



HIDiC - Design, Sensitivity and Graphical Representation

Meyer, K.; Ianniciello, L.; Nielsen, J. E.; Bisgaard, Thomas; Huusom, Jakob Kjøbsted; Abildskov, Jens

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Meyer, K., Ianniciello, L., Nielsen, J. E., Bisgaard, T., Huusom, J. K., & Abildskov, J. (2014). *HIDiC - Design, Sensitivity and Graphical Representation*. Poster session presented at 10th International Conference on Distillation and Absorption, Friedrichshafen, Baden-Württemberg, Germany.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

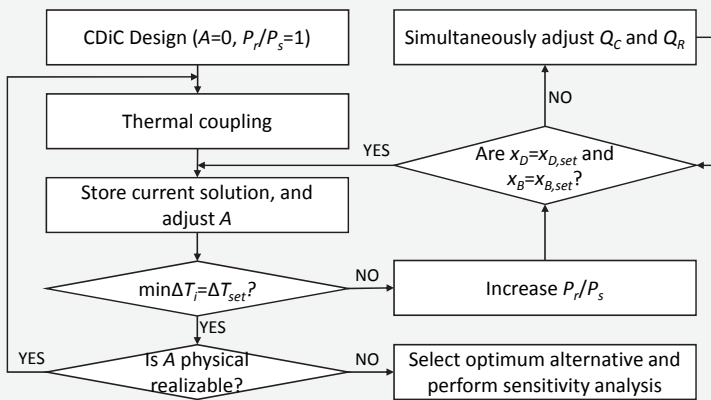
HIDiC – DESIGN, SENSITIVITY AND GRAPHICAL REPRESENTATION

Introduction

The internally heat integrated distillation column (HIDiC) is a potential replacement for the conventional distillation column for certain applications, offering reduced utility consumption of separation in more complex equipment. In addition, the conceptual design of the HIDiC is significantly more difficult and classical short-cut methods such as that of McCabe-Thiele are not eligible. This work provides an application of a proposed algorithm for systematically generating feasible HIDiC designs for the separation of isopropanol/water (IPA/W).

Design Algorithm

HIDiC design [1,2,3] is not uncomplicated. In this work, a pragmatic approach is presented to provide fundamental insights in the design of a HIDiC to identify its strength and limitations:



Heat Transfer Area and Pressure Ratio

As thermal coupling has been established, two remaining design degrees of freedom exists: The internal, stage-wise heat exchange area (A) and the pressure ratio between sections (P_r/P_s).

The proposed algorithm is employed for the separation of IPA/W, and the obtained path/isotherm is illustrated in Figure 2 along with the feasible design window for two different thermal couplings. Here, a weighted combination of reboiler duty and electricity consumption is used as an evaluation criteria to be minimized but TAC can also be employed.

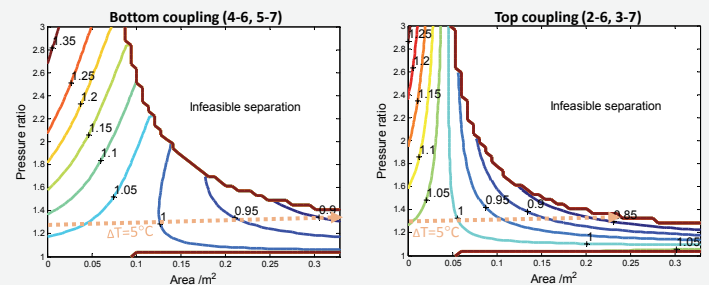


Figure 2. Examples of contour plots of normalized total energy consumption defined by $(Q_R + 2W_s)_{HIDiC} / (QR)_{CDiC}$ for different couplings.

The top coupled configuration is chosen since the most significant energy savings can be obtained. Since the energy consumption decreases along the isotherm, the maximum feasible heat exchange area is used leading to:

$$P_r/P_s = 1.35$$

$$A = 0.215 \text{ m}^2$$

A stop criteria for the maximum heat exchange area could be based on geometric considerations for the concentric HIDiC [1], which in this case is relatively small (Table 1).

Table 1. Evaluation of HIDiC design. Column area estimated by conventional method using 80% flooding.

Section	Column	Estimated area /m ²	
		Proposed heat area	Possible heat area [1]
Rectifier	0.0014	0.215	0.026
Stripper	0.0016		

Thermal Coupling

It is often observed that a large heat exchange area is required for obtaining high thermodynamic efficiency, and thus the amount of thermal coupling is preferably maximized. However, the sizes of the distillation column sections and their temperature profiles are important factors.

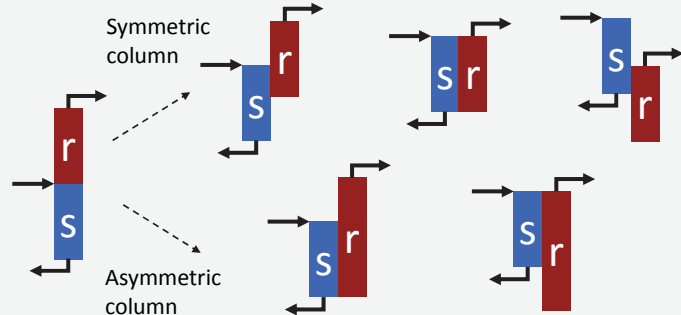


Figure 1. Example thermal couplings for the HIDiC. Note flow exchange streams between sections in the HIDiCs are omitted for simplification.

IPA/W is an example of a non-ideal mixture, which relative volatility varies from 1.8 in the top ($x_D=0.57$) to 42 in the bottom ($x_B=0.001$). See Figure 2 for column temperature profile.

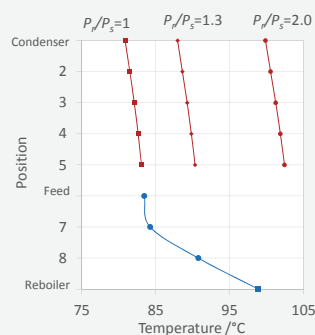


Figure 2. Study of influence of pressure on temperature profile using rigorous simulation.

Concluding Remarks

- A proposed algorithm for generating feasible HIDiC designs has been presented
- The algorithm has been applied on the separation of aqueous isopropanol with obtained energy reduction of 17%

References

- [1] M. Gadalla, L. Jiménez, Z. Olujic, P.J. Jansens, *Comput. Chem. Eng.* 31(2007): 1346-1354.
- [2] T. Wakabayashi, S. Hasebe, *Comput. Chem. Eng.* 56(2013): 174-183.
- [3] A. Harwardt, K. Kraemer, W. Marquardt, *Distillation Absorption* (2007): 55-60.
- [4] T. Bisgaard, J.K. Huusom, J. Abildskov. 10th IFAC International Symposium on Dynamics and Control of Process Systems (2013): 373-378.