Ansys

CASE STUDY /

Ansys + mRING

"Hydrodynamic cavitation is a process of generation, growth, and collapse of vapor cavities leading to intense localised shear and energy dissipation. Controlling and utilizing these localized harsh conditions has the potential to revolutionize emulsion formation on demand. It is, however, essential to develop high-fidelity computational models to accurately simulate the inception and extent of cavitation and their subsequent impact on droplet size distribution. We are using Ansys computational fluid dynamics (CFD) tools to achieve this. Simulation was essential in designing cavitation devices and optimizing operating parameters to produce liquid-liquid emulsions of desired drop size distribution."

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CASE STUDY

Developing a ‘Factory in a Box’ Platform for Personalised Emulsions

Personalized products are gaining significant attention in many sectors around the globe. Liquid-liquid emulsions are one of the key delivery platforms for such products. There is an urgent need to develop truly distributed and flexible manufacturing platforms that can deliver desired liquid-liquid emulsions on demand.

/ Challenges

Current bulk manufacturing technologies are slow in responding to changes, are capital-intensive, use unsustainable methods, and are not flexible in meeting personalized needs. While the emulsions are simple in concept and widely used in practice, obtaining desired droplet size distribution, which controls critical quality attributes (CQAs) of the formed emulsion, is still a significant challenge. Breakage of liquid droplets in turbulent flow is a complex process involving shear, stretching, surfactants, and interphase transport processes. In this work, we have harnessed novel hydrodynamic cavitation devices for producing liquid-liquid emulsions. We are using Ansys computational fluid dynamics (CFD) tools to gain insights into inception and extent of cavitation and subsequent droplet breakage processes to develop optimal designs and operating protocols.

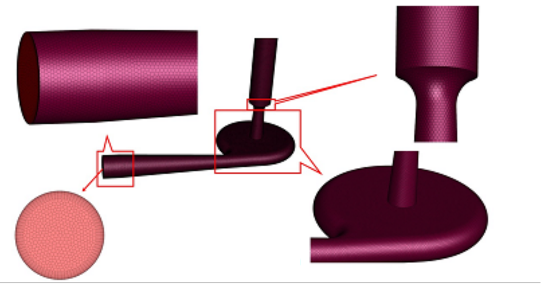


Figure A: Computational mesh

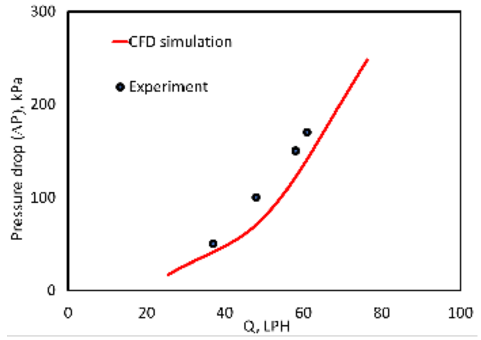


Figure B: Comparison of pressure drop with data

/ Engineering Solution

The complex flow behavior and droplet breakage were successfully simulated using the suite of Ansys CFD tools. Ansys products were used to generate high-quality mesh for simulating complex, recirculating, turbulent, multiphase flows with phase change (Figure 1). Appropriate turbulence and cavitation models were selected from the comprehensive library of models in-built with Ansys Fluent. The simulations were used first to compare macroscopic paramters like pressure drop with the experimental data (see Figure 2). Full transient simulations were needed to achieve accurate predictions (Figures 3 and 4). The validated computational model was then used to optimize the design of hydrodynamic cavitation devices and the overall process of producing emulsions on demand.

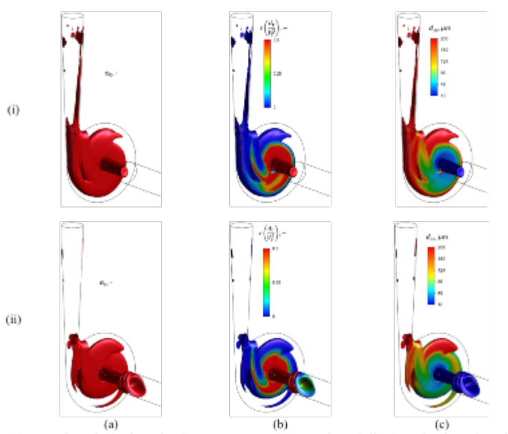


Figure C: Simulated flow field

/ Benefits

Ansys products were very useful for reducing the number of experiments required to achieve the desired drop size of the emulsions. The population balance models, different breakage kernels and a facility of user-designed functions available in Fluent were very helpful in simulating droplet breakage in complex cavitating flows. The insight gained via detailed knowledge of local energy dissipation rates, turbulent kinetic energy, and shear led to new ideas for improving the device design. The work has created a sound basis for the development of “Factory in a Box” platforms.

/ Company Description

Our group, mRING (Multiphase Reactors and Intensification Group) at the University of Limerick, use experiments, computational flow modeling, population balance models, and machine learning to obtain new insights in multiphase flows, multiphase reactors, and process intensification. The group is developing novel fluidic devices; modular, agile, intensified, and continuous (MAGIC) processes; soft sensors; and "factory in a box" platforms.

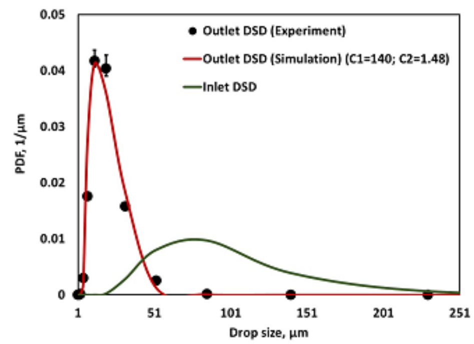
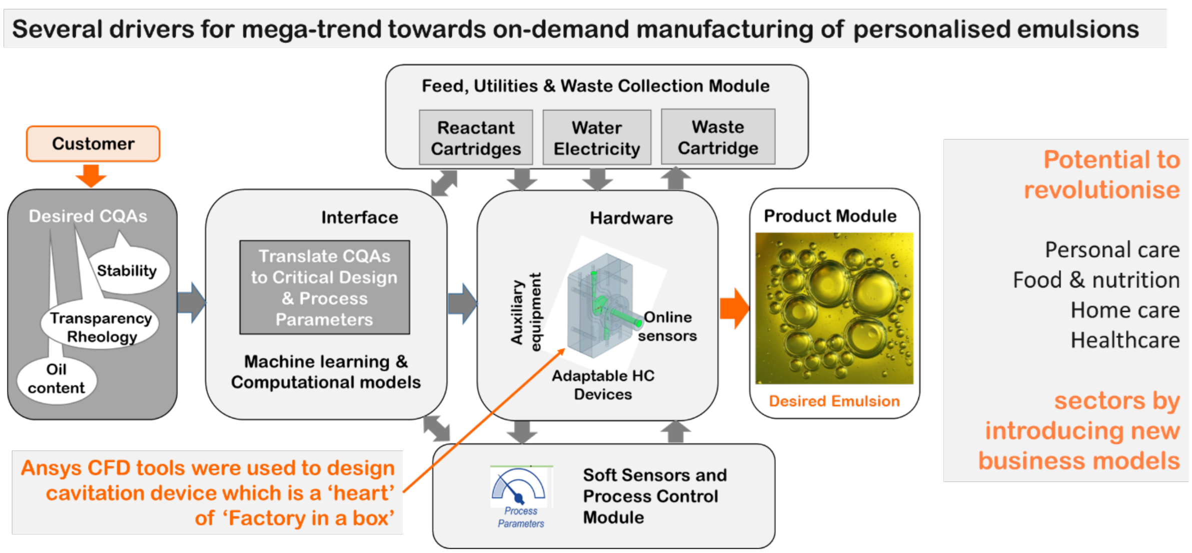


Figure D: Comparison of DSD with data

/ Ansys Products Used

- Ansys DesignModeler
- Ansys Meshing module
- Ansys Fluent
- Ansys CFD-POST



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