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Dividing wall column for industrial multi purpose use

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ABSTRACT

Dividing wall columns (DWC) for the distillation of multicomponent mixtures have received much attention in the past 15 years and have experienced a booming development. Since DWC demand higher efforts in equipment design and process control they are predominantly used in continuously operated dedicated production plants and spread only over a limited number of chemical companies. No open literature can be found where DWC are used in multi-purpose plants. The distillation equipment in those plants, typically batch wise operated, has to show a high degree of flexibility – an attribute that hardly seems to fit for dividing wall columns. Lonza set up the worldwide first multi-purpose DWC on the production site in Visp that fully meets the demands of a steadily changing production environment characterized by several different production campaigns, processes and products produced in the same plant throughout a year.

This paper reports on the equipment design and the specific technical solutions that had to be implemented in order to satisfy the harsh specifications of multi-purpose production. Particular attention is put on the modelling and simulation of the column and the control scheme that has been applied. The paper contributes a new approach for setting up a flowsheet simulation that overcomes the frequently occurring problems in convergence and enhances robustness of the simulation.

Since the launch of the column several different processes were successfully operated in this equipment. In each single case we directly transferred the process concept from simulation to the plant without piloting. The launch and operation of the column are explained in detail and finally the simulation results are compared to real operation data from the production.

1. Introduction

1.1. Dividing wall columns

Distillation is by far the most important separation technology in the chemical industry and is responsible for an important part of the world-wide energy consumption [1]. Raising energy and raw material costs over the past decades as well as increasing market competition has been the major driver to steadily search for potential energy savings, even for a mature operation like distillation. This financial pressure finally yielded in energy improved and intensified distillation processes, e.g. the heat integrated distillation column (HIDiC) and the dividing wall column (DWC). Contrary to the HIDiC which is still to a great extend an academic field of investigation the DWC is already widely applied in the chemical industry [2]. Although the concept is not new and originates from the 1930s [3], it took a couple of decades until scientific investigations focused again on heat coupled columns (e.g. [4–6]). Finally BASF in Ludwigshafen took up research in the beginning of the 1980s [7,8] and set up the first production scale column in 1985 [9].

The main advantages of DWC are the considerable savings in energy consumption and investment costs for a wide range of different mixtures. The cost reduction for invest and operation lies around 30% [10]. Therefore, the number of installed units has continuously increased since the 1980s and today this technique can be considered to be well established in chemical industry.

The reason for the dramatic reduction for both, energy consumption and expenditures for the investment, results directly from the construction of the DWC. Considering a zoetrope ternary mixture (A, B, C wherein A is the light boiler and C is the heavy boiler) two conventional distillation columns are necessary in order to separate the mixture into the three pure components. Traditionally the direct (light boiling component is separated first) and the indirect split (lowest boiling component is separated first) are used to gain the three pure fractions (Fig. 1). Besides the two mentioned splits, lots of others are possible. However, it is not feasible to separate the three components in pure fractions via a side-stream using a conventional single-column setup without a dividing wall.

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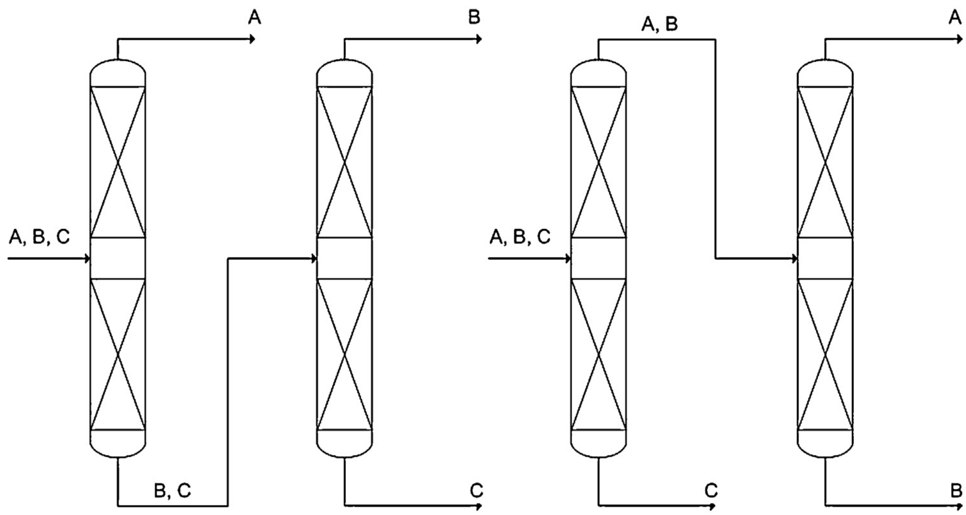

Fig. 1. Direct (left) and indirect (right) sequence to separate azeotrop ternary mixture into three pure components.

The DWC is a single shell distillation column which goes back to the idea of Petlyuk (Fig. 2). The Petlyuk setup uses three columns to separate the above mentioned zoetrope ternary mixture [2]. The first column separates A and B in the distillate stream and B and C in the bottom stream. Both, distillate and bottom stream, are subsequently fed into distillation columns wherein B is the bottom product of the distillate column as well as the overhead product of the bottom column. It is obvious that the Petlyuk setup needs one column more than the direct or indirect split for the separation; therefore it never gained industrial relevance. At the same time it can easily be seen that merging these three columns into one shell with a dividing wall in the middle of the column transfers the concept into a very promising setup. With this idea the DWC (Fig. 3) was born and a lot of research was, and still is, put on this new intensified distillation process. A DWC always has 6 separation sections: 2 on the left side and 2 on the right side of the dividing wall, one above and one below the dividing wall. Like in every other intensified process the requirements for equipment design are more demanding compared to the standard operation.

There are a couple of specific design problems that had to be solved for the DWC. Compared to a distillation column for the separation of a binary mixture, the DWC shows three additional degrees

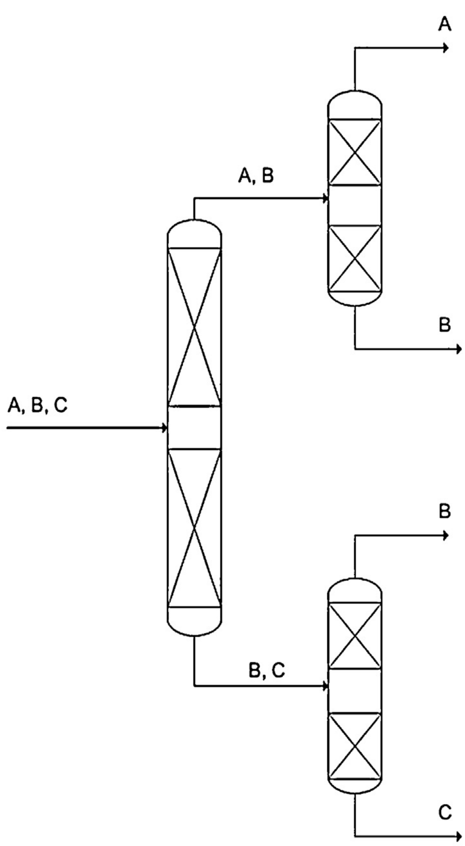

Fig. 2. Petlyuk distillation setup to separate a zoetrope ternary mixture into three pure components.

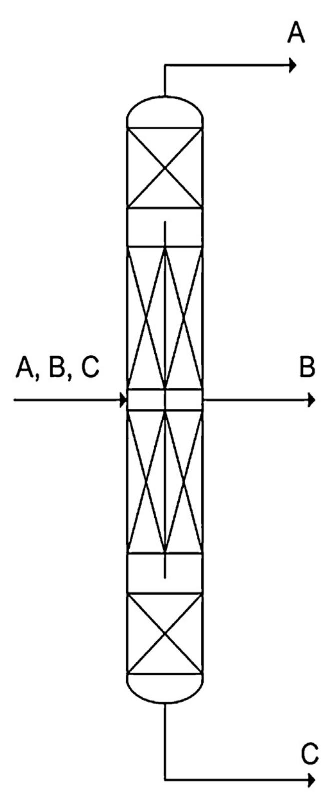

Fig. 3. Dividing wall column to separate a zoetrope ternary mixture into three pure components.