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Development of a Model for a Reaction Mixing Pump

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Motivation

- **Reaction Mixing Pumps (RMPs):** Promising alternatives to stirred tank reactors
- Combining **transportation** and **mixing** of reaction media
- Using RMPs for mixing sensitive reaction systems due to **high internal circulation flows**
- Development of a **1D Fluid Dynamical Model** and a **Compartment Model** to describe the behavior of a RMP as a reactor

Experimental Setup

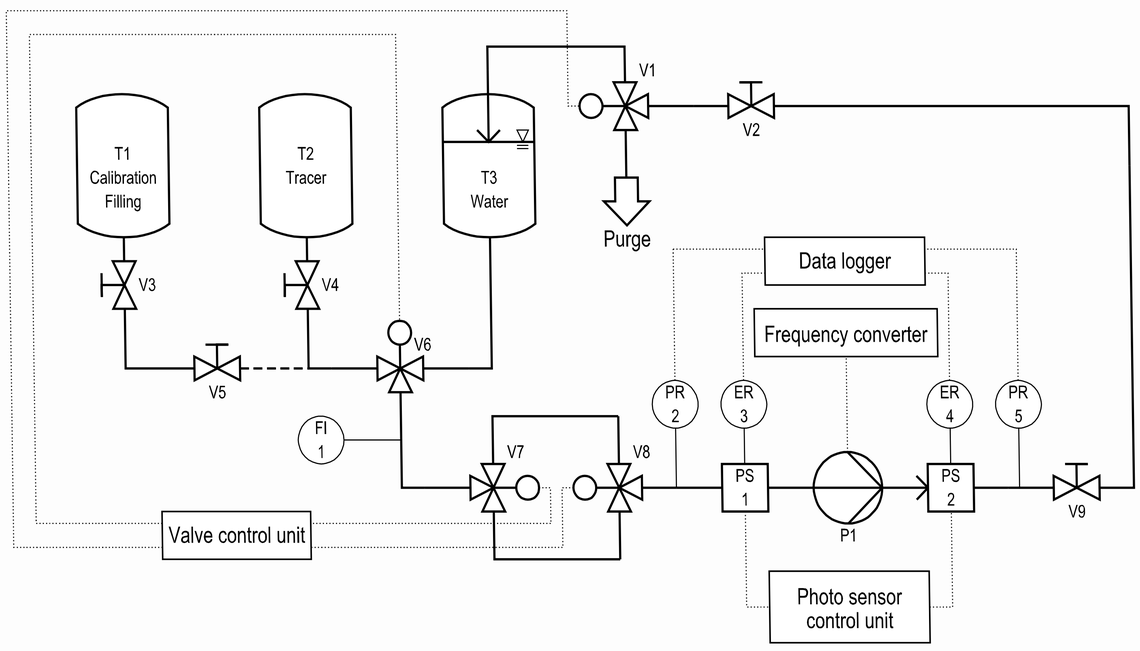

Fig. 1: Flowchart of the experimental setup for measuring pump characteristic curve and residence time (left), and RMP with sensors (right).

Model

- **Fluid Dynamical Model:** Based on mass and momentum exchange between side- and impeller channel of the RMP [1]
- **Compartment Model:** Division of the RMP volume into smaller compartments, each behaving like an ideal Continuous Stirred-Tank Reactor (CSTR)

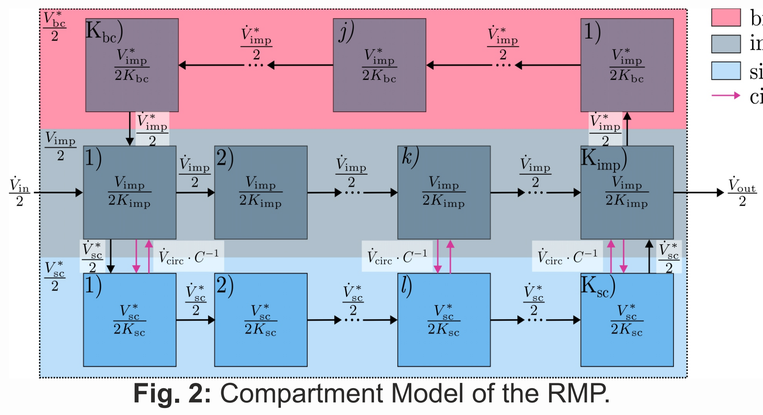

Fig. 2: Compartment Model of the RMP.

Modeling Procedure

Optimization of **friction loss-dependent parameters** of the fluid dynamical model based on the experimental pump characteristic curve

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Prediction of **internal flow rates** and **mixing behavior** using the fluid dynamical model

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Prediction of **residence time** using the compartment model

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Finding **operating parameters** for which the behavior of the RMP comes close to that of an **ideal CSTR**

Results

Parameterisation

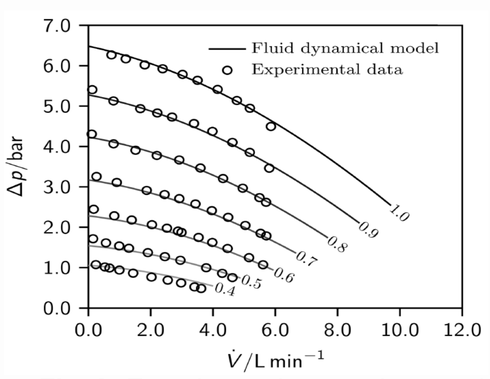

Fig. 3: Experimental pump characteristic curve and the fluid dynamical model fitted to the experimental data. The numbers next to the graphs represent the proportion of the maximum impeller speed.

Prediction of Internal Flow Rates

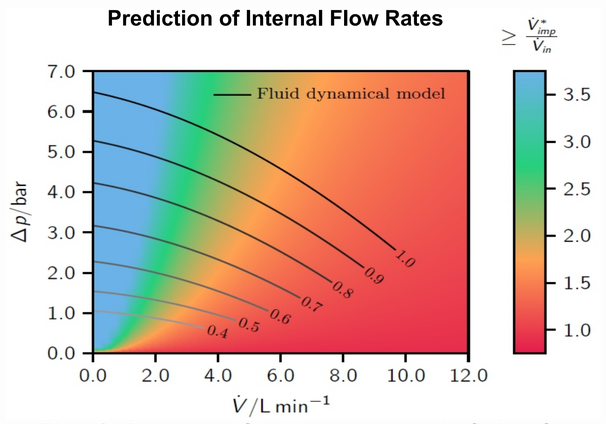

Fig. 4: Division of the characteristic field of the pump into different mixing zones.The numbers next to the graphs represent the proportion of the maximum impeller speed.

Prediction of Residence Time

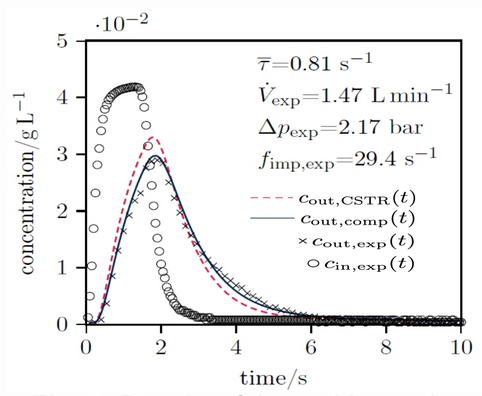

Fig. 5: Results of the residence time for the RMP. Symbols are measured concentrations of a tracer (brilliant black).

Prediction of Yield

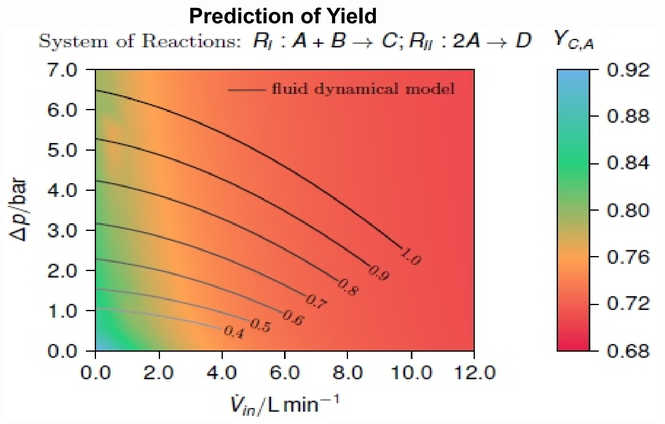

Fig. 6: Yield of component C due to component A in the RMP predicted by the compartment model.The numbers next to the graphs represent the proportion of the maximum impeller speed.

Conclusion

- Good adaptation of the fluid dynamical model to the experimental data
- More accurate predictions of the residence time behavior by the compartment model than by the CSTR model
- Prediction of operating parameters for which the behavior of the RMP comes close to that of an ideal CSTR

Outlook

- Using different mixing sensitive reaction systems in the RMPs
- Study of two phase systems in the RMPs
- Integration into a reaction process

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[1] G. H. Grabow and N. D. Suong, Forschung im Ingenieurwesenvol. 58, no. 11-12, 1992, pp. 273–282.