Film cooling is a technology used in the field of turbomachinery, such as for example land based power generation and aircraft engines, which serves to provide a safe thermal condition in key hot hardware components. Due to the turbulence present in the flow-field, these film cooling jets emanate into a crossflow environment in such a way that is very challenging for computational fluid dynamics to predict. One impact of such is significant uncertainty for those in industry when conducting both aerodynamic and thermal designs.

This study presents both new and high-fidelity numerical approaches on film cooling flow-fields, which are underpinned by experimental measurements on corresponding geometrical specimen and testing conditions. Extensive taxonomy and modifications are given to eddy viscosity-based turbulence models, and their available constituent components, which will directly benefit those in industry designing hardware. Additionally, unique models are presented which have previously not been evaluated on similar industrial or canonical flow configurations. These models account for the anisotropic state of the turbulence from the turbulent dissipation rate equation and prove viable in naturally mitigating some of the typical sources of error to be expected in eddy-viscosity models. Additionally, large eddy simulation study is conducted for thorough comparisons of such models, and as well to purport ideas of an uncertainty parameter which can be useful when understanding failures of typical turbulence models in such flow-fields.

Lastly, these assertions regarding turbulence modeling are complemented with a machine learning algorithm focused on predicting the anisotropic nature of the turbulence. The algorithm is trained on combinations of data from six high quality simulations, whereby making successful predictions on a film cooling flow-field. From this evidence that machine learning can predict the turbulence anisotropy in this class of flow-fields, such turbulence models presented can be sensitized and improved with this new formulation.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2013, University of Central Florida
Master's of Mechanical Engineering, MS, 2015, University of Central Florida

Committee in Charge:
Jayanta Kapat, Chair, Department of Mechanical and Aerospace Engineering
Paul Wiegand, Natural Computation & Coadaptive Systems Lab Advanced Research Computing Center
Ranajay Ghosh, College of Mechanical and Aerospace Engineering
Samik Bhattacharya, College of Mechanical and Aerospace Engineering

Approved for distribution by Jayanta Kapat, Committee Chair, on February 5, 2020.

The public is welcome to attend.