International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET229458

Performance Analysis of Ejector Expansion Refrigeration System on The Basis of Area Ratio

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Article Info
Volume 9, Issue 4

Page Number : 345-349

Publication Issue :
July-August-2022
Article History
Accepted : 05 August 2022
Published: 20 August 2022

ABSTRACT
Vapour compression refrigeration system is the conventional way existing for the refrigeration these days. Although to overcome the loses in conventional method there are several ways to improve the performance of vapour compression refrigeration cycle. This paper provides an alternative method of increasing the performance by varying the area ratio of the ejector. As Ejector is the most simple and economical replacement of throttling valve. A Simulation model is developed and parametric study of ejector is done. It was found that there will be increase in performance as area ratio is changed. This cycle is named as Ejector expansion Refrigeration System.
Keywords : VCR Cycle, Refrigeration System, Coefficient of Performance

I. INTRODUCTION

These days world is experiencing electricity crises on a high note. The Demand for electricity in world has been growing at an average rate of around 8% annually over the last years. The electricity consumption in the field of refrigeration is about 23% of the total energy consumption. In order to reduce this demand a high energy efficiency systems should be adopted. The most common and widely used system in refrigeration industry is vapour compression refrigeration system. There are several ways of enhancing the performance of a vapour compression refrigeration system. One of the way is using ejector as expansion device. In conventional VCR Cycle, the expansion is done by a throttle valve or by capillary tube.

Throttling is one of the thermodynamic losses processes in VCR cycles but it is most loss prone irreversible proves in a conventional vapour compression refrigeration cycle. In order to reduce this loss, various devices and technique have been attempted to use instead of the conventional devices. Ejector is a device that uses a high pressure fluid to pump a low pressure fluid to a higher pressure at a diffuse outlet. Its low cost, no moving parts and ability to handle two phase flow without damage make it attractive for being the expansion device in the refrigeration system.

II. LITERATURE REVIEW

Nehdi E et al. gives the use of an ejector as an expansion device by replacing the throttling valve in the vapour compression refrigeration cycle and by varying the geometrical parameters there is a increase of COP by 22%.

Sandeep Kashyap et al found that the use of ejector in vapour compression system for the improvement of COP has great influence as the COP of ejector refrigeration cycle depends on ejector geometry, operation condition and property of working fluid. Comparative analysis were made on ejector refrigeration cycles with working fluid R410a and R134a in same ejector geometry and same operating condition using one dimension modal. On based of study COP of ejector refrigeration cycle depends on ejector geometry, operation condition and property of working fluid. COP of system increased as boiler temperature increased while Cop is decreased when Compression ratio and condenser temperature increased. For different ejector ratio the performance of system are different but ejector ratio Ø= 7.84 at 353K have higher COP comparative other ejector ratio. All area ratio and operating temperature the performance R134a is better than R410a.

Reddick , Christopher et al aim of the work is to experimentally study the possibility of improving the energy efficiency of a vapour compression refrigeration system where a two-phase ejector replaces the expansion valve. A test bench using refrigerant R134a was designed and built which functions in both the conventional mode and in ejector mode. The primary nozzle of the ejector was equipped with a double throat, having an adjustable area for the first throat and a fixed area for the second throat. Experimental results showed an improvement of 11% in the coefficient of performance (COP) in ejector mode as compared with the conventional mode.

Giorgio Besagni et al gives an comprehensive literature review on ejector refrigeration systems and working fluids. It deeply analyzes ejector technology and behaviour, refrigerant properties and their influence over ejector performance and all of the ejector refrigeration technologies, with a focus on past, present and future trends.

Vu V. Nguyen et al presents an experimental study of the influence of a variable geometry ejector (VGE) design on the performance of a small-scale, 1.5 kW nominal capacity solar heat driven ejector air conditioning system under real-life working conditions. Under variable operating conditions (e.g. solar radiation, ambient temperature) fixed geometry ejector performs poorly, therefore the objective of the present work was to prove the benefit of the VGE concept. In the experimentally tested VGE the area ratio through a movable spindle (SP) and the nozzle exit position (NXP) can be adjusted in order to respond to the operating conditions. The results showed very stable operation of the cooling cycle during the experiments. Both NXP, SP had considerable influences on the cooling cycle performance.

Hafiz Ali Muhammad et al develops a single mathematical correlation that can predict the ejector performance with reasonable accuracy. The proposed correlation relates the entrainment ratio and the pressure rise across the ejector to the area ratio and the mass flow rate of the primary flow.

Hassan S. Jawad et al presents a paper where an ejector was designed and manufactured from brass metal as part of a cooling system operating with steam the type of the primary nozzle is converge diverge. The ejector was manufactured from a number of interconnected parts to give the final shape. The performance of the ejector was analyzed theoretically using the equations of continuity, momentum and energy, and through operating conditions change and the examination, it was found that the mixing ratio increases with the increase of the primary pressure, the mixing ratio decreases with increasing suction pressure and the mixing ratio increases to a certain value and then decreases with increasing discharge pressure.

III. MODELLING

The layout of the ejector expansion vapour compression refrigeration cycle is shown in fig 1 and the corresponding p-h diagram is shown in fig 2 . The primary flow from the condenser and the secondary flow from the evaporator are expanding through primary and secondary nozzles, respectively to mixing chamber pressure, mixing at constant pressure. The mixed flow is discharged through the diffuser of the ejector and then separated in forms of vapour and liquid so that this ratio matched with the inlet ratio of primary and secondary flows. Then the liquid circulates through the expansion valve and evaporator whereas the vapour circulates through the compressor and the condenser. This cycle is very efficient and widely accepted with various simulations and optimization been performed.

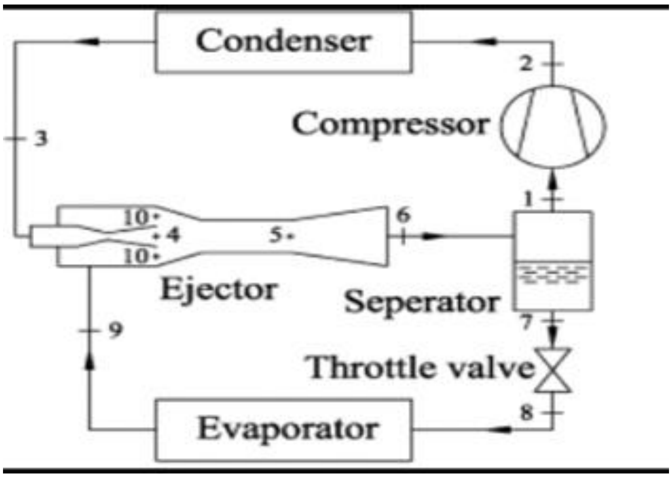

Figure 1 Schematic of the EERS

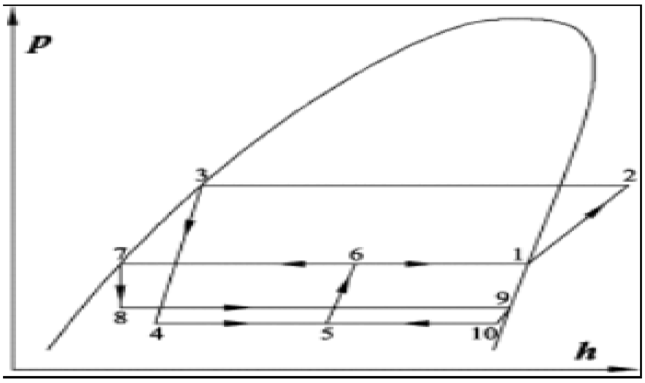

Figure 2 P-h Diagram

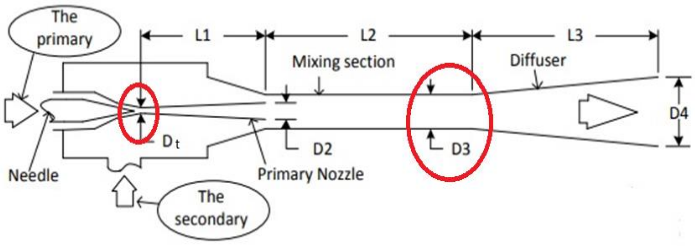

Figure 3 : Schematic of Ejector

Components of ejector and their functions

1) Motive Nozzle or Primary Nozzle : A Nozzle in which high pressure side refrigerant flowing from the condenser is converted into a kinetic energy so that refrigerant is expanded iso entropically.

2) Secondary Nozzle : A high speed motive stream from the motive nozzle entrains/sucked low pressure stream from the evaporator up to expanded pressure.

3) Mixing Chamber : Both Primary and secondary streams exchange momentum, kinetic and internal energies in the mixing chamber and become one stream with almost uniform pressure and speed.

4) Diffuser: The stream converts its kinetic energy in to internal energy in the diffuser to reach a pressure higher than the suction stream inlet pressure.

Parameters used in modified EERS CYCLE which significantly influence the system performance:-

a) Entrainment Ratio (ω) : It is the ratio of secondary mass flow rate of refrigeration coming out from the evaporator(Vapour) to the primary mass flow rate of refrigerant coming out from the condenser(liquid).

$$(\omega) = \frac{ms}{mp}$$

b) Pressure Lift Ratio(¥): It is the ratio of diffuser exit pressure (P_6) to secondary inlet pressure (P_9).

¥= P_6/P_9

c) Area Ratio (ϕ): It is ration of mixing chamber area (A_3) to throat area (A_t).

Area Ratio (Φ)= A3/At

d)Secondary Nozzle Pressure Drop(£) : It is the amount of vapour refrigerant pressure drop that takes place in secondary nozzle coming out from the outlet of the heat exchanger.

£ = P_9-$P_{10\ ejector}$

IV. RESULTS AND DISCUSSION

Ejector is analysed and keeping the throat diameter(A3) constant and varying the mixing section diameter(At), we get different entrainment ratio. Based on that readings plot is made. Simulation model is used to get the optimal design of the ejector. Entrainment ratio directly influence the performance of refrigeration as mixing is getting better by increasing the mixing area. Modified EER cycle gives better performance as compared to conventional VCR Cycle. Entrainment ratio is directly proportional to coefficient of performance.

PLOT OF ENTRAINMENT RATIO V/s AREA RATIO

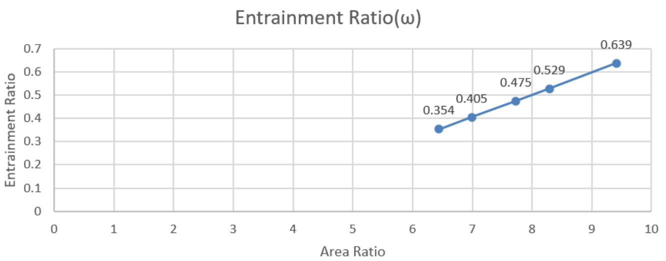

Figure 4 Entrainment Ratio v/s Area Ratio

V. CONCLUSION

This paper provides an performance evaluation on the basis of geometrical parameter of ejector i.e, area ratio. Proposed modification in EERS is better than conventional system as it will increase the refrigerant effect and decreases the work input. Mixing chamber is a innovative way to enhance the performance. This model will definitely help in increasing COP of Ejector Expansion Refrigeration system.

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Cite this article as :

Chinmay Mishra, Sharad Chaudhary, "Performance Analysis of Ejector Expansion Refrigeration System on The Basis of Area Ratio", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 4, pp. 345-349, July-August 2022. Available at doi : https://doi.org/10.32628/IJSRSET229458

Journal URL : https://ijsrset.com/IJSRSET229458