Announcing the Final Examination of Jahed Hossain for the degree of Doctor of Philosophy

Time & Location: October 27, 2016 at 12:00 PM in Engineering II 202A
Title: Fundamental Understanding of Interactions Among Flow, Turbulence and Heat Transfer in Jet Impingement Cooling

The flow physics of impinging jet is very complex and is not fully understood yet. Since impingement cooling itself is a broad topic, effort is being made in the current study to narrow down on three particular geometric configurations (a narrow wall configuration, an array impingement configuration and a curved surface impingement configuration) that appears in a typical gas turbine impingement problem in relation to heat transfer. Impingement problems are difficult to simulate numerically using conventional RANS models. It is worth noting that the typical RANS model contains a number of calibrated constants and these have been formulated with respect to relatively simple shear flows. As a result, typically these isotropic eddy viscosity models fail in predicting the correct heat transfer value and trend in impingement problems where the flow is highly anisotropic. The common RANS-based models over predict stagnation heat transfer coefficients by as much as 300% when compared to measured values. Even the best of the models, the $\nu^2$-$f$ model, can be inaccurate by up to 30%.

In the open literature there is not enough study where experimental heat transfer and flow physics data are combined to explain the behavior of gas turbine impingement cooling application. The problem is further exacerbated for array of impingement jets where the flow is much more complex than a single round jet. Despite the myriad number of experimental and numerical work published on single jet impingement; the knowledge gathered from these works cannot be applied to real engineering impingement cooling applications as the dynamics of flow changes completely.

The main objective of the current study is to provide a better understanding of impingement heat transfer in relation to flow physics associated with it. This work emphasizes the importance of understanding mean velocities, turbulence, jet shear layer instability and its importance in heat transfer application. The present work shows detailed information of flow phenomena using Particle Image Velocimetry (PIV) in a single row narrow impingement channel. Then the results from the RANS and LES simulations were compared with the Particle Image Velocimetry (PIV) data. The accuracy of LES in predicting the flow field and heat transfer of an impingement problem is also presented in the current work and validated against experimental flow field measured through PIV.

“I am an old man now, and when I die and go to heaven there are two matters on which I hope for enlightenment. One is quantum electrodynamics, and the other is the turbulent motion of fluids. And about the former I am rather optimistic.” (Scienceworld). This is a quote from the famous mathematician Horace Lamb (1849-1934), who candidly expressed the level of difficulty associated with the understanding of turbulence in fluid mechanics. Turbulence is one of the most difficult problems to solve, thus studies such as this where the experimental heat transfer and flow physics data are combined to explain the behavior of gas turbine impingement cooling applications may bring us a little closer to understand the turbulent motion of fluids.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2008, Bangladesh University of Engineering & Technology
Master's of Mechanical Engineering, MS, 2011, University of North Carolina at Charlotte

Committee in Charge:
Jayanta Kapat, Chair, Mechanical Engineering
Kareem Ahmed, Mechanical Engineering
Ali Gordon, Mechanical Engineering
Paul Wiegand, Institute for Simulation & Training

Approved for distribution by Jayanta Kapat, Committee Chair, on October 11, 2016.
The public is welcome to attend.