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A Review Paper on Hybrid Distillation Pervaporation

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Abstract : *Hybrid Distillation Pervaporation process can be applied for many applications like separation of Ethanol water and benzene cyclone hexane separation. This review paper shows the different application of Hybrid Process. The Research work is going on for the hybrid process.*

IndexTerms – Pervaporation, Hybrid Distillation, Ethanol Water

I. Introduction

Distillation is oldest and widely used separation process for chemical industry. Distillation is very difficult in some cases like azeotrope, close boiling mixture and extractive distillation. Likewise membrane process, pervporatio has high initial cost and operation cost. But by the use of the hybrid process we can eliminate the drawbacks of distillation and pervaporation.

II. DEFINITION OF HYBRID PROCESS

A hybrid process is essentially a bundled set of diverse unit operations intricately connected and fine-tuned to accomplish a specific predefined objective. Two types of hybrid processes are listed in literature.

1. Hybrid processes consisting of processes which are ‘essentially performing the same function'. This would mean that in the case of pervaporation based hybrid processes all processes in the package would be separation processes. These hybrid processes are referred to as type S (eparation).
2. Hybrid processes which are an offspring of two different processes. In the case of pervaporation based hybrid processes this group includes the combination of PV and a reactor. These hybrid processes will be referred to as type R (eactor). (1)

III. DISTILLATION BASED HYBRID PROCESS:

Distillation stands out as the prevalent technique for segregating mixtures of compounds featuring comparatively low molecular weights. Nevertheless, numerous liquid systems of industrial significance pose challenges for straightforward continuous distillation due to the presence of factors like azeotropes, tangent pinches, or an overall low relative volatility in their phase behavior, making separation difficult or even impossible.

One solution is to combine distillation with one or more complementary separation technologies to form a “hybrid”. The separations task is switched among the technologies in such a way that each operates in the region of the composition space where it is most effective. Hybrid processes includes augmentation and/or retrofitting of existing distillation columns with alternative technologies (membranes, adsorption, extraction, crystallization, absorption, etc.) to debottleneck processes and reduce energy. (1)

IV. DISTILLATION-PERVAPORATION HYBRID PROCESS

As mentioned earlier, pervaporation has surfaced in the last few decades as a supplementary class of separation processes, introducing several advantages over the established mass transfer methods. These include elevated selectivity, reduced energy consumption, a favorable cost-to-performance ratio, and a streamlined, modular design.

Distillation is a widely recognized method with a capital cost lower than that of pervaporation. Nevertheless, pervaporation boasts lower energy consumption, as it is only necessary for the vaporization and expansion of the selectively transported compounds through the membrane. On the flip side, the capital cost in pervaporation is higher, primarily attributed to the expenses associated with membranes, modules, and auxiliary equipment. (1)

A hybrid process strategically leverages the benefits of both pervaporation and distillation while mitigating their drawbacks. The distillation-pervaporation hybrid process presents promising solutions across various applications, ranging from the established dehydration of organic compounds to the extraction of organic compounds from water and the segregation of organic mixtures. The potential uses of pervaporation-based hybrid processes encompass the separation of liquid mixtures across all concentration ranges. Generally, two distinct types of pervaporation-based hybrid processes can be identified: Pervaporation serving as the final step in a process that attains the desired concentration of retentate and/or permeates. Pervaporation acting as a primary process, integrated with other steps within a larger process to achieve the necessary concentration of retentate and/or permeates. (1)

V. APPLICATION OF HYBRID DISTILLATION PERVAPORATION PROCESS

1. Ethanol- Production Process

The hybrid pervaporation-distillation process is utilized for the separation of ethanol-water mixtures, aiming to break the azeotrope and ultimately dehydrate the ethanol. In contrast to the conventional azeotropic distillation, which demands four distillation columns, published literature showcases different configurations of pervaporation (PV) hybrid processes, presenting them as an efficient solution for cost savings in both investment and operation. This efficiency is attributed to factors such as lower energy consumption, diminished wastewater treatment needs, and the absence of a chemical entrainer, as highlighted in the literature.

In 1983, Tusel and Ballweg introduced a patented system that integrates a distillation column followed by two pervaporation (PV) units, each featuring distinct hydrophilic membrane types. The first membrane, characterized by 'high flux-low selectivity,' is employed to break the azeotrope, while the second membrane, with 'low flux-high selectivity,' serves as a polishing step. A simplified depiction of the process layout is illustrated in Figure 1. (2)

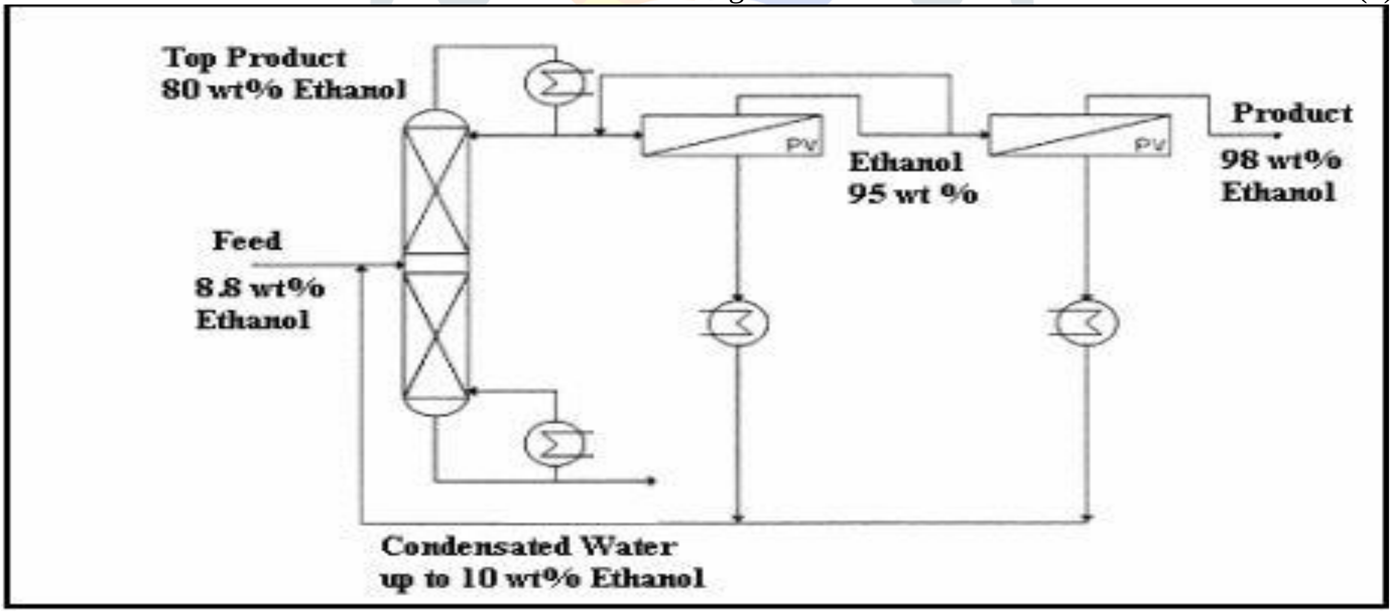

Fig.1 Ethanol Production (Tusel and Ballweg, 1983)

2. Separation of benzene-cyclohexane mixture:

The separation of a feed mixture of benzene-cyclohexane (50 mol% cyclohexane) into 99.2 mol% cyclohexane and 99.5 mol% benzene was carried out by a hybrid process with extractive distillation using furfurol as carrier and organophilic (benzene-philic) pervaporation integrated with two distillation columns. The first column separated cyclohexane from a furfurol - benzene mixture, the second column benzene from furfurol and the PV unit removed benzene from the cyclohexane-rich top product of the first distillation column. The hybrid process could save up to 20% of the overall costs of conventional extractive distillation processes. (3)

There many other application of Hybrid distillation processes are listed in the literature like separation of IPA- Water, separation of fusel oil, carboxylic acid aster production, dimethyl carbonate production etc.

VI. CONCLUSION:

From the review we can conclude that by application of the hybrid distillation pervaporation process, limitations of the distillation and pervaporation process can be eliminated. Lot of research is going on hybrid process and still there is huge scope for hybrid process for reactor and separation.

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