Design of a Modularized, Intensified Milli-Reactor for Production Scale

Miprowa® Technology:
1. Flat rectangular product channels: High surface-to-volume ratios
2. Static mixing insert (SM) are exchangeable
   - Intensified heat exchange capacity
   - Forced convection over the entire reactor length
   - Narrow and defined residence time distribution
   - Homogenous reaction conditions
   - Continuous dispersion of two-phase systems

Heat and Mass Transfer Experiments
- Experimental setup for heat and mass transfer experiments
- Overall heat transfer coefficient calculated using the logarithmic mean temperature difference:
  \[ k = \frac{Q_{\text{PM}}}{A \cdot \Delta T_{\text{in}}} \]
- Comparison of different SM shows the influence of the inclination angle of the comb structure on the heat transfer
- Significant intensification of convective heat transfer in channels with the comb layers compared to the empty channel

Influence of the static mixing inserts on the overall heat transfer
- Calculation of the gain factor Nu/Nu0 [1,2]
  \[ \frac{1}{K} = \frac{1}{K_0} + R_W + \frac{1}{R_{\text{Nu0}}} \]
  \[ \text{Nu} = \frac{\alpha L}{h} \]
- For low-viscosity fluids with high specific heat capacity the heat transfer coefficient is up to \( K = \frac{2000}{W \cdot m^2K^1} \)
- For a glycerin water mixture (80 Vol.-%) and isopropanol \( k = 1000 \ W \cdot m^2K^1 \)

Residence Time Behavior
- Experimental setup to investigate the residence time
  - Measurement and comparison of conductivity at the in-and outlet using a pulse tracer (NaCI) in the process medium
  - Mathematical treatment of the conductivity signals
  - Narrow residence time distribution can be used as a measure of the mixing quality in single-phase systems

Influence of the static mixing inserts on the residence time distribution
- Calculation of the dimensionless residence time density function \( E(t) \)

References

Quick and Reliable Scale-Up
- Increasing the throughput by numbering-up of the product channels while keeping the channel cross section constant
  ⇒ Constant heat transfer capacities

Channel numbering-up

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