In order to obtain the average temperature and also to measure the temperature of the brine solution three RTD sensors were placed at different heights. The wattmeter measure the heater load in the compressor and pressure, temperature and flow indicators were provided over the control panel. To check the leakage of the refrigerant a pressure gauge was connected to the circuit. The condition of the refrigerants is observed by a sight glass which is provided at the liquid line. To balance the effect of variations due to the environment change, the whole set up was preserved inside a temperature controlled room.

Fig. 2. Experimental Setup of Refrigeration System

3.2 Hybrid Lightning Search Algorithm-Simplex Method (LSA-SM)

Normal LSA has a firm convergence rate, but there are still some limitations, such as early convergence, easy fall into local optimum, low solution accuracy, and less capability to solve multimodal optimization issues. LSA's search performance can be improved by adopting a hybrid lightning search algorithm-simplex method (LSA-SM). In view of the inadequacies of LSA, two optimization approaches, namely, simplex method (SM) and elite opposition-based learning (EOBL), are included to the standard LSA.

i) Simplex Method (SM)

In local search Simplex method has unique benefits and are often enhanced to attain higher precision. Simplex method is based on the idea of relating the values of the objective function at the N+1 vertices of a polytope (simplex) in N-dimensional space and as the optimization progress the polyhedron is moved towards the minimum point. In this paper, with the reduced objective function values are chosen as 'k' step leaders and to improve their positions simplex method is used. This allows the algorithm to be closer to the finest solution, increase its exploit ability, and find the optimal solution to speed up the process. The processes of the SM in this study are shown as follows.

Step 1: According to the objective function values of all searched step leaders, find the optimal point (with minimum function value) yg the suboptimal point yb, and the K worst points; take one of them as yw .

Step 2: Calculate the centre $\bar{y}$ of the optimal point yg and suboptimal point yb.

$$\bar{y} = \frac{yg + yb}{2} \quad (1)$$

Step 3: Reflect yw through the centre $\bar{y}$ to a new point yr. And calculate the objective function value at this point.

$$yr = \bar{y} + \alpha\left(\bar{y} - yw\right) \quad (2)$$

Where, $\alpha = 1$ is reflection coefficient.

Step 4: If $f(yr) < f(yg)$, then perform expansion to generate a new point ye otherwise go to Step 5. If $f(ye) < f(yg)$ then replace yw by ye; otherwise replace yw by yr.

$$ye = \bar{y} + \gamma\left(yr - \bar{y}\right) \quad (3)$$

Where, $\gamma = 1.5$ is expansion coefficient.

Step 5: If $f(yr) > f(yw)$, reflection failed, and then perform contraction on point yw to produce a new point yc; otherwise go to Step 6. If $f(yc) < f(yw)$ then replace yw by yc.

$$yc = \bar{y} + \beta\left(yw - \bar{y}\right) \quad (4)$$

Where, $\beta = 0.5$ is contraction coefficient.

Step 6: If $f(yg) < f(yr) < f(yw)$ then shrink yw to generate a new point ys. The shrinkage coefficient is the same as the contraction coefficient.

$$ys = \bar{y} + \beta(\bar{y} - yw) \quad (5)$$

To find a better position at each iteration the SM allows the present worst step leaders, which may be improved than the optimal point. This evades the population searching at the edge, managing it towards the global optimum and the convergence exactitude and the algorithm rate are improved.

ii) Elite Opposition Based Learning (EOBL)

The convergence accuracy of the LSA is improved by SM and easily falls into the local optimum, to increase the diversity of population and expand the search space, for this the EOBL strategy is introduced. Opposition-based learning (OBL) is a new model of machine intelligence that takes into account the current and opposite estimation to achieve an enhanced solution. It has been shown that an opposite candidate solution has an advanced chance to be closer to the global optimal solution than a random candidate solution. Elite opposition-based learning (EOBL) is depended on the elite step leader using OBL principle to create elite opposition-based population to take part in economical evolution, so as to develop population diversity of LSA.

The step leader with the best fitness value is defined as elite step leader, $X_g = (x_g, x_{g,2}, \ldots, x_{g,D})$; elite opposition-based solution of step leader, $X_h = (x_{h,1}, x_{h,2}, \ldots x_{h,D})$ can be defined as $X'_h = (x'_{h,1}, x'_{h,2}, \ldots, x'_{h,D})$ using the following equation.

$$x'_{h,j} = k \cdot (Lb_j + Ub_j) - x_{e,j}, \quad h = 1,2,\ldots,z \quad j = 1,2,\ldots\ldots,D \tag{6}$$

$$x'_{h,j} = rand(Lb_j, Ub_j), \quad \text{if} \quad x'_{h,j} < Lb_j \text{ or } x'_{h,j} > Ub_j \tag{7}$$

Where, z is the population size, D is the dimension of $X, k \in U(0,1)$, and (Lb_j, Ub_j) is the search bound. If the elite opposition-based step leader $x'_{h,j}$ exceeds the search boundary respectively.

4. EXPERIMENTATION AND RESULT DISCUSSION

The proposed technique is implemented in the working platform of Mat Lab environment with the system specification.

Processor: Intel Core 2 Quad @ 2.5 GHz

RAM: 3GB

Operating System : Windows 7

Mat Lab Version : R 2014a Version 8.3

The performance prediction of the refrigeration system is analyzed in the Mat Lab with the experimented data and the test result are plotted in the given tables below.

4.1 Testing Process of Refrigeration System

Pull Down: Test Pull-down time is defined as the time needed for varying the brine solution temperature from ambient condition (30°C) to the preferred final temperature (2°C). The cooling rate of the system is decided by this test. Off time of the refrigeration cycle will be increased with the increase of cooling rate. The calorimeter door was opened for the whole day to achieve the thermal equilibrium of brine solution with the surroundings. Once the system reached the desired temperature the doors were closed and the test was in progress. Temperatures were recorded at every 20 seconds during the pull down test until the temperature of the brine solution reaches 30°C to 2°C.

i) Energy Consumption of the Compressor

The test rig was kept inside a test room to measure the compressors energy consumption. At 32°C surrounding temperature the performance tests were led and at a steady state condition all the remarks were taken after four hours. The energy consumption was noted with an energy meter with ±1W accuracy.

In figure 1, a comparative analysis is carried out for the energy consumption of Linde-Hampson Refrigerating System with different proportion of R290 and R600a refrigerants. The proposed compositional mixtures are compared with the conventional R134a refrigerants for the optimal performance of energy consumption respectively.

ii) Refrigerant Effect in Refrigeration

In figure 2, the refrigeration effect of the Linde-Hampson Refrigerating System is compared with the conventional refrigerants. The different composition of R290 and R600a refrigerants are compared with the conventional R134a refrigerants respectively. From the evaluation, the proposed composition mixtures are getting optimal efficiency than the conventional refrigerants respectively.

iii) Coefficient of Performance (COP) in Refrigeration

At a particular calorimeter temperature, to calculate the actual COP and refrigeration effect, the brine solution calorimeter is needed. To find the definite

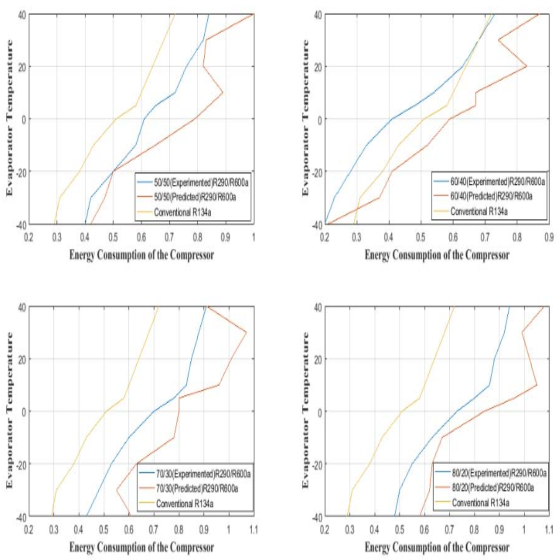

Fig. 1. Comparative Analysis of Energy Consumption in Refrigeration

refrigeration effect and power of compressor for numerous calorimeter temperatures (temperature of brine solution) at 2°C, 5°C and 8°C were carefully chosen, and the heater load was in tune by a dimmer stat. For any selected calorimeter temperature the system was allowed to run at balance condition. The balance state was determined by confirming that the calorimeter shell temperature and compressor's power consumption. For at least four hours the heater stayed unchanged. At this state, heater load and compressor power were noted. The heater load is the refrigeration result at a balance condition. The above procedure was repeated twice, and the average value has been calculated.

In figure 3, the coefficient of performance in proposed refrigeration system is compared with the conventional refrigerants. The proposed refrigerants R290 and R600a are mixed at different ratio and analysis for the maximum coefficient of performance. From the analyzed results the proposed composition has higher efficiency than the conventional R134a respectively.

5. CONCLUSION

A Linde-Hampson refrigerator designed to work with R-134a with a gross capacity of 239 milliliters are used in the experiment. An experimental study is carried out in a Linde- Hampson refrigeration system operated with blends of hydrocarbons propane (R290) and butane (R600) as the low-temperature working fluid. The compressor power and refrigerant temperature and pressure at the inlet and outlet of the compressor are recorded and

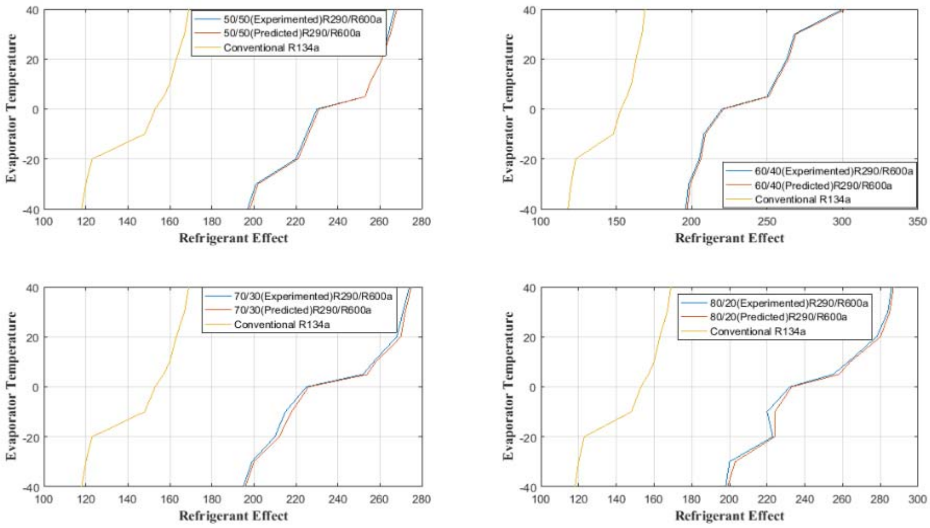

Fig. 2. **Comparative Analysis of Refrigeration Effect**

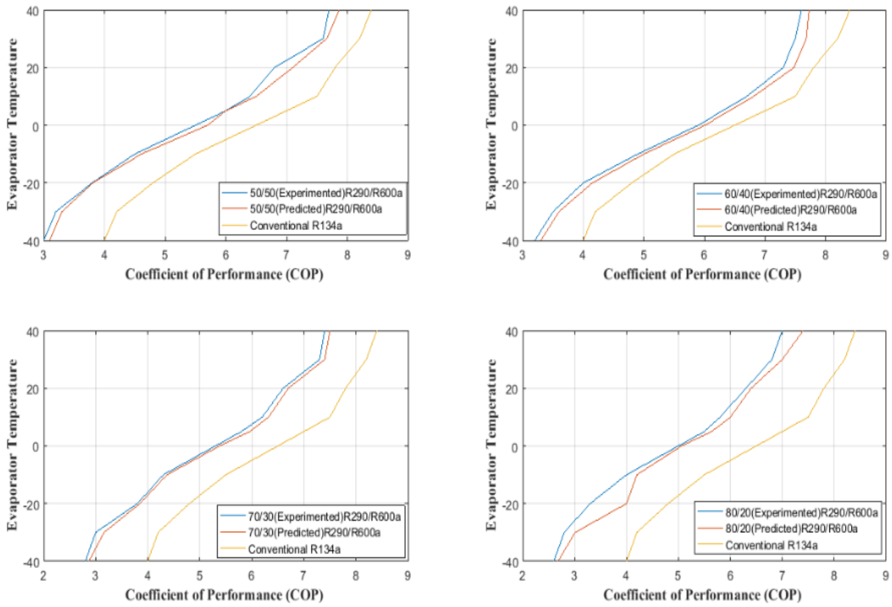

Fig. 3. Comparative Analysis of COP in Refrigeration

Table 1 Energy Consumption of the Compressor

Evaporator Temperature	Efficiency Defect In Condenser								
	Conventional R134a	R290/R600a							
		Experimented				Predicted			
		50/50	60/40	70/30	80/20	50/50	60/40	70/30	80/20
-40	0.29	0.40	0.20	0.43	0.48	0.42	0.21	0.61	0.58
-30	0.31	0.42	0.23	0.48	0.50	0.47	0.37	0.55	0.62
-20	0.38	0.50	0.28	0.53	0.55	0.50	0.41	0.63	0.63
-10	0.43	0.58	0.33	0.60	0.63	0.65	0.52	0.78	0.67
0	0.51	0.61	0.41	0.70	0.73	0.79	0.59	0.80	0.84
5	0.58	0.65	0.48	0.78	0.80	0.84	0.67	0.80	0.96
10	0.60	0.72	0.54	0.83	0.86	0.89	0.67	0.96	1.05
20	0.64	0.76	0.63	0.85	0.88	0.82	0.83	1.01	1.02
30	0.68	0.82	0.68	0.88	0.92	0.83	0.74	1.07	0.99
40	0.72	0.84	0.73	0.91	0.94	1.00	0.87	0.91	1.08

Table 2 Refrigeration Effect in Refrigeration

Evaporator Temperature	Refrigeration Effect (KJ/kg)								
	Conventional R134a	R290/R600a							
		Experimented				Predicted			
		50/50	60/40	70/30	80/20	50/50	60/40	70/30	80/20
-40	118	197	196	195	198	198	197	196	199
-30	120	201	198	199	200	202	199	200	203
-20	123	220	205	210	223	221	206	212	224
-10	148	225	208	215	220	226	209	218	224
0	153	230	220	225	232	231	221	226	233
5	157	253	250	252	255	253	251	254	258
10	160	255	254	257	263	255	255	258	264
20	163	261	263	268	278	261	264	270	280
30	167	264	268	271	284	265	269	272	285
40	169	267	300	274	286	268	302	275	287

analyzed as well as the distributions of temperature at various positions in the experimental set up to validate the performance of hydrocarbon mixtures. The experiments are conducted with various compositions of the mixture of hydrocarbons refrigerants under loading and no load condition at a surrounding temperature of 303K and at last the possibility of using hydrocarbon mixtures in this experimental setup is studied. Thus from the experimental analysis, the proposed composition of R290 and R600a score higher ratio of performance in terms of energy consumption, refrigeration effect and coefficient of performance respectively.

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