VILLANOVA UNIVERSITY

MECHANICAL ENGINEERING DEPARTMENT

Fall 2019 SEMINAR SERIES

Seminar Date: October 4th, 2019

Lecture: Synthetic Jets Fundamentals in heat transfer enhancement and flow control

Speaker: Dr. Luis Silva-Llanca, Research Associate
Department of Mechanical Engineering, University of La Serena, Chile

Abstract:
The periodic ejection and injection of fluid from and to an orifice or channel—under the right conditions—synthesizes a coherent flow that resembles a jet. In the last decade, these so called "Synthetic Jets" gained attention in the electronic cooling community as a thermal management solution by impinging them onto heated surfaces. At small scale and confined geometries, they can be optimized to remove heat more efficiently than conventional steady jets. The fluctuating forcing of fluid generates a train of counter-rotating vortex pairs that sustain the outwardly advecting cooling flow that reaches the wall, leading to a complex surface vortex interaction, which is key to understanding the jet's fundamental convective heat transfer mechanisms: (1) When the primary vortex advects in a direction parallel to the target surface it gives rise to a secondary vortex with opposite rotation. (2) The secondary vortex is largely responsible for the heat transfer enhancement within the wall jet region. (3) Under certain conditions, vortex coalescence occurs, leading to the degradation in the heat transfer due to the reduction in the number of secondary vortices interacting with the heated surface. Understanding, quantifying and predicting the mechanisms that drive the vortex merging phenomenon, can help optimize the Synthetic Jets operation. When a pair of adjacent Synthetic Jets interact, the resulting fluid dynamics vectorizes the combined flow, meaning that the flow tilts at angles depending on the actuating conditions. Vectoring more strongly manifests when the jets operate with some delay between each other (phase-shifted). They appear as a promising technique when the heat transfer requires flow directionality, e.g. a hot spot whose location over a heated surface varies over time. Synthetic Jets can also be combined with other main flows, such as Data Center tile flow, to control the angle at which the cooling air emanates from the perforated tiles. This way we propose directing the air toward areas with higher cooling demand. By using the overall Exergy Destruction as a metric to quantify inefficiencies, we found that vectoring can improve the delivery of cold air into the servers.

VILLANOVA UNIVERSITY

MECHANICAL ENGINEERING DEPARTMENT

Fall 2019 SEMINAR SERIES

Biography:

Luis Silva Llanca obtained his BS and Master's degree in Mechanical Engineering in December 2006 at the Universidad de Santiago de Chile (USACH). During this time, he utilized a Finite Volume Method formulation to study the fluid mechanics and heat transfer in problems involving non Newtonian fluids with phase change. In November 2012 he graduated from his Ph.D. in Mechanical Engineering at Villanova University. His dissertation focused on the fundamental behavior of Synthetic Jets, which led to three journal publications and five presentations at electronic cooling-oriented conferences (InterPACK, Itherm).

In January 2013, he began his two year post-doctoral work at Villanova University. During this time, he worked in a National Science Foundation funded project related to energy efficiency in Data Centers. In the first year, he developed a numerical tool that locates and quantifies energy inefficiencies in the delivery of cooling air into the servers. He expanded this work into his second year, by studying the transient phenomena in localized cooling, particularly overhead coolers.

In November 2014, Luis was granted a CONICYT Chile project through a program intended to stimulate the return of Chilean researchers to the country. The two-year project was executed at the Universidad de La Serena in Chile beginning in April 2015. This effort led to a Master's dissertation and two journal papers. In November 2016 he was granted a three-year CONICYT-FONDECYT Initiation in Research project, which is currently under execution.

Luis was hired as a full-time Research Associate by the Universidad de La Serena in April 2017. During this time, he actively participated in the development of a Ph.D. program in Energy, Water and Environment. The program began in April 2018, and Luis is currently its Associate Director. Luis has published nine papers in top-tier scientific journals related to Thermal Efficiency in Data Centers and Synthetic Jets.

Host: Prof. Alfonso Ortega