Impact of a Collector Box on the Pressure Recovery of an Exhaust Diffuser System

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. This study aims to further understand how exit boundary conditions affect the performance of a diffuser system. In this investigation, the exhaust diffuser remained constant through each test, with collector box geometries being varied. The same uniform velocity profile was maintained at the diffuser inlet for all geometries considered. The local pressure recovery through the diffuser with 4 axial ports at 4 circumferential locations was reported along with 14 locations in the accompanying ECB. A system performance analysis for each geometry was conducted using the total pressure loss from inlet to exit of the model. 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. Three (3) different ECB geometries are investigated at a Reynolds number of 60,000. Results obtained from these experimental tests are used to validate the accuracy of a 3-dimensional RANS with realizable k-? turbulence CFD model from the commercial software package STAR-CCM+. The study confirms the existence of two strong counter-rotating helical vortices at the exit of 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. Extending the length of the ECB proved to decrease the total pressure loss of the system by up to 19% experimentally. Additionally, the realizable k-? turbulence was able to accurately represent the total pressure loss of the system within 5%. Despite the extremely complex flow field within the ECB, the computational domain reasonably represented the system in both magnitude and trends.

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Conference Location:
Vancouver, Canada

Conference Date:
Monday, June 6, 2011
Paper Reference:
GT2011-46455
Conference Name:

ASME Turbo Expo 2011

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