

**Department of Mechanical and Aeronautical Engineering
Western Michigan University
MAE Seminar Presentation**

**“Numerical Investigation of Plasma-Based Flow
Control Strategies for Transitional Highly
Loaded Low-Pressure Turbine Blades”**

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Room D-201 Parkview Campus, WMU**

Abstract:

Low-pressure turbines are commonly utilized as the propulsion systems of unmanned air vehicles, which are employed for reconnaissance and combat purposes. Due to a reduction in atmospheric density during high-altitude cruise, such low-pressure turbines may encounter Reynolds numbers, based upon blade axial chord and inlet conditions that are below 25,000. In this situation, the laminar boundary layers which form on the blade surfaces are particularly susceptible to separation. This results in blockage of the flow passages, transition to turbulence, wake total pressure losses, and a decrease of turbine efficiency. The present simulations explore the use of asymmetric dielectric-barrier-discharge plasma-based flow control actuators to mitigate separation, thereby decreasing wake losses and increasing turbine efficiency. Various aspects of control strategies for an isolated turbine blade are investigated, including the magnitude of the plasma force required for control, both continuous and pulsed actuation, the control direction, the forcing frequency and duty cycle for pulsing cases, the location of actuation relative to separation, and the use of multiple arrangements of actuators. These strategies were studied by obtaining solutions to the time-dependent three-dimensional compressible Navier-Stokes equations, which were augmented by a phenomenological model that was used to represent plasma-induced body forces imparted by the actuator on the fluid. The numerical method utilized a high-order time-implicit finite-difference scheme, employing domain decomposition to carry out calculations on a parallel computing platform. A high-order overset grid approach was used to describe the turbine blade flowfield, and preserve spatial accuracy in a locally refined embedded mesh region. Details of the numerical method will be presented, along with results for the simulation of 19 individual cases. Features of the flowfields will be described, characteristics of the control mechanisms elucidated, and resultant solutions compared with each other, and with the baseline case where no control was enforced.