MECHANICAL ENGINEERING SEMINAR

Monday, August 5 2024 at 14:30, D. Dan and Betty Kahn Building, Room 217

Online: https://technion.zoom.us/j/99950258562

Transient Phenomena in Fluid Mechanics

Omri Ram
Assistant Professor of Mechanical Engineering
Technion – Israel Institute of Technology
Email: omri.ram@technion.ac.il ; Website: www.tfmltechnion.com

Hosted by: Prof. Wolf Alon

The Transient Fluid Mechanics Laboratory was established three years ago with the goal of studying complex transient phenomena in fluid mechanics. Our primary focus has been to explore intricate fluid dynamics using cutting-edge experimental techniques and advanced data processing methods. This presentation will highlight key achievements and ongoing research projects that reflect our lab's growing capabilities and contributions.

First, I will show how we have experimentally captured detailed transient flow fields around rising spheres, providing insight into the turbulence and vortical structures in the sphere's wake. We did so through the implementation of tomographic Particle Tracking Velocimetry (PTV) using Shake-the-Box particle tracking and refractive index-matched techniques to measure the flow around freely rising light spheres in quiescent fluid. In the future, we aim to relate transient loading caused by vortex shedding to the oscillatory motion of the spheres to yield a comprehensive understanding of the flow behavior associated with buoyancy-driven objects. Additionally, we have performed time-resolved PIV studies in round pipes with sudden cross-sectional area changes, adding acrylic spheres to the pipe flow to study their motion in accelerating/decelerating flow fields. Our use of fluorescent tracers has been key to refining and improving the accuracy of particle tracking and flow characterization.

In the second part, I will show another central project in the lab that focuses on the evolution of propagating shock waves as they traverse through area changes into conduits with larger cross-sections. We constructed a unique shock tube that enables us to track shock propagation in conduits for longer timescales than had been done before and used it to examine the diffraction processes and downstream evolution of normal shock waves as they move across gradual and step expansions. By following the shock wave evolution as it diffracts, reflects off the walls of the expanded conduit, and eventually builds up to a new, weaker normal shock wave, we have gained a better understanding of the complex shock reflection patterns and pressure fluctuations generated during these interactions. We were able to combine these measurements with numerical simulations and reduced order models to identify the governing mechanism that leads to the formation of a uniform shock front far downstream from an abrupt area expansion. Additionally, we have developed a new empirical relation for predicting the shock velocity far downstream of the expansion for both gradual and abrupt step expansion. This constitutive model depends only on the inlet shock Mach number, the expansion ratio, and an empirical geometry-dependent coefficient. In addition to improving our fundamental understanding of shock dynamics, these findings have substantial implications for various engineering applications where shock waves are involved.

The current research topics in our lab cover a wide range of studies on transient flow phenomena in fluids. These include rapid phase change in cavitation and boiling, shock wave propagation in complex geometries, and fluid-structure interactions. These studies all focus on measuring highly transient phenomena occurring in fluids that are characterized by high accelerations and induced forces. Our goal is to further our fundamental understanding of such problems and explore new ways to study more complex problems with significant implications in industrial processes. We are excited to continue our efforts to expand the boundaries of experimental fluid mechanics research and contribute to solving real-world challenges faced by energy and flow engineers.

Seminars Coordinator: Assoc. Prof. Shmuel Gal.