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Tdyn-CFD+HT - Validation Case 7

Two-Dimensional Thermal Analysis

Tdyn

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15.1.0

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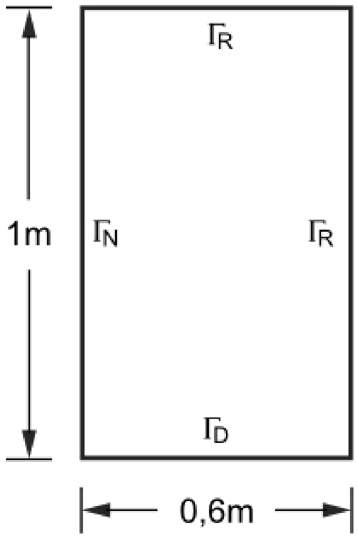
1 Validation case 7 - Two-Dimensional Thermal Analysis

This validation case is one of the NAFEMS Benchmark tests for thermal analysis. It is focused on calculating the steady-state temperature distribution over a spatial domain, in order to compare Tdyn results with NAFEMS Benchmark test.

It is performed in a two-dimensional spatial domain Ω of 0.6 meter wide by 1.0 meter high. An initial temperature of 0ºC has been considered on all the space domain. The temperature is fixed to 100ºC at the lower boundary, whereas a heat flux boundary condition is set at both upper and right boundaries, with a convective heat transfer coefficient of 750 $W/m^2 \cdot {}^oC$. An homogeneous Neumann condition is considered on the rest of the boundary.



The initial and boundary conditions of the problem are summarized as follows:

- T(x,0)=0ºC in Ω
- T(x,t)=100ºC on Γ_D (lower boundary)
- Reactive heat flux=750 $W/m^2 \cdot C$ on Γ_R (Upper & right boundary)
- $\partial T/\partial n=0$ on $\Gamma_N=\partial\Omega\backslash(\Gamma_R U\ \Gamma_D)$ (Left boundary)

A complete description of this problem is given in reference [1].

Problem description

The problem consists of a two-dimensional thermal analysis, with the following characteristics:

- User defined problem
  Simulation dimension: 2D plane

  Multi-physics analysis: Fluid flow & Fluid heat Transfer

- Geometry
  0.6x1.0 meters rectangular domain.

- Domain
  Steady-state, stationary.

- Material properties
  Thermal conductivity K=52W/mº·C

  Specific Heat C=1 J/kgºC

  Density ρ=1kg/m^3

  Heat source field Q=0W/m^3

- Boundary Conditions
  Fixed temperature: The temperature is fixed at the bottom of the domain. It is set to 100 ºC.
  - T(x,t)=100ºC on Γ_D (lower boundary)

  Insulation: Leaving the left boundary without any condition assigned, makes it a perfect insulator.
  - $\partial T/\partial n=0$ on $\Gamma_N=\partial\Omega\backslash(\Gamma_R \cup \Gamma_D)$ (Left boundary)

  Heat flux: A heat transfer condition is assigned both on the upper and right boundary of the domain. The reactive heat flux value is set to 750 W/(m^2·ºC).
  - Reactive heat flux=750 W/m^2·C on Γ_R (Upper & right boundary)

- Solver parameters
  Assembling type: mixed.

  Symmetric solver: Conjugate Gradient (tolerance = 1.0E-07) with ILU preconditioner.

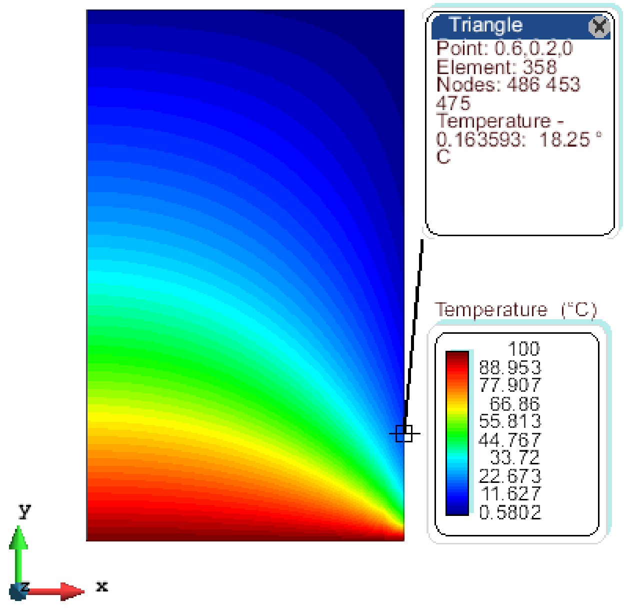
  Notice that 'Steady state solver' option has been set to 'On'.

Mesh

The two-dimensional space domain is discretized by a 30x15 structured grid of linear triangular elements. The finite elements mesh has 946 nodes and 1905 elements (triangles).

Results

The results given below correspond to the steady-state temperature distribution on the spatial domain Ω, at the last time step (t=0.5s).



Steady-state thermal distribution on the domain and temperature at point (0.6,0.2,0.0)

The solution of the NAFEMS Benchmark case given in ref. [1] has been used in this case to validate the solution obtained with Tdyn.

The following table shows the temperature value resulting from the numerical solution of Tdyn for the given mesh, versus NAFEMS Benchmark, at the point (0.6,0.2,0.0) of the domain.

Reference	Temperature [ºC]	Relative error (%)
NAFEMS Benchmark	18.25	-
Tdyn	18.25	0.00

The table above also shows the relative difference between NAFEMS Benchmark and Tdyn computation. It must be emphasized that Tdyn result is exactly equal to the NAFEMS Benchmark result.

References

[1] A.D. Cameron, J.A. Casey, G. B. simpson. Benchmark Tests for Thermal Analyses. NAFEMS Documentation.

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018