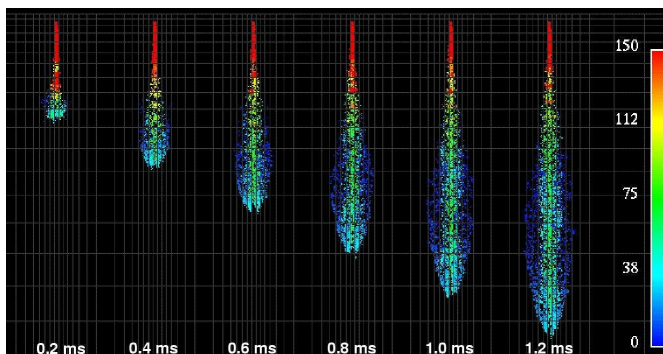


# COMPUTATIONAL ENGINE RESEARCH

Franz X. Tanner

Environmental concerns, health issues and the limited resources of fossil fuels are the main driving forces behind today's engine research. The objectives of this research include the understanding and description of the flow, spray and combustion processes in order to determine their influence on fuel efficiency, power output and pollution formation. One of the most expedient and economic ways to achieve these goals is by means of computer simulations.



*Evolution of a nonevaporating spray. The color scale represents the particle diameters in  $\mu\text{m}$ .*

Dr. Franz X. Tanner's engine research focuses on the development and implementation of new models and numerical techniques to create a versatile computational tool which can be used in the design of cleaner and more efficient engines. The backbone for the realization of this goal is the open source code *KIVA- $\beta$* , originally developed at Los Alamos National Laboratory, which serves as the main modeling platform. Dr. Tanner conducts his research in collaboration with other research groups at universities and research institutes, as well as with partners and sponsors from industry.

Dr. Tanner has developed and validated many new models and solution methods which include the Cascade Atomization and Drop Breakup (CAB) model and the Least-Square-Fitted Ignition Transport (LIT) model. Due to its reliable performance in many engine simulations, the CAB model has been implemented into the widely-used commercial code STAR-CD in a collaborative effort with the Technical Research Center (VTT Energy) of Finland. Dr. Tanner's turbulence scaling studies of the spray-induced in-cylinder flow in diesel engines, conducted in collaboration with the Engine Research Center of the University of Wisconsin-Madison, have motivated the development of a non-equilibrium turbulence dissipation rate correction, which in turn has resulted in improved predictions of the combustion behavior in diesel engines.

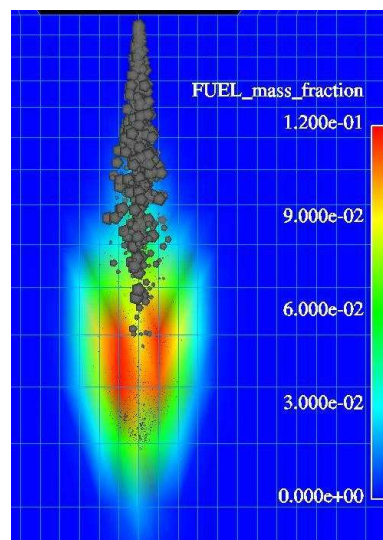
These model developments, together with implementations of emission, combustion and turbulence models from the literature, have produced a powerful and efficient research code for investigating engine in-cylinder processes. This code has been tested in various research projects of

*In collaboration with Argonne National Laboratory, Dr. Tanner's spray simulations have led to the award Best Presented Paper of the Joint CIMAC/ASME World Congress 2004 in Kyoto, Japan.*

large marine diesel engines for the engine manufacturer Wartsila Ltd. These studies have made a significant contribution in the design of new and improved fuel injection systems such as a nozzle arrangement which avoids undesired spray interactions, a water injection strategy to reduce nitric oxide pollutants, and the development of a common rail injection system.

Currently, Dr. Tanner supervises two Ph.D. projects within the CSERI. One project, conducted in collaboration with the Combustion Engine Laboratory of Helsinki University of Technology, deals with the computationally problematic coupling of the liquid and gas phases. The improved methodology which has been implemented within the scope of this project has led to significantly less mesh dependence and has improved the accuracy and stability of the computations. In the other project, a conjugate gradient method has been employed which allows the fully automated search for optimal engine operating conditions with respect to low emissions and high fuel efficiency. This approach has proved to be computationally very efficient in comparison with the more popular optimization methods used in this context.

In a collaborative effort with the Center for Transportation Research at Argonne National Laboratory, Dr. Tanner uses computer simulations to provide insight into the interpretation of data obtained from X-ray measurements. This research has been awarded Best Presented Paper of the Joint CIMAC/ASME World Congress 2004 in Kyoto, Japan.



*Fuel mass fraction of an evaporating spray.*

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