Technology Opportunity

Turbine Aerothermodynamic Design and Analysis Software

The National Aeronautics and Space Administration (NASA) seeks to transfer assorted computer aided engineering (CAE) and computational fluid dynamics (CFD) software for performing an aerothermodynamic design and analysis of axial, mixed-flow, and radial-inflow turbines. These computer codes can be used to facilitate and enhance the various phases of the design and analysis process.

Potential Commercial Uses

- Conception of turbine flow path and blading geometry for such applications as gas turbine engines, turbochargers, turboexpanders, and rotodynamic schemes for extracting shaft power from a relatively high-pressure gas source
- Design optimization
- Assessment of the aerothermodynamic performance characteristics of new and existing turbine hardware
- Performance upgrade of existing turbine hardware

Benefits

- Improves turbine aerothermodynamic perfomance and reliability
- Reduces design and development cycle
- Makes design changes more cost effective
- Enables the deployment of turbine components in nontraditional applications

The Technology

The NASA Lewis Research Center has transformed many of the fruits produced from its innovative research on the aerothermodynamics of turbomachines into a highly effective tool chest that can assist an engineer in executing an accurate and tractable turbine design and performance assessment. The CAE and CFD tools contained in this tool chest can be briefly described as follows:

- TURBAN*—A rapid sizing code for axial turbines; it is based on meanline vector diagrams and performance appraisal. The output includes flow path dimensions, vector diagrams, and efficiencies.
- TD2*—Performs a streamline analysis, which allows control of both stagewise and spanwise distributions of vector diagrams and performance for axial turbines.
- AXOD*—Spanline or meanline off-design code for axial turbines that uses simple radial equilibrium. Off-design losses are computed from given reference values for vanes and blades.
- RTD*—Executes a conceptual design for a single-stage radial-inflow turbine.
- RTOD*—Predicts the off-design performance of a radial-inflow turbine by using reference losses for rotor and nozzle.
- CPF*—Predicts the heat transfer and average flow properties in any turbomachinery coolant flow path geometry that consists of a single flow passage with a unique inlet and exit.
- MERIDL—Calculates an axisymmetric representation of the subsonic flow in axial, mixed-flow, and radial turbomachinery blade rows and ducts. The effects of total pressure losses can be simulated with user-supplied information. A combination of MERIDL/TSONIC/BLAYER called MTSB* is available for predicting turbine blade row or stage performance at both design and off-design conditions.
- TSONIC*—Calculates the quasi-three-dimensional (Q3D) subsonic potential flow on blade-to-blade surfaces of revolution for axial, mixed-flow, and radial turbomachinery configurations.
- PCPANEL*—Calculates the two-dimensional (2D) subsonic potential flow on blade-to-blade surfaces of revolution for planar cascades.

- RVCQ3D—Calculates the Q3D viscous flow on blade-to-blade surfaces of revolution for arbitrary single-element turbomachinery blade sections.
- DVC2D—Calculates the axisymmetric viscous flow in ducts.
- STAN5—A 2D boundary layer code for heat transfer and viscous dissipation predictions.
- BLAYER—An integral 2D boundary layer code.
- RVC3D—A 3D viscous-flow code that uses periodic C-meshes for a single turbomachinery blade row.
- CCGEOM—A 3D geometry generator for arbitrary turbomachinery blade rows.
- TCGRID—3D C- or H-grid generation code for single-element turbomachinery blade rows.

* Available through COSMIC

Options for Commercialization

NASA has no patents on the CAE and CFD software. These computer codes are primarily intended to be used to conceive new products or to enhance existing ones.

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Key Words

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Aerothermodynamic Code Requirements and Uses in Various Turbine Design Stages

Code	Requirements	Typical trade studies	Aerothermo uses
Conceptual design stage			
TURBAN TD2/AXOD RTD RTOD CPF	Robustness; Minimal input; User friendly; Extremely fast computationally; Reasonable accuracy	Turbine sizing and synthesis; Number of stages; Cooling requirements; Weight estimates; rpm and material requirements	Stage loading; Vector diagrams; Blade row average turning; Efficiency potential and off-design characteristics
Preliminary design stage			
RTD/RTOD TD2/AXOD MTSB (include MERIDL, STAN5, BLAYER, TSONIC & PCPANEL) CPF CCGEOM	Robustness; User friendly; Fast computationally; Good accuracy	Spanwise distribution of aero parameters; Flow path definition; Internal coolant passages	Performance prediction; Pressure/thermal loads; Conception of flow path and blading; Coolant passage heat transfer and pressure drops
Detailed design and diagnosis stage			
MTSB/CCGEOM RVCQ3D RVC3D TCGRID	Excellent accuracy; Computationally affordable; User friendly; Robustness	Detailed blading design, including heat transfer/cooling requirements; Investigation of critical problem areas	Performance prediction; Pressure/thermal loads; Conception of flow path and blading

Experience and Time Requirements for NASA Turbine Aerothermodynamic Prediction Codes

Code	Typical user experience	Typical time required to learn to use code, weeks	Set-up time	Typical computational times for an average case	Computer required
TURBAN	Low	<1	~minutes	<1 sec	PC
TD2	Moderate	~2	<1 day	<1 sec	PC
AXOD	High	~2	<1 day	~sec	PC
RTD	Moderate	~1	~minutes	<1 sec	PC
RTOD	High	~1	~minutes	~sec	PC
CPF	Low	~2	<1 day	~sec	PC/mini
MTSB	Moderate	~2	<1 wk	~sec	PC/mini
RVCQ3D	Moderate	~2	<1 wk	~min	PC/mini
RVC3D	High	~3	< 2 wk	~hrs-days	Super mini

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