IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 6.252
Volume 2, Issue 3, June 2022

Implementation of Multimodal Evaporator for Water filtration at Alkyl Amine Plant Pune

Pravin Petkar[a], Amit Sukhdeve[b], Gourav Gajbhiye[b], Pratik Bhoyar[b], Arpit Thakre[b], A. Kolhatkar[b]
[a]Assistant Professor, Mechanical Engineering Department
[b]Students, Mechanical Engineering Department,
Jhulelal Institute of Technology, Nagpur, Maharashtra

Abstract: *This paper present the development of a model and an algorithm to design a multiple effect evaporator system. Also, it is required to make to evaluate the amount of steam saved by the use of vapour compression. The use of vapour compression allows us to use the energy in the vapour leaving the last effect. Since evaporators are energy intensive system, use of vapour compression can considerably reduce steam consumption, but at the cost of electrical energy needed to run the compressor. If a single evaporator is used for the concentration of any solution, it is called a single effect evaporator system and if more than one evaporator is used in series for the concentration of any solution, it is called a multiple effect evaporator system. Paper aims to compare and review available model of evaporator and make modification in multi effective purpose which used in industry.*

Keywords: Evaporator, development, consumption, energy

I. INTRODUCTION

Evaporation falls into the concentration stage of downstream processing and is widely used to concentrate foods, chemicals, and salvage solvents. The goal of evaporation is to vaporize most of the water from a solution containing a desired product, or in the case of drinking water from seawater, an undesired product. After initial pre-treatment and separation, a solution often contains over 85% water. This is not suitable for industry usage because of the cost associated with processing such a large quantity of solution, such as the need for larger equipment. If a single evaporator is used for the concentration of any solution, it is called a single effect evaporator system and if more than one evaporator is used in series for the concentration of any solution, it is called a multiple effect evaporator system.
Unlike single- stage evaporators, these evaporators can be made of up to seven evaporator stages or effects. Adding on evaporator to the single effect decreases the energy consumption to 50% of the original amount. Adding another effecter duces it to 33% and so on. The number of effects in a multiple-effect evaporator is usually restricted to seven because after that, the equipment cost starts catching up to the money saved from the energy requirement drop. [1]

II. LITERATURE SOURCE

The problem associated previous evaporator was improved by using different kind of mechanism. In the industrial application modification has done on evaporator. The some of the contributors are:
One of the earliest works on optimizing a multiple effect evaporator by modifying the feed flow sequence was done by Harper and Tsao in 1972 by developing a model for optimizing a MEE system by considering both forward and backward feed flow sequence. This work was extended by Nishitani and Kunugita (1979) in which they considered all possible feed flow sequences to optimize a MEE system for generating a non inferior feed flow sequence. All these mathematical models are generally based on a set of linear or non- linear equations and on changing the operating strategy, a whole new set of equations were required for solving the new operating strategy. This problem was addressed by Stewart and Beveridge (1977) and Ayangbile, Okeke and Beveridge (1984). They developed a generalized cascade algorithm which would be solved again and again for the different operating strategies of a multiple effect evaporator system.
'Evaporation' is a process of removing water or other liquids from a solution and thereby concentrating it. The time required for concentrating a solution can be shortened by exposing the solution to a greater surface area which in turn

would result in a longer residence time or by heating the solution to a higher temperature. But exposing the solution to higher temperatures and increasing the residence time results in the thermal degradation of many solutions, so in order to minimize this, the temperature as well as the residence time has to be minimized. This need has resulted in the development of many different types of evaporators. [2]

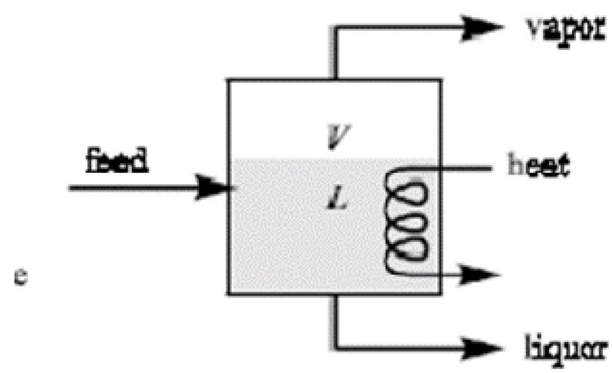

Fig. 2.1: Schematic Diagram of a Single Effect Evaporator. Source

2.1 DIFFERENT TYPES OF EVAPORATORS

Evaporators are broadly classified to four different categories:

1. Evaporators in which heating medium is separated from the evaporating liquid by tubular heating surfaces.
2. Evaporators in which heating medium is confined by coils, jackets, double walls etc.
3. Evaporators in which heating medium is brought into direct contact with the evaporating fluid.
4. Evaporators in which heating is done with solar radiation.

2.1.1 Horizontal tube evaporators

This was the first kind of evaporator to receive general recognition and was a design utilizing horizontal tubes. This type is seldom used except for a few special applications.

It has the simplest of designs with a shell and horizontal tube arrangement with heating medium in the tubes and evaporation on the shell side.

2.1.2 Horizontal spray film evaporators

The liquid in the horizontal, falling-film evaporator when distributed by recirculation through a spray system, gives the horizontal spray film evaporators. Gravity helps the sprayed liquid fall from one tube to another.

Advantages include:

(1) Non condensable are easily vented
(2) Distribution is more easily accomplished
(3) Precise levelling is not needed
(4) Vapour separation is easily accomplished

2.1.3 Short tube vertical evaporators

It was the first type to become really popular commercially. The first was built by Robert and the vertical tube evaporator is often called Standard Evaporator. It is also called calandria.

Circulation of liquid past the heating surface is induced by boiling (natural circulation). Since the circulation rate through the evaporator is many times the feed rate the downcomers are required to permit liquid flow from the top tube sheet to the bottom tube sheet. Downcomers should be so sized that it reduces the liquid holdup above the tube sheet as this setup improves fluid dynamics, reduces foaming and increases heat transfer rate.

2.1.4 Basket type evaporators

The only difference between a standard evaporator and this one is that in the basket type the downcomer is.
The annual downcomer is more economical as it allows the evaporator to be removed for cleaving and repair.
Also, a deflector is installed to reduce "burping" which is caused due to entrainment. A difficulty sometimes is associated with the steam inlet line and the condensate outlet line and differential thermal expansion associated with them.
Multiple effect evaporator systems can be modeled in 2 ways:

1. In a model based on equations, the equations are developed for each effect and for every operating condition separately and are solved for the unknown variables.
The following equations are written for each evaporator in a mathematical model of a five effect evaporator system (Radovic et al, 1979) [3]
Lambert, Joye and Koko in 1987 presented a model which was based on the non linear enthalpy relationships and boiling point rise. Curve fitting techniques and interpolation were used to reach these relationships.
Other similar equation based models were developed by Holland (1975), Mathur (1992), Bremford and Muller-Steinhagen (1994), El-Dessouky, Alatiqi, Bingulac, and Ettouney (1998), El-Dessouky, Ettouney, and Al-Juwayhel (2000) and Bhargava (2004).

2. A generalised cascade algorithm for steady state simulation of multiple effect evaporator systems is discussed. The algorithm, capable of handling any feed arrangement, includes heat recovery features such as liquor and condensate flash units and feed preheating. This is made possible by the use of composite flow fractions which fully describe the internal flow connections. The user-provided models for these units and all effects may be of varying.
Thus on changing the operating conditions like addition of flash tanks or introduction of vapour bleeding or changing the feed flow sequence does not require a change in the algorithm and the same program which is independent of the equations can be used for all operating conditions (Bhargava et al, 2010).[4] Another generalized model has been proposed by Stewart and Beveridge. The algorithm is based on the simultaneous solution of linearised forms of the effect models derived from knowledge of the significant factors determining their performance. The coefficients of these linear equations are process. Two linearisations are described, the first being adequate for lumped parameter effect models and the second for detailed effect models with strong interaction between the two-phase fluid flow and heat transfer phenomena (Stewart and Beveridge, 1977).
Another generalized model was developed by Ayangbile, Okeke and Beveridge in 1984.
Out of these evaporator designs, evaporators with tubular heating surfaces are the most common of the different evaporator designs. In these evaporators, the circulation of liquid past the heating surfaces is induced either by natural circulation (boiling) or by forced circulation (mechanical methods).
The reported literature considers a number of energy reduction methods such as flashing, steam and feed splitting, vapours bleeding and using an optimum feed flow sequence. In connection to these in the present work vapour compression is applied to an existing industrial multiple effect evaporator and overall cost computations will be made.
Thus to achieve this target following objectives are to be met:
• To develop governing equations for multiple effect evaporator system with the induction of vapour compression.
• To compute the operating cost as well as capital cost of the modified system
• To define a number of combinations in multiple effect evaporator and compressor to choose best combination based on total annual cost.

III. METHOD

An evaporator with three effects (3-stages) is a tube-type forced circulation evaporator in which strong steam is used forthe first effect to evaporate the solvent from the feed. In the second effect, the vaporized solvent is used to evaporate thefeed at atmospheric pressure. In the third effect, the evaporation of the concentrating feed from the second stage is usedto evaporate solvent from the second stage. The evaporated solvent from the third effect is finally condensed withcooling water on the other side of the steam condenser. In all three processes, condensate is collected in condensate receiving tanks. The pure solvent in this condensate can be reused in the subsequent process.

Multiple Effect Evaporator (MEE) is a system used widely for many applications in industries to achieve evaporationand obtain desired concentration as output by using an efficient amount of heat source. A Multiple Effect Evaporator (MEE) is equipment uses efficient heating source either steam, Hot Water or Thermic Fluid to evaporate water. In

Evaporation system, water is boiled in a single vessel using the heat source which results in the concentrate outlet andalso the vapours generated from the boiled water. Whereas in multiple-effect evaporator the equipment consists of asequence of vessels, The heat source is given only at the first effect and the feed/water is also fed to the first effect, whenthe feed gets boiled it produces the vapours these vapours are used as the heat source to the next effect which results ineffective usage of heat source. The concentrate from the first effect is fed to the next effect to achieve further evaporation.

The pressure in each effect is lower than the last due to which the boiling point of water decreases as pressure decreases.

The important consideration in the industry is the economy of the system. Here, Kg of the liquid evaporated per Kilogram of steam is used. Hence the Multiple Effect evaporator achieves the desired concentration with less consumption of theheat source.

IV. RESULT & DISCUSSION

A comparison can draw from above literature and found that available evaporator model for industrial application that it is more economical to use a multiple effect evaporator that a single effect evaporator as vapours generated in one effect will feed vapours in another effect and so one ,used in multi staging. It also shows that evaporative capacity and steam consumption decreases as the efficiency of process increases. Proper utilization of energy for the entire system.

REFERENCES

[1]. Warren McCabe, Julian Smith, Peter Harriott , Unit Operations of Chemical Engineering,7thed.

[2]. Walker, Lewis, McAdams, and Gilliland, Principles of Chemical Engineering. 3rd ed.,1937. p.475, 1937

[3]. Radovic,L.R.,Tasic,A.Z.,Grozanic,D.K.,Djordjevic,B.D.,&Valent,V.J.Computer design and analysis of

[4]. operation of a multiple effect evaporator system in the sugar industry, Industrial and Engineering Chemistry Process Design and Development,18318–323. ,1979

[5]. R. Bhargava , S. Khanam, B. Mohanty, A.K. Ray, " Selection of optimal feed flow sequence for a multiple effect evaporator system", Computers and Chemical Engineering 322203–2216, 2008

[6]. Curtis H. Whitson M.L. Michelson, "The Negative Flash", Fluid Phase Equilibrium, 53 (,51-71,1989

[7]. S.Ranjatun,J.Gukhol,andD.Seebaluk,"CombinedHeatandPowerSystemenhancement in Mauritian Cane Sugar Factories", Science and Technology Journal, October1998

[8]. J.M. Ogden, S. Hochgreb, M.G. Hulton, Process Energy Efficiency and Cogeneration in Cane Sugar Factories, 1990

[9]. Ray, A. K., Rao, N. J., Bansal, M. C., & Mohanty, B., Design data and correlations of waste liquor/black liquor from pulp mills. IPPTA Journal, 4 1–21,1992

[10]. CharlesDonaldHolland,FundamentalsandModelingofSeparationProcesses:Absorption,Distillation,Evaporation ,and Extraction: Absorption, Distillation, Evaporation, and Extraction, 1st ed, p 25-29, 1975

[11]. Dessouky, Ettouney, Juawayhel, Multiple Effect Evaporation and Vapour Compression in desalination processes, TransI Chem E, Vol78,Part A,May2000.

[12]. A.S. Nafey , H.E.S. Fath , A.A. Mabrouk ,Thermoeconomic design of a multi-effect evaporation mechanical vapor compression(MEE–MVC)desalinationprocess,August2006