

Simulation of the Water-Diesel Separation Process in Hydrocyclones

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The separation of dispersed water droplets from diesel fuel is an important process in fuel conditioning because metal and halogen ions are water-soluble causing corrosion effects within combustion engines. For the water removal low-cost but high-efficiency separation apparatuses must be used in automotive applications. A hydrocyclone is an adequate separator which can be realised at small-scale dimensions. The power input for the separation process is provided by the fuel pump. For the prediction of the separation characteristics of this liquid-liquid separation process simultaneous droplet separation, droplet breakage and coalescence must be considered with respect to the separation efficiency. In order to calculate the shift in droplet size distributions population balances are applied. The kinetics of droplet interactions is dependent on the local flow conditions in the separation process. For the characterization of the separation behaviour one cannot use the classical grade efficiency curve calculated from droplet size distributions at the cyclone inflow, overflow and underflow but one has to use the so-called real droplet size distribution accounting for droplet-droplet interaction effects.

Small hydrocyclones of some centimeters in size were used to separate a system of water droplets dispersed in diesel fuel. The volume flow rates were taken to 0.1 m³/h and 0.2 m³/h with water droplet volume concentrations of 1% or less. The volume mean droplet size at the cyclone inlet was taken with 60 µm and 300 µm. The droplet size distributions at the cyclone inflow, underflow and overflow were measured by laser spectroscopy and show good agreement with simulation results.

These results indicate that a net reduction in droplet size distribution occurs at high cyclone volume flow rates and/or large droplet sizes of some hundred microns at the cyclone inlet. Droplet coalescence is dominating at low volume flow rates and/or small droplet diameters with some ten microns.

Geometric modifications of cyclone separators were dedicated to cyclones with a single and a double cone geometry and with one or two tangential cyclone inlets. The application of two cyclone inlets leads to reduced breakage rates compared to the cyclone geometry with only one inlet. The application of a cyclone geometry with double cone and a further reduction of velocity gradients in the inlet region lead to an improved separation efficiency caused by a decreased droplet breakage rate. Especially the simulation results show in detail whether droplet coalescence and breakage occur before or after the separation step in the centrifugal field so a specific design optimisation is possible.