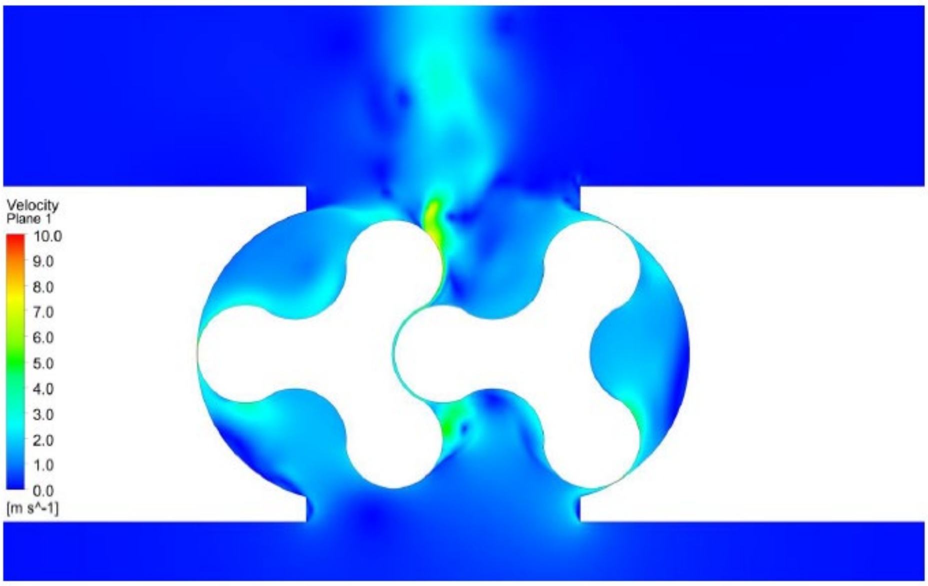
Experimental study of flow in a reversable positive displacement pump

With a growing share of intermittent renewable energy sources grid stability can be maintained, and flexibility enhanced, by applying pumped hydropower energy storage. ALPHEUS, is a EU-project where Chalmers is one of the partners [1-2].The goal of the project is to improve reversible pump/turbine (RPT) technology and adjacent civil structures needed to make pumped hydro storage economically viable in shallow seas and coastal environments with flat topography. One of the promising technologies considered is a so-called positive displacement RPT which is a fish friendly and seawater-robust, low cost technology. ALPHEUS plans stepwise development, starting by validating current assumptions in the lab and optimizing efficiency with numerical simulations. ALPHEUS is addressing environmental aspects, including fish friendliness, scenery and land use, juxtaposed with the ability of decentralized pumped hydro storage to stabilize the grid over a range of timescales and therefore allow higher penetration of intermittent renewable energy supplies. This will result in a methodology for assessing potential sites for pumped low-head and ultra-low head energy storage.

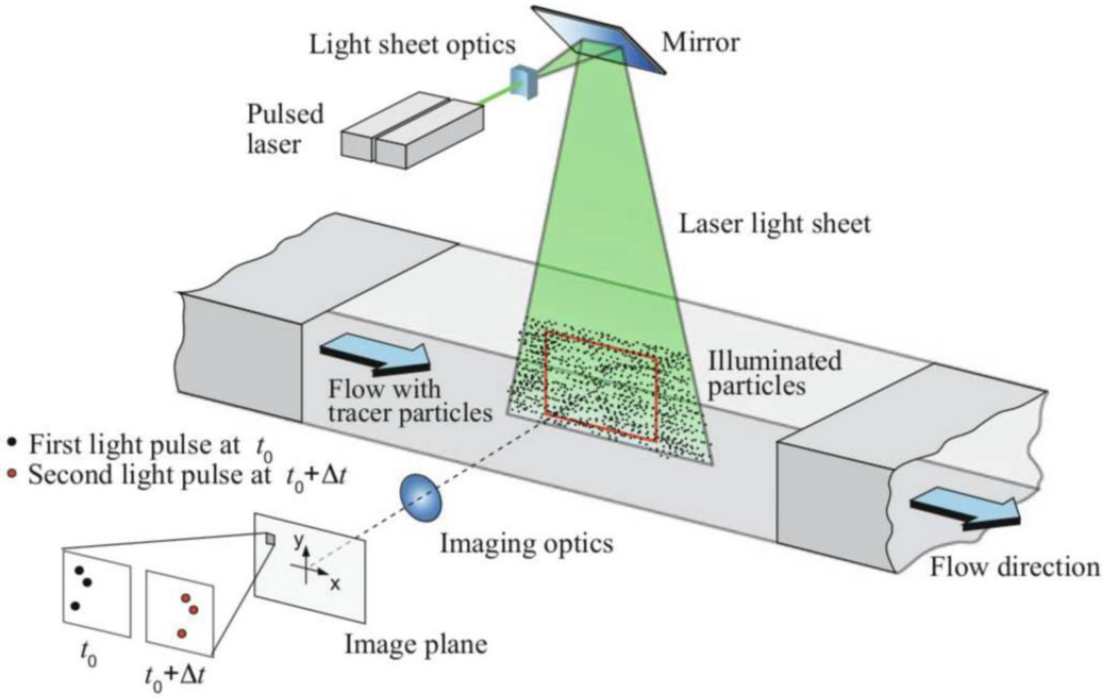
One of the sub-tasks of the ALPHEUS project dedicated to Chalmers is to perform measurements in a small-scale model of a positive displacement pump. The geometry of the positive displacement pump is shown in a figure below. The pump operates reversibly, either as a pump or turbine.



2D CFD simulations of flow in a positive displacement pump from an ALPHEUS partner report.

The model of the pump will be built according to the provided geometry. The students, with help from Chalmers personnel, will need to make the mechanical design of the test rig. The model will be made in transparent acrylic for maximum optical access. The test liquid will have the density and viscosity similar to that of water and refractive index similar to the acrylic. This will minimize the light reflections and distortions for Particle Image Velocimetry (PIV). PIV will be used to measure the flow velocity in the pump at several operating conditions.

PIV is currently the most popular and accurate non-intrusive optical fluid velocity measurement method. Figure below shows a schematic of a typical PIV experiment. Particles (seeding) are added to the fluid to visualise the flow. Two consecutive images with known time intervals are recorded. A laser is used to illuminate the flow. The displacement of the particles is evaluated by means of cross-correlation. The flow velocity vectors are evaluated from the displacement and the time interval. These calculations are performed in a dedicated PIV software and further post-processing is performed in Matlab.



Prerequisites for the thesis
Interest in hydro-pumps, fluid dynamics, construction, CAD, advanced optical methods, advanced analysis in PIV software and Matlab.

Examiner
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References
[1] https://www.gp.se/ekonomi/han-jobbar-f%C3%B6r-att-l%C3%B6sa-framtidens-energifr%C3%A5gor-1.25977327 .

[2] https://alpheus-h2020.eu/