International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 6 Series III || June 2021 || PP 14-18

Review of recent advancement in Vapour Absorption Refrigeration System.

Mr. Pratap Vishwas Patwardhan[1], Dr. Abhijit A. Patil[2]
[1](Department of Mechanical Engineering, Sanjay Ghodawat University, Maharashtra, India)
[2](Assistant Professor, Department of Mechanical Engineering, Sanjay Ghodawat University, Maharashtra, India)

ABSTRACT :
The Vapour refrigeration system now a days becomes the most promenant refrigeration system over last three decades. The limitations of vapour compression refrigeration system as the environnemental aspects of use of refrigerants gives rise to most developed system of vapour absorption refrigeration system. Though the vapour absorption refrigeration system is reflecting more difficulties in operation, the new methodologies proves it more sustainable. Vapour absorption refrigeration system works on the principle of utilization of low grade heat energy whereas vapour compression refrigeration system works on mechanitcal energy. The coefficient of performance of vapour absorption refrigeration system can be augmented by various means. The use of green energy and low grade waste heat are the key aspects in future development of vapour absorption refrigeration system. This review paper focuses on energy conservation methodologies suggested by various researchers for the optimization of coefficient of performance of the system and to reduce the causes like green house effect and ozone layer depletion.

KEYWORDS– *Vapour absorption refrigeration, Vapour compression refrigeration, Energy conservation, Coefficient of Performance.*

Date of Submission: 06-06-2021 Date of Acceptance: 19-06-2021

I. INTRODUCTION:

The increase in industrial sector in last three decades, demands more space and technologies in refrigeration and air conditioning techniques. The methods of refrigeration and air conditioning are more preferably demanded for various applications like space cooling, comfort conditioning, food storage, engineering methods like cryogenics etc. Majorly the vapour refrigeration systems are classified as vapour compression refrigeration (VCR) system and vapour absorption refrigeration (VAR) system. The VCR system uses the high grade mechanical energy while the VAR system uses low grade heat energy for the generation of pressure energy of the working fluid. Both of the systems are comprising with the same components like condenser, expansion device and evaporator as per the applications. VCR system generates pressure energy of the working fluid by means of the set of absorber and generator while VCR system generates it with the use of compressor. Though the VCR system is compact in nature but undergoes with the tremendous issues of environment. The conventional refrigerants used as a media in VCRS, like hydrocarbons (HCs) and hydrochlorofluorocarbons (HCFCs) contributes to ozone depletion and global warming. The international community of engineers are trying to protect the ozone layer and the environment by introducing organic refrigerants. The restriction of the use of chlorofluorocarbons (CFCs) and HCFCs under the two important protocols adopted in 1987 (Montreal) and 1997 (Kyoto). According to NASA [1] the hole in the ozone layer has expanded from about 24,000,000 km^2 in 1994 to some 28,300,000 km^2. The European Commission (EC) adopted the restriction on the use of all HCFCs by 2015 [2,3] in October 2000. As reported by an institute on climate change, average global temperature has increased by 0.6 K, since the beginning of the present century, and it is expected to rise by1.4–4.5 K by 2100 if the current trend continues [4]. Due to such heavy environmental problems by the refrigerants used in VCR system, there is a demand of replacement of conventional refrigeration system by the newly adopted green energy sources. It also demands the use of waste heat energy usage and adoption of renewable energy sources [5-8]. The VAR system requires heat energy in the generator to separate the concentrated working fluid in vapour form. The use of waste heat or renewable energy like solar can be implemented for this purpose. Such type of VAR systems uses a very minimum conventional energy to be supplied for pumping the strong solution from the absorber to the generator. The application of waste heat and green energy thus not only helps to prevent the ozone layer depletion but also economically improvement in COP of the system.

II. VAPOUR ABSORPTION REFRIGERATION SYSTEM:

The vapour absorption refrigeration system is one of the oldest vapour refrigeration system which uses secondary low grade heat energy instead of primary mechanical energy. In this system the compressor is replaced by the generator and the absorber to increase the temperature and pressure of the cooling agent. Fig. 1 shows the typical vapour absorption refrigeration system. It consists of absorber, pump, generator, condenser, expander and evaporator. In generator the temperature and pressure of the cooling agent gets increased by providing sufficient heat to the strong solution. The latent heat possessed by the cooling agent vapour is rejected to the atmosphere in the condenser hence converts into liquid form. The cooling agent is further expanded by the expander where the temperature and pressure both drops. The low pressure, low temperature cooling agent entering into the evaporator absorbs the latent heat from the enclosed space and reduces the temperature of the cabinet. As the latent heat of evaporation is absorbed by the cooling agent converts its phase from liquid to gaseous form. The fumes of cooling agent mixes with the week fluid solution present in the absorber. The strong solution from the absorber is pumped to the generator and the cycle repeats.

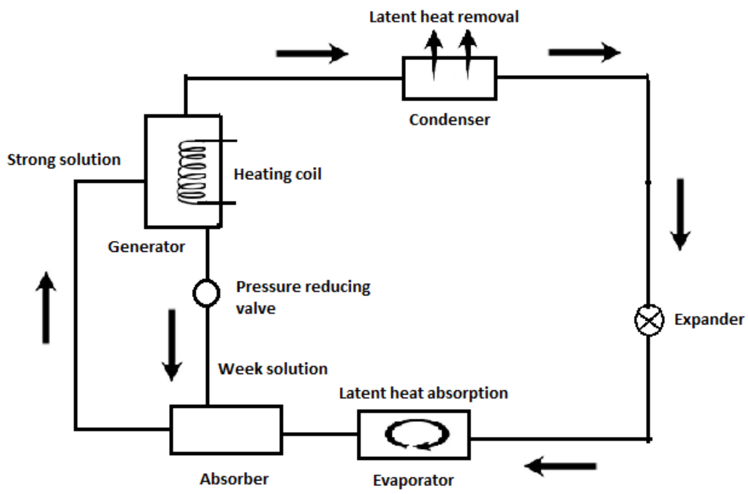

Fig. 1 Simple vapour absorption system

III. LITERATURE REVIEW:

Many authors discussed regarding the amount of heat energy wasted in the applications of conversion of one form of energy into another form, like internal combustion engine. The energy required to power VAR system is available in the engine exhaust. A. T. Rego et al [9], designed and tested a prototype for an absorption refrigeration system, powered by the exhaust gas heat of a 260 kW diesel engine. The evaluation was made at constant engine speed and also at various engine speeds. It was found that the quantity of exhaust gas energy is sufficient to power the $0.215m^3$ refrigerator. The typical values of the temperature were found between 180-250ºC. Andre Aleixo Manzela et al [10] designed and tested a prototype for VAR system. The exhaust gas heat of a 260 kW from a typical diesel engine is supplied to operate the VAR system. The performance of the engine speed over 2000rev/min. result into the increase in temperature inside refrigerator. The experiment was carried by fixing the engine speed by 1500rev/min. and by the opening the throttle value for 25%, 50%,75% and wide opening. The experimental results found that the temperature inside the refrigeration system is dropped faster when throttle value opened widely. The relative humidity was 29% for 25% of throttle opening and 35% for wide opened throttle value. The highest temperature drop was found for 25% throttle value opening and COP increases. For wider opening of throttle value cooling capacity increases and COP decreases. Andy Pearson et al [11], published a review paper on the application of ammonia. In the review paper it was discussed the causes by which the ammonia is suitable to use in industrial applications of cooling. Dolz et al [12], performed the study of different bottoming Rankine cycles using water stream. They described the innovative steps for waste heat recovery in heavy duty diesel engine. The experimental work was divided into two parts. The first part was the detailed study of HDD engine and available waste energy from the engine. The application in bottoming cycle to reduce the external irreversibility was studied due to waste heat energy source. The second part dealed with the analysis of the various innovative processes in HDD engine. Charles Sprouse and Christopher Depcik [13] studied the organic Rankine cycle with waste heat recovery from internal combustion engine. It was found that the organic Rankine cycle works well with medium grade energy from engine exhaust. The parameters of working fluid and expander was found as the large impact on the system performance. The results obtained shoed the improvement of 10 % fuel economy with the help of modern refrigerants and expanders. P. Praveen et al [14] studied the performance analysis of VAR system using waste heat from 105 L diesel IC engine. The analytical treatment was done by using SageMath 9.0 to save time and money. The mass and energy balance were derived on designed VAR system. The heat transfer from various components of the system is determined. The COP was found for various heat inputs from the exhaust temperature of the diesel engine. The COP was compared at various generator temperatures. The performance of the VAR system at various load conditions was calculated. The results found shows that the performance of the system increased with the increase in input temperature. C. V. Papade at al [15] studied the analysis of VAR system with the application of solar energy for industry and domestic purposes. The moving parts in the conventional vapour absorption refrigeration system was excluded to reduce the maintenance. The parabolic trough collector was used to supply energy to the generator about 96ºC. The cycle was run for 6 hours in two phases to obtain the results. It was found that the amount of refrigeration effect is based on the maximum temperature of the generator. The maximum cooling in the evaporator was estimated as 4ºC. Shubham Srivastava et al [16] reviewed the various papers on the analysis of vapour absorption refrigeration system. The paper gave a wide history of cases of the use of the CFC refrigerants and its effect on the environment. It also includes the necessity to adopt the green technology and the low grade energy in the application of refrigeration system. Yogesh H. Kadam et al [17] studied the design of waste heat driven vapour adsorption cooling system of 2 KW for vehicle air-conditioning and refrigeration. They found that the waste heat driven Vapour adsorption cooling system is eco-friendly, efficient, & reliable in nature. It was alos seen that the COP of such system is low as compared to the existing systems. The adsorber was considered as the key component of the cooling system. The paper includes the design of adsorber bed, adsorber and adsorbate mass, design of evaporator & condenser, Coefficient of performance (COP), Specific cooling power (SCP) and the other performance affecting parameters. Engr. Uhamir Patrick and Prof. Dr. Hussain Bux Marri [18] studied the thermodynamic modeling of VAR system for the optimization of the most economic refrigeration system. The software was developed named as Engineering Equation Solver (EES) for the parametric analysis which would help in suggesting design modifications in a VARS for the improvement of its COP. A. Solanki and Yashpal [19] studied the thermal examination of 100 kW triple-effect vapour absorption system using experimental design method. The parabolic trough collector was used for designing of the system with different parameters. The pressurized water of 140-180ºC was supplied to the generator at a mass flow rate of 7 kg/s through parabolic trough collector. It was found that the radiation drops in the month of November due to cosine losses as compared to May and direct normal irradiance decreases in the month of December, January, July, August, and September. Suraj D. Shinde and Manojkumar D. Hambarde [20] studied the implementation of a single effect absorption libr-h_2O refrigeration chiller of 100TR by using thermodynamic modeling and steady state simulation. The entry and exit condition of the steam supplied to the generator was studied with the program to obtain the thermodynamic properties. It was found the addition one heat exchanger increases the COP with reduction in heat input source and the heat transfer area in the generator. The results found that as the temperature rises from 100°C to 125°C the heat capacity of each heat exchanger changes. Heat transfer was increased linearly from low to high. Prof. Narale Pravin [21] studied the VAR system with R-717 as refrigerant and water as working fluid by using solar energy. It was found that the VAR system provides large potential for reducing heat pollution of the environment. The use of solar panel for generating cooling effect gave substantial results as compared to high grade energy driven compression technology. Shabari Girish K. [22] studied the geometrical modelling of VAR system. A prototype model was designed, fabricated in laboratory using scrap material and tested. The performance of the unit was analyzed. A parabolic solar trough was used as a source of heat. Various components were modeled in computer and analyzed using ANSYS. The performances and effectiveness of the unit was studied by determining refrigeration effect (RE) and coefficient of performance (COP). Vatsal Agrawal [23] studied the vapour compression-absorption hybrid refrigeration system for the optimization with cooling tower. It was found that the R134-DMF vapour compression and absorption hybrid refrigeration system increase the performance of the system. It was also found that the hybrid system results into decrease in energy consumption with effective rase in efficiency. Arun Bangotra [19p] studied the design and analysis of a generator in VAR system for automotive air- conditioning. The designed generator was located nearest to the exhaust manifold at tail-end where the heat is available from exhaust gases. The waste heat available was 5 kW, at the exit which is sufficient for evaporating the refrigerant in the generator of VAR system to operate the air conditioning system of 0.8 TR. Ajay Pawar et al [24] worked on the CFD Analysis of evaporator in VAR system of 1 TR by using ANSYS fluent. The exhaust of an IC engine was used as a heat source. The design of the evaporator was calculated on the basis of enthalpy parameters at different points in the system. The data was analyzed using the first and second laws of thermodynamics. the modeling was done by using solid edge software and the analysis was carried by using ANSYS fluent. The working parameters were considered as the condenser pressure of 10.7 bar and evaporator pressure of 4.7 bar. Ammonia is used as the refrigerant in the system and water as absorbent in the system.

IV. CURRENT AND FUTURE ASPECTS OF DEVELOPMENTS:

The present review paper is the summery of extensive use of different aspects of VAR system to improve the performance as well as to protect the environment from the issues like greenhouse effect and the ozone layer depletion. The present VAR system needs the improvement in technology to achieve the maximum optimization in the performance, as many papers shows the result improvement by using waste heat recovery as well as the with the use of green energy. The further research requires the direction and care in the following areas:

1. Improvement in the properties of working fluid for the better performance of the system.
2. Advanced low grade heat recovery methods for the enhancement of the system parameter like generator.
3. Reduction in complex design with the help of sub components into the system.
4. View of the system to locate in less space as compared to the conventional system.
5. Design of higher performance absorber generator circuits.
6. Utilization of solar or geothermal thermal energy sources in a optimized design structure.

V. CONCLUSION:

The various significant methods for enhancing the performance of VAR systems are reviewed. Major components for the developments include the cycle design, heat recovery methods, change in the properties of working fluids, hybrid systems of VCR and VAR with subcomponents and optimizing the operating conditions. A summary of the findings is presented as follows:

1. The major intension of focus is to protect the environment from pollution and to reduce the impact of green house effect and ozone layer depletion. It can be achieved by replacing the system of CFC refrigerants and the conventional systems by advanced VAR system.
2. The low grade waste heat of internal combustion engine is significantly used in VAR system. The results show the enhancement in the performance as well as the COP of the system. Such systems can give the direction in the research of air conditioning system implied to automobile cars.
3. The generator and absorber design can be modified and tested by using different engineering fluid flow software to reduce the cost and the time of research.
4. The green energy sources like solar energy, geothermal energy can be implemented in the typical VAR system for the improvement in COP of the system.
5. The hybrid use of VAR and VCR system implies the improvement in the performance of the system.

REFERENCES:

[1]. D. Wang, Y. Li, D. Li, Y. Xia, J. Zhang, A review on adsorption refrigeration technology and adsorption deterioration in physical adsorption systems, *Renew. Sustain. Energy Rev.14*, 2010, 344–353.

[2]. M. Anisur, M. Mahfuz, M. Kibria, R. Saidur, I. Metselaar and T. Mahlia, Curbing global warming with phase change materials for energy storage, *Renew. Sustain. Energy Rev.18*, 2013, 23– 30.

[3]. H. Hassan and A. Mohamad, A review on solar cold production through absorption technology, *Renew. Sustain. Energy Rev. 16,* 2012, 5331–5348.

[4]. Y. Morabiya and T. Shaikh, Review of solar absorption refrigeration system using LiBr-water and simulate the performance of the system, *International Journal of Advance Engineering Research and Science*, 2013, 57–60.

[5]. M. Siddiqui and S. Said, A review of solar powered absorption systems, *Renew. Sustain. Energy Rev. 42*, 2015, 93–115.

[6]. W. Wu, B. Wang, W. Shi and X. Li, An overview of ammonia- based absorption chillers and heat pumps, *Renew. Sustain. Energy Rev. 31,* 2014, 681–707.

[7]. H. Yabase and K. Makita, Steam driven triple effect absorption solar cooling system, *International Refrigeration and Air Conditioning conference, Purdue*, July 16-19, 2012, 2363, 1-8.

[8]. Y. Yuan, X. Cao, L. Sun, B. Lei and N. Yu, Ground source heat *pump system: A review of simulation in China, Renew. Sustain. Energy Rev. 16,* 2012, 6814–6822.

[9]. Rego A.T., Hanriot, S.M., Oliveira, A.F., Brito P. and Rego T.F.U., *Pontifical Catholic University of Minas Gerais, Department of Mechanical Engineering, Av. Dom Jose Gaspar, 500, 30535-901– Belo Horizonte, Brazil*, 64, 2014, 101– 107.

[10]. Andre Aleixo Manzela, Sergio Morais Hanriot, Luben Cabezas-Gomez and Jose Ricardo Sodre, 'Using engine exhaust gas as energy source for an absorption refrigeration system', *Applied Energy, Elsevier,* 87, 2010, 1141-1148.

[11]. Andy Pearson, 'Refrigeration with Ammonia and Hydrocarbons', *International Journal of Refrigeration, Star Refrigeration Ltd., Glasgow G46 8JW, UK*, 31, June 2008.

[12]. Dolz V., Novella R., Garcia A. and Sanchez J., CMT- Motores Termicos, *Universitat Politecnia de Valencia, Camino de Versa s/n, 46022, Valencia*, Spain 36, 2012, 269-278.

[13]. Charles Sprouse and Christopher Depcik, Review of organic Rankine cycles for internal combustion engine exhaust waste heat recovery, *Applied Thermal Engineering*, 51, 2013, 711-722

[14]. P. Praveen , S. Santhosh , R. Raaghul and A. S. Pramoth Kumar, Performance Analysis of Vapour Absorption Refrigeration System using Waste Heat from IC Engine, *International Journal of Advanced Science and Technology*, 29(5), 2020, 10879-10892.

[15]. C. V. Papade and S. V. Karande, 'Analysis of Solar Operated Intermittent Vapour Absorption Refrigeration System', *International Journal of Engineering Trends and Technology (IJETT),*60(2), June 2018, 142-146.

[16]. Shubham Srivastava, Ravi Kumar Sen, Arpit Thakur and Manish Kumar Tated, Review paper on analysis of vapour absorption refrigeration system, *International Journal of Research in Engineering and Technology (IJRET),* 4(6), June-2015, 2321-7308.

[17]. Yogesh H. Kadam, Diwakar H. Yadav, Swapnil J. Mohite, Prathamesh P. Panchal and V. K. Dongare, Design of waste heat driven vapour adsorption cooling system for vehicle air-conditioning and refrigeration, *International Journal of Research in Engineering and Technology,* 5(4), Apr-2016, 2321-7308.

[18]. Prof. Dr. Hussain Bux Marri and Engr. Uhamir Patrick, Thermodynamic Modeling of Vapor Absorption Cycle-An Overview,

International Conference on Industrial Engineering and Operations Management, March 5, 2019, 3467-3472.

[19]. A. Solanki and Yashpal, Thermal Examination of Vapour Absorption System using Experimental Design Method, *International Journal of Engineering and Advanced Technology (IJEAT)*, 8, August 2019, 1101-1104.

[20]. Suraj D. Shinde and Manojkumar D. Hambarde , Implementation of a Single Effect Absorption LiBr-H2O Refrigeration Chiller by using Thermodynamic Modeling and Steady State Simulation, *International Journal of Recent Technology and Engineering (IJRTE)*, 8(2), July 2019, 2900-2906.

[21]. Prof. Narale Pravin, Mr. Pisal Pravinkumar, Mr. Shende Kiran, Mr. Shende Onkar and Mr. Sawant Rahul, Vapour Absorption Refrigeration System by using Solar Energy, *International Journal for Scientific Research & Development (IJSRD)*, 3(11), 2016, 499-503.

[22]. Shabari Girish K.V.S., Praveen R., Dipesh Nair and Debjyoti Sahu, A Case Study on Solar Vapour Absorption Refrigeration System, *International Journal of Engineering & Technology*, 2018, 44-47.

[23]. Vatsal Agrawal, Rohan Juneja, Kahaan Dalal, Tirek Prajapati and Dr. Bansi Raja, Vapour Compression-Absorption Hybrid Refrigeration System and Optimization using Cooling tower, *International Research Journal of Engineering and Technology (IRJET)*, 07, May 2020, 3629-3633.

[24]. Ajay Pawar, Ajay Ekka, Anmol Pagaria, Arjun Parmar and Bhupesh Chouhan, CFD Analysis of VARS Component (Evaporator) on ANSYS Fluent, *International Research Journal of Engineering and Technology (IRJET)*, 04, May 2017, 579-586.

Mr. Pratap Vishwas Patwardhan, et. al, “Review of recent advancement in Vapour Absorption Refrigeration System.” *International Journal of Engineering Science Invention (IJESI)*, Vol. 10(06), 2021, PP 14-18. Journal DOI- 10.35629/6734