COMPASS
www.compassis.com

Tdyn-CFD+HT - Validation Case 8

Two-dimensional Heat Conduction and Convection

Tdyn

Version
15.1.0

Compass Ingeniería y Sistemas http://www.compassis.com
Tel.: +34 932 181 989 - Fax.: +34 933 969 746 - E: info@compassis.com - C/ Tuset 8, 7o 2a, Barcelona 08006 (Spain)

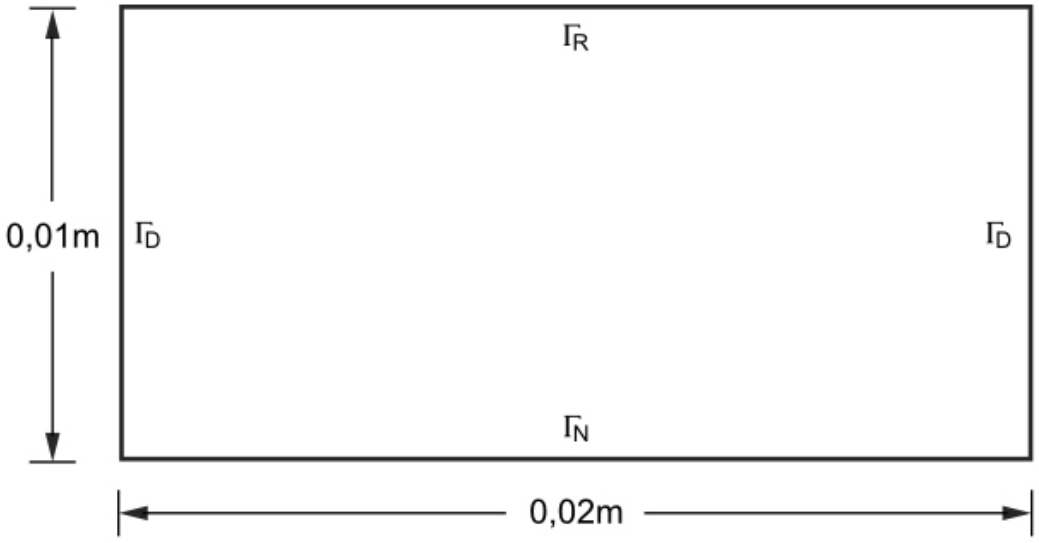
http://www.compassis.com
info@compassis.com
November 2018

Table of Contents

1 Validation case 8

This transient heat transfer validation case is performed in a two-dimensional spatial domain Ω of 0.02 meter wide by 0.01 meter high.

The vertical boundaries are kept at a uniform temperature of 300ºC. A heat flux boundary condition is set at the upper boundary, with a convective heat transfer coefficient of 200 $W/m^2 \cdot C$. It has been considered an initial uniform temperature of 300ºC on all the space domain, and an homogeneous Neumann condition on the lower boundary.



A summary of the initial and boundary conditions of the problem is presented next:

- T(x,0)=300ºC in Ω
- T(x,t)=300ºC on Γ_D (Vertical boundaries)
- Heat flux=200 W/m^2 on Γ_R (Upper boundary)
- Reactive heat flux=200 $W/m^2 \cdot C$ on Γ_R (Upper boundary)
- $\partial T/\partial n=0$ on $\Gamma_N=\partial\Omega\backslash(\Gamma_R U\ \Gamma_D)$ (Lower boundary)

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

Problem description

The problem consists of a 2D transient heat conduction and convection, with the following characteristics:

- User defined problem
  Simulation dimension: 2D plane

  Multi-physics analysis: Fluid flow & Fluid heat Transfer

- Geometry
  2x1 cm rectangular domain.

- Domain
  Transient.

- Material properties
  Thermal conductivity K=3 W/mC

  Specific Heat C=800 J/kgC

  Density ρ=1600 kg/m^3

  Heat source field Q=0 W/m^3

- Boundary Conditions
  Fixed temperature: The temperature is fixed at both side edges of the domain.
  - T(x,t)=300ºC on Γ_D (Vertical boundaries)

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

  Convection boundary: A convective heat transfer condition is assigned to the top of the domain. The value of the ambient temperature is 50ºC and the convective heat transfer coefficient is h=200 W/m^2·ºC.
  - Heat flux=200 W/m^2 on Γ_R (Upper boundary)
  - Reactive heat flux=200 W/m^2·C on Γ_R (Upper boundary)

- Initial condition:
  Uniform temperature
  - T(x,0)=300ºC in Ω

- Solver parameters
  Time step: 2 s

  Number of steps: 6

  Assembling type: mixed.

  Non-symmetric solver: Bi-conjugate Gradient (tolerance = 1.0E-07) with ILU preconditioner.

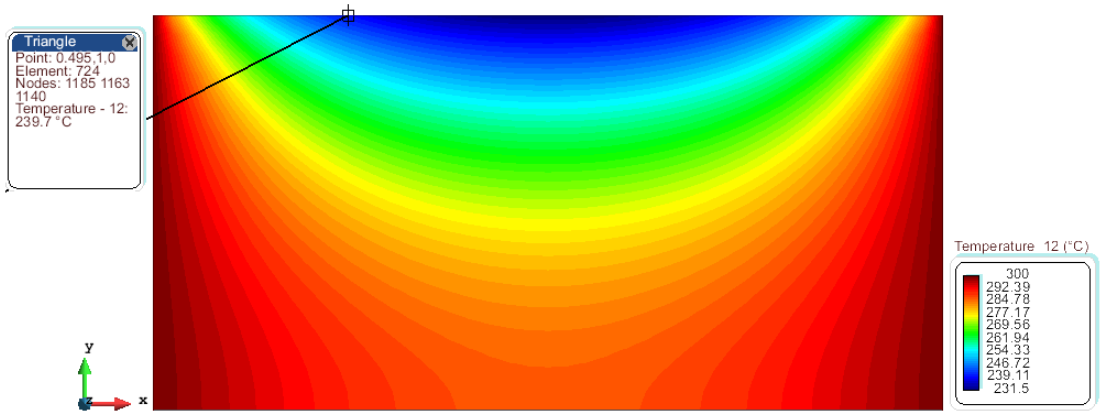
  Symmetric solver: Conjugate Gradient (tolerance = 1.0E-07) with ILU preconditioner.

Mesh

The two-dimensional space domain Ω is discretized by a 10x20 structured grid of linear triangular elements. The finite elements mesh has 431 nodes and 860 elements (triangles).

Results

The results given below correspond to the material temperature distribution on the domain Ω, at the last time step t=2s.



Thermal distribution on the domain and temperature at point (0.495,1.000,0.000)

The following table shows the temperature values in ºC associated with the numerical solution for the given mesh, of three different software packages (STAND 7, MecSolver and Tdyn) versus the exact analytical result, at the point (0.495,1.000,0.000) of the domain.

Reference	Temperature [ºC]	Relative error (%)
Exact analytical result	243.32	-
STAND 7	238.21	-0.0210 (-2.10%)
MecSolver (Midas NFX Structure)	239.50	-0.0156 (-1.56%)
Tdyn	239.70	-0.0148 (-1.48%)

The table above also shows the relative error (the difference between the exact value and the approximation), and the percent error, for each solver. It is important to note that Tdyn offers the best approximation to the exact result, as can be seen in the table.

References

[1] J.P. Holman. Heat Transfer. McGraw-Hill, 1989.

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