Thermo-Mechanical Modeling and Analysis for Turbopump Assemblies

Mike Platt
Concepts NREC

Matt Marsh
NASA MSFC
Outline

- Technical Need
- Project Goals
- Technical Approach
- Development Status
- Conclusion
Project Support

- NASA SBIR, through TD61
- Spin-off to IHPRPT
- Spin-off to industry
Technical Need

- Life, reliability, and cost are strongly impacted by steady and transient thermo-mechanical effects
- Design cycle can suffer big setbacks when working a transient stress / deflection issue
- Balance between objectives and constraints is always difficult
- Requires assembly-level analysis early in the design cycle
Technical Need – Operating Point

Temperature

Absolute temperature limits and thermal gradient limitations

Displacement

Critical clearances, fits, and gaps

Stress

Stress margins, LCF life, HCF margin, preloads
Technical Need - Transient
Project Goals

- Develop thermo-mechanical modeling software tools
- Push thermo-mechanical modeling earlier in the design process
- Reduce cost and risk of designs
- Improve life and reliability of propulsion systems
- Integrate existing tools
- Improve the design process
- Open system for 3rd party software
Technical Approach

• Design data and results flow from component analysis tools to the assembly model
• Software operates in a collaborative environment
  – Data-centric approach to multi-disciplinary analysis
  – XML provides flexible open data format
• Integrate with CAD data
  – Parasolid kernel
• Integrate with multi-disciplinary optimizer
Data Flow to Assembly

Meanline

3D Blading & CFD

Stress & Vibration

CONCEPTS NREC
Data Flow to Assembly

Meanline

3D Blading & CFD

Stress & Vibration

CONCEPTS NREC
Data Flow to Assembly

CONCEPTS NREC
XML Data Set

- Flexible, recursive data tree stores geometry, modeling parameters, and results from different disciplines.
- XML provides robust open technology for data sharing
  - Format is self-descriptive and self-checking
  - Growing supply of XML tools for C++, Java, Perl, Python

CONCEPTS NREC
Import/export of CAD files can be time consuming and error prone.

Individual tools can become segregated from design data flow (more time lost in the design cycle).

Using Parasolid geometry kernel from EDS Unigraphics:
- Robust geometry functions for curves, surfaces, volumes
- Read native files from Unigraphics
- Use IGES for other CAD systems

CONCEPTS NREC
Conclusion

- Software tool integration will push thermo-mechanical modeling upstream in the design process
- Open format data-centric approach has many advantages for sharing design data and results
- CAD integration provides a crucial link the the design process
- Software integration enables automated multi-disciplinary design trades