COMPARISON BETWEEN PREDICTED AND EXPERIMENTALLY MEASURED FLOW FIELDS AT THE EXIT OF THE SSME HPFTP IMPELLER

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ABSTRACT

Validation of CFD codes is a critical first step in the process of developing CFD design capability. The MSFC Pump Technology Team has recognized the importance of validation and has thus funded several experimental programs designed to obtain CFD quality validation data. The first data set to become available is for the SSME High Pressure Fuel Turbopump Impeller. LDV Data was taken at the impeller inlet (to obtain a reliable inlet boundary condition) and three radial positions at the impeller discharge.

Our CFD code, TASCflow, is used within the Propulsion and Commercial Pump Industry as a tool for pump design. The objective of this work, therefore, is to further validate TASCflow for application in pump design. TASCflow was used to predict flow at the impeller discharge for flowrates of 80, 100 and 115 percent of design flow. Comparison to data has been made with encouraging results.
Approach

- Develop Computational Model
  - TRUEGRID
  - ICEM CFD

- Set Inlet Boundary Condition Based on Measured Inlet Conditions
  - LDV Measurements Obtained From Rocketdyne and NASA/MSFC at Q/Qd=0.8, 1.0, and 1.15

- Compute Flow for SSME HPFTP Impeller at Q/Qd=0.8, 1.0, and 1.15.
  - Computations Performed With TASCflow

- Compare Predicted Exit Velocity Profiles to Measured
  - LDV Measurements Obtained From Rocketdyne and NASA/MSFC at Q/Qd=0.8, 1.0, and 1.15
  - Non-Dimensional Velocities (Vel/Utip)
Computational Grid
89x29x60 (154860 Nodes)
SSME HPFTP IMPELLER COMPUTATIONAL DOMAIN AND BOUNDARY CONDITIONS

- Inlet/Outlet
- Counter Rotating Turbulent Walls
- Slip Walls

GRID COLORED BY PRESSURE
Collocated, Finite Volume, Primitive Variable

Incompressible - Subsonic - Transonic - Supersonic

Viscous - Laminar or Turbulent (k-e)

Steady or Unsteady

Stationary or Rotating Frame of Reference

Porous Media

Heat Transfer Including Conjugate Heat Transfer

Natural Convection

Species Transport

Chemical Reaction
GRID STRUCTURE AT R/RTIP - 1.013

EXPERIMENTAL DATA

TASCflow PREDICTION

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EXPERIMENTAL DATA

TASCflow PREDICTION

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ABS. FLOW ANGLE FOR Q/QD=1.0, R/RTIP=1.013

EXPERIMENTAL DATA

TASCflow PREDICTION

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ABSOLUTE VELOCITY. 50 PERCENT B2

R/RTIP=1.036, Q/OD=1.0

• EXPERIMENTAL
- PREDICTION

ANGULAR LOCATION (DEGREES)
ABS. FLOW ANGLE FOR Q/QD=1.0, R/RTIP=1.036

EXPERIMENTAL DATA

TASCflow PREDICTION

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ABSOLUTE FLOW ANGLE. 50 PERCENT B2

R/RTIP=1.036. Q/QD=1.0

EXPERIMENTAL
PREDICTION
GRID STRUCTURE AT R/RTIP = 1.060

EXPERIMENTAL DATA

TASCflow PREDICTION

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EXPRESSMENTAL DATA

TASCflow PREDICTION
ABSOLUTE VELOCITY, 50 PERCENT B2

R/R1P-1.06, Q/QD-1.0

EXPERIMENTAL
PREDICTION

ANGULAR LOCATION (DEGREES)
EXPERIMENTAL DATA

Hub

Shroud

TASCflow PREDICTION

Hub

Shroud

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Absolute Velocity (C/Ut) at Impeller Discharge

Abs. Velocity: C/Ut at R/R_{tip}=1.013, 50\% B2
Non-Dim. Abs. Velocity \times 10^{-3}

Abs. Velocity: C/Ut at R/R_{tip}=1.060, 50\% B2
Non-Dim. Abs. Velocity \times 10^{-3}
Absolute Flow Angle at Impeller Discharge

Abs. Flow Angle: Alpha at R/Tip=1.013, 50% B2

Abs. Flow Angle: Alpha at R/Tip=1.060, 50% B2