The effects of an industrial gas turbine's Exhaust Collector Box (ECB) geometry on static pressure recovery and total pressure loss were investigated in this study experimentally and computationally. This study aims to further understand how exit boundary conditions affect the performance of a diffuser system as well as the accuracy of industry standard computational models. A design of experiments approach was taken using a Box-Behnken design method for investigating three geometric parameters of the ECB. In this investigation, the exhaust diffuser remained constant through each test, with only the ECB being varied. A system performance analysis was conducted for each geometry using the total pressure loss and static pressure recovery from the diffuser inlet to the ECB exit. Velocity and total pressure profiles obtained with a hotwire anemometer and Kiel probe at the exit of the diffuser and at the exit of the ECB are also presented in this study. A total of 13 different ECB geometries are investigated at a Reynolds number of 60,000. Results obtained from these experimental tests are used to investigate the accuracy of a 3-dimensional RANS with realizable k-ε turbulence model from the commercial software package Star-CCM+. The study confirms the existence of strong counter-rotating helical vortices within the ECB which significantly affect the flow within the diffuser. Evidence of a strong recirculation zone within the ECB was found to force separation within the exhaust diffuser which imposed a circumferentially asymmetric pressure field at the inlet of the diffuser. Increasing the ECB width proved to decrease the magnitude of this effect, increasing the diffuser protrusion reduced this effect to a lesser degree. The combined effect of increasing the ECB Length and Width increased the expansion area ratio, proving to increase the system pressure recovery by as much as 19% over the nominal case. Additionally, the realizable k-ε turbulence model was able to accurately rank all 13 cases in order by performance; however the predicted magnitudes of the pressure recovery and total pressure loss were poor for the cases with strong vortices. For the large volume cases with weak vortices, the CFD was able to accurately represent the total pressure loss of the system within 5%.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Science in Aerospace Engineering, BS, 2010, University of Central Florida

Committee in Charge:
Dr. Jayanta Kapat, Chair, MMAE
Dr. Seetha Raghavan, MMAE
Dr. Weiwei Deng, MMAE

Approved for distribution by Dr. Jayanta Kapat, Committee Chair, on March 14, 2012.

The public is welcome to attend.