Styrene Monomer Purification with MellapakPlus: Some Case Studies

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Introduction

Current situation in styrene monomer distillation with structured packings

- structured sheet metal packings have been in commercial use since mid 70's
- ever growing area of application due to high separation performance and low pressure drop
- more than 10'000 column with structured packings delivered by Sulzer Chemtech, of which some 100 columns for styrene monomer distillation
- current design philosophy for ethylbenzene/styrene (EB/SM) splitters relies upon structured packings, notably Mellapak 250.Y; most formerly trayed columns have been converted to structured packings

Introduction

Main drivers for the use of structured packings

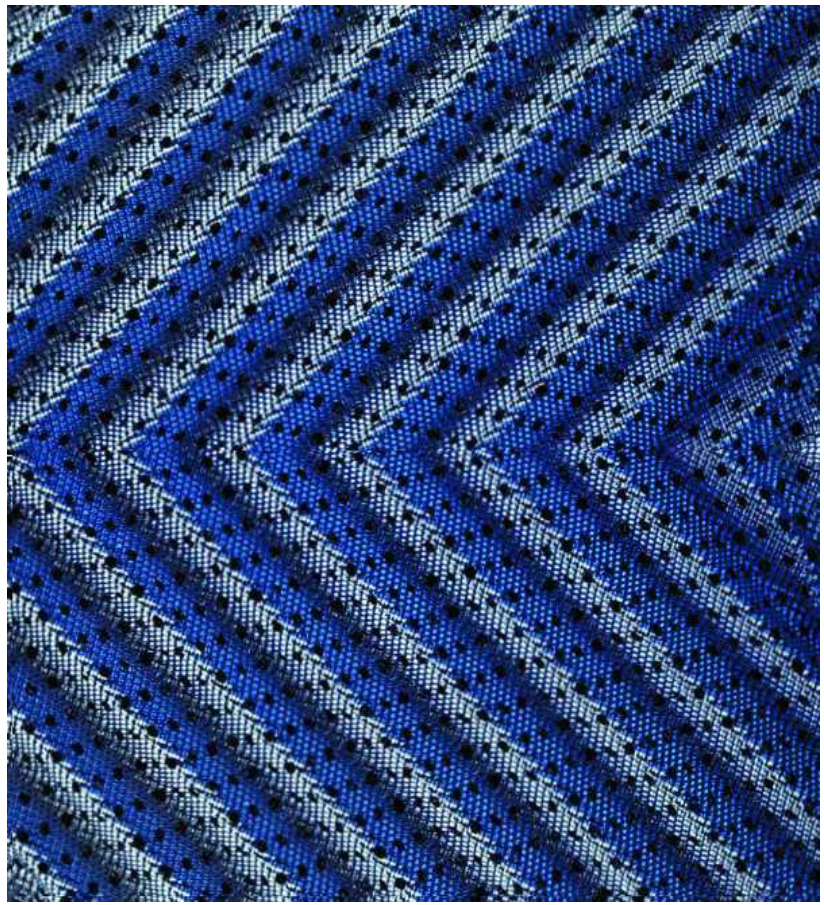
- prevention of polymer formation because of reduced pressure drop, leading to low bottom temperatures
- suppression of polymer formation and reduction of inhibitor consumption because of reduced mean residence time and smaller residence time distribution
- increase in capacity
- increase in yield and purity, above all ethylbenzene (EB) content in styrene monomer (SM), because of high number of separation stages

These are also the drivers for the use of new generation structured packings, namely MellapakPlus.

MellapakPlus: a short history

Background

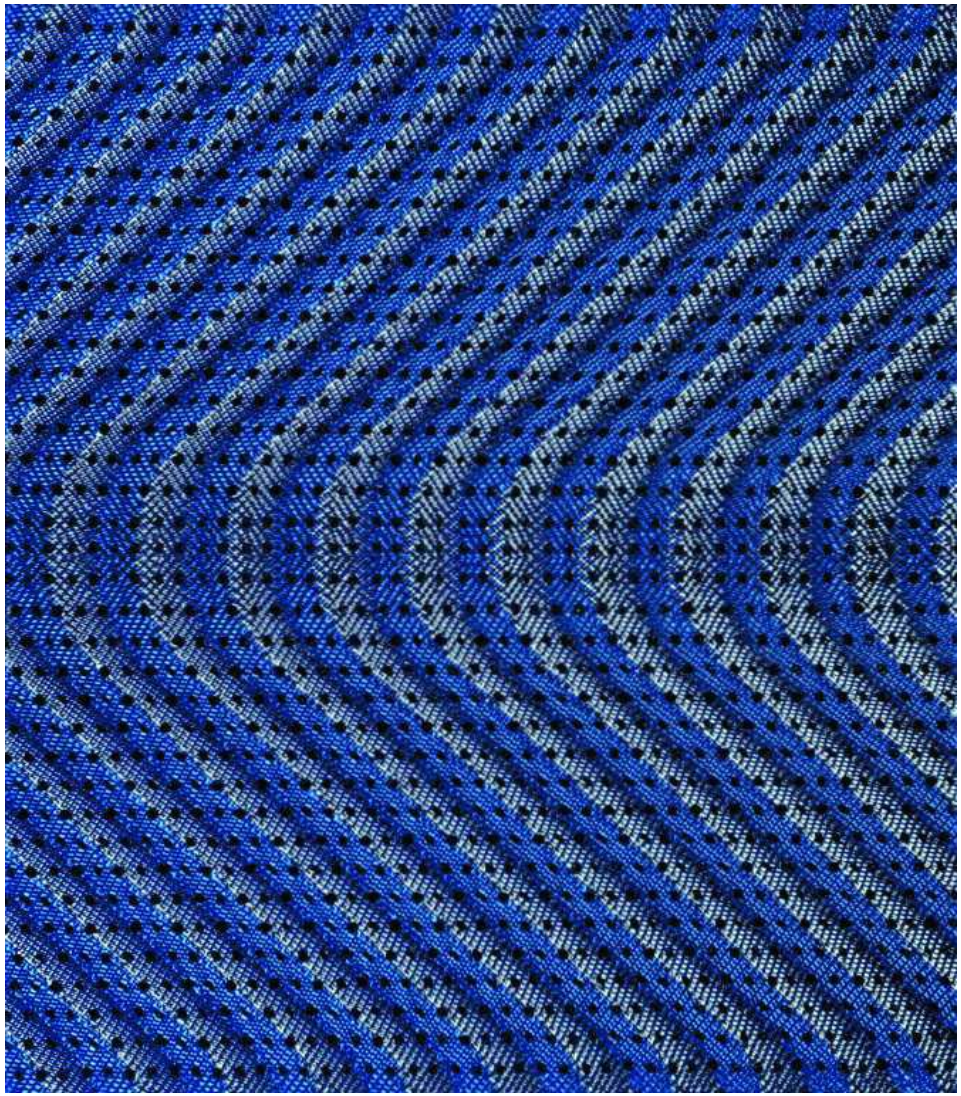
- Research has revealed that flooding in Mellapak starts where two layers of packings touch, long before the bulk of the packing reaches its capacity limit. Flooding then spreads upwards, into the bulk of each element. Reasons:
  - increased pressure drop due to sudden change in flow direction
  - increased liquid film thickness at lower sheet end.



Geometry: Mellapak .....

MellapakPlus: a short history

- The flow channels of MellapakPlus guarantee a smooth and steady change in the direction of gas flow and decrease gas velocity at the intersection between two packing elements;
- therefore flooding at this intersection is greatly suppressed.



... and MellapakPlus

MellapakPlus: a short history

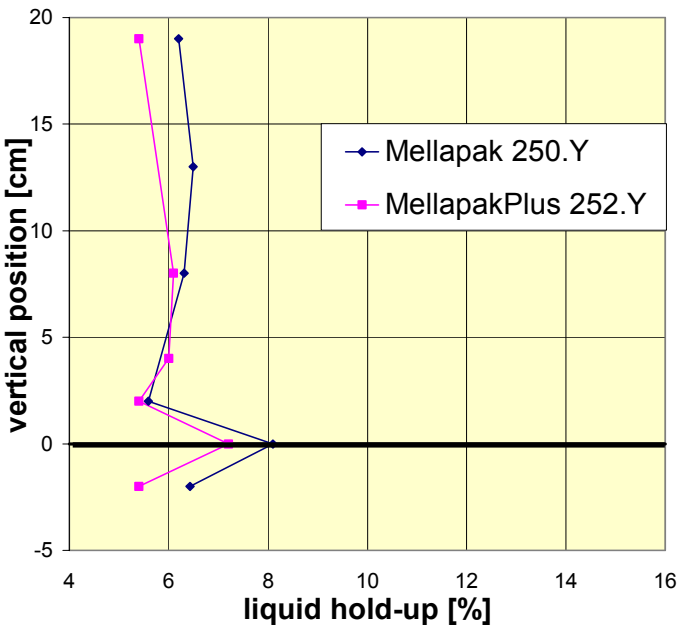
Vertical liquid hold-up profiles

Column diameter: 1m

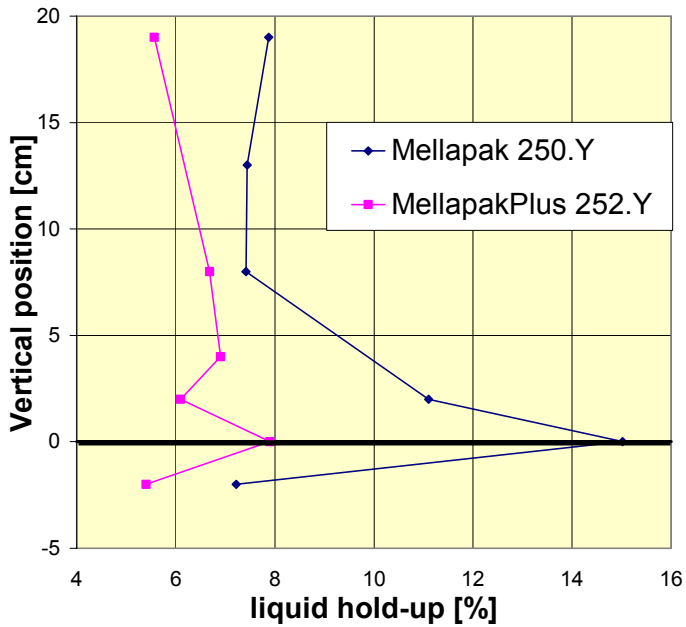
Test mixture: air/water, specific liquid load L = 16m^3/m^2h

measurements by γ-ray scanning

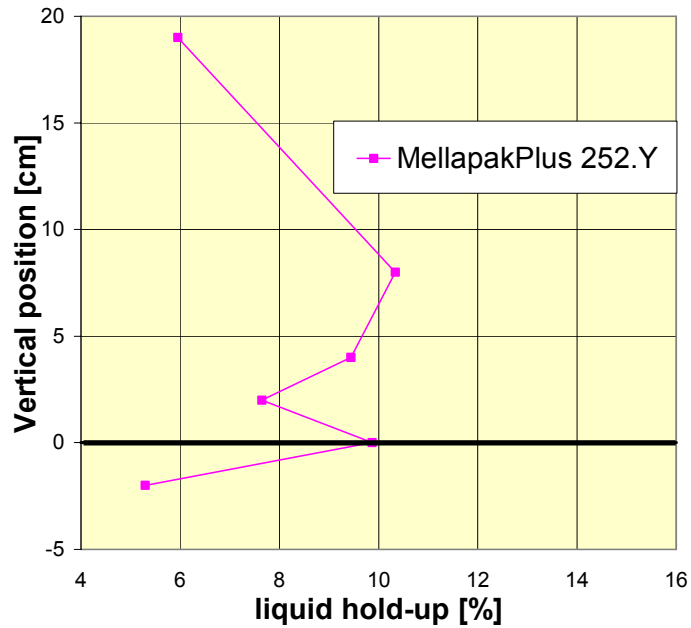
F=2 Pa $^{0.5}$



F=3.5 Pa $^{0.5}$

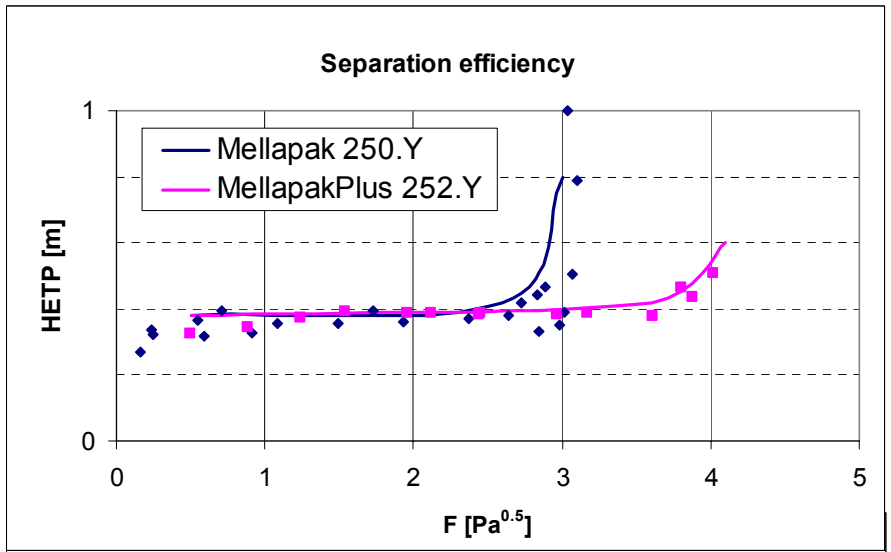


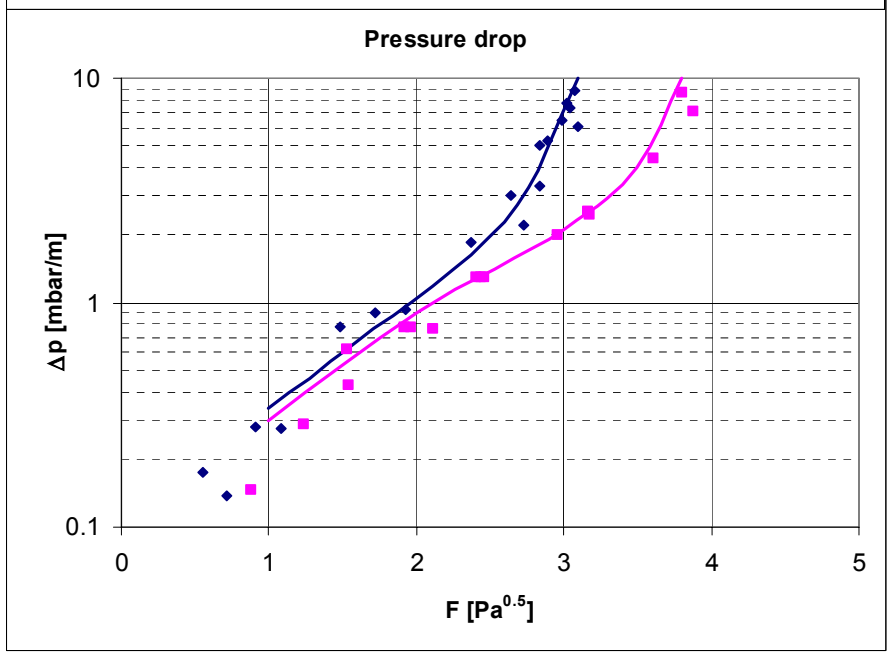
F=4.5 Pa $^{0.5}$



MellapakPlus: a short history

MellapakPlus 252.Y →





MellapakPlus Performance

Column diameter: 1m

Test mixture: chlorobenzene/ethylbenzene

100 mbar top pressure

total reflux conditions

Types considered:

MellapakPlus 252.Y

MellapakPlus 452.Y

MellapakPlus 752.Y

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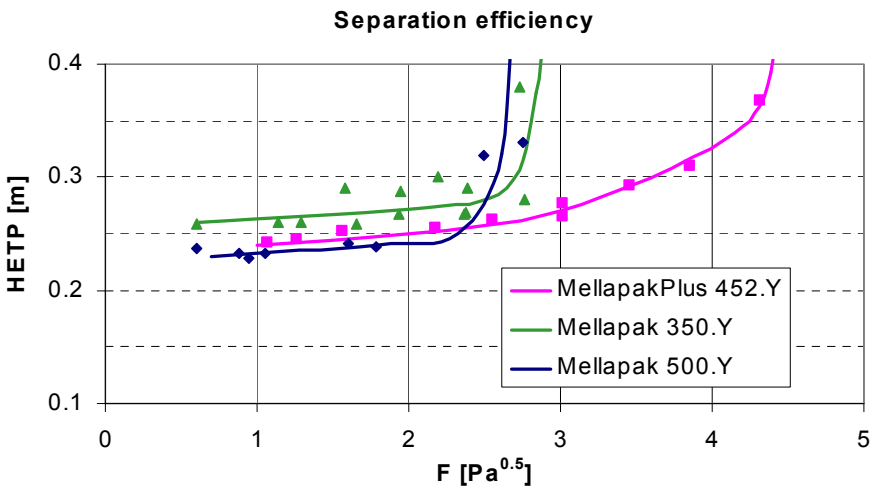
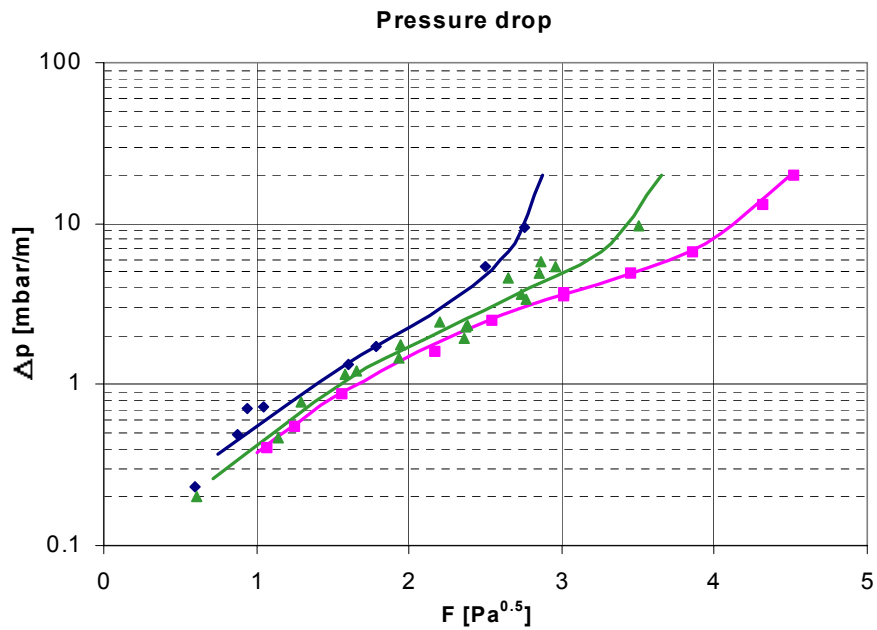
Technology

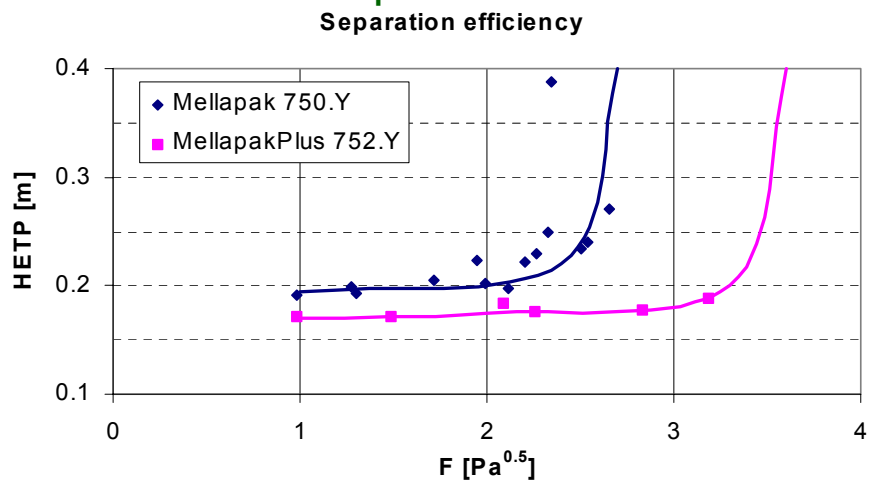
MellapakPlus: a short history

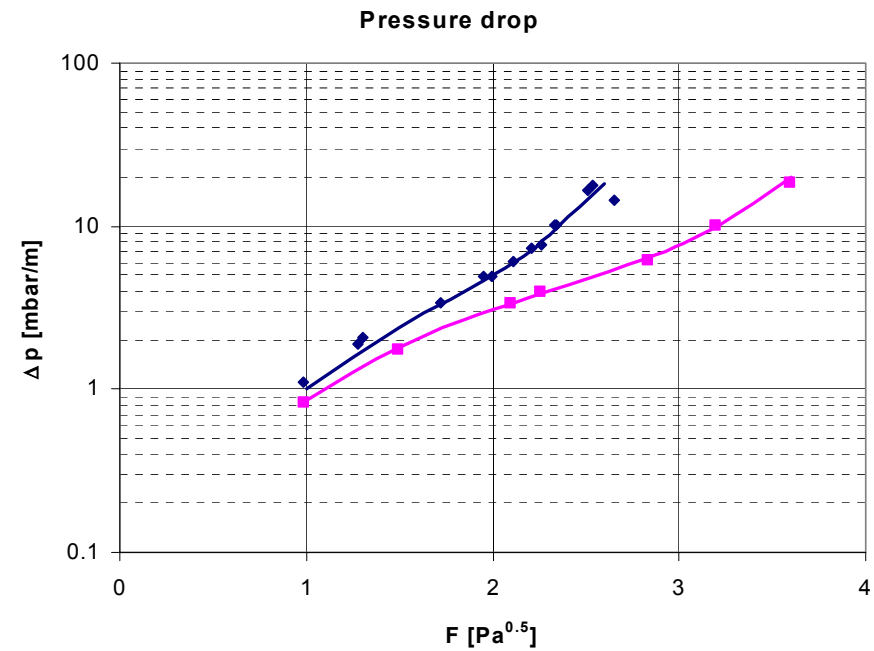
MellapakPlus 452.Y





MellapakPlus 752.Y





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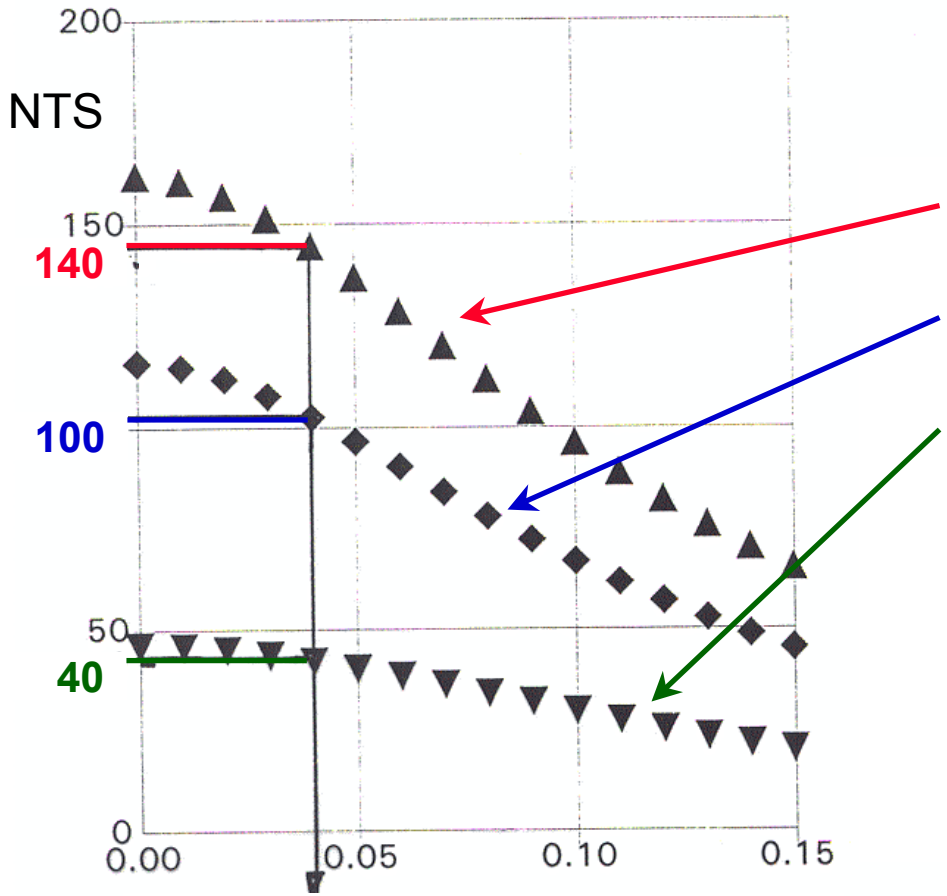
Technology

1. case: revamp of an EB/SM splitter with typical 6 bed design

Operating data			Actual M250.Y	Option A M252.Y	Option B1 M452.Y	Option B2 M452.Y
SM Capacity		[to/year]	198'000	277'500	265'000	295'000
Capacity increase		[%]		40	33	49
SM Top		[wt %]	1.55	1.55	1.0	1.55
EB Bottom		[ppm]	150	150	< 10	150
Pressure	Top	[mbar]	106	106	106	106
	Bottom	[mbar]	146	173	215	215
Temperature	Top	[ºC]	68	68	68	68
	Bottom	[ºC]	88	90	96	96
Internal reflux ratio		[-]	8.1	8.1	8.1	7.25
F-Factor range		[$Pa^{0.5}$]	1.7 – 2.2	2.5 – 3.1	2.3 –2.8	2.3 – 2.8
NTS	Top		25	25	40	40
	Bottom		68	68	100	100

1. case: revamp of an EB/SM splitter with typical 6 bed design

Maldistribution analysis for new alternative B (Mellapak 452.Y)



NTS total

NTS in stripping section

NTS in rectifying section

Maldistribution coefficient λ defines deviation from ideal liquid distribution. For a good distributor: $\lambda = 0.04$

2. case: revamp of an EB/SM splitter from 4 to 5 bed design

Operating data			Actual mixed	Option A1 M452.Y	Option A2 M452.Y
SM Capacity		[to/year]	120'000	121'500	139'000
SM Top		[wt %]	4.15	0.5	2.0
EB Bottom		[ppm]	1'150	80	500
Pressure	Top	[mbar]	100	100	100
	Bottom	[mbar]	200	190	190
Temperature	Top	[ºC]	67	67	67
	Bottom	[ºC]	94	92	92
Condenser Duty		[MW]	9.08	8.82	8.64
Reboiler Duty		[MW]	8.79	8.53	8.32
F-Factor		[$Pa^{0.5}$]	2.2 – 3.3	2.1 – 3.2	2.1 – 3.2
NTS	Top		28	31	31
	Bottom		35	57	57

Conclusions

- The presented cases show that MellapakPlus offers vast improvements in one of the key applications of structured packings, the purification of styrene monomer.
- The improvement can lay in a significant increase in capacity, in better purity, higher yield, energy savings, or any combination.
- Lower and more uniform hold-up in MellapakPlus anticipate reduced polymer formation.
- Columns revamped so far fully confirm these expectations.