Catalytic liquid load point measurement in a reactive distillation packing by X-ray tomography

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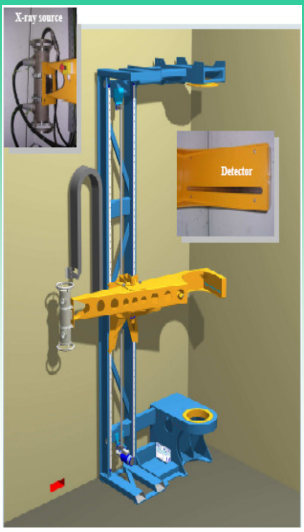
Abstract

We report on the use of X-ray tomography to visualize and to quantify the catalytic liquid load point in modular catalytic distillation packing elements (Katapak-SP11 and Katapak-SP12). The liquid load point corresponds to the liquid superficial velocity above which the catalytic baskets are totally filled with liquid. For liquid superficial velocity values higher than the liquid load point, the excess of liquid start to flow in the distillation section (Mellapak corrugated sheets). From images obtained by x-ray tomography, we show that the liquid load point is not unique. It logically depends on the gas flowrate, but also on the vertical position in the packing element and on the position of the packing element in the column. Its value also depends on the position of the catalytic basket in the packing element (internal or external).

X-ray tomograph (Balteau NDT, BE)



Voltage : 30 - 420 kV
Current : 2 - 8 mA

X-Ray source (high energy)
Focal spot : 0.8 mm
Collimator : Pb
Aperture: 40°
Thickness: 1mm

Linear detector
1280 photodiodes
(0.3 mm x 0.6 mm)
Pitch : 0.4 mm
CdWO4 scintillator

Carriage
Vertical movement (3.8 m)

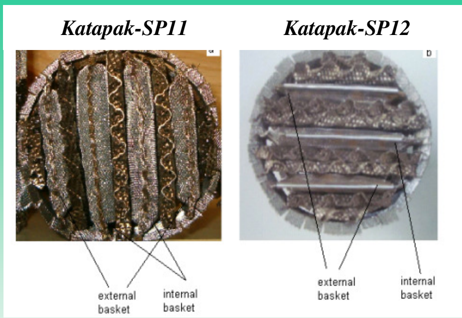
Rotating table
360° (t_{mes} : 45s)
Max . diam. : 0.45 m
Max. height : 3.8 m

Experimental set up

COLUMN (transparent PVC)
D = 0.1m
H = 3.8 m

PACKING BED (top → bottom)
3 Mellapak 752Y
4 Katapak-SP12 or 4 Katapak-SP11
1 Mellapak 752Y

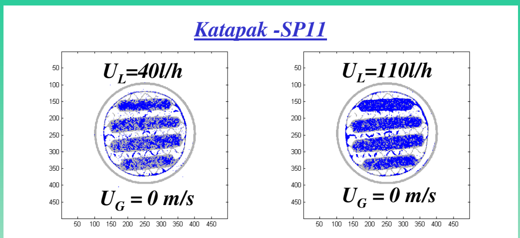
MELLAPAK 752Y
Element height : 0.2 m
Diameter : 0.1 m
Holes in corrugated sheets
2 wall wipers / element

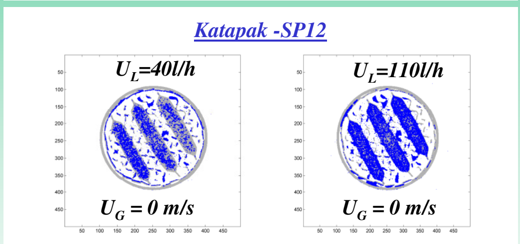


KATAPAK-SP12
(1 catalytic basket / 2 corrugatedsheets)
Element height : 0.2 m
Basket height : 0.2 m
Diameter : 0.1 m
3 baskets / element
8 corrugated sheets / element
3 wall wipers / element

KATAPAK-SP11
(1 catalytic basket / 1 corrugated sheet)
Element height : 0.2 m
Basket height : 0.2 m
Diameter : 0.1 m
4 baskets / element
5 corrugated sheets / element
3 wall wipers / element

Irrigated images



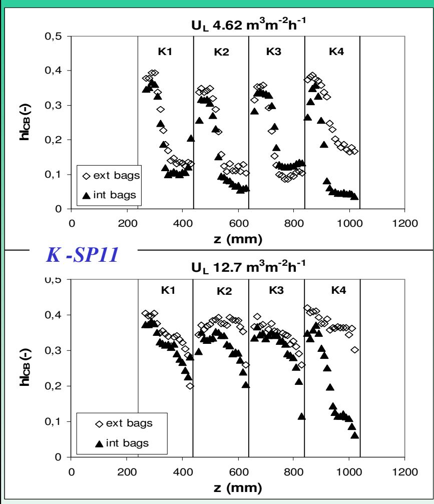


Liquid is not uniformly distributed: more liquid flows in external baskets than in internal ones.

Wall wipers redistribute the liquid towards the inside of the packing, preferentially inside the external baskets.

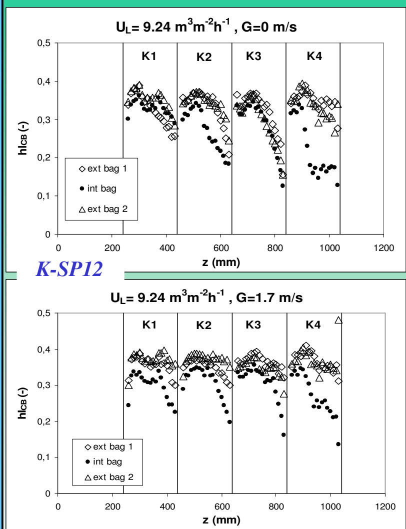
Flows in Katapak-SP11 and Katapak-SP12 exhibit the same behaviour.

Influence of liquid flowrate



***Liquid holdup** in **internal basket(s)** is **lower** than in **external baskets**.*
*For very **low liquid flowrate**, **baskets** are almost **empty**.*
*At the **loading point** ($u_L = u_{L,LP}$), **baskets** are **filled** with liquid.*
*The **loading point** ($u_{L,LP}$) **depends on** the vertical position (z).*

Influence of gas flowrate



Counter-current gas forces the liquid to flow inside the baskets.

Liquid load point is reached for lower liquid flowrate values.

Conclusions

The catalytic liquid load point is not unique as its values not only depends on the gas flowrate but also on the height in the packing element, on the position of baskets (external or internal) and on the packing element position in the column. The present study shows that X-ray tomography, that allow to visualize and to quantify the liquid distribution in a packed bed, is an appropriate technique to determine catalytic liquid load point in complex** packing **such as Katapak SP11 and Katapak SP12. These values of catalytic liquid load point are very important, as it is one the most important parameter in models used to predict fluid dynamic related parameters, such as the pressure drop or mass transfer coefficients in catalytic distillation packings.