Appendix F

SINAS: Generic tool for mapping lumped parameter temperatures to a finite element model for thermo-elastic analyses

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SINAS

A generic tool for mapping lumped parameter temperatures to a finite element model for thermo-elastic analyses

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Topics

- What is SINAS?
- History
- Overview of functionality (What it can do and what it not can do)
- The method
- Example
- How to get it

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What is SINAS

- Suite of modules that convert/interpolate

Lumped parameter thermal node temperatures

↓

Finite element nodal and element temperatures

For thermo-elastic analysis

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History

- Developed by Dutchspace (former Fokkerspace)
- Under a series of small ESA contracts from around 1985 until 1998
- Initiative from the ESA/ESTEC structural section
- IPR handed over to ESA in 2004
- Currently maintained by ESTEC TEC-MCV
  - No more planned development

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Available information for mapping

- Thermal lumped parameter model side (in most cases):
  - Only radiative geometry (GMM)
    - Often does not coincide with structural geometry
  - No geometry for the conductive nodes
    - Have to rely on sketches in model description
- Structural finite element model side:
  - Geometry is typically based on mid-plane geometry
  - Does not include thermal-only relevant items (e.g. TPS, MLI)

In case of perfect matching geometry:

- Non-matching meshes

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Overview of functionality

- Mapping building functionality
  - Automated mapping for thermal and structural meshes on coinciding surfaces
  - Manual mapping is supported for meshed non-matching/non-coinciding geometry
  - Manual mapping is supported for thermal nodes without related geometry
- User interface
  - Graphical user interface for manipulation of model correspondence fully integrated in MSC.PATRAN (implemented in PCL)
  - Other modules require command-line manipulations

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Overview of functionality (cont)

- Supported lumped parameter codes: Any
  - temperature have to be converted to SINAS format (converters provided)
- Supported FE formats: MSC.NASTRAN, ASKA
  - Generates FE node temperature loads
  - Generates element temperature loads for cross-sectional thermal gradient (e.g. for honeycomb panels)
  - Requires NASTRAN DMAP license for matrix extraction

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The method in 3 steps

Build Correspondence	MSC.PATRAN GUI
↓	
Matrix generation	Command-line/batch modules in combination with FEM-code
↓	
Solve interpolation equations	Command-line/batch module

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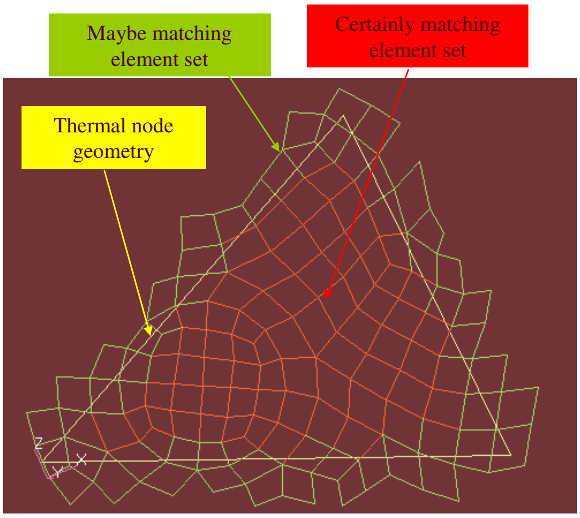
The method in 3 steps
Step 1: Correspondence building

- Build correspondence/mapping between:
  - Lumped parameter thermal nodes
  - Structural finite elements
- Using MSC.PATRAN GUI
- Automatic overlap detection



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The method in 3 steps
Step 2: Matrix generation

- Constraint matrix: Prescribed average temperature
  - Weighted average temperature of FE nodes of elements corresponding with thermal node is equal to thermal node temperature
- Element shape functions used to obtain weighting coefficients

$$T_j^t = \sum_i a_i T_i^f \Rightarrow \underline{T}^t = A\underline{T}^f$$

$$\sum_i a_i = 1$$

Constraint matrix

T_i^f = FEM node temperature

T_j^t = Thermal node temperature

a_i = Weighting coefficient

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The method in 3 steps
Step 2: Matrix generation (cont)

- Conduction matrix for structural FEM-mesh
  - Use structural finite element model
  - Replace structural material properties with thermal conductive material properties
  - Use FEM-code (NASTRAN or ASKA) to extract the conduction matrix

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The method in 3 steps
Step 3: Solving interpolation equations

- Solve the interpolation system equations for the FEM-node temperatures $\underline{T}^f$:

$$\begin{bmatrix} C & A^T \\ A & 0 \end{bmatrix} \begin{bmatrix} \underline{T}^f \\ \underline{q} \end{bmatrix} = \begin{bmatrix} \underline{0} \\ \underline{T}^t \end{bmatrix}$$

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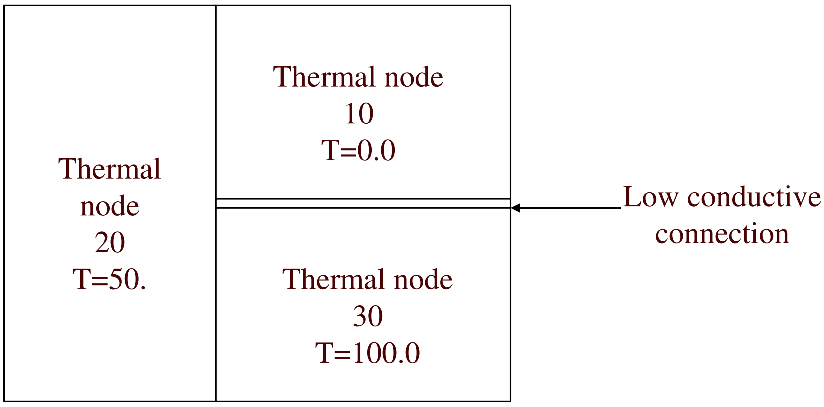
Example



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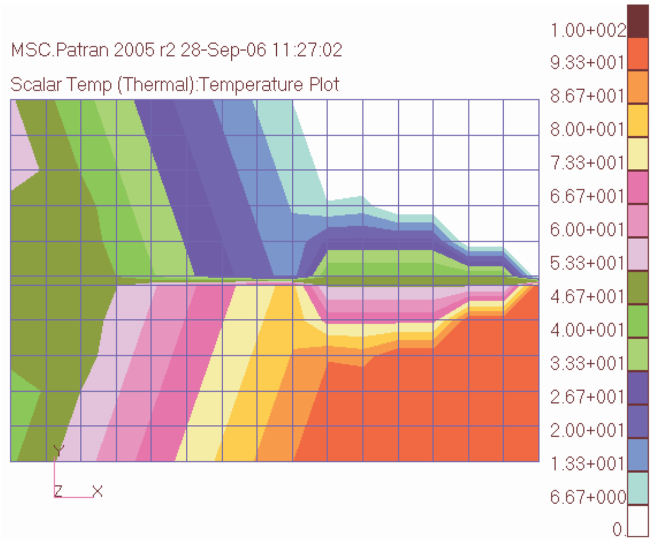
Example (cont)

Purely geometrical interpolation of TLP temperatures on FE mesh



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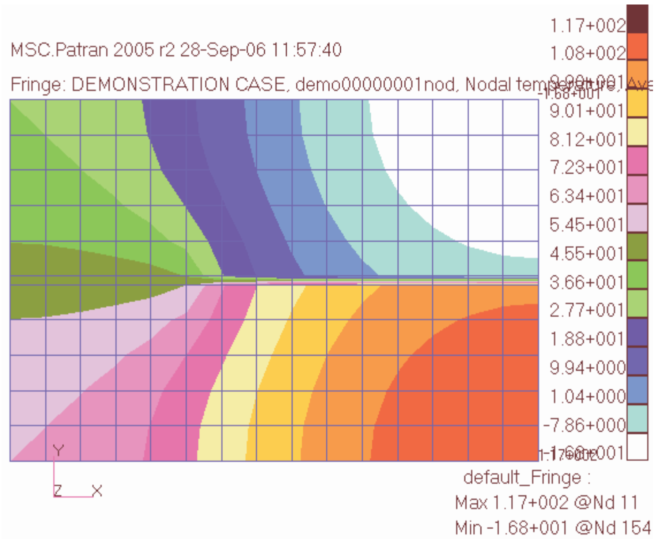
Example (cont)

SINAS results



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Projects that used SINAS

- Ariane 5 Engine Frame (Dutchspace)
- GAIA, LISA path finder (ESA ESTEC)

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How to get SINAS

- The SINAS IV software can be obtained from:

https://exchange.esa.int/restricted/sinas/

- Through the web-page access to the download area can be requested

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