"DEVELOPMENT AND PERFORMANCE ANALYSIS OF A MULTI EVAPORATING SYSTEM"

Jeevan Wankhade[1], Madhuri Tayde[2], Shylesha Channapattana[3]

[1]*PG Student [Heat Power Engg.], Dept. of Mechanical, Dr.D.Y.P.S.O.E, Ambi, Pune, India*
[2]*PG Student [Heat Power Engg.], Dept. of Mechanical, Dr.D.Y.P.S.O.E, Ambi, Pune, India*
[3]*Assistant professor, Dept. of Mechanical Engg., R.S.C.O.E. Thathawade, Pune, India*

Abstract

Refrigeration is one of the most important aspects of thermal environment engineering. The term refrigeration may be defined as the process of removing heat from a substance under controlled conditions. It also includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. In other words, the refrigeration means a continued extraction of heat from a body whose temperature is already below the temperature of its surrounding. There are many applications of refrigeration in our daily life. With the advancement of science and technology, the luxuries of yesterday are necessity of today. In addition, refrigeration embraces industrial refrigeration, including the processing and preservation of food, removing the heat from the substances in chemical, petroleum and petrochemical plants; and many special applications such as those in the manufacturing and construction industries. Medical industries have progressed a lot with application of refrigeration such as drugs and medicine storages, blood and skin storages etc. Refrigeration also has wide application in road, railways, marine and air transport. Refrigeration may be produced by several methods. One of these methods is vapour compression system. It is used in majority of refrigeration applications. In this method, alternately condensation and evaporation takes place. In evaporation, the refrigerant absorbs latent heat from the surrounding to be cool and cooling is accomplished by evaporation of liquid refrigerant at reduced pressure and temperature. While in condensation, it gives out its latent heat to the circulating water/air of cooler. According to the requirement, vapour compression system is further modified for better performance and control. Such systems are compound systems, cascade systems and multi evaporator systems. In many refrigeration installations, different temperature are required to be maintained at various point in the plant such as in hotels, large restaurants, institutions, industrial plants and food markets where the food products are received in large quantities and stored at different temperatures. For example, the fresh fruits, fresh vegetables, fresh cut meats, frozen products, dairy products, canned goods, bottled goods have all different conditions of temperature and humidity for storage. In such cases, each location is cooled by its own evaporator in order to obtain more satisfactory control of the condition. For these type of case, system with more than one evaporator i.e., multi evaporator system is used. Multi evaporator systems yields the higher value of coefficient of performance compared to single evaporator system meant for different temperatures. There is easy control of fluctuations in loads by controlling individual evaporator. Also saving in initial cost and space required are the additional advantages with single compressor multi evaporator systems. Considering the above advantages of multi evaporator system over single evaporator system one can easily recommend its use in similar situations. But generally multi evaporator systems are overlooked by assuming it as complex system and hence a problem arises in maintaining specific temperature conditions economically.

Keywords: *Refrigeration, Evaporator, Condenser, Compressor.*

---***---

1. INTRODUCTION

According to the monthly oil market report issued by IEA in March 2010, the worldwide oil demand will grow by 1.8%, and will reach to 86,6mb/d, which is 70kb/d more than the anticipation in February. In the other hand, huge oil demand also means huge gasoline waste. The gasoline waste causes the decrease in the amount and in the quality for various reasons, and causes a loss of economic value, during the entire process including production, discharge, transportation, loading, storage and sale. The gasoline waste can be divided into three main categories: the leakage, the mix and the evaporation. The volatility characteristic of oil and its products causes a serious evaporation waste during the exploitation, processing, which makes a great deal of energy waste, environment pollutions and the danger of fire and so on. According to the existing data, the evaporation waste occupies a considerable proportion in total gasoline waste. Although there is not an exact data, many statistical materials show that the gasoline evaporation rate is between 2% and 3% in various countries.

At present, there are three gasoline gas reclaiming programs: the gasoline gas pipe system program, the special apparatus program, and the gasoline gas pipe system and special apparatus combining program. The condensation is the special apparatus programs in the field of gasoline gas reclaiming programs. The special apparatus program is such a program that gasoline gas is transported to a special apparatus through pipes to be reclaimed. It requires the special apparatuses and the cost input including purchase, management, maintenance, operation, and energy consumption.

Different component of the gasoline gas has different saturated temperature. In the way of mechanical refrigeration, the gas is continuously cooled and its components are condensed into liquid status at different temperatures in different stages.

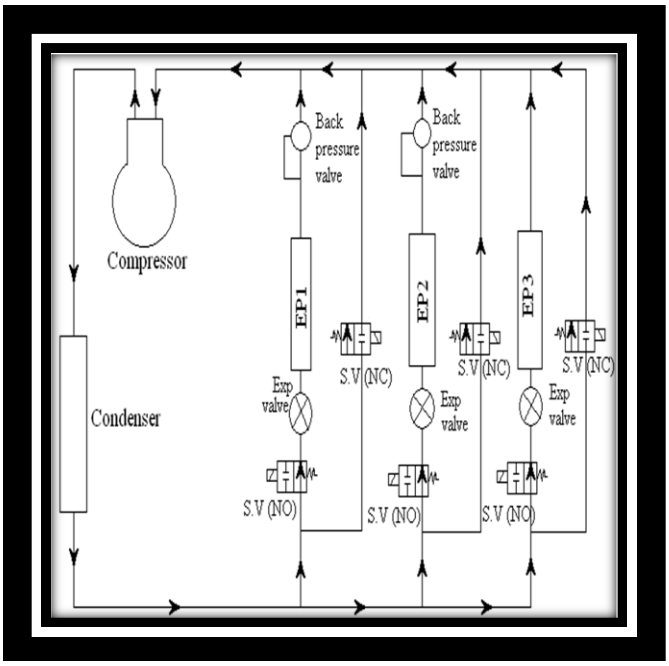

Fig-1: Experimental set up for Multi Evaporator system with single compressor and individual expansion valve

2. PRESENT THEORY AND PRACTICE

Kumbhar A. D. [1] developed the system with a single compressor and three evaporators of 1 tone, 0.6 tons, 0.4 tons capacities. He used reciprocating hermetic compressor of 2 tons capacity, an air cooled condenser with 4 circuits, a through type receiver, 23-B type of drier, three hand operated type expansion valve and calorimeter type evaporator. Result shows that it is possible to maintain the design temperatures in three evaporators i.e. -3˚C, 2˚C, 7˚C evaporator coil temperature in evaporator I, evaporator II and evaporator III. Tests were conducted to evaluate the system by varying the condensing temperature from 37˚C to 42˚C with a step of 1˚C. Also the system was evaluated by varying the evaporator operating combinations.

Bhaskar Dixit C. S [2] developed the system with a single compressor and three evaporators in which each evaporator is capable of taking a heat load equivalent to that, generated by the CPU of a computer. He used hermetic compressor AE72A7, plate type natural convection condenser for heat rejection, capillary as expansion device, refrigerant R-12 and plate type natural convection cooling coil as evaporator. In one of the cabinet thermostat was provided to control the compressor during no load condition. Result shows that it is possible to maintain the temperature of 22 ± 2˚C in the three evaporator cabinets with a heat load of 100W in each cabinet. From tests it was found that the system has very less power consumption as compared to room air conditioner. The system uses only 10% power of that of room air conditioner.

3. PROPOSED WORK

It is proposed to develop a multi evaporator system (3 evaporators) to maintain the different operating temperature in evaporators with a single compressor, an individual expansion valve and an air cooled condenser. This system is used to maintain -10˚C, 0˚C and +10˚C in three tanks with methyl ethyl glycol solution. An air conditioner compressor of 1.5 tons, available in scrap, will be used. Refrigerant R22 will be used as it is required for compressor model AH5522E.

The aims of experimental work:

- Verification of this system will be done so as to obtain the required temperature of methyl ethyl glycol solutions.
- Effect on system performance and remaining evaporators due to change in load on one of the evaporator.
- Effect on the system performance for varying the evaporator operating combinations.

4. MULTI-EVAPORATOR SYSTEM MODELLING

In many refrigeration or air conditioning installations, different temperatures are required at various points in the plant. This is true in case of supermarkets, food storage plants etc., where food products of all kinds are received in large quantities and stored at different conditions. Similarly, in some other cases, a large number of spaces have to be maintained at almost similar temperature. This occurs in the case of air conditioning of big residential complexes. Depending on the system requirements, various arrangements of vapour compression system scan be made that can serve that particular purpose with respect to environmental and energy conservation. A basic vapour compression system can thus be used as a building block to develop complex air conditioning and refrigeration units.

The primary objective of this chapter is to demonstrate the necessity and feasibility of advanced model based control for multi-evaporator air conditioning systems. Few research studies have been conducted till date on this issue. Static modelling and analysis work was done by which is not helpful for research on dynamic and control. Lee et al. did work on control of a dual evaporator system using online system identification methods and their results showed good controller performance but analysis of the cycle dynamics was not presented. Stack and Finn worked on multi-evaporator systems however their model was useful for refrigeration applications only. Václavek et al. also proposed a strategy applicable only to refrigeration systems by using electronic pressure regulating valves. With this background, in this chapter, we contribute uniquely by introducing and validating first principles based modelling methodology for multi-evaporator air conditioning systems, which are dynamically more complex than the refrigeration systems. The resulting model provides significant insight into the system dynamics which is useful for the design of advanced control strategies

4.1. Complex Multi-Evaporator Systems

Classification of complex air conditioning system can be done in the various ways. The evaporators can be arranged in series or parallel. There can be just a single expansion valve catering to all the evaporators or there can be an individual expansion valve for each evaporator. In the similar way, a single compressor (staged or non-staged) can cater to all the evaporators or their can be multiple compressors in the system too. In certain cases, the system can have different outdoor units also, depending on the condensing requirements. The choice of the system arrangement depends on application, initial and operational costs. The most common of these arrangements is one with multiple evaporators connected in parallel, each with an individual expansion device, a variable speed compressor or a staged set of compressors and a single outdoor or condensing unit.

In other arrangements, more commonly available in residential units, there are two air conditioning circuits, a primary and a secondary. In the primary circuit a high performance refrigerant is used to produce a certain base line cooling effort which is transferred to the secondary circuit through the other refrigerant, usually water which is circulated to the air conditioned spaces. The flow rate for secondary refrigerant is controlled separately for each of the space rather than controlling the primary cycle. Many times, it is advantageous to use dual or higher stage compressor stacks where initial cost of a variable speed / variable displacement compressor is not tolerable. It is however not particularly evident, whether, in a new design, one big compressor should serve all evaporators or their should be an individual compressor for each evaporator or their should be an intermediate number of compressors.

One basic disadvantage of a single compressor catering to all evaporators is that maintenance shut down affects all refrigerated spaces. However, there are some advantages of single compressor systems that more than shadow this disadvantage. In a residential air conditioning system, a big capacity compressor can cater to large number of rooms, each having its own evaporator, thus avoiding complex high voltage electrical circuitry for more than one compressor. Also, a multi-evaporator system with single compressor can be designed to work more efficiently than a number of single evaporator systems Figure 2. shows single stage compression multi-evaporator systems.

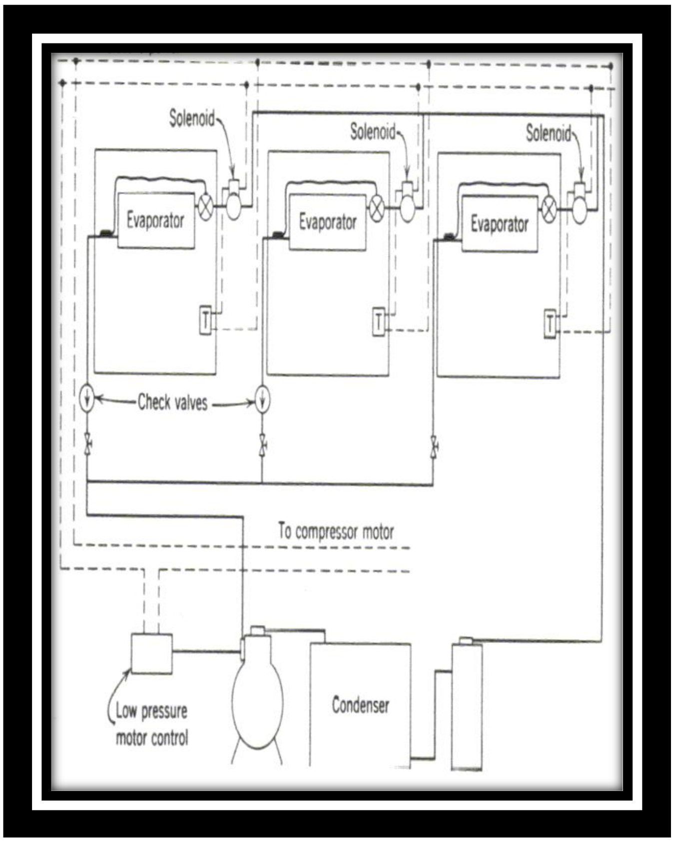

Fig-2: single stage compression multi-evaporator systems

5. CONCLUSIONS

We can then conclude that by using multi-evaporator system there can be reduction of energy used for different compressor and condenser for separate evaporators as well sufficient and required temperature and cooling can be maintained for different products at the same periods, cost saving is the another benefit by utilizing multi-evaporator system.

ACKNOWLEDGEMENTS

We would like to thank our guide Prof. Shylesha Channapattana Sir for his valuable guidance also we are thankful to our Principal Dr.A.M.Nagraj Sir for his support and motivation, we also would like to thank to all those who directly or indirectly contributed to our work.

REFERENCES

[1] Kumbhar A. D., "Design, fabrication and performance evaluation of a single compressor multi evaporator system", M.E. Dissertation, WCE, Sangli 1989.

[2] Bhaskar Dixit C. S., "Design, fabrication and performance evaluation of a single compressor multi evaporator system for high temperature applications", M. E. Dissertation, WCE, Sangli 1991.

[3] 2010 ASHRAE Handbook—Refrigeration

[4] A. D. Althouse, C. H. Turnquist, A. F. Bracciano, "Modern Refrigeration and Air Conditioning", Goodheart-Willcox Publisher, 2010

[5] Arora C. P., "Refrigeration and Air conditioning", Tata McGraw Hill Private Limited, 3rd Edition, 2008.

[6] Dossat R. J., "Principles of Refrigeration", Pearson, 4th Edition, 2007.

[7] Badr, O., O'Callaghan, P. W., Probert, S. D., "Vapor Compression Refrigeration Systems", *Applied Energy*, v 36, n 4, pp. 303-333, 1990.

[8] Lee G., Kim, M. S., Cho, Y. M., "An Experimental Study of the Capacity Control of Multi-Type Heat Pump System using Predictive Control Logic", *7th Int. Energy Agency Heat Pump Conference 2002*, pp. 158-165, May 2002.

[9] Stack, A., Finn, D. P., "Modeling and Validation of a Multi-Evaporator Vapor Compression Cycle Subject to Non-Uniform Loading in Transport Refrigeration Applications", *Int. Refrig. Conf. at Purdue*, R18-2, July 2002.

[10] Václavek, L., Lohan, J. M., Ryan, A. M., "Optimization of Temperature Control during Cooling in aMultizone Refrigeration System", *ASHRAE Trans.* v 108 (PART 2), pp. 119-128, 2002.