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ANALYSIS OF MULTIPLE EVAPORATOR REFRIGERATION SYSTEM

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ABSTRACT- There are many applications where refrigeration plant is required to meet the various refrigerating loads at different temperatures. For example, systems for hotels, large restaurant, institutions and food preservation industries. In these cases, it is necessary that each location is cooled by separate evaporators to maintain the particular temperature and produce the required refrigeration load. Hence it requires different refrigerating units with single evaporator for each location. Instead it will be beneficial to use a refrigerating unit with multiple evaporators working at different temperatures. Therefore, it is the purpose of this paper to introduce vapor compression system which uses a single compressor and individual expansion devices to provide the concurrent testing. Also we have to analyse the performance of the refrigeration system when different refrigerants are used in the same system with changing suction and discharge pressure. The performance parameters will be COP & the refrigerating effect obtained at evaporator.

I. INTRODUCTION

There are many applications where refrigeration plant is required to meet the various refrigerating loads at different temperatures. For example, systems for hotels, large restaurant, institutions and food preservation industries. In these cases, it is necessary that each location is cooled by separate evaporators to maintain the particular temperature and produce the required refrigeration load. Hence it requires different refrigerating units with single evaporator for each location. Instead it will be beneficial to use a refrigerating unit with multiple evaporators working at different temperatures. Therefore, it is the purpose of this paper to introduce vapor compression system which uses a single compressor and individual expansion devices to provide the concurrent testing.

II. DESIGN AND SELECTION OF COMPONENTS

A. Compressor

The rated cooling capacity of compressor is 5.265 kW i.e., 1.5TR. These capacity is divide into three evaporator for experimental work in which lowest temperature evaporator (Evaporator-I) is designed for 0.08 TR capacity, middle temperature evaporator (Evaporator-II) is designed for 0.23 TR capacity and the high temperature evaporator (Evaporator-III) is design for 0.49 TR capacity. Compressor model CR-22-K6M-PF1 choose for this system which give rated condensing pressure up to 21 bar and evaporative pressure 5.02 bar. During selection of compressor, speed, volumetric efficiency, refrigerant, condensing and Evaporative temperature is considered.

Table 2 Specifications of compressor

No.	Parameter	Unit	Value
1	Capacity	TR	1.528
2	Evaporating Temperature	0c	7.2
3	Condensing Temperature	0c	55
4	Suction Pressure	bar	5.02
5	Discharge Pressure	bar	21

B. Condenser

Condenser is the nothing but the heat transfer surface which rejects the heat at constant pressure so it is selected by calculating condenser load.It is simply calculated by formula.
Condenser load = Compressor capacity × heat rejection factor (1)
An air cooled fin typecondenserhaving surface area 55 cm × 42.5, 4 rows and 17 passes is selected which is capable to reject heat absorbed in evaporatorsand the energy equivalent of the work of compression in compressor. Heat rejection factor is obtained fromcondensing and evaporating temperature of system. The condenser capacity is determine using following formula[3]
$Q = U_o \times A_o \times \Delta T$ (W)

U_o= Overall heat transfer coefficient based on outside area (W/m2˚C),
A_o= Outside area of tube (m2),
ΔT = L.M.T.D for condenser (°C)
Thermostatic Expansion valve (TX2) having temperature range -40/+10˚C/-40/+50˚F) is selected which give the require pressure drop for the evaporator.

C. Evaporator Design

The rated cooling capacity of compressor is 5.265 kW i.e., 1.5TR. In order to have satisfactory performance of multiple temperature evaporator system, consider the actual cooling capacity given by compressor is 0.8 TR. For present work lowest temperature evaporator (Evaporator-I) isdesigned for 0.08 TR capacity. Evaporator I is used to store milk and dairy products. Evaporator II is used to store milk and dairy products.Evaporator III is used to store agriculture product like beans, potato, mango, oranges. While designing, Evaporator temperature and Condensing temperature is important which give the cooling capacity of the evaporator, the value of evaporator cooling capacity obtained from standard data sheet of compressor. Materials of evaporator, velocity of refrigerant, thickness of wall and contact surface area are some parameters which affect the cooling capacity of evaporator. Formula given below is used to design evaporators

$$\mathbf{Q = UoA\ (T2-T1)\ (W)} \qquad (3)$$

Where,
Uo= Overall heat transfer coefficient (W/m2)
A = Area of evaporator surface in (m2),
T2= outside the evaporator Temperature (°C),
T1= inside the evaporator Saturation temperature (°C).
Then mass flow of refrigerant is calculated by formula theoretically
Q=mr × (h2-h1)(W) (4)
Where
(h2-h1)= Enthalpy difference between compressor inlet and outlet (kJ/kg)
M =Mass flow of refrigerant (kg/sec)

III. EXPERIMENTAL SETUP

An experimental setup consists of a single compressor three evaporator system to maintain -10˚C, 0˚C and +10˚C in three separate compartments with cooling load. The major components of the system are compressor, condenser, fan, receiver, filter-drier, expansion devices, back pressure valves, evaporators, and accumulator. A setup manufactured to experimentally investigate the performance of multi evaporator system with three evaporator and refrigerant R-22.

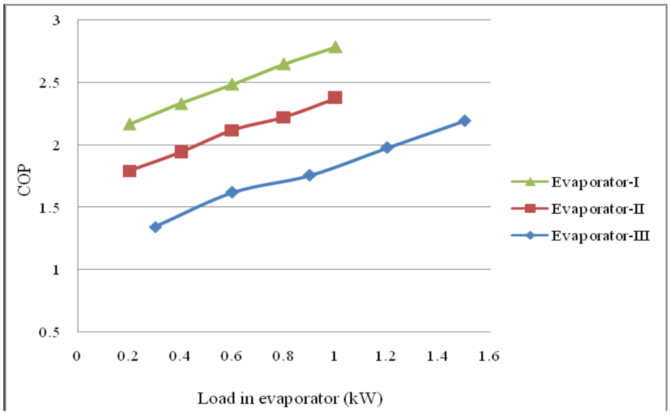
Table 1 Specifications of system

Sr. No	**Parameters**	**Description**
1	Type	Multi Evaporator system
2	Refrigerant	R-22
3	Capacity	1.5 TR
4	Compressor	Hermetically sealed, Reciprocating, two cylinders.
5	Condenser	Finned coils, Air cooled
6	Expansion device	Thermostatic expansion valve
7	Evaporators	Bare tube type finned- 3 Evaporators

Experimental setup consist of four major part of refrigeration system such as compressor, which compresses refrigerant, condenser which rejects the heat from refrigerant at constant pressure, an expansion device which drop down the temperature and pressure of the refrigerant and finally evaporator which is absorbs heat from refrigerated space. All the component of the refrigeration system is mounted on portable metallic panel. Measurement instruments such as pressure gaugesand thermocouples are placed before and after each component for data collection in order to understand the fluid medium conditions during the heat transfer process.

IV. RESULT AND DISCUSSION

An experiment is conducted with the change in load of the evaporators various heat inputs at the simulator to test the performance of the system to maintain the temperature of evaporators. The heat inputs are tuned down from 1500 W to 300 W in steps of 300 W and each test is given a time interval of 20minutes to reach steady state conditions. Figure 1shows the response of the power consumed by compressor at the various heat loads supplied. It is observed that increase in load increases the mass flow rate of refrigerant. Hence compressor requires more power for suction of refrigerant. Figure 2 shows the response of coefficient of performance at the various heat loads supplied. It is observed that as load increases power consumed by compressor also increases .But comparatively increase in power consumed is less than increase in load. Hence coefficient of performance of the system increases with increase in load.



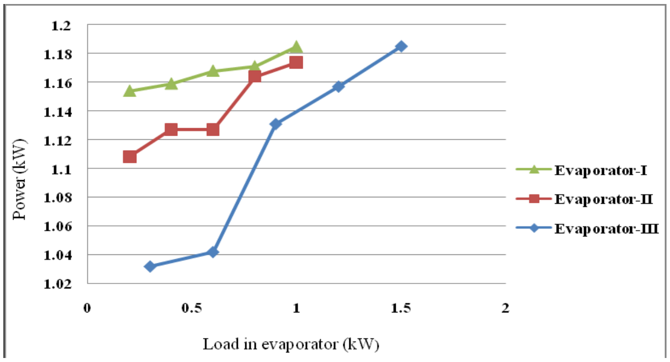


Figure 2 Graph for Coefficient of performance v/s Load on evaporator

V. CONCLUSION

In this paper, multi-evaporator refrigeration system which features independent control of the cooling capacity at each evaporator is presented. The combined action of the thermostatic expansion valve and back pressure valve allows the cooling capacity at the evaporator to be controlled for testing of evaporator under various heat loads. The result of the test conducted by change in load on evaporators shows that with increase in load on any evaporator, power consumed by compressor increases. It is found that comparatively total load on evaporator is more than power consumed. Hence coefficient of performance increases with increase in load.

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