WORKGROUP FOR MULTIPHAS FLOWS

Aerated stirred tanks

Grant number

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Project title

Experimental investigation and numerical calculation of a ventilated stirred vessel

Project leader

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Keywords

ventilated stirred vessel, Volume of Fluid, Bubble concentration, rotating flow

Short description of the project

The aim of this research project is the extension and adaption of an Euler/Lagrange method for the numerical calculation of the gas dispersion in a stirred vessel. Therefore a three dimensional calculation program for the prediction of the dispersion of solid particles in stirred vessels developped at this chair should be extended. The non-stationary flow around the stirrer is considered the so-called "multiple reference frame"-method in this approach. This includes the calculation of the turbulent fluid flow in the region of the stirrer using a rotating coordinate system whereas the almost stationary vessel flow is calculated using a stationary coordinate system. The coupling between both calculation areas is assured by appropriate boundary conditions. The Reynolds averaged conservation equations will be closed with the k-epsilon turbulence model at first. For the calculation of the gas pads behind the stirring blades the so-called "volume of fluid" (VOF)-method should be implemented. Therefore an additional conservation equation for the gas content has to be solved. The phase boundary will be reconstructed in that control volumes in which the local gas content lies between one and zero.

Using the Lagrangian approach the bubble phase will be simulated by tracking a multitude of bubbles on the flow field calculatec before. At the same time all relevant forces will be considered. Bubble coalescence and bubble breakup will be described based on stochastic models. Finally, it is necessary to describe the interaction between the bubbles and the gas pads as well as the formation of new bubbles out of the gas pads. For these phenomena no detailed investigations and modelling approaches describing the effects are available up to now. That's why it is necessary to develop these models in connection with detailed laboratory experiments in a stirred vessel. Besides, the measurements provide data for the validation of the numerical calculations.

A stirred vessel with a diameter of 400 mm is available for the experimental investigations. It is put in a rectangular external tank which is why the stirred vessel could be adapted in the refraction index using different fluids. With that the bending of the wall of the stirred vessel is invisible for optical measurement techniques. In the vessel dimethylsulfoxide, whose properties are similar tc those of water, should be used as fluid allowing to adjust turbulent Reynolds numbers without problems. In the external tank a tempered water glycerin mixture is used. The power input is controlled by a torque measuring shaft.

The shape of the gas pads behind the stirring blades and the interaction between the bubbles and the gas pads will be visualize by a laser light sheet method and high resoultion CCD cameras. For this reason the stirred vessel is optically accessible from th bottom, too. The bubble velocities, the bubble contours and the bubble sizes can be determined using a double pulse laser and evaluation program based on a particle tracking method developped at this chair. With that it is possible to determine the bubble properties in almost all regions of the stirred vessel. Extensions of the evaluation program are only necessary for the measurement of the bubble concentration. Besides, fluorescent tracer particles could be added for the determination of the fluid velocity. The velocities of both phases can be measured simultaneously using two CCD cameras with appropriate optical band pass filters.

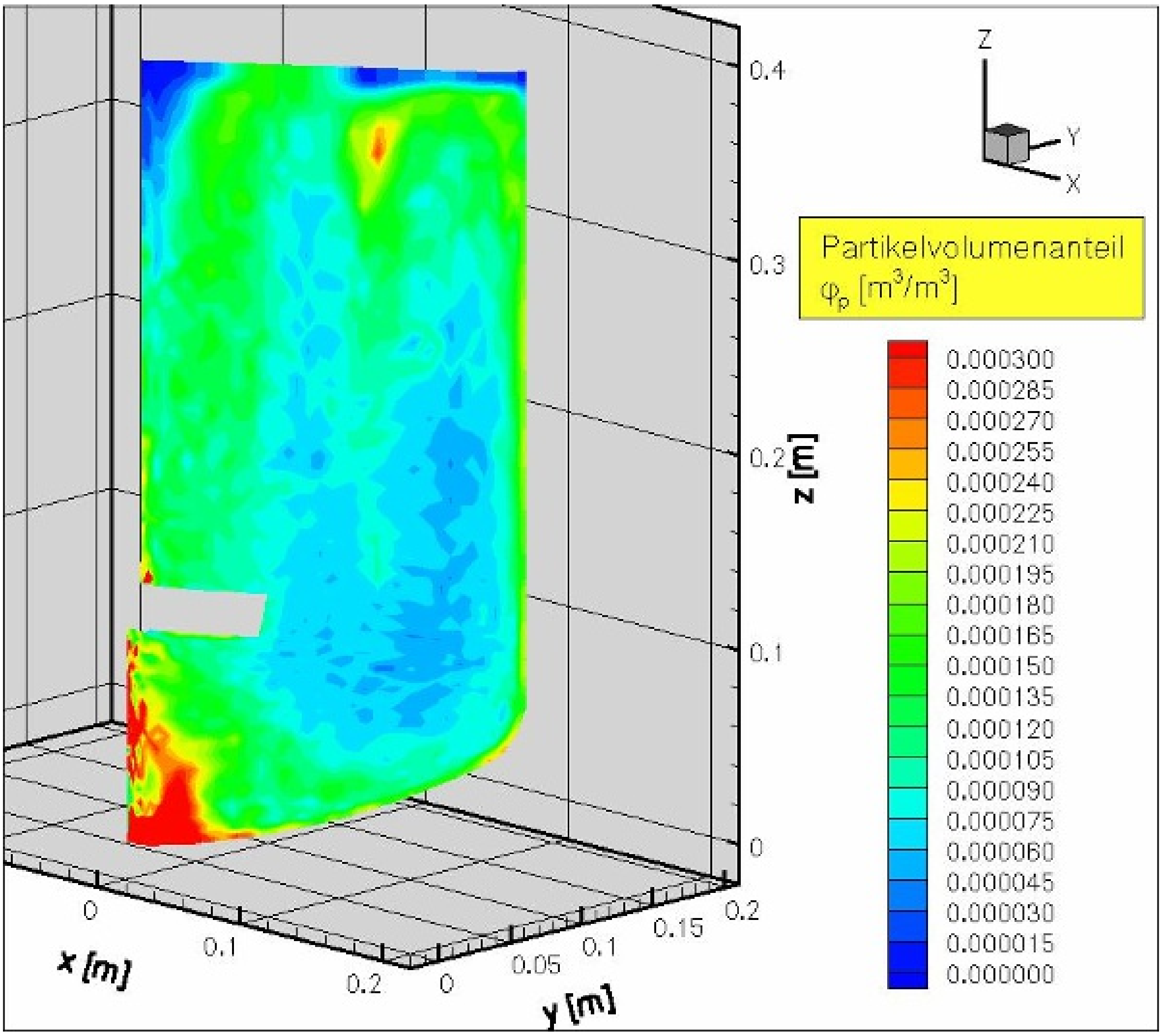

Photo: Diagram of a ventilated stirred vessel

After finishing the project the detailed numerical calculation of the dispersion of the gas inside a stirred vessel using an Euler/Lagrange method will be possible for the first time. This will exceed all now available programs that usually use a simple tv fluid model without consideration of the bubble size distribution for the aforementioned processes. Finally, medium-sized and sm enterprises can be much better supported in the reliable determination of the dispersion processes in stirred vessels using the proposed developments.