Appendix E

Application of ESATAP for automatic thermal model validation

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Abstract

Obviously the quality of a thermal analysis depends on the quality of the thermal model used. Complexity and size of thermal models have been increased in the last years. Due to this also the model validation became more complex and time consuming. This presentation is focused on the evaluation of the capabilities provided by ESATAP to automate the model validation process. Based on a simple example it is shown how ESATAP can perform some automatic checks on thermal models to assist the validation process.

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Application of ESATAP for Automatic Thermal Model Validation

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Background

- Quality of thermal analysis depends on the quality of the model used
- Thermal model sizes increase in the last years
- Thermal model validation becomes more complex and time consuming
- Automatic model verification is desirable
- New ESATAP version (2_1 beta1) is available for testing

→Why not evaluate, how ESATAP can be used for automatic thermal model validation??

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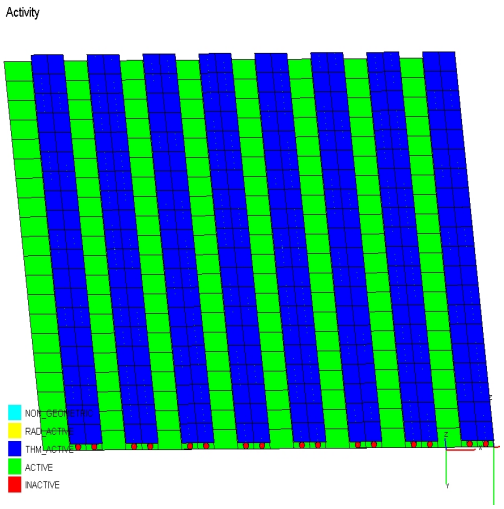
Simple example model

- Radiator Panel
  - 20 mm Honeycomb
  - 0.2 mm Facesheets
  - Outer side OSR covered
- For Groups of interest
  1. Radiator outer side
  2. Radiator inner side
  3. SMHP‘s
  4. Interface nodes



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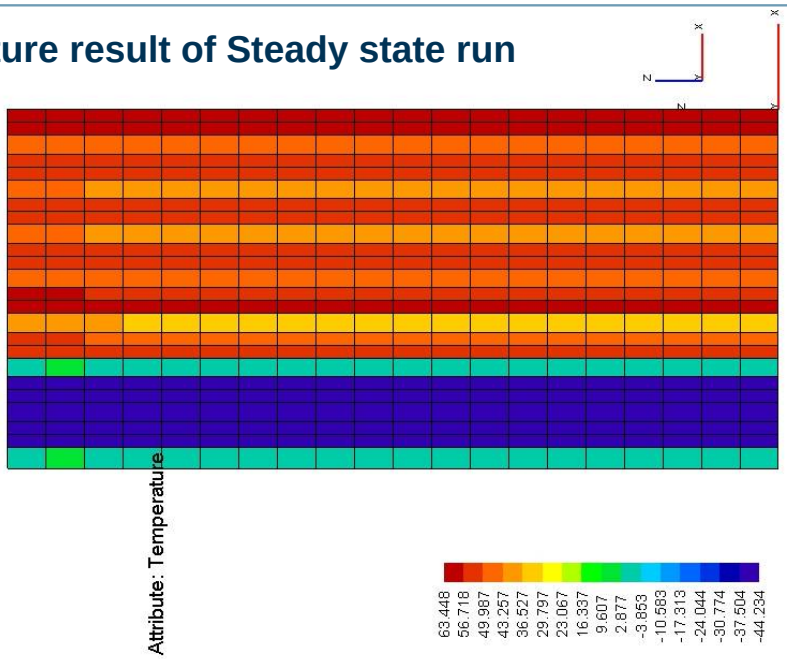
Temperature result of Steady state run



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Basic checks for model validation

1. Heat balance for each group of interest and to the environment.
2. Report all nodes with an entitiy above a given value, e.g. all nodes with a capacitance above 400 J/(kgK)
3. Report all nodes where conductors with different order of magnitude are connected
4. Do a rough mass check by: Sum mC_p over all nodes (per group) and divide the sum by a given Cp
5. On structure panels, report thermal doubler nodes and nodes with reduced coupling.

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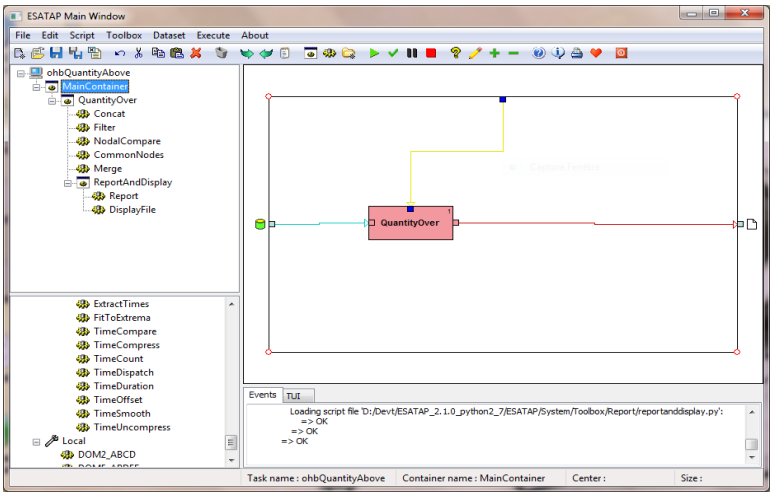
2. Report all nodes with a quantity above a given value

- Example report all nodes with m_Cp above 400
- The task contains a call to the single container QuantityOver



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2. Report all nodes with a quantity above a given value/ Results

Fichier Edition Affichage Favoris Outils ?

Output Report Example

Nodes with ['mC_p', '>', 400.0]

Time step: 0.000 [s]

Type	ID	Label	mC_p [J/K]	mC_p_ampl [J/K]
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110101	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110102	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110103	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110104	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110105	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110106	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110107	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110108	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110109	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110110	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110111	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110112	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110113	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110114	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110115	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110116	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110117	SMHP 1	450.900	50.900
Node	HP_RAD_LCT_AC_RAD_LCT/SMHP/110118	SMHP 1	450.900	50.900

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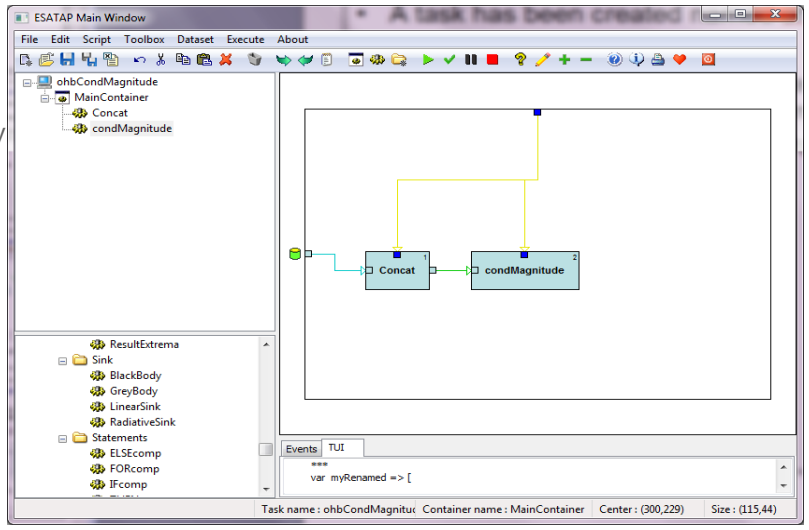
3. Check all nodes if conductors have different order of magnitude

The task contains:

- Concat to concatenate
  - all our input results in a super_datacube used by other components
- "condMagnitude" component



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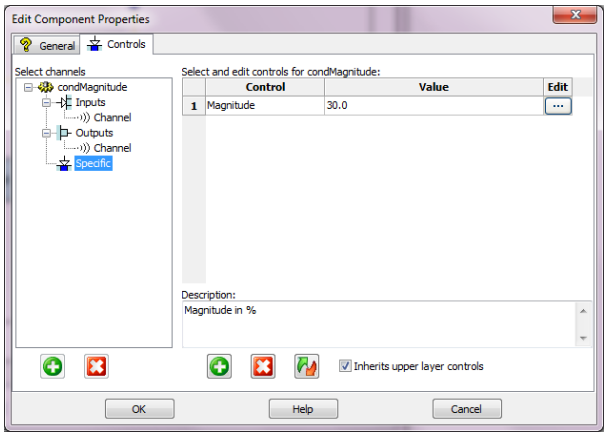
3. Check all nodes if conductors have different order of magnitude



INFO : Processing component condMagnitude

INFO : **WARNING Time step:0.000 Node :HP_RAD_LCT_AC_RAD_LCT/SMHP/110102 has GR with magnitude greater than 30.0 % Delta is 39.8541639171 %**

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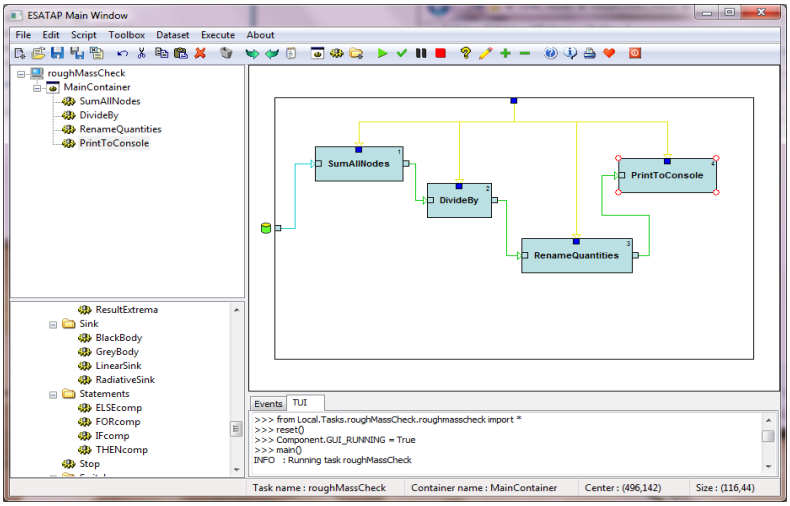
4. Do a rough mass check

This task sums mC_p over all nodes (per group) and divide the sum by a given Cp to compute a rough mass check

- SumAllNodes compute the mC_p sum of nodes of the group
- The DivideBy component divides the group mC_p by our Cp
- RenameQuantities: rename the resulting quantity to m(Kg)



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4. Do a rough mass check / result

With a Cp of 900 J/(kgK) →

PrintToConsoleResult is:

```
INFO   : PrintToConsole(Input1): 'myRenamed'
         ***
         var  myRenamed => [
         [  Time: 0.000 [s]=
            Group: RADIATOR OUT (4002)= m: 1.352 [kg],

         ]
         ]
         ***
```

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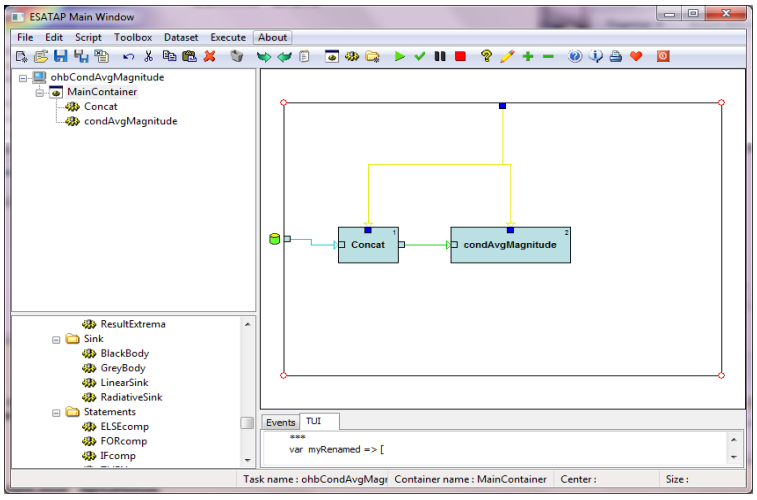
5. Report thermal doublers and nodes with reduced coupling



Sum the GLs for each node a group and report the ones where the sum is less than ‘magnitude’ times the average values of the sums

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5. Report thermal doublers and nodes with reduced coupling / results

- The result of the task is the following for a model were no problem is identified is:

INFO : Processing component condAvgMagnitude

INFO : Time :0.0 CHECK OK: The sums of the **GLs** for each node differs less than 80.0% of the GLs sum average

INFO : Time :8612.76464844 CHECK OK: The sums of the **GLs** for each node differs less than 80.0% of the GLs sum average

- The result of the task is the following for a model were a problem or doubler is identified:

INFO : Processing component condAvgMagnitude

INFO : WARNING Time :0.0 Node :HP_RAD_LCT_AC_RAD_LCT/RADIATOR/222118 GL sums 0.3368772 differs more than 30.0% GLs sum average 0.258922145455 Delta is 30.1075268817 %

INFO : WARNING Time :0.0 Node :HP_RAD_LCT_AC_RAD_LCT/RADIATOR/222119 GL sums 0.3368772 differs more than 30.0% GLs sum average 0.258922145455 Delta is 30.1075268817 %

Summary

- Application of ESATAP successfully tested for automatic model validation
- With already existing components easy check like a rough mass check can be performed
- Due to the high flexibility the user can combine existing components for own model checks
- New components like “CondAvgMagnitude” have been implemented on request