# A cascade atomization and drop breakup model in STAR-CD

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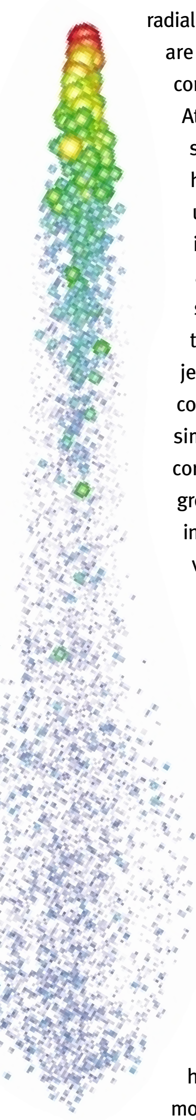
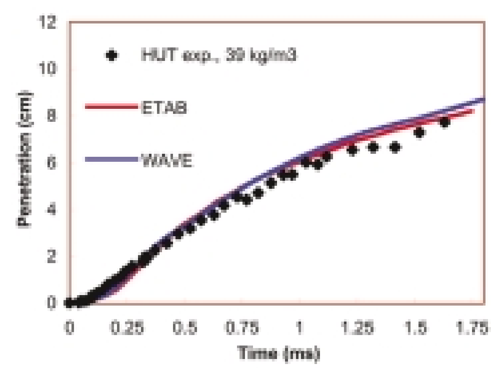
The breakup of liquid fuel jets in diesel combustion engines plays a decisive role in the evolution of the spray and its subsequent processes; it has a direct influence on an efficient and clean engine operation. Recent investigations conducted by various researchers, utilizing different experimental techniques, show that transient, high-pressure-driven fuel jets are broken into liquid fragments of various shapes and sizes at the time they exit the injector nozzle or shortly thereafter. Subsequently, these liquid fragments are subject to aerodynamic forces, which lead to further breakups until the droplets reach a stable state. The fundamental mechanisms responsible for the aerodynamic breakup are either the Rayleigh-Taylor or Kelvin-Helmholtz instability on the liquid/gas interface.

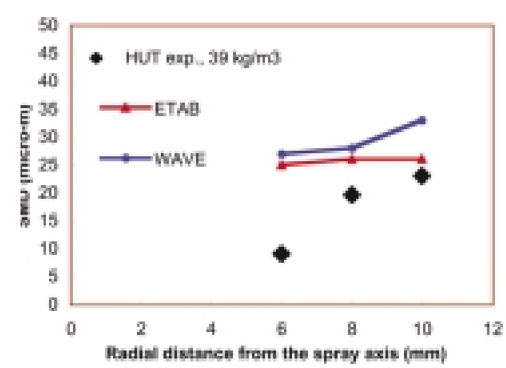
The Enhanced Taylor Analogy Breakup (ETAB) model simulates this liquid jet disintegration process as a cascade of drop breakups. The breakup criterion is determined by Taylor's linear drop deformation dynamics and the associated drop breakup condition. Breakup occurs when the normalized drop distortion exceeds a critical value. The breakup into product droplets is modeled after the experimentally observed bag or stripping breakup mechanisms and the radial velocities of the product droplets are derived from an energy conservation consideration.



At the nozzle exit, the liquid jet is simulated as a sequence of large, high velocity drops which are very unstable. In order to avoid an immediate breakup, they are assigned a deformation velocity such that their lifetime is extended to match experimentally observed jet breakup lengths. This computational artifice leads to the simulation of a fragmented liquid core, as reported by various research groups. An additional benefit of this initial breakup delay is the radial velocity of the product droplets at first breakup, which results in an automatic adjustment of the spray cone angle to changes in the gas density. On the other hand, the model requires an initial drop size distribution in order to compensate for the neglect of the surface stripping near the nozzle exit. This phenomenon determines the fuel-air mixing near the nozzle exit, and has a strong influence on the ignition location. The performance of the ETAB model has been compared with the WAVE model, as implemented in STAR-CD, and with measurements obtained under controlled conditions from a constant volume bomb. The simulations showed good overall agreement with experimental data, especially the drop sizes were well predicted. In addition, the amount of model tuning for a particular injection condition is considerably reduced due to the automatic adjustment of the spray cone angle to the changes in the gas density.




*Spray penetrations for the ETAB and WAVE computations compared with experimental data*




*Drop sizes expressed as Sauter mean diameter (SMD) for the ETAB and WAVE computations compared with experimental data*