Turbomachinery Capabilities in SU2: Current Status and Future Perspectives

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Our Main Goal with SU2

Provide Industrial-Strength Design Methods for NextGen Turbomachines...of any kind!

- Simulation of complex flows (NICFD: pure fluids + mixtures, two-phase, unsteady with ROMs)
- Multi-physics analysis (e.g. FSI)
- Multi-disciplinary design optimization
- Robust optimization

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Focus of today!

ROMs = reduced order models, e.g. harmonic balance

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Current Status



Turbo Features as of Now

- NICFD → complex TMD models (hard-coded, FluidProp, LuT)
- Method of Moments for non-equilibrium condensation
- Turbo features \rightarrow NRBC, MP, SLI and HB for even pitches
- Discrete turbo adjoint solver: steady/unsteady

For single and multi-row

Emphasis (for now) is on compressible flows!



NRBC = Non-reflecting Boundary Conditions MP = Mixing Plane SLI = Sliding Interface

Future Perspective: Turbomachinery Aero-Mechanics



Aero-Mechanics Phenomena

Forced Response



Failure due to bending fatigue caused by Forced Response (Australian Transport Safety Bureau, 2010)

Flutter



Failure due to Flutter in the last stage of a geothermal LP steam turbine during part-load operation (Mazur, 2005)

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Forced Response



Failure due to bending fatigue caused by Forced Response (Australian Transport Safety Bureau, 2010)



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Forced Response Due to Unsteady Inflow



What is Needed for Industrial-Strength Turbo Aero-Mechanics?

- Efficient unsteady CFD solver
- Efficient FEA solver

Reduced order models!

- Efficient (coupled) adjoints
- (3D) CAD-based parametrization





Harmonic Balance Flow Solver in SU2

- Time-domain formulation
- Fully differentiated







Working on Phase-lag BCs...

Harmonic Balance Structural Solver

Coming Soon to SU2



(Some) Preliminary Results



Validation of Aero-Elastic Objectives

 $(-\omega^2 M + \omega D + K) \hat{x} = \hat{F}$



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CAD-Based Parametrization



ParaBlade: CAD-based Turbo Modeler

- Any type of turbomachine
- "Turbo" design variables
- Coupled to SU2
- Released open-source "soon"







ParaBlade: CAD-based Turbo Modeler



ParaBlade Coupled with SU2



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Challenge

feature_TMZHB

- Turbomachinery Features
- Harmonic Balance Fluid

feature_FEA

- Finite Element Method

feature_TURBO_FSI

- Ongoing development

Integration in:

feature_turbo_MDO!

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Thank you for your attention...!!!

