Energy Analysis of Window Air Conditioning System

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Abstract— Energy consumption is the most important problem in the present day. The energy analysis gives only energy consumption and energy losses of systems. It does not provide information about internal inefficiency of equipment. The exergy analysis, when applied to process or a whole plant tells us how much is the usable work potential or exergy supplied as input to the system & consumed by process or plant..Unequal duration of the active and passive phases of the heat source, and consequently of the heat storage and discharge, is allowed.After exergy analysis of shell and tube type heat exchanger there are loses of energy of all part we can try to minimize energy loses and improvement in exergy.we are to follow standard procedure for measuring exergy which I can get from reference paper or some text book related to exergy.Secondly, when I learn the standard procedure I will learn where to measure and what to measure to analyze exergy of air conditioner. After getting all data in the of air conditioner I will able to tell what is an improvement.

Key words: Availability or Energy, Air conditioner, Rapid expansion

I. INTRODUCTION

Refrigeration plays a very important role in industrial, domestic and commercial sectors for cooling, heating and food preserving applications. There are innumerable applications of such systems and they are the major consumer of electricity around the world. Energy consumption is directly proportional to the economic development of any nation, however this area is in great interest now because of increase in the cost of conventional fuels and environmental concerns globally. The scientists are looking for new and renewable sources of energy so as to minimize the costs. Due to the increasing energy demand, degradation of environment, global warming and depletion of ozone layer etc, there is urgent need of efficient energy utilization and waste heat recovery for useful applications. The researchers are concentrating on the alternate and environment friendly refrigerants, especially after the Kyoto and the Montreal protocols. However, in a quest to find out alternate and environment friendly refrigerants, the energy efficiency of the equipment having conventional refrigerants is also very important in the present age of competitive business community. The aim of the scientific community all over the world is to switch to new and renewable energy sources besides, efficient utilization of all conventional sources. In this study, the main objective is to investigate the performance of a simple VCR system based on exergy analysis. The experimental analysis has been done on a 1TR window air conditioning system using R-22 as refrigerant. With the objective to find out the losses at different operating conditions for vapour compression cycle, exergy analysis has been done by various of refrigerant charge. The system has been modified for experimental study to find the possible design conditions with the minimum exergy destruction. In the present study, the effects of temperature changes in the condenser and evaporator on the plant's irreversibility rate was determined. The analysis is performed by doing energy and exergy balances for the system. The properties of refrigerant at each state point are calculated using Forane software and the results are discussed.

First law of thermodynamics is used and is based on law of conservation of energy. This law only quantifies the energy at various components and tells nothing about how to reduce the energy consumption in these systems. In addition to this the second law of thermodynamics in its fundamental form is not used in energy utilization analysis and therefore, some of its derived principles are used in energy conservations. In the interest of energy conservation, minimization of irreversible effects is sought in any thermodynamic process. Any process that occurs without any change of initial state. A number of physical effects which cause a loss of energy available for doing work, or cause an increase in energy required to produce desired output are as follows

A. *Temperature Difference:*

Large temperature difference causes greater losses during heat transfer, therefore, temperature difference should be kept as small as practical e.g. in evaporators and condensers.

B. *Friction:*

Friction causes loss of useful energy and therefore should be minimized. For example, regular cleaning of tube walls prevents scale build-up. Thus fluid friction will be less and less energy will be lost in pumping power.

C. *Rapid Expansion:*

The adiabatic expansion of a high pressure fluid to a low pressure, sometimes called throttling, is a process that wastes some energy available in the high pressure fluid which could have been used to do some work.

D. *Mixing:*

Mixing of fluids will results in a loss of the useful available energy.The term entropy is a physical property of substances related to energy utilization and conservation. Entropy is a measure of the energy that is not available to do work. For a fluid with isentropic nature the amount of work done in compressor is minimum. A constant entropy (i.e. isentropic) process is an ideal reversible process which can never take place. Hence, in a real process where work is required, the entropy increases and efforts are made to minimize this increase.

1) *Availability Or Energy:*

Availability is the maximum useful work that can be obtained from a system at a given state. A system is said to be in the dead state when it is in thermodynamic equilibrium with the surroundings. At the dead state, a system is at the temperature and pressure of its surroundings as well as in thermal, chemical and mechanical equilibrium. It has no kinetic or potential energy relative to its surroundings and does not reacts with the surroundings. A system has zero availability at the dead state. The notion that a system must go, the dead state at the end of the process to maximize the work output can be explained as follows

If the system temperature at the final state is greater than or less than the temperature of the surroundings, we can always produce additional work by running a heat engine between these two temperature levels. If the final velocity of the system is not zero, we can catch that extra kinetic energy by a turbine and convert it to rotating shaft work and so on. However, no work can be produced from a system that is initially at the dead state. The atmosphere around us contains a tremendous amount of energy. However, the atmosphere is in the dead state and the energy it contains has no work potential therefore, we conclude that a system will deliver the maximum possible work as it undergoes a reversible process from the specified initial state to the state of its environment, the dead state. This represents the maximum work potential of the system at the specified state and it is called availability.

The work potential of the energy contained in a system at a specified state is simply the maximum useful work that can be obtained from the system. The work done during a process depends on the initial state, final state and the process path. In an availability analysis, the initial state is specified and thus it is not a variable. The work output is maximized when the process between the two specified states is executed in a reversible manner. Therefore all the irreversibilities are disregarded in determining the work potential. Finally the system must be in the dead state at the end of the process to maximize the work output.

II. LITERATURE REVIEW

Anand, Tyagi et al[1] detailed experimental analysis of 2TR (ton of refrigeration) vapor compression refrigeration cycle for different percentage of refrigerant charge using exergy analysis. An experimental setup has been developed and evaluated on different operating conditions using a test rig having R22 as working fluid. The coefficient of performance, exergy destruction, and exergetic efficiency for variable quantity of refrigerant has been calculated. The present investigation has been done by using 2TR window air conditioner

A 2TR window air conditioner equipped with different pressure, temperature, and flow measuring devices has been studied experimentally using energy and exergy analysis. The unit is charged with refrigerant R-22 in four steps, i.e., 25, 50, 75, and 100%, respectively, and the system performance is analyzed in each case. The reference temperature is measured to be 25 °C. the results indicate that the losses in the compressor are more pronounced, while the losses in the condenser are less pronounced as compared to other components, i.e., evaporator and expansion device. The total exergy destruction is highest when the system is 100% charged, whereas it is found to be least when the system is 25% charged.

R.S Mishra et al[2] performance of vapour compression refrigeration system using multiple evaporators and compressors with individual or multiple expansion valves have been considered by using first law and second law analysis. Numerical models have been developed for parallel and series expansion valves in the VCR. Thermodynamic analysis in terms of energy and exergy analysis of multiple evaporators and compressors with individual expansion valves (system-1) and multiple evaporators and compressors with multiple expansion valves (system-2) have been carried out and following conclusions was drawn from present investigation. For same degree of subcooling, fixed evaporators and condenser temperatures system-2 is the best system with comparisons of system-1. R600, R600a and R152A show better performances than other refrigerants for both systems (system-1 & system-2) but due to inflammable property of R600 and R600a, R134a is preferred for both systems. First law efficiency and second law efficiency of system-2 is 3%- 6% higher than System-1.

J.U.Ahamed at el[3] were emphasized on the possibilities of researches in the field of exergy analysis in various usable sectors where vapor compression refrigeration systems are used. Exergy losses, exergy efficiency, second law efficiency and irreversibility of the system components as well as of the whole system are measured. In the vapor compression system, R134a, R290 and R600a are considered as refrigerants. Exergy parameters in the compressor, evaporator, condenser and expansion devices are calculated and analyzed. Exergy losses depend on evaporator temperatures, condensing temperature, refrigerants and ambient temperature. Most of the exergy losses occur in the condenser. Expansion device has the lowest losses. Exergy loss for butane and isobutene are less than that of the refrigerant R134a in the present test unit. In the higher evaporating temperature exergy loss is decreased for all refrigerants. Exergy efficiency is also higher for butane compared to that of isobutene and R-134a as refrigerants. Exergy loss in the compressor is higher than that in the other parts of the system i.e. up to 69% of the total exergy loss occurs in the compressor.

R.S.Mishra at el[4] detailed energy and exergy analysis of multi-evaporators at different temperatures with single compressor and single expansion valve using liquid vapour heat exchanger vapour compression refrigeration systems have been done in terms of performance parameter for R507a, R125, R134a, R290, R600, R600a, R1234ze, R1234yf, R410a, R407c, R707, R404a and R152a refrigerants. The numerical computations have been carried out for both systems. It was observed that first law and second law efficiency improved by 20% using liquid vapour heat exchanger in the vapour compression refrigeration systems. The First law efficiency (COP) and Second law efficiency (Exergetic efficiency) of vapour compression refrigeration systems using R717 refrigerant is higher but is has toxic nature can be use by using safety measure for industrial applications. COP and exergetic efficiency for R152a and R600 are nearly matching the same values. are better than that for R125 at 313K condenser temperature and showing higher value of COP and exergetic efficiency in comparison to R125. For practical applications R-134a is recommended because it is easily available in the market has second law efficiency slightly lesser than R-152a which was not applicable for commercial applications. The increase in dead state temperature has a positive effect on exergetic efficiency and EDR, i.e. EDR decreases and exergetic efficiency increases with increase in dead state temperature.

Both R-152a and R-600 show the identical trends for exergetic efficiency are nearly overlapping. The exergetic efficiency for R-600 is higher than that of R-134a for the practical range of dead state temperature considered.

Vijay Singh at el[5] were performance study of a vapour compression refrigeration system with refrigerants R-12, R134a and R1234yf. A computational model based on energy first law analysis is presented for the investigation of the effects of evaporating temperatures, degree of subcooling, dead state temperatures and effectiveness of the liquid vapour heat exchanger on the relative capacity change index, coefficient of performance of the vapour compression refrigeration cycle. It concludes that the R1234yf could increase the performance of system at higher degree of subcooling. R1234yf has highest value of relative capacity change index (RCI) of all the three refrigerants.. The performance of system with and without pressure drop at both condenser temperatures 50 and 35˚C, at evaporator temperature 0˚C is carried out. The R12 system performance is most affected by pressure drop. COP is decreases with increase in pressure drop. In the descending order of decrease in COP these refrigerants can be arranged as R12, R1234yf and R134a. Thermodynamic analysis result concluded that R1234yf is good drop in replacement and it has also advantage of lower GWP value than R12 and R134a. R134a system highest work required of all the three refrigerants. With the use of liquid vapour heat exchanger R1234yf has highest value of relative capacity change index (RCI) of all the three refrigerants increases with increase in degree of subcooling system using R1234yf. R1234yf shows the highest percentage increase in COP. R1234yf is the only refrigerants of all the refrigerants used in present work that satisfy MAC directive (2006/40/EG) because of its GWP value less than 150.

Kapil Chopra at el[6] were thermodynamic analysis, the comparison and impact of environmental friendly refrigerants (R410a, R290, R600, R600a, R1234yf, R125, R717 and R134A) on multiple stage vapour compression refrigerator with flash intercooler and individual throttle valve (system-1) and multiple stage vapour compression refrigerator with flash intercooler and multiple throttle valves (system-2) has been carried out on the basis of energetic and exergetic approach. They conclude that First law performance (Energetic) and second law performance (exergetic performance) of system-2 is higher than system-1 for selected temperature range of condenser and evaporators with chosen ecofriendly refrigerants. For both systemsR125 shows minimum thermodynamic performance in terms of COP, second law efficiency and irreversibility in terms of exergy destruction in the components as well as in the both system Thermodynamic Performances in terms of COP and second law efficiency of R600and R717 better in comparison of other selected ecofriendly refrigerants for system-1 and system-2. ASR717 is toxic and limited to industrial applications, therefore R600 is recommended for both systems by taking safety precautions. Performance of R134a is slightly lesser tha R600, therefore R134a can also be used for practical applications without taking of any safety precautions. The maximum percentage difference of COP between system-2 and system-1 is 9.59% for R125 at 15^{o}C, high temperature evaporator. Irreversibility in system-1 is 1.4-2.1%, 1.3-2.2% and 1.6-2.0% using R600 and 1.8-3%, 1.7-3.1%, 2.2-2.7% using R125 is lower than system-2 for low, intermediate and high temperature evaporator respectively. This marginal irreversibility differences between system-1 and system-2 can be neglected.

III. Conclusion

The energy analysis gives only energy consumption and energy losses of systems. It does not provide information about internal inefficiency of equipment. The energy analysis, when applied to process or a whole plant tells us how much is the usable work potential or energy supplied as input to the system & consumed by process or plant..Unequal duration of the active and passive phases of the heat source, and consequently of the heat storage and discharge, is allowed.After energy analysis of shell and tube type heat exchanger there are loses of energy of all part we can try to minimize energy loses and improvement in energy.

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