CFD Post processing of Industrial Gas Turbine Exhaust Diffuser and Optimization of 1D Analysis Tool

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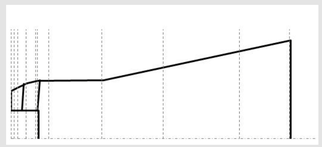
Introduction

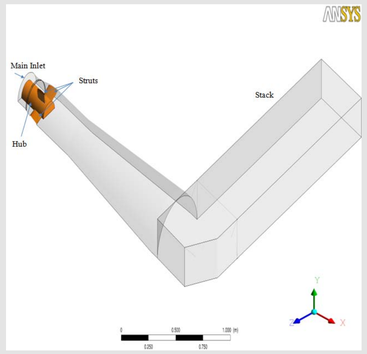
This project initiates the development of a catalogue system to summarize performances of industrial gas turbine exhaust diffusers. The catalogue can be used to improve geometrical shape and performance predictions of designs developed in a diffuser meanline tool. The present development effort focuses on a diffuser model of ITSM test rig

Diffuser Catalogue

Geometry

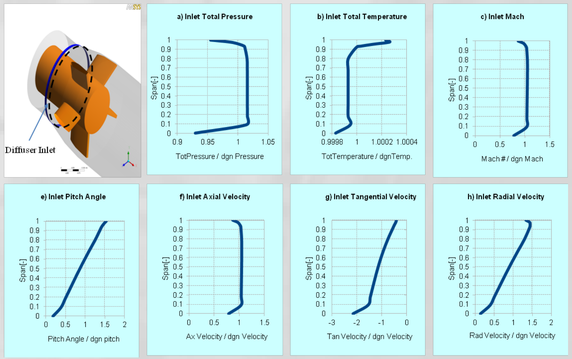
- Longitudinal views of CAD model (cold geometry)
- 2D views of CFD model (hot geometry)
- Area plots : Area vs. x, AR vs. x/L





Aerodynamics

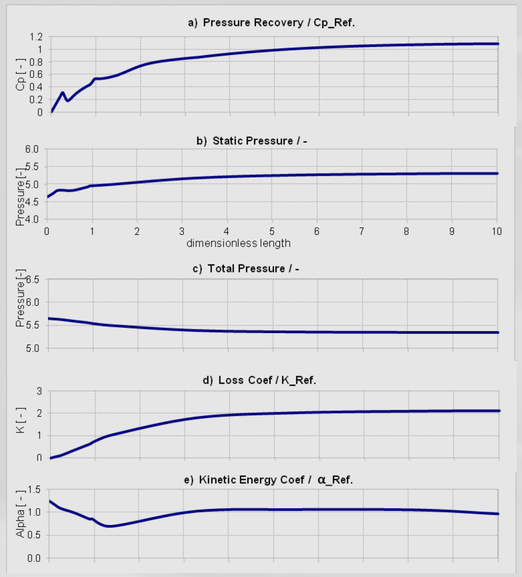
- Radial plots: Inlet P_t, T_t, Mach#, swirl, pitch, V_{axial}, V_{tan}, and V_{rad}
- Struts: 2D profiles, pressure coef vs. chord @ hub, mid-span, and casing



- Circumferential averaging to determine inlet profiles
- Normalized inlet profiles and diffuser performance data

Performance

- Area vs. x/L (with strut blockage)
- Dimensionless plots: C_p, total loss, kinetic energy coef., P, and P_t

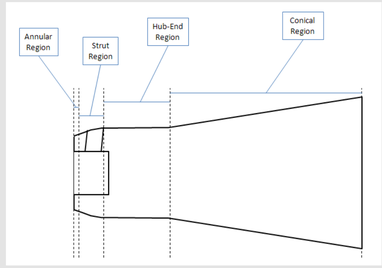


1D Analysis Tool

- Diffuser meanline tool evaluate the performance and validate the design for further CFD and experimental analyses
- 1D tool is composed of:
  - Input of inlet boundary conditions
  - Geometry inputs
  - Sections of segmented diffuser
  - Correlations for drag predictions on struts
  - Results

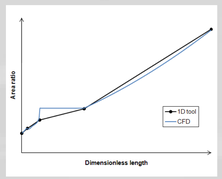
Diffuser computation

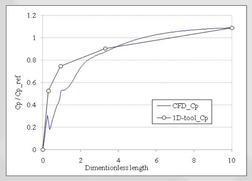
- 4 computing regions : annular, strut, hub-end, and conical
- Incompressible and steady flow
- Inlet conditions obtained from CFD
- Implemented drags:
  - Skin-friction drag (Prandtl-Schlichting)
  - Incremental (pitched struts), interference, and profile drags
  - Base drag in hub-end region

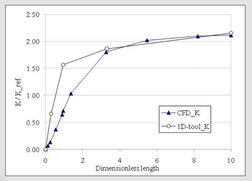


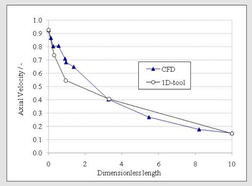
Results

- 1D tool predictions compared to CFD results: area ratio, pressure recovery, total pressure loss coef., axial velocity

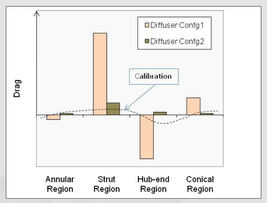








- 1D tool cross sectional area calculations are comparable to CFD
- Performance over-predicted in annular, strut, and hub-end regions
  - Drag correlations based on NACA struts
  - Boundary layer blockage not computed
  - Locations for diffuser partitioning are influential



Future work

- Systematic method for diffuser partitioning
- Develop drag calibrations for diffuser regions