# Comparative Evaluation of S–γ Model and AMUSIG Model in Predicting Droplet Size Distributions in Narrow-Gap Homogenizers

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In the dynamic working field of emulsion processing, the accurate prediction of droplet size distribution is an important factor in enhancing and improving efficiency and product quality in various industries. This project resulted in a comparative analysis of the performance of two models, the S-γ model and the Adaptive Multiple Size Group (AMUSIG) model under various conditions by using STAR-CCM+ simulation software, allowing the provided analysis to methodically verify hypotheses, designs, and models in a controlled environment.

Field functions were analyzed across different operational conditions to enhance understanding of fluid dynamics and energy efficiency, important for system performance optimization. The cumulative volume fraction was examined against droplet diameter to better align model predictions with experimental data and gain insights into the breakup and coalescence parameters' effect on the model's droplet size performance. Additionally, a spatial comparison across system regions provided information about the model's feature set and its predictive accuracy for droplet behavior under varying parameter conditions, including a deeper investigation into flow dynamics' impact on droplet size.

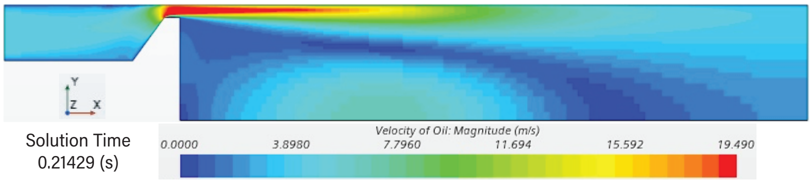

**Figure 1:** *Field function for Velocity of Oil: Magnitude (m/s).*

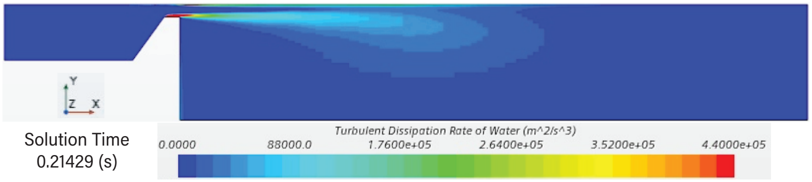

**Figure 2:** *Field function for Turbulent Dissipation Rate of Water (m^2/s^3).*

In field analysis, high-velocity profiles and turbulent dissipation rates confirmed model stability across high-shear and laminar flows (**Figures 1, 2**). As for Cumulative volume fraction analysis, by comparing models against experimental data, the S-γ exhibited a feature that is conservative for small droplets, while AMUSIG aligns better across sizes, particularly in the mid to larger ranges. While doing models tuning for breakup and coalescence rates, theoretical predictions showed that lower breakup rates and higher coalescence rates resulted in larger droplets and identified a critical point in parameter space indicating the dominance of coalescence, pivotal for creating larger droplets (**Figure 3**). Within the Analysis of Spatial Comparison, the S-γ model features in single peak performance provided stable scenarios where droplets predominantly coalesce and result in a uniform droplet size distribution characterized by a log-normal pattern (**Figure 4**). It was also observed that different conditions impact to the S-γ model droplet size, such as higher surface tension maintains moderate, uniform droplet sizes, lower flow rates resulted in larger droplets, and increased viscosity leads to smaller, more uniform droplets.

Refining the S-γ and AMUSIG models for broader industrial use, including advanced calibration and exploring parameters beyond viscosity, flow rate, and surface tension would be the next step to continue this work. Further research into breakup and coalescence rates will deepen understanding, leading to a comprehensive hybrid model with both models' advantages, which can be used to enhance emulsion process efficiency and a wide range of applications.

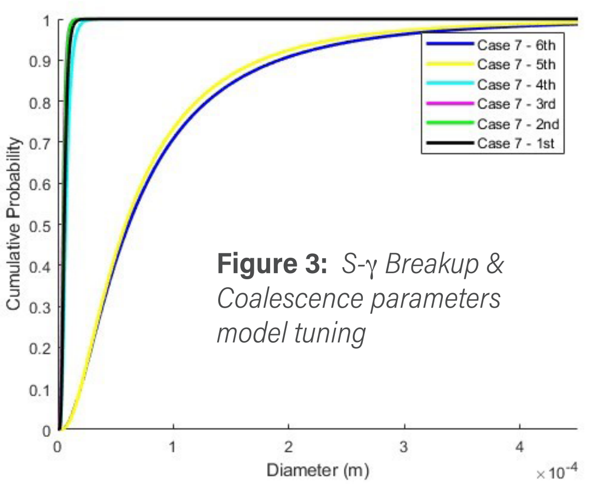

**Figure 3:** *S-γ Breakup & Coalescence parameters model tuning*

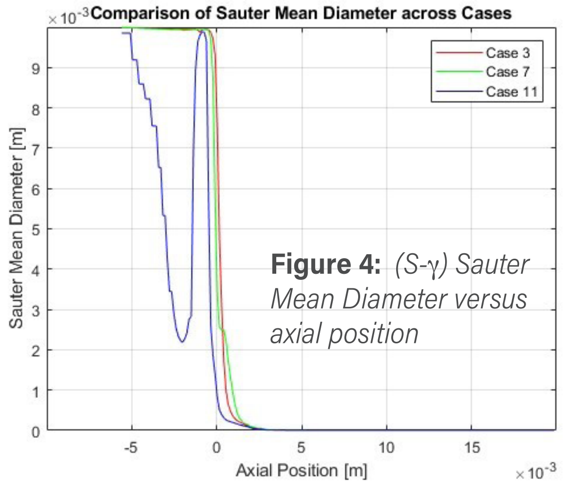

**Figure 4:** *(S-γ) Sauter Mean Diameter versus axial position*