# A fundamental understanding of drop breakup in emulsification devices brings new hope for lowering the energy cost of homogenization

**HANSSON A. (1), OLAD P. (1), INNINGS F. (1)**
1 Lund University, Lund, Sweden

*Objective*
Emulsification–via rotor-stator mixers (RMSs) or high-pressure homogenizers (HPHs)–is an important unit operation in the industrial production of many foods and beverages, e.g., milk and mayonnaise. These processes, however, suffer from high energy cost and low thermodynamic efficiency. A deeper understanding of drop breakup in these devices will lead the way to more efficiency designs. Previous investigations show breakup occurring due to turbulent stresses. Less is known about details of the role of turbulent eddies in food emulsion drop breakup. The aim of this study is to provide a detailed understanding of how turbulent eddies break emulsion drops in food emulsification by HPHs and RSMs.

*Methods*
Numerical breakup experiments (direct numerical simulations coupled to highly resolved interface tracking) are used to study individual drops subjected to either idealized turbulence (isotropic, homogenous) or the turbulence of a confined wall-interacting jet (resembling the turbulence in a RSM or HPH). Conditions are set to resemble breakup of a milk globule in a HPH. This method allows for an almost full characterization of morphology during deformation, as well of the stresses acting on the drop from turbulent eddies, with high spatial and temporal resolution.

*Results*
Drops show distinctively different breakup morphologies depending on their Weber number, i.e., large milk drops entering the homogenizers break from a different mechanism than the drops just large enough to break. The limiting drop (determining physical stability of the emulsion) breaks from a bulb-neck mechanism– turbulent eddies deform the drop until a neck forms separating two bulbs. Once the curvature of the neck exceeds that if the smallest bulb, the internal flow becomes destabilizing, leading to deterministic breakup. The sequence of interactions leading to this state is highly stochastic and requirea several individual drop-eddy interactions.

*Conclusions*
Due to a combination of numerical breakup experiments (this study) and high-speed visualizations (previous and ongoing studies), the mechanism of turbulent breakup in these commonly used food processing unit operations is now relatively well understood. Knowing where and how breakup takes place gives now opportunities for redesigning HPHs and RSMs so as to reduce the energy cost.