Analysis of Compressor Assisted Ejector Refrigeration System

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Abstract- *Refrigeration systems consume most of the total produced energy, so it is necessary to develop an energy-efficient systems. Use of refrigeration system is cooling a space/system to lower/maintain its temperature below the ambient temperature . The vapor compression refrigeration system consumes high power for its function so we use the compressor assisted ejector refrigeration system. In compressor assisted ejector refrigeration system, ejector is the main component of the system, assisted by the compressor. The work required from the compressor is less, hereby the electrical energy required to run the compressor is also less in this system. As work load on compressor reduced this system promises longer life of the compressor. This system helps to reduce energy consumption and also satisfy to meet required refrigeration effect*

I. INTRODUCTION

Among all the systems for refrigeration and air conditioning, the ejector the refrigeration system has attracted much interest in recent years because of its merits over the other cycles. The system uses low-grade energy for its working. In this system, the ejector is assisted by the compressor which have capability of driving the refrigerant effectively.

The main function of an ejector is to suck vapours or gases from low-pressure places to high-pressure ones by converting the kinetic energy to pressure energy. As the ejector has no moving parts, power is not required for its operation.

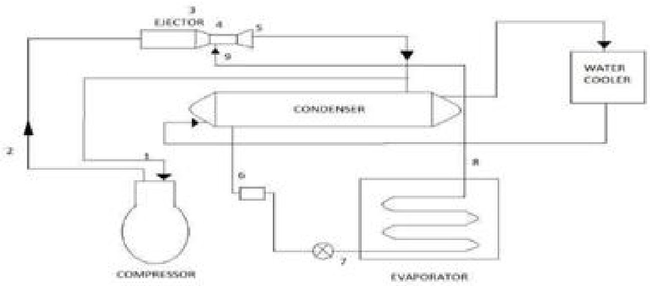
By using ejector it gives us following benefits:

COP improvement, No maintenance issues etc.

Description Of Test apparatus:

The test apparatus is shown in below fig 1 which consist of compressor, ejector, condenser, evaporator and expansion device. The arrangement of components is such that compressor is connected to primary nozzle of ejector, evaporator is connected to secondary nozzle of ejector, ejector outlet is partly connected to compressor and condenser and from condenser refrigerant is sent to evaporator inlet through expansion device.

Refrigerant circuit diagram:



Compressor:

In this system we use two ton hermetically sealed compressor made by emersion. It runs on 220-230V and 50Hz single phase supply. This type of compressor is used mostly refrigeration system.

Location of compressor is shown in circuit diagram of refrigerant.

Ejector:

Ejector is main components of system which consists of primary nozzle through which flow from compressor comes. This flow is mixed with secondary flow which has relatively less pressure. The mixing of both pressure and enthalpy are increase in throat section of ejector. Outlet of ejector is connected to inlet condenser. Ejector pressure is considered is 2.17 bars.

II. MATHEMATICAL MODEL

There are two basic approaches for ejector design. It include mixing of the motive vapor and entrained vapors either at constant pressure or atconstant area. Design models of stream mixing at constant pressure gives a better performance as compare to constant area model. In this study the constant pressure model is developed.

The geometry of the ejector is as shown in fig. 2. To design the ejector there are some assumptions and baseline conditions which are given in the tableno.1. Based on these conditions the ejector is designed, the dimensions of the ejector are given in the table no.2.

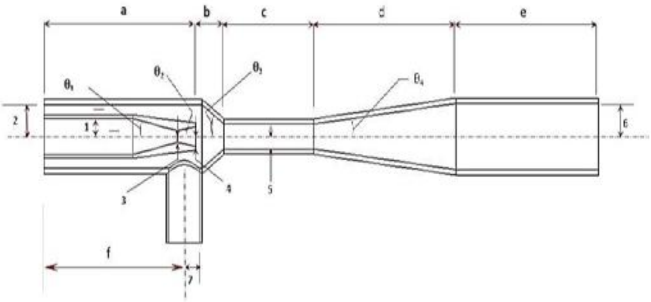


Table 1 Baseline condition used for ejector design

Operating condition	Value
Refrigerant	R134a
Generator Temperature	95°C
Condenser Temperature	35°C
Evaporator Temperature	8°C
Cooling Capacity	0.5TR
Nozzle Efficiency	90%
Diffuser Efficiency	78%
Entrainment Efficiency	63%
Entrainment Ratio	0.45

Table 2 Dimension of ejector

Length (L)	Value (mm)	Radius (r)	Value (mm)
a	63	1	5.517
b	9.2	2	1.4198
c	32.2	3	1.4265
d	51.5	4	7.828
e	51.5	5	3.20
f	55	6	6.3498
L_{Total}	239.6		

Primary nozzle convergent angle $\theta_1 = 12°$
Primary nozzle divergent angle $\theta_2 = 7.5°$
Secondary nozzle convergent angle $\theta_3 = 30°$
Secondary nozzle convergent angle $\theta_4 = 3.5°$

Condenser:

In condenser vapor refrigerant is converted into liquid refrigerant. Condenser works on temperature of 35°C and degree of subcooling of 10°C is considered at the outlet of condenser which is given to the evaporator through expansion valve. Most of time condenser are constructed according to the certain specification set by client. These specifications are typically included on a manufacturer's sheet for condenser design and selection.

The specification of condensers are given in following table 3.

Table 3 Thermal Design data for Condenser

Type	Shell and Tube
Cooling Load on the condenser	7034kW
No of tubes (NT)	9
Tube outer diameter, mm	25
Tube inner diameter, mm	20
Tube Length, m	1

Expansion device:

The function of expansion valve is to expand the refrigerants so it decreases its pressure and then it gives to evaporator. Thermostatic expansion valve is the mostly used throttling devices in refrigerator and air conditioning systems.
TEV (Thermostatic expansion valve) is automatic valve that maintains proper flow of the refrigerant in the evaporator.

Evaporator:

In evaporator liquid refrigerant is converted into vapor and its working temperature is considered as 7.2°C and 40°C of superheat. It is most important component of refrigeration system where liquid refrigerant is evaporated.
Shell and coil type of evaporator is used in this system. The evaporator is designed with assuming the pipe diameter 0.0127m.

Type	Shell and coil evaporator
Cooling load on coil	1758.5kW
Tube OD, cm	1.5
Tube ID, cm	1.27
Length of coil, cm	11
No of coils(N_c)	12
Depth of coil (D), mm	152.4

Water Cooler:

Water cooler is a machine that cools and dispenses water with refrigerant unit. It located mostly near to restroom so we can get close access to plumbing. A drain line is provided to sewer system. Water cooler generally divided into two categories 1) Point of Use and 2)Bottled water cooler.

The cooling capacity of water is cooler is 2 TR.

Cooling Water Pump:

Use of pump is that it has many advantages over compressor as it uses less power. In system it used to circulate the water from water cooler to condenser and back. It is mounted with water cooler.

Calculation:

In this system we are calculating cooling capacity of system and compressor power. The data analysis process determines the overall performance of system.

CoolingCapacity $\dot{Q}L = m.C_p(\Delta T)$--------------(1)

Where

m= $\rho * V$ ---------------- (2)

WorkInput $\dot{W}$ =(3600*REV)/(C*Time)

Where

C= Energy meter constant

Coefficient of Performance, COP can be calculated as follows:

COP= $\dot{Q}L$/W

Specific Power consumption

kW/TR= W*3.517/$\dot{Q}L$

III. RESULT

Ejector refrigeration system can works more efficiently than vapor compression system working between similar operating condition as that of compressor assisted ejector refrigeration system.

In following table, Experimental analysis of ejector refrigeration system where we find cooling capacity, work input of compressor and COP from Initial temperature and final temperature of Evaporator water temperature. By controlling mass flow rate to compressor we noted initial temperature and final temperature.

Flow To Compressor	Time	m	CP	ΔT T initial	Tfinal	QL	WC	COP
80%	1800	35.20	4.187	34	24	0.8189	0.128	7.62
70%	1800	35.20	4.187	25	22	1.0645	0.112	8.72
60%	1800	35.20	4.187	32	21	0.900	0.108	8.33
50%	1800	35.20	4.187	35	23	0.982	0.10	9.80
40%	1800	35.20	4.187	33	21	0.982	0.108	9.09

IV. CONCLUSION

In today world energy efficient system are becoming need to fulfill this requirement compressor assisted ejector refrigeration system is developed. This compressor assisted ejector refrigeration system saves the energy and produce maximum work output by reducing energy consumption required for compressor. System utilized mechanical device ejector as a prime device to save energy consumption. Experimental analysis work is done on compressor assisted ejector refrigeration system this work is mainly based upon condensing temperature parameter. This parameter is used as a prime condition for producing highly efficient system as compared to simple vapor compression system. By investigating parameter for higher efficiency of the system from experimental analysis it show that working of CAER system on when flow to the compressor is 40% it maximum COP and reduces its compressor work. By saving the energy consumption and also, rest of the work is minimized with help of ejector since this device is not available in simple vcc.

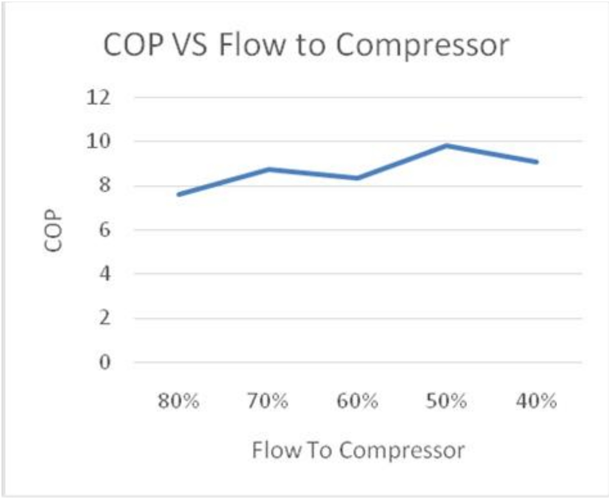


Fig Shows Flow to compressor and COP graph

V. ACKNOWLEDGMENT

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Nomenclature(Sample)

C	Energy meter constant(kWh)
QL	Cooling capacity(kW)
WC	Compressor power input(kW)
COP	Coefficient of performance