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Review

Dividing wall columns in chemical process industry: A review on current activities

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ABSTRACT

In spite of being an energy intensive process, distillation remains the most important separation method in the chemical process industry. Especially for the separation of mixtures with three or more components, the total energy requirement and the capital cost are very high. In this respect, dividing wall columns (DWCs) represent a very promising technology allowing a significant energy requirement reduction. This article reviews current industrial applications of DWCs and related research activities, including column configuration, design, modelling and control issues. Furthermore, the application of DWCs for azeotropic, extractive and reactive distillation is highlighted.

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Abbreviations: A-DWC, azeotropic dividing wall column; ACM, Aspen Custom Modeller; CSTR, continuous stirred-tank reactor; DMC, dynamic matrix control; DWC, dividing wall column; E-DWC, extractive dividing wall column; ETBE, ethyl-tert-butyl-ether; EtOH, ethanol; GMC, generic model control; HETP, height equivalent to a theoretical plate; HPNA, heavy poly nuclear aromatic; LQG, linear-quadratic gaussian; LQR, linear-quadratic regulation; MIMO, multi-input multi-output; MeOH, methanol; MPC, model predictive control; NMP, *N*-methyl pyrolidine; PID, proportional integral derivative; PEP, Pacol Enhancement Process; R-DWC, reactive dividing wall column; RBA, rate-based approach; SISO, single-input single-output.

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Nomenclature

B	bottoms rate
D	distillate rate
L	reflux rate
Q	heat duty
R	reflux ratio
S	side stream rate
V	vapour boilup rate
x	mole fraction
Greek letters	
α	relative volatility
β	internal split ratio in DWC
Subscripts	
B	bottom
C	condenser
D	distillate
L	liquid
R	reboiler
S	side stream
V	vapour

1. Introduction

Process intensification represents a dominating trend in the chemical process engineering, mostly due to increasing awareness of the society of limited energy resources [1]. Besides, the last achievements in the process modelling as well as growing computational power and advanced numerical methods make process intensification possible. Amongst others, apparative process integration shows a great potential.

For the separation of multicomponent mixtures, most often a sequence of distillation columns is applied. In case of three components, at least two columns are necessary, for instance, the direct and indirect sequence shown in Fig. 1. An energetically favourable alternative configuration is shown in Fig. 2. In this so-called Petlyuk configuration, the vapour and liquid streams leaving the first column are directly connected with the second column [2]. The first column performs a sharp split between A (light boiling component) and C (heavy boiling component), whereas the middle boiler B is distributed naturally between the top and bottom products. A further separation towards high-purity components takes place in the second column. The improvement of the thermal efficiency, due to avoiding unnecessary mixing effects, leads to considerable energy savings of about 30% [3] compared to the direct or indirect sequences. Since only one reboiler and one condenser are used, the capital costs are also reduced.

Further integration and cost saving can be obtained, if these two columns are integrated into one shell. This alternative to conventional columns is identified as a dividing wall column (DWC) and illustrated in Fig. 3 [4]. Due to the large number of design parameters, for many years, it has been virtually impossible to simulate, design and built DWCs. The first industrial application of DWCs was accomplished in 1985 by BASF SE [5]. Since then the number of application of DWCs has increased rapidly to more than 100 in 2010 [6]. According to Schultz et al. [3], the DWC will become a standard distillation tool in the next 50 years.

A recent review by Dejanović et al. [7] gives a comprehensive overview of DWCs, covering both the theoretical description and

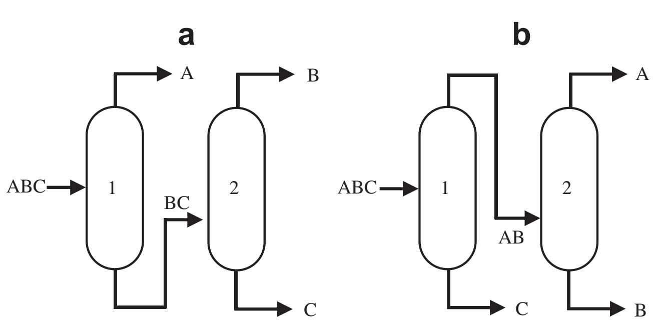

Fig. 1. Direct (a) and indirect (b) sequence for separating a three-component mixture (ABC; A: light boiling component, B: middle boiling component, C: heavy boiling component).

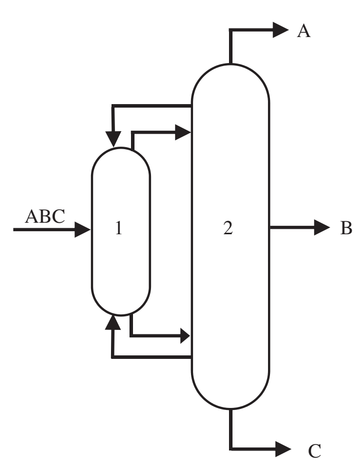

Fig. 2. Petlyuk configuration.