

Southwest Mechanics Lecture Series

SEMINAR



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Baltimore, MD 21218

Friday, April 1, 2011
3:00 p.m. - 4:00 p.m.
Huitt-Zollars Pavillion

“THE IMPACT OF SMALL SCALE EDDIES GENERATED BY ROUGHNESS ELEMENTS ON THE CHARACTERISTICS OF TURBULENCE IN A ROUGH WALL BOUNDARY LAYER”

ABSTRACT:

The presentation focuses primarily on measurements of flow structure and turbulence in the inner part of a turbulent channel flow over a rough wall. To resolve the flow near and between the pyramidal roughness elements, the experiments have been conducted in an optically index matched facility, in which the refractive index of the acrylic wall is matched with that of the liquid. High-resolution planar PIV measurements provide the mean flow and turbulence statistics, and digital holographic microscopy (DHM) resolves the characteristic 3D flow structures. Results show that the turbulence production and dissipation rates peak at the top of the roughness elements, and that the roughness-induced spatial variations in mean flow and turbulence parameters are confined to 2 roughness heights (k) above the peak of the roughness elements. The spatial turbulent energy and shear spectra show an increasing contribution of large-scale motions, and diminishing role of small ones with increasing distance from the wall. However, the outer layer spectra still have distinct bumps in wavenumbers corresponding to $1-3k$, or $15-30$ times the Kolmogorov scales. Instantaneous realizations show that these roughness-scale eddies are generated near the wall, and lifted up rapidly by large scale structures that populate the outer-layer. The latter share some common features with hairpin packets, and appear as inclined quasi-streamwise vortices in the 3D data. This process floods the outer-layer with an excessive number of “roughness-scale” eddies. Consequently, although the imprints of roughness diminish in outer-layer Reynolds stress statistics, in agreement with the wall similarity hypothesis, the transported roughness scale eddies dominate the subgrid energy flux and significantly affect the dissipation rate at all elevations. The presentation will conclude with other examples of other measurements made possible in the optically index-matched facility, such as the flow structure and turbulence within tip leakage vortices of axial turbomachines.

BIO:

JOSEPH KATZ, the William F. Ward Sr. Distinguished Professor, completed his undergraduate studies at Tel Aviv University and his graduate studies at Caltech. Dr. Katz joined Johns Hopkins in 1988 where he manages the Laboratory for Experimental Fluid Dynamics and is technical editor of the Journal for Fluids Engineering. Dr. Katz’s research extends over a wide range of fields, with a common theme involving experimental fluid mechanics and development of advanced diagnostics techniques, including Particle Image Velocimetry (PIV) and holography. Other research interests include cavitation phenomena, multiphase flows, complex flow structure and turbulence within turbomachines, and flow structure and turbulence in the bottom boundary layer of the coastal ocean. Dr. Katz has also developed porous lubricated nozzles and mixing tubes for preventing wear in abrasive water jets used for cutting, and is president of Lubrijet, Inc. Lubrijet is start-up company pursuing commercialization of this innovative, cost-cutting technology. Dr. Katz is widely published and received the 2004 Fluids Engineering Award for the American Society of Mechanical Engineers, which recognized outstanding contributions over a period of years to the engineering profession and, in particular, to the field of fluids engineering through research, practice or teaching.