Development of an I/F Software for Patran/Thermal and ESARAD

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All the space you need

Contents

I. Problem Definition
II. Interface Approach
III. Data Transfer
IV. Interface Handling
V. Verification and Test
VI. Summary
Problem Definition

The Structural Analysis “World”:
- Use of FEM meshes - edge nodes
- Thermo-elastic distortion analysis from thermal input
- Lack of ray tracing (no specular reflection)
- No orbital analysis capability

The Thermal Analysis “World”:
- Use of FDM - surface centered nodes
- Ray tracing and orbital load analysis implemented

Current Drawbacks:
- Mainly manual temperature mapping from FDM to FEM mesh
- Separate effort for thermal and structural model creation
Interface Approach

Analysis Work Flow:

**CATIA**
- Creation of CAD Drawings, Geometry Simplifications

**PATRAN/Thermal**
- Geometry Adaptation for Thermal Model, Input of Material Properties

**I/F Program**

**ESARAD/Thermica**
- Orbit Analysis, Calculation of Thermal Loads and REF

**PATRAN/Thermal**
- Thermal Analysis, Temperature Mapping, Thermal-Distortion Analysis

**I/F Program**

Interface Approach

**Structural Analysis**
PATRAN/NASTRAN

**Thermal Analysis**
PATRAN/Thermal:
- Geometry creation
- Thermal mesh creation (edge nodes used)
- Calculation of linear conductors
- Definition of thermo-optical properties
- Definition of internal heat loads
- Temperature calculation

ESARAD/Thermica:
- Calculation of REF
- Orbit Analysis
Advantages

• Exchange of geometry data according to project needs
• No duplication of geometry
• Makes best use of capabilities of both “worlds”:
  - Pre- and post-processing capability of PATRAN
  - PATRAN/Thermal functions to calculate linear conductors
  - Orbit analysis tools and ray-tracing in ESARAD/Thermica
• Capable of generating automated temperature mapping of structural model for thermal distortion analysis without extrapolation
  → Addition of functionality and saving of time

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Data Transfer

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II. Interface Approach
III. Data Transfer
IV. Interface Handling
V. Verification and Test
VI. Summary
Interface Patran/T to ESARAD

- Define Esarad geometry file: *.erg
- Select the view factor input file: vfin.dat
- Select thermo-optical property data: template.dat

→ Automated transfer to Esarad geometry file:
   Optical, points, triangles, rectangles and groups
   (one model hierarchy level can be defined via media node)

Interface ESARAD to Patran/T

- Select the Esatan input file: *.d

→ Automated definition of thermal loads in qmacro.dat, qbase.dat, micro.dat
→ Creation of vfres.txt containing radiative couplings for edge nodes in Patran/Thermal
→ Adaptation of qin.dat to read ASCII file vfres.txt before solving
I. Problem Definition

II. Interface Approach

III. Data Transfer

IV. Interface Handling

V. Verification and Test

VI. Summary

Verification of Radiative Approach

Radiative Model:
- Three triangles of same size with same normal vector
- Surface Indices: \( p, q = I, II, III \)  
- Edge Indices: \( i, j = 1, 2, \ldots 6 \)
- Number of edges: \( n_p = 3, \ n_q = 3, \ n_{III} = 3 \)
- REF of triangles: \( GR_{I,III} = GR_{II,III} \), \( GR_{I,II} = 0 \)

HF calculated in ESARAD:
\[ \hat{Q}_{\text{tot, ESARAD}} = \hat{Q}_{I,III} + \hat{Q}_{II,III} - \sigma \left[ GR_{I,III} \left( T^+_I - T^-_I \right) + GR_{II,III} \left( T^+_II - T^-_II \right) \right] \]

HF calculated in PATRAN:
\[ \hat{Q}_{\text{tot, PATRAN}} = \sigma \left[ \begin{array}{c}
\left( T^+_I - T^-_I \right) \frac{R_{1,5}}{R_{1,6}} + \left( T^+_I - T^-_I \right) \frac{R_{1,7}}{R_{1,8}} + \left( T^+_I - T^-_I \right) \frac{R_{2,5}}{R_{2,6}} + \left( T^+_I - T^-_I \right) \frac{R_{2,7}}{R_{2,8}} \\
+ \left( T^+_II - T^-_II \right) \frac{R_{3,5}}{R_{3,6}} + \left( T^+_II - T^-_II \right) \frac{R_{3,7}}{R_{3,8}} + \left( T^+_II - T^-_II \right) \frac{R_{4,5}}{R_{4,6}} + \left( T^+_II - T^-_II \right) \frac{R_{4,7}}{R_{4,8}}
\end{array} \right] \]

\[ \rightarrow \text{HF values are identical for:} \quad R_{i,j} = \sum_{p,q} \frac{n_p \cdot n_q}{GR_{p,q}} \]
Test Examples

Model Comparison

- First a satellite model is built in ESARAD
- Temperature calculations are performed with ESATAN using ESARAD nodes
- A second similar satellite model is built in PATRAN
- Temperature calculations are performed with PATRAN/Thermal using edge nodes

→ Verification of correct geometry transfer from PATRAN to ESARAD
→ Verification of correct transfer of thermo-optical properties
→ Verification of correct calculation of external loads for both geometries

Test Examples

Geometry Transfer

Geometry build in PATRAN/Thermal: After Transfer to ESARAD:
**Test Examples**

**Planet Heat Flux Results**

Geometry converted from PATRAN:

Geometry created in ESARAD:

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**Test Examples**

**Ball Model**

Build and meshed in PATRAN/Thermal:

... and what arrived in ESARAD:

→ There is still a significant amount of work ahead!
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Summary

- I/F software has been implemented to link ESARAD and PATRAN for analysis of thermal distortion problems.
- An algorithm has been developed to assign the REF from ESARAD to PATRAN/Thermal.
- Triangular and rectangular surfaces are supported
- I/F software is coded in Matlab
- Future activities:
  - Creation of I/F to Thermica,
  - Verification of temperature calculation,
  - Software test in real project environment