Fouling mitigation in membrane based perfusion systems by oscillating tangential flow

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Fouling Mitigation and Hydrodynamic Characterization of Membrane based Perfusion Systems (XCell™ ATF)
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Background

- Fouling is a major drawback of membrane processes
  - Deposit layers lead to reduced flux and filtration efficiency
  - Permeation of target molecules changes
- Cell retention device using alternating tangential flow (ATF) are applied, but mechanisms appear not to be fully understood
- High residence times influence cell viability

Hypothesis

- Alternating stress due to oscillating tangential flow can mitigate deposit layer formation, thus enhancing flux, permeation and filtration efficiency.
- Residence times can be minimized by optimizing cycle time and tangential flow velocity
- Residence times depend on particle properties

Experimental setup

- The filtration plant and model suspension
  - Diaphragm pump at the end of the filter is air pressure driven
  - After full inflation/deflation phases are switched
  - Permeate is removed by a peristaltic pump

Results

Particle accumulation in the diaphragm dead space

- Particle accumulation in the diaphragm dead space and HFM
- Accumulation depends on the alternating tangential flow
- Medium flow rates are favorable in terms of cells' residence time within the perfusion device
- Particle size distribution indicates that smaller particles are enriched in the diaphragm dead space
- Hydrodynamic lift forces increase with particle size, they can thus better remove cells from the HFM

Principal component analysis of pressure data from both phases

- Transmembrane pressures increase with increasing flux
- Tangential flow velocity during exhaust phase has higher influence on pressure data than during pressure phase
- Settings with unfavorable conditions regarding particle accumulation can be identified by the first principal component
- Settings with similar tangential flow velocity during pressure phase behave similarly, independent from pressure phase settings

Conclusion

The choice of tangential flow velocity …

- ... highly influences particle deposition and residence time within the follow fiber module and therefore can establish unfavorable conditions (e.g. starving of cells)
- ... enhances particle flush out if high tangential flow velocity during pressure phase is chosen
- ... during the exhaust phase mainly influences the transmembrane pressure

Perspectives

Evaluating the impact of alternating stress on fouling

with different flow patterns, process variables and particles sizes

Fig. 1: Alternating tangential flow induced by a diaphragm pumps

Fig. 2: Dry cell weight of retentate compared to the feed

Fig. 3: Particle size distribution of accumulated particles compared to the initial feed

Fig. 4: Principal component analysis of yeast filtration with varying tangential flow velocity and flux. The permeate was recycled to the feed to obtain constant conditions.

Fig. 5: Options for flow modes: Steady flow (std. crossflow as control), pulsating forward flow, and alternating tangential flow (w/o deadspace)

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