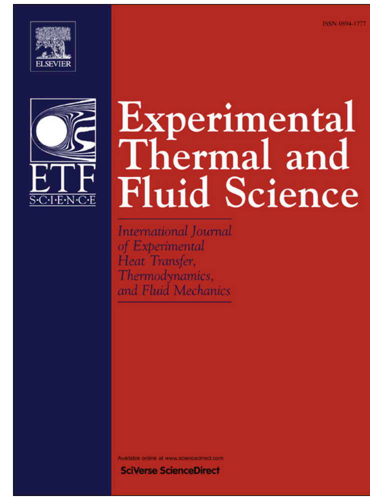
Accepted Manuscript



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PII: S0894-1777(14)00134-4
DOI: http://dx.doi.org/10.1016/j.expthermflusci.2014.05.013
Reference: ETF 8229

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 18 August 2013
Revised Date: 11 May 2014
Accepted Date: 23 May 2014

Please cite this article as: H. Ma, X. Wu, F. Feng, D. Wang, C. Yang, C. Zhuo, An Experimental Study on Fuel Spray-induced Vortex-Like Structures, *Experimental Thermal and Fluid Science* (2014), doi: http://dx.doi.org/10.1016/j.expthermflusci.2014.05.013

An Experimental Study on Fuel Spray-induced Vortex-Like Structures

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Abstract: The properties of spray-induced vortex-like structures for asymmetric pressure swirl atomizer were studied experimentally with different injection pressures. The high-speed Particle Imaging Velocimetry (PIV) was used to study the spray characteristics such as velocity and vorticity. The vortex centers were identified by velocity weighted vorticity. The translational velocity components of vortex centers were computed from its displacement divided by the time interval. For five different pressure conditions, the motion trajectories of vortex center were the same in an earlier period of spray, but were different in a later period of spray. The normalized translational velocity of vortex center and normalized time were introduced to compare with vortex ring model. The results indicated that the normalized axial translational velocity decreased with increasing normalized time, which converged to the predictions of the model in long time limit where α= -0.75 in the turbulent case. However, the results for the normalized radial translational velocity were different from the predictions of the model. The normalized radial translational velocity decreased with the increase of the normalized time when the injection pressure was lower than a critical value, but it obviously increased with the increase of the normalized time in case of the injection pressure higher than the critical value. Furthermore, the average vorticities at the vortex center were obtained and increased with the increase of the injection pressure. This study provides references for developing spray theory and improving injection technology.

Key words: Swirl atomizer, PIV, Spray, Vortex, Vorticity

Nomenclature

A constant in the approximation of $V_z = At^{\alpha}$

B constant in the approximation of $\Omega_{ave} = B - C * D^P$

C constant in the approximation of $\Omega_{ave} = B - C * D^P$

D constant in the approximation of $\Omega_{ave} = B - C * D^P$

D_0 diameter of injection hole

$e_{\max}$ maximum location error of vortex center

$e_{velocity}$ error of translational velocity of vortex center

l_{Pix} length of a pix

P dimensionless pressure

P_{inj} injection pressure

P_{amb} ambient pressure

t_{init} the time at which vortex was first observed

$t_{lasting}$ the lasting time of vortex

z_v the distance of vortex center from r-axial

$U(x, y)$ x directional velocity component at (x, y)

V_r radial translational velocity of vortex center

$\overline{V}_r$ non-dimensional radial translational velocity of vortex center

V_z axial translational velocity of vortex center

$\overline{V}_Z$ non-dimensional axial translational velocity of vortex center

$V(x, y)$ y directional velocity component at (x, y)

α the power of time functions

φ angle between the z-axis and diagonal line

ν kinematic viscosity

Ω_{time_ave} time-average vorticity at vortex center

Ω_{ave} average vorticity at vortex center

$\Omega(t)$ the vorticity of vortex center at time t