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CONCEPT OF MASS EXCHANGER NETWORK FOR WASTE MINIMIZATION

Engineering

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ABSTRACT

In the age of modernization. to fulfil the need of the modern people industrial development is necessary. With the industrial revolution the pollution problem is also exceeds. The chemical industries are the main source of the waste generation. It also generates some toxic materials and gases which are very harmful to the human being. If amount of certain organic materials exceeds from the permissible level, then they cause death of the living one. Mass Exchanger Network is the available tool to minimize the waste. By applying different operations of mass transfer in the network form one can minimize the waste. Main objective of the MEN is to reduce the pollutant level in the waste stream upto its permissible limit. It uses pinch technology approach to minimize the operating cost of the MEN. For this purpose, the mass separating agents is used to extract the pollutant from the waste stream. Mass exchanger network is a useful framework for designing recycle and reuse system. The design of MENs has drawn increasing attention in recent years mainly because of attractiveness in pollution prevention and material recovery.

KEYWORDS

Mass exchanger network, MEN, waste minimization, pinch technology

I. INTRODUCTION

Waste minimization[1]:-

It is an integrated approach. Waste minimization can be done by auditing the manufacturing process with respect to optimal use of resources, improved housekeeping more optimum process operation etc.

Waste minimization is one of the effective tools for the managers of the industry today to greeting of business and in raising the profitability. In the period of growing environmental concerns and competition, it is perhaps the industry's answer to survival. In this preventive approach, the costs of waste treatment system get substantially reduced and, in some cases, even eliminated. Wastes are inherently reduced in this approach; the overall resource utilization factor improves leading to improved profitability and competitiveness.

II. Pinch Technology[4]

Energy saving in process plant design has essentially been a trial-and-error procedure between changes in structure and simulation until satisfactory reductions are achieved. Energy saving reflects itself in many ways, for example reduced fuel consumption or reduced maintenance cost due to lower load on various items of plant equipment.

Pinch technique, which has evolved as an energy-saving technique, presents simple and easy ways of optimisation based on complex thermodynamics rules. The technique gives the process engineer a clear picture of the optimum energy needed for any process:

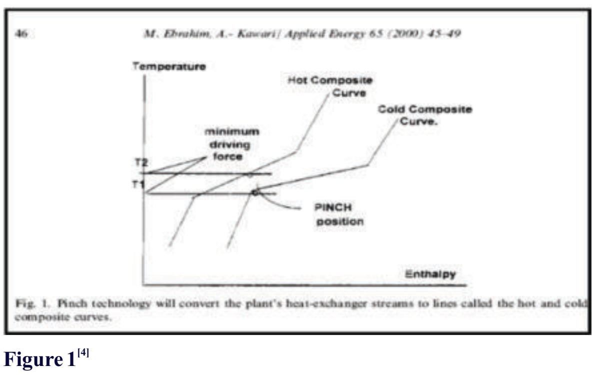

Figure 1[4]

It can save effort and expenditure spent by engineers. From the curves shown in Fig. 1.1, the performance of the plant can be determined.

This technique will give both the process engineer and top management a clear overall picture of the plant's performance rather than having to calculate the performance of each item of equipment individually.

III. The Pinch Technique[4]

It is based on identifying energy targets and identifies the minimum driving force across any of the heat-exchanger's inlet/outlet streams. But for the mass exchanger network the pinch technique is used to optimize the MSAs required for the waste minimization.

Recently, the technique has been extended to address capital cost, in which the Capital-cost targets have been developed ahead of the design stage.

An overall thermodynamic method has emerged which brings together energy and capital costs. In the beginning, the technique was applied for grass-root designs and subsequently it has been extended for the retrofits of old designs.

Applying the pinch principle leads to promising, accurate results. In figure 2 shows levels of temperature, which for the hot and cold composite curves are a means of separating the plant into two parts, are called streams above and below the pinch. This separation is important to indicate to the process engineer whether the locations of heaters and coolers are correct or not. Wrong positions cause energy losses.

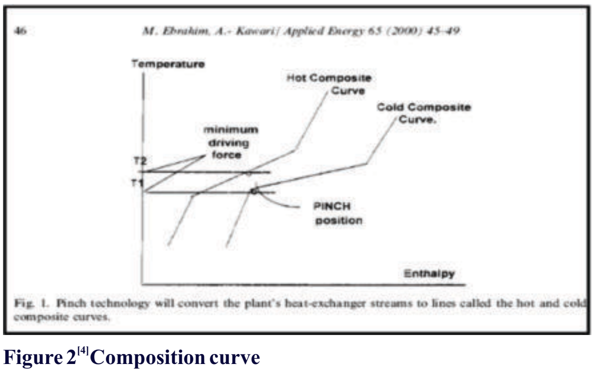

Figure 2[4] Composition curve

In the mass exchanger network the same approach is used. But here in this case this approach is used to minimize the Mass Separating Agents required and to minimize the cost of the operation.

IV. Mass Exchanger Network[1]

Mass integration (El-Halwagi and Manousiouthakis, 1989; El-Halwagi and Manousiouthakis, 1990; El- Halwagi, 1997) is a systems engineering approach that provides a holistic methodology to understand the flow of a species within a process, and determines the optimal routing and allocation between sources and demands.

Sources can be regenerated by purification techniques to change compositions and allow recycle/reuse to meet demands that would not be possible otherwise.

El-Halwagi and Manousiouthakis (1989) introduced the concept of a mass exchange network (MEN). The MENS problem can be stated as:

- Given a number of rich streams and a number of lean streams, also known as mass separating agents (MSAs), it is desired to synthesise a cost-effecti6e network of mass exchangers that can preferentially transfer certain species from the rich streams to the MSAs.
- Given also are the flow rate of each rich stream, Gi, its supply (inlet) composition, y^s_i, and its target (outlet) composition, y^t_i. In addition, the supply and target compositions, X^s_j and X^t_j, are given for each MSA.
- The mass transfer equilibrium relations are also given for each MSA. The flow rate of each MSA is unknown and is to be determined as part of the synthesis task.

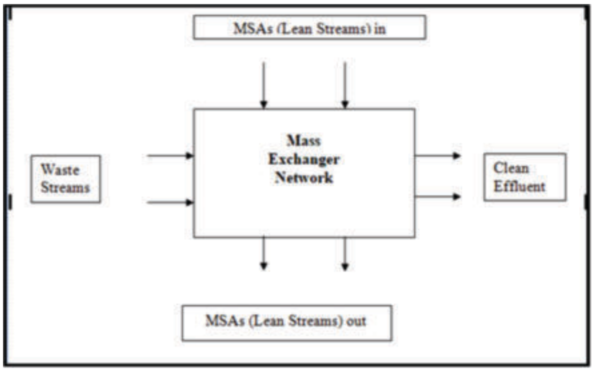

Figure. 3. Schematic Representation of MEN[1]

Given a number of waste rich streams and a number of lean streams (MSAs), it ids desired to synthesize a network of mass exchangers that can transfer certain species from the waste streams to the MSAs at a minimum cost.

For each waste stream, the flow rate and supply (inlet) composition are known from the material balance on the process from which the waste stream originate. The target (outlet) composition of each waste stream is typically dictated by environmental regulations on emission standards for the pollutant in the question. The supply composition of each MSAs corresponds to the concentration of the pollutant in the fresh or the regenerate MSAs.

On the other hand, the target composition for the MSAs are determined based on the number of considerations which may be physical (e.g. solubility), technical (e.g. corrosion, fouling), environmental (e.g. regulations on emission standards), safety (e.g. flammability limits), and/or economic (e.g. to optimize the cost of subsequent regeneration of MSAs). In addition, the flow rate of each MSA is unknown and it to be determined so as to minimize the operating cost of the system.

A mass exchanger can be any direct contact, counter current, mass transfer operation that employs MSAs such as adsorption, absorption, solvent extraction, leaching and ion exchange. Potential MSAs include solvents, adsorbents and ion exchange resins.

Over the past few years, significant contributions have been made in solving general categories of the MEN synthesis problems. These categories involve the situation of MENs with a single pollutants, multiple pollutants, MSA regeneration, reactive MSAs and non isothermal operation. The MENs have been integrated with other pollution prevention systems such as membrane separations and biological processes.

The MEN synthetic procedure starts with a targeting phase in which the minimum cost of MSAs is established, without commitment to the network structure. This target is aimed at minimizing the operating cost of the system, since the cost of MSAs is typically the predominant operating expense in MENs.

Hence, any design featuring the minimum cost of MSAs is referred to as a minimum operating cost (MOC) solution. Once the MOC solution is determined, a network is synthesized in which the number of mass exchangers provides an appropriate method for minimizing the fixed cost of the network.

V. Mass Separating Agents

In chemical separation processes, a mass separating agent (MSA) is a chemical species that is added to ensure that the intended separation process takes place. It is analogous to an energy separating agent, which aids separations processes via addition of energy. An MSA may be partially immiscible with one or more mixture components and frequently is the constituent of highest concentration in the added phase. Alternatively, the MSA may be miscible with a liquid feed mixture, but may selectively alter partitioning of species between liquid and vapor phases.[5]

Types of Mass Separating Agents:-[5]

The candidate MSAs (lean streams) can be classified as,
Process MSAs
External MSAs.

Process MSAs:-

The process MSAs already exist on the plant site and can be used for a low cost (often virtually free).[5]
E.g. aqueous ammonia

External MSAs:-

On the other hand, the external MSAs can be purchased from the market and their flow rates are to be determined by economic consideration.[5]
E.g. methanol

VI. Different Methods to Prepare MEN[5]

1. Graphical Method:-

The first is a graphical method which is based on plotting mass transfer composite curves (Fig. 4). Note that in MENS, stream compositions are not equivalent. This contrasts with HENS where stream temperatures are equivalent regardless of which stream is being considered. The concept of corresponding composition scales in order to consider all streams on a common basis. This tool establishes a one-to-one correspondence among the compositions of all streams for which mass transfer is thermodynamically feasible.

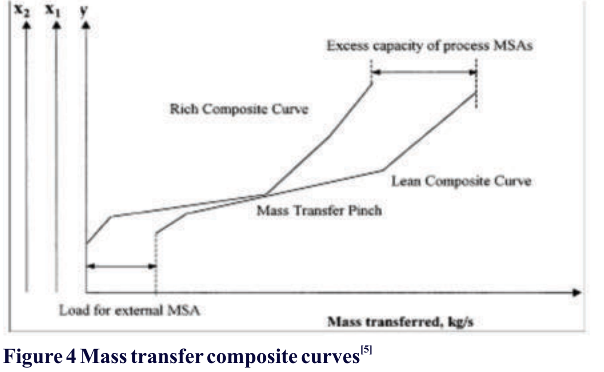

Figure 4 Mass transfer composite curves[5]

This correspondence depends on the equilibrium relations and the value of ε. As shown in Fig. 4, each MSA composition, x, is mapped as a corresponding y value and this allows all MSAs to be represented on the same plot. Note that this accounts for driving force considerations since ε values are included in this transformation. Thus, even though the rich and lean curves touch at the pinch, this does not mean there is a zero-driving force there. The targets for the minimum MSA requirements are read off this plot as shown in Fig. 4. The second method is a numerical method called the composition interval method.[5]

2. Pinch Design Method[5]:-

The pinch design method is used to design MENs which achieve these targets. This method divides the problem into two separate regions, above the pinch (containing all streams or parts of streams richer than the pinch composition) and below the pinch (containing all streams or parts of steams leaner than the pinch composition), and treats each region independently. This 'pinch division' means that no mass transfer should take place across the pinch.

In design, El-Halwagi and Manousiouthak is recommended using the minimum number of units as an attempt to minimise the capital costs. However, this is not always sufficient since the sizes of the exchangers are also important. Designs were steered towards the minimum number of units in an attempt to minimise capital costs.

Achieving the minimum number of units would minimise the capital costs. It was only later, when targets for surface area became known, that capital costs could be dealt with properly. For MEN, ε is an optimization parameter. Increasing ε increases the cost of utilities, but results in lower capital costs. It is noted that the TAC of a network would pass through a minimum, which corresponds to the optimal value of ε.

However, there was no way of knowing the capital costs until the network was designed and so the optimisation could only be done by carrying out many repeated designs. The absence of a capital cost target also meant that there was no guarantee that the capital cost of a network was the minimum attainable for a specific value of ε.

VII. Different Processes
Constant Load And Constant Flow Rate Process[4]

1. Constant Load : -
The method applies to fixed contaminant-load (FC) operations that are quality-controlled (Polley and Polley, 2000), and that may be modelled as mass transfer units (e.g., washing, scrubbing, extraction). Here, if water is used as the only mass separating agent (Wang and Smith, 1994; Hallale and Fraser, 1998) that picks up a fixed load of contaminant from the process stream. Each operation has the maximum allowable inlet and outlet contaminant concentrations specified based on process constraints. Since the inlet flow rate is identical to the outlet flow rate for each unit operation, the wastewater. Flow rate for the network equals the targeted freshwater flow rate.[4]

1.1 Fixed Flow Rate:-
Fixed flow rate operations are quality controlled. For such Water-using units like boilers, cooling towers and reactors that do not involve any mass Transfer, the main concern is the flow rate (Wang and Smith, 1995; Hallale, 2002) and not the amount of contaminant picked up. These units have specified inlet and outlet flow rates, which may not necessarily be equal and therefore can account for water losses. This allows units that have multiple inlet streams and multiple outlet streams to be modelled. [4]

2 Batches and Continuous Process:-
2.1Continuous Process:-
Most of the research work is carried out on the continuous process. Mass exchange networks for continuous processed El-Halwagi and Manousiouthakis introduced the concept of MENS on a continuous mode, in which the problem statement can be stated as:

Given a number N_R of waste (rich) streams and a number N_S of MSAs (lean streams), it is desired to synthesise a cost-effective network of mass exchangers that can preferentially transfer certain undesirable species from the waste streams to the MSAs. Given also are the Cowrate of each waste stream, Gi, its supply (inlet) composition, and its target (outlet) composition Y_i^t. In addition, the supply and target compositions, X_j^s and X_j^t, are given for each MSA. The rate of each MSA is unknown and is to be determined so as to minimise the network cost.

2.2 Batch process:-
Very less research work is carried out by the batch process. The very early work addressing energy integration for batch processes was reported by Vaselenak et al. (1986). They worked on the heat recovery between vessels whose temperatures vary during operations.

The only work on mass exchange network (MEN) design for batch process based on Pinch analysis is reported by Wang and Smith (1995) for the special case of water minimisation. Clearly, more work. The main drawback of this representation is the absence of the time variable to indicate how the various processes are interlinked.

CONCLUSION:
After doing all this work on the MEN, we can summarize that MEN is effective solution for the waste minimization and pollution prevention with the least operating cost.

In the designing of the MEN, mainly two parts are included in the designing first one is the targeting part and second one is designing based on the target which we achieved during the targeting phase.

MEN are retrofitted to the existing plant for the waste minimization MEN are also the effective tool for the liquid waste minimization. It is mainly used in the industry for the waste water minimization.

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