Structured packings for the internal Heat Integration in Distillation Columns (HIDiC)

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August 2015
ECN-L--15-070

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Background & Concept

Why?

- Energy use of distillation is 40 % of the total in the chemical and refinery industries (=180 PJ/y in the Netherlands)
- Separation of close boiling liquid mixtures are highly energy intensive (such typical column uses 90 MW of energy)
- The HIDiC concept was introduced to radically improve the energy efficiency
- Determine mass and heat transfer coefficients
- Determine the optimum operating conditions
- Assess the economic viability

How?

- Concept of Vapor recompression (VRC) are already known [1] see Figure 1
- In HIDiC [2]
  - Vapor leaving the stripping is compressed before entering rectifier
  - Rectifier operates at higher temperature/Pressure to allow heat integration between rectifying and stripping
  - Reversibility of the column can be increased by upgrading the heat rejected in rectification section and transferring it to stripping section

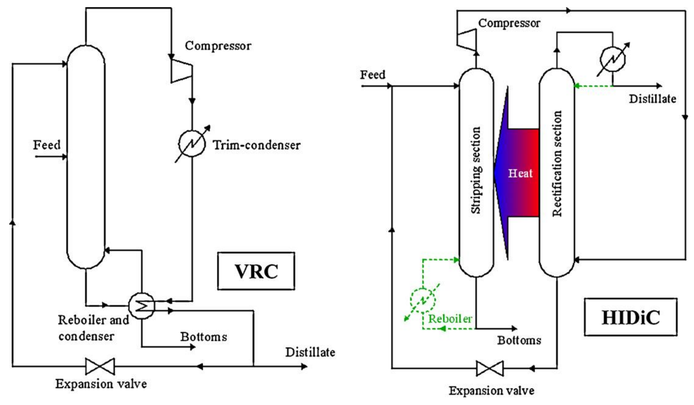

Figure 1: The VRC and HIDiC column

Experimental set-up

- This structured HIDiC contains 3 sections (Figure 2)
- Basic unit of plate packing HIDiC consists of two layers of 5 stacked corrugated sheets (0.2m X 0.2m) of Mellapak 350.Y (Sulzer) (Figure 3)

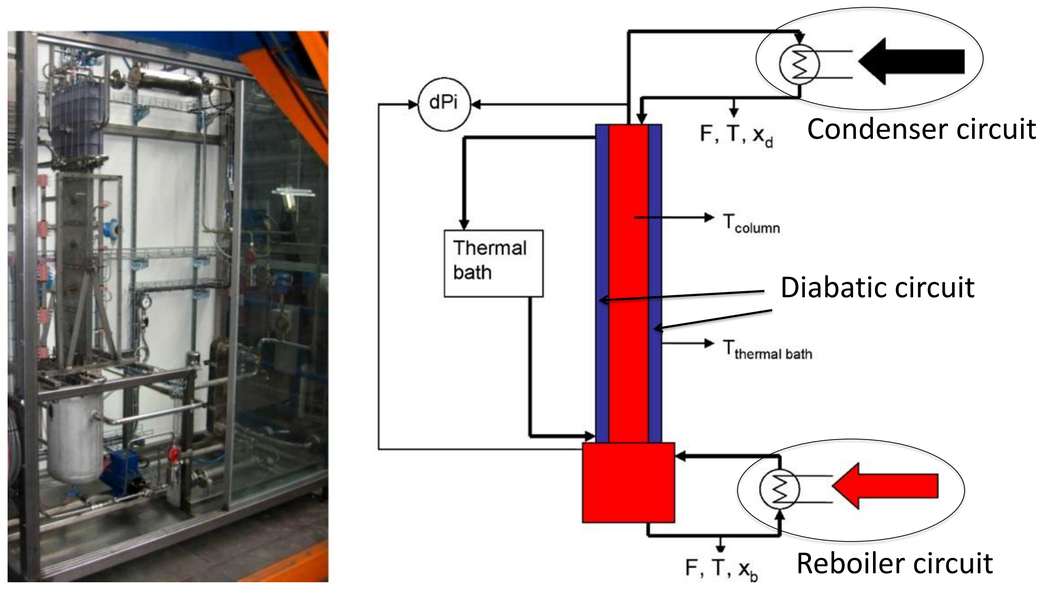

Figure 2: HIDiC (left) before insulation, flow sheet (right) showing sampling points

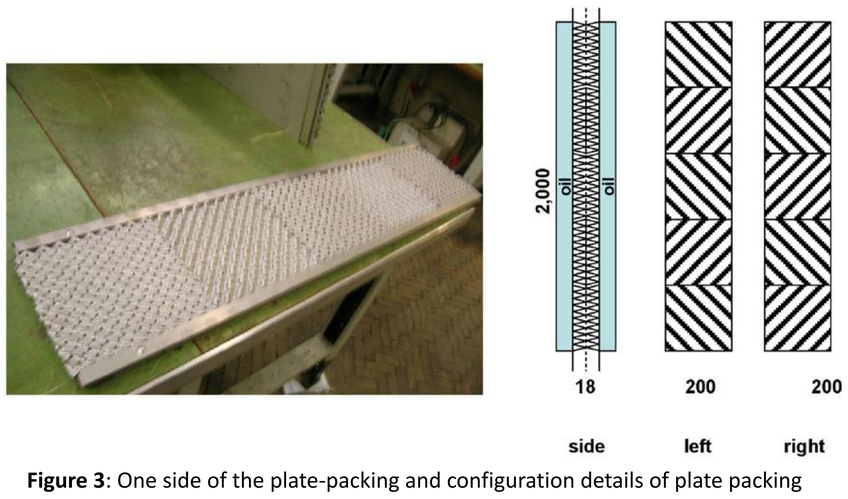

Figure 3: One side of the plate-packing and configuration details of plate packing

Results

- The Height equivalent to a theoretical plate (HETP) is decreased and ΔP increased when load (F-factor) increased (Figure 5, Figure 6)
- The heat transfer coefficient is fairly insensitive to changes in load
- Primary energy usage is 80 % lower than in conventional columns (Table 1) calculated from heat transfer (Figure 4)

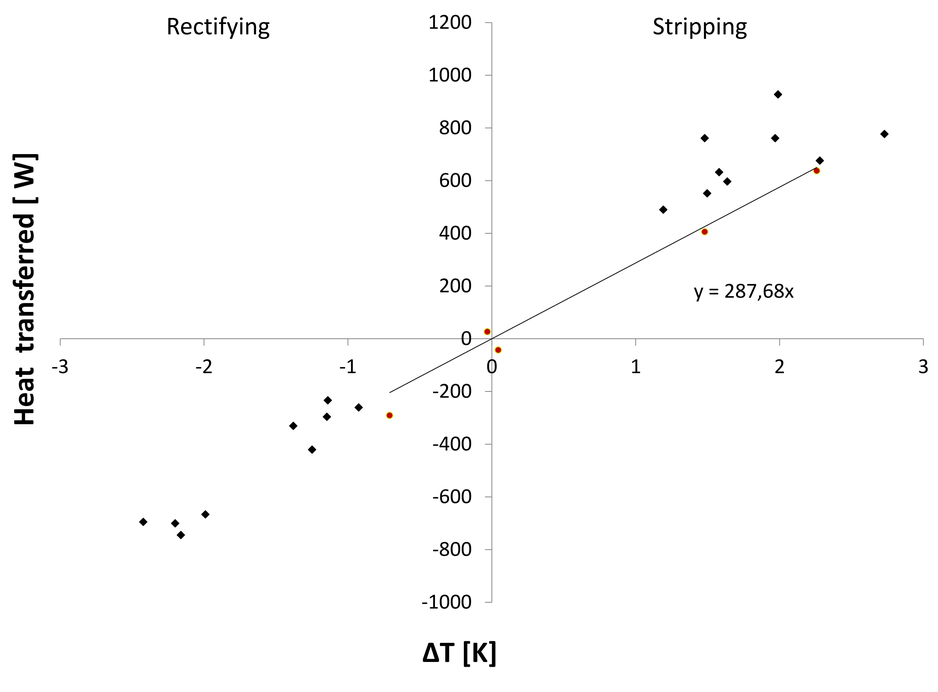

Figure 4: Heat transferred in HIDiC for rectifying and stripping mode as a function of ΔT

Table 1: energy and economic data

Column	Conv. Col.	PP-HIDiC
F-factor [Pa $^{0.5}$]	1.81	1.6
Q_R [MW]	2.12	
W_{comp} [MW]		0.19
Prim. Energy [MW]	2.49	0.59
CAPEX [k€]	468	1393
OPEX[k€/y]	536	104
PBP [y]	-	2

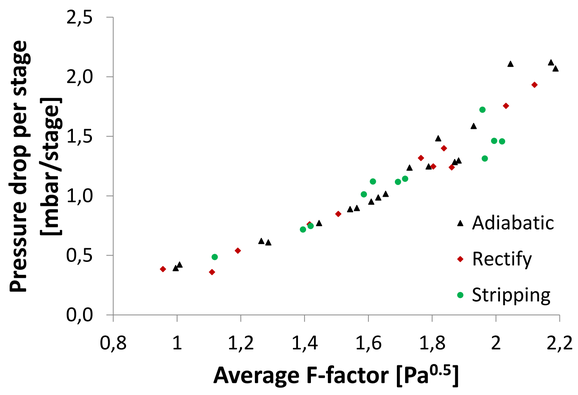

Figure 5:ΔP/stage in 3 different modes with increasing load

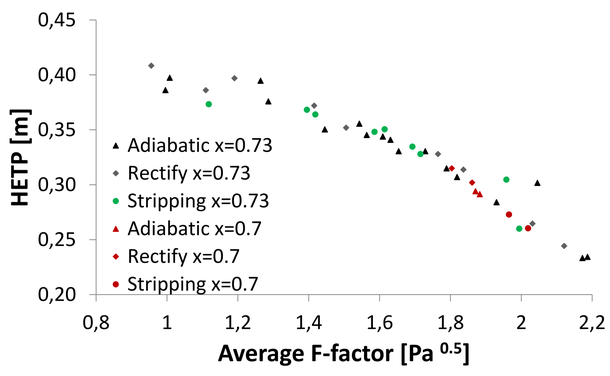

Figure 6: HETP in 3 different modes with increasing load

Conclusion

- Structured packings have been experimentally shown to have excellent mass and heat transfer properties, which make them suitable for heat integrated distillation columns (HIDiC)
- HETP of 0.34 m and pressure drop of 0.95 mbar/stage were measured
- Energy efficiency improvement over conventional columns can be as high as 80 %
- The payback times for HIDiC columns can be as low as 2 years
- Structured HIDiC extends the application of heat pumps in distillation from close boiling mixtures to a ΔT of 40 - 50 °C

References

1. A. Kiss and O. Žarko.” A review on process intensification in internally heat-integrated distillation columns”. Chem Eng Proc 86 (2014) 125.
2. O.S.L. Bruinsma et.al, “ The Structured heat integrated distillation column”. Chem Eng Res Des 90 (2012) 458.

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