Farukh Khan, 2021, 9:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

A Review Based on Energy and Exergy Refrigeration System

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Abstract- In the field of HVAC engineering, electricity has been utilized to energize the air-conditioning and refrigeration systems since last decades. Normally one-third to half of the annual total electricity consumption is used forair-conditioning and refrigeration in the metropolis worldwide as reported. The most commercially developed solar cooling technology is the absorption systems. In an absorption cycle, a refrigerant and an absorbent are a pair of substances that work together. NH_3-H_20 andLiBr-H_20 are the most common working pairs in refrigeration and air conditioning absorption refrigeration system. Although the NH_3-H_20 cycle is an older technology, it still remains essentially applied to large scale process plants, and LiBr-H20 absorption cycle concentrates most of the current research.

Keywords- Adsorption refrigeration, coefficient of performance, Exergetic Efficiency

I. INTRODUCTION

With a view to search for a system which can be used for high temperature lift at lower pressure ratios without using the harmful ozone depleting refrigerants such as the chlorofluorocarbons (CFCs) as used in the conventional vapour compression systems, a novel system called the compression-absorption system was developed in 1895 by Osenbrueck, which became a German patent.

Later in 1950, the idea of combining a compressor to an absorption system was presented by Altenkirch. Among the heat pump technologies, absorption/compression cycles are suitable for large temperature lifts and high temperature applications. Furthermore, non-conventional sources of energy such as solar, waste heat, and geothermal can be used as their primary energy input. This system is a hybrid of the conventional vapour compression and absorption systems which possesess best features of both the types.

Many industrial processes have Heating demands in the temperature range of 75-100°C. At the same time, waste heat holding typically a temperature of 30-50°C is available. The limitation in heat pump alternatives for temperatures around 100°C after the high temperature refrigerant CFC-114 was abandoned has turned the focus on alternative heat pump processes using natural working fluids. Efficient heat pumping technologies like compression-absorption systems are therefore attractive in order to reduce the specific energy consumption. Such systems are gaining popularity because they operate on environment friendly refrigerants conforming Montreal and Kyoto protocols. The compression-absorption systems can be operated over a wide range of temperatures, between -10 and 160°C, using ammonia-water as the working fluid and with pressures not exceeding 20 bar (Stokar and Trepp, 1986).

These systems utilize the available low temperature waste heat sources thus providing high temperature lifts required in many industrial applications such as pasteurization, dairy technology and steam production etc.This system operates on a refrigerant-absorbent mixture unlike the vapour compression system which uses a pure refrigerant fluid. A key advantage of the compression-absorption cycle is the extended range of temperatures available for a mixture compared to pure refrigerants.

This is the effect of reduced vapour pressure obtained for a refrigerant in a mixture with a less volatile component. Therefore, refrigerants which, as pure components, are restricted by too high pressures at the required temperatures can be used over new temperature ranges. One example is NH_3 which has a saturation pressure of 25 bar at58.2°C. When mixed with H_2O it could be possibly be used upto 150-160°C at similar pressures. Thus, by using mixtures, it is possible to cover temperature regimes where it is difficult to find a suitable pure refrigerant [1]. An ammonia-water mixture is a non ideal mixture which possesses more than Raoult‟s law of stability. Mixing of ammonia and water isaccompanied by the absorption of heat. Ammonia-water mixture is suitable for high temperature heat pump applications because of the reduced pressure when working at higher temperatures. This non-azeotropic mixture has therefore been chosen for the present study.

Another advantage of this cycle is the gliding temperature profiles obtained in the absorber and desorber. Gliding temperature here refers to the temperature change obtained as the volatile component is absorbed into or evaporated out of the solution. Within the given temperature limits of the heat source and sink there is a considerable freedom of placing the solution field within the corresponding saturation pressures of the pure solute and solvent. This characteristic feature provides greater design flexibility than is possible for single fluid heat pumps. By a suitable choice of the concentration range external conditions can be optimally matched to the properties of the working pair and the heat pump components.

Desorption and absorption processes follow non-isothermal paths at constant, but different pressures due to the fact that bubble points of the desorbing and the resorbing solution change as the concentration of the refrigerant lessens or increases respectively. This behaviour can be utilized to reduce exergy losses by counter current heat exchange when non-isothermal heat sources and sinks are available such as ground water and district heating water.By using a compression-absorption cycle instead of a single fluid compression cycle at identical temperature levels, the process pressure levels are reduced. Depending on the thermodynamic properties of the refrigerant-solution the pressure ratio may become smaller which favourably affects compressor lifetime [1]. Compared with a single-fluid compression cycle, the performance of the compression/absorption cycle is improved as the external temperature gradients increase. Although the compression/absorption cycle is usually only put forward as an alternative to compression cycles for applications involving large external temperature gradients, this study has shown that this cycle is also interesting for applications where the external temperature gradients are small. The more isothermal the conditions are, however, the greater is the need to optimize the parameters within the cycle in order to maximize its performance. From the results presented in this thesis it is clear that the compression/absorption heat pump cycle offers several advantages over other types of heat pumps. In many cases it gives a higher or equally high COP compared with the single-fluid compression heat pump but also the smaller SCD (i.e. size of the compressor) found for this cycle is an advantage.

II. LITERATURE REVIEW

A thorough review of literature has been carried out to understand the basic concepts and to explore the theoretical work carried out on compression-absorption systems. Although the basic ideas are old, the technique is new, and hence an understanding of the concepts involved with a few clarifying explanations is required to comprehend the system under study. Morawetz [1] defined the elementary and improved sorption-compression heat pumps. He discussed the merits of the resorption-compression heat pumps. They reviewed the performance of an ammonia-water heat pump designed for the production of process vapour.

The heat source was the expansion steam from waste water at a temperature of 95 C. They found the performance of this heat pump as impressive.Minea and Chiriac [2] discussed the main thermodynamic and hydraulic parameters and gave design guidelines for a medium temperature, ammonia-water based compression- resorption heat recovery system for district domestic hot water production. They produced hot water at 55 C from cooling water at 36 C used as a waste heat source.

International Journal of Science, Engineering and Technology

An Open Access Journal

Pourezza-Djourshari and Radermacher [3] presented the performance results of single and two stage vapour compression heat pumps with solution circuits both operating on R22- DEGDME mixture as the working fluid. The desorber temperatures considered were in the range -25^{0}C to -20^{0}C and 5 to 10^{0}C and the absorber temperature was from 500C to 60^{0}C.They found a significant increase in the coefficient of performance in both the cycles as compared to the R22. The COP of the two stage cycle was found to increase upto 50% at 45% lesser pressure ratio as compared to the conventional vapour compression system using pure R22 as the working fluid.Arun et al [4] analysed a compression-absorption heat pump with a single stage solution circuit operating on HFC143a-Dimethylacetamide (DMAC) mixture. They studied the effects of suction and discharge pressures, generator and absorber temperatures on the performance parameters such as circulation ratio, coefficient of performance, and discharge temperature.

They also compared the performance with that of the conventional HFC134a vapour compression heat pump and generated the operating domain diagram for various average solution concentrations. From the results obtained after their analysis, they found that at low pressure ratios and high temperature lifts, the compression-absorption heat pump gave better performance than compression system.Brunnin et al [5] defined the model of a compression-absorption heat pump using ammonia- water mixtures.

They also studied the working domains of a compression heat pump and a compression-absorption heat pump which were limited by the technical constraints of minimum coefficient of performance, minimum volumetric heating capacity, minimum low pressure and maximum high pressure. They found that the use of ammonia-water mixtures in a compression-absorption heat pump covered the whole working domain of high temperature heat pumps with performance comparable to that of compression heat pumps.Ahlby et al [6] carried out the optimization study of the compression-absorption cycle working on ammonia-water mixture. They found the optimum operating point for the cycle corresponding to various external conditions. They also showed that the cycle performance can be improved by optimizing the temperature gradient in the absorber. They made comparison of the cycle with the vapour compression cycle working on pure R12 refrigerant and found a higher COP. COP of the CA cycle was found to be 9-21% higher than that for the R12 system.George et al [7] carried out a thermodynamic study of a R22-DMF compression-absorption heat pump. They studied the effects of varying the temperatures in the absorber and thedesorber, pressure ratio of the compressor on the performance of the system. The absorber heat load was 1 kW, with the absorber temperature varying between 45^{0}C to 85^{0}C and the desorber temperature from 20^{0}C to 40^{0}C. They correlated the data resulted from the analysis and developed the expressions for the COP, CR, Concentration difference and the limiting temperature for the absorber.Hulten and Berntsson [8] studied theoretically the performance improvement of an industrial single stage compression-absorption heat pump operating on an ammonia-water mixture. They found that higher COPs can be obtained if the pressure ratios are increased for such a heat pump. They suggested some design improvements for the heat pump which could raise its performance such as the use of longer falling film tubes in the absorber and the desorber increased the COP.

They also compared the performance of the system with that of a two stage compression heat pump using isobutene as working fluid.Hulten and Berntsson [9] studied the influence of some operating parameters such as the absorber glide, concentration change in the absorber, absorber and desorber falling film tube lengths, heat exchanger area distribution on the COP of a CAHP. They also compared an ammonia-water based CAHP with a CHP working on isobutane by considering the local heat transfer coefficients and the pressure drops. They observed that for large temperature glides (> 20 K), the CAHP gives 12% better performance than a CHP. They also found that for longer falling film tubes in the absorber and the desorber, the COP obtained was higher.Boer et al [10] studied the performance of double effect absorption compression cycles using methanol-

TEGDME and TFE-TEGDME as the working pairs. They found that performance of a double effect absorption cycle using these organic mixtures could be improved by introducing a compression stage between the evaporator and the absorber. They also observed that the cycle could work even if low grade heat was available as the heat source delivering higher COP.Pratihar et al [11] performed thermodynamic modeling and feasibility analysis of a compression absorption refrigeration system working on ammonia-water mixture. He studied the effects of various operating parameters like the absorber and desorber temperatures, compression ratio and heat exchanger effectiveness on the coefficient ofperformance. He obtained a COP of 5.39 at an absorber pressure of 20 bar, desorber temperature of 40 C, compression ratio of 4 and heat exchanger effectiveness of 0.7.Ferreira et al [12] investigated the performance of a twin screw compressor operating under two phase compression for an ammonia-water CAHP cycle both theoretically and experimentally. They have tried to increase the isentropic efficiency of the compressor that makes wet compression-absorption heat pumps a competitive technical option.

III. CONCLUSION

The above literature review reveals that this technology is still at its developmental stage. Although many works have been conducted to analyze the performance of a compression-absorption system, few attempts have been made to modify it. There has been enormous work done on the first law analysis of the system but very little work regarding the second law analysis has been reported in the literature.

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