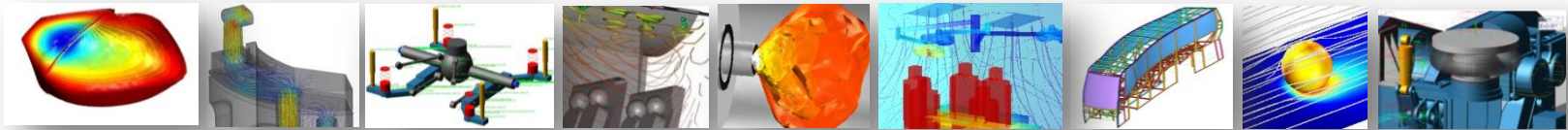

BE CAE & Test



How Apps Can Support COMSOL Multiphysics® Users?

Giuseppe Petrone and Carmelo Barbagallo

BE CAE & TEST, Viale Africa 170 Sc. A, 95129 Catania (ITALY)

Rotterdam, 18-20 October 2017





BE CAE & Test (<http://www.be-caetest.it>) provides consultancy services in several industrial sectors by using innovative **CAD/CAE modelling tools** and carrying out **experimental campaigns**

The company collaborates with **industrial partners** and **research centers** in several technologic fields



<http://www.be-caetest.it/>

COMSOL
Certified Consultant

Prodotti Workshop Webinar Supporto Contatti

BE CAE & Test

BE CAE & Test provides consultancy services for applications based on numerical simulations. Our company recognizes that virtual prototyping plays an important role in several engineering fields. It serves as a powerful tool for optimizing the design of products and processes, while also reducing the time to market ratio. We strongly believe that complex problems have to be analyzed using a multiphysics approach.

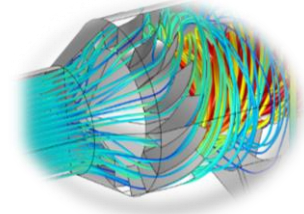
Our team of engineers and researchers supports companies and individuals during their products and processes development by using advanced CAD/CAE tools and organizing accurate experimental tests.

The experience gained in experimental vibro-acoustics, FEM and Multibody numerical simulation and the use of Multiphysics packages make BE CAE & Test the ideal partner to guarantee reliability, innovation and competitiveness of your products and processes.

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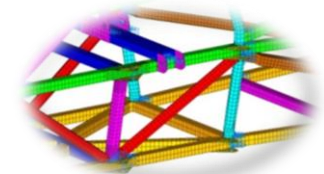
➤ **Fluid dynamics and thermal analyses**

- Environmental energetics (HVAC, thermal comfort, IAQ)
- Industrial energetics (Thermal design, energy conversion, reacting flows)



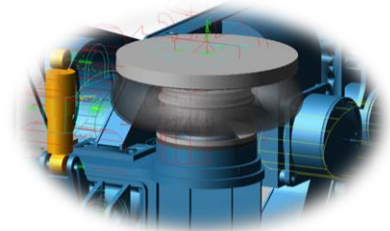
➤ **Structural analyses**

- Linear and non-linear statics, dynamic and vibro-acoustics analyses in industrial and civil applications



➤ **System dynamics and Multi-Body analyses**

- Vehicle and rail dynamics (handling, ride comfort)
- Kinematics, dynamics, rigid and flexible bodies analyses of mechanisms



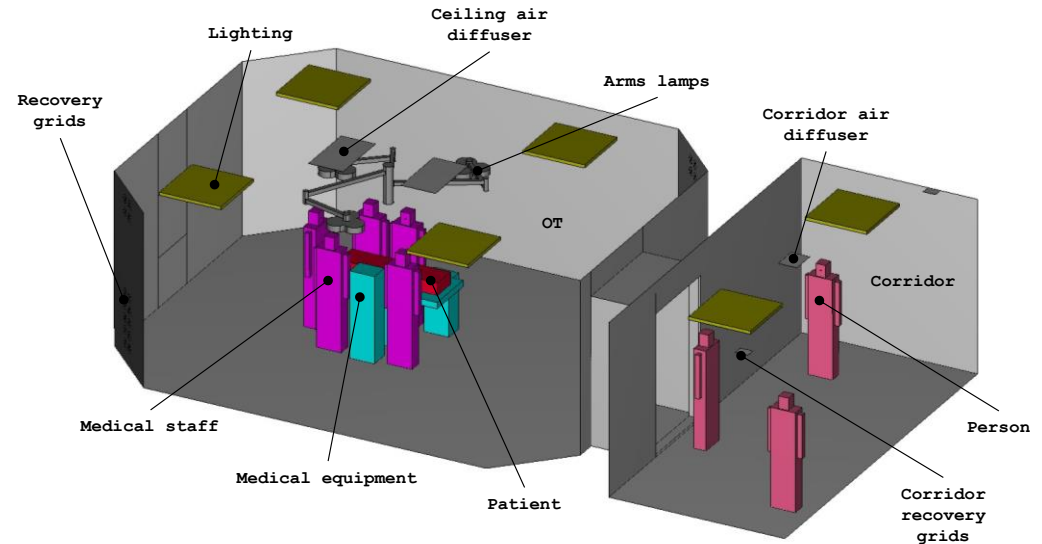
➤ **Experimental testing**

- Ride comfort (NVH), modal analyses
- Vibro-acoustics
- Indoor micro-climate

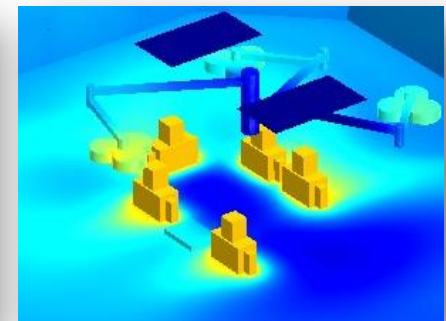
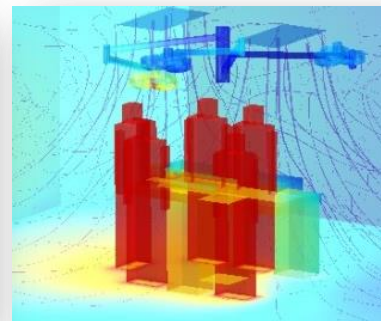
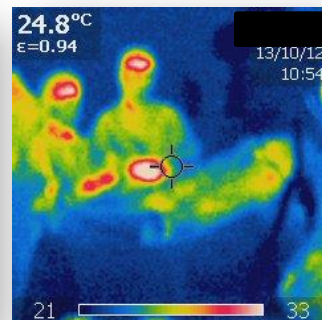


➤ Flow-chart for “traditional” CAE activities

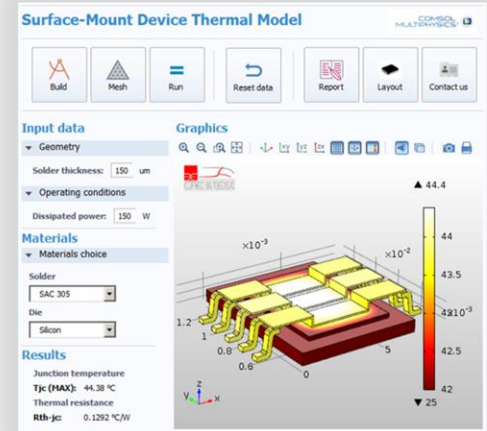
1. Topics / targets / feasibility study
2. Data transmission (CAD, functional / operative conditions, ...)
3. Model set-up (equations, parameters / functions, BC, meshing, solvers, ...)
4. Test run /numerical study of the model / numerical-experimental validation
5. Parametric runs for predictive analyses



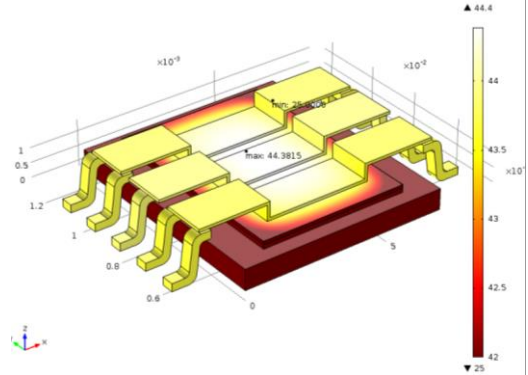
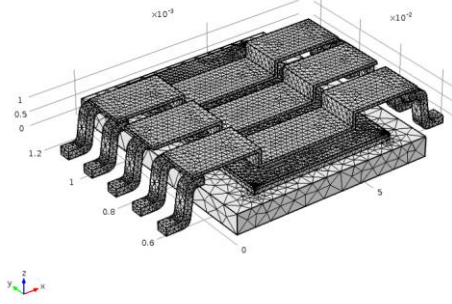
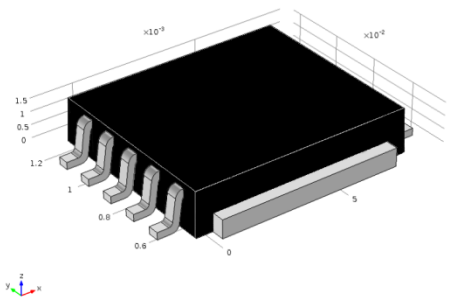
>> REPORT RELEASE <<



Beyond a traditionally relationship with the Customers



FROM MODEL TO APP

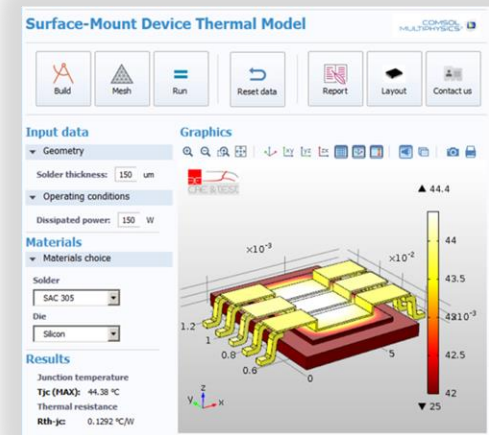


➤ Why building a COMSOL App*?

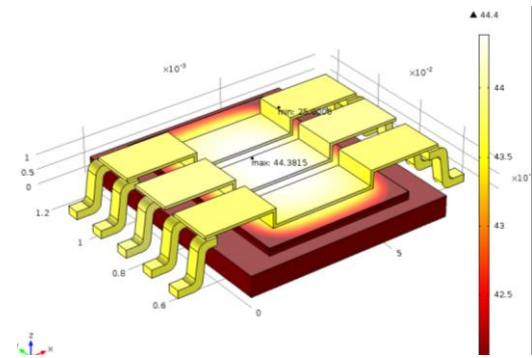
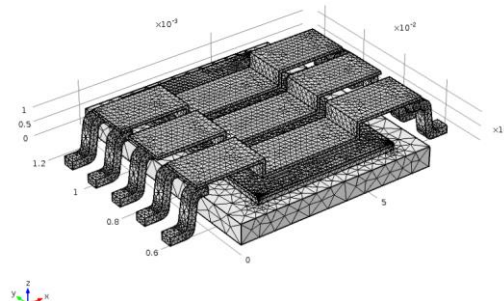
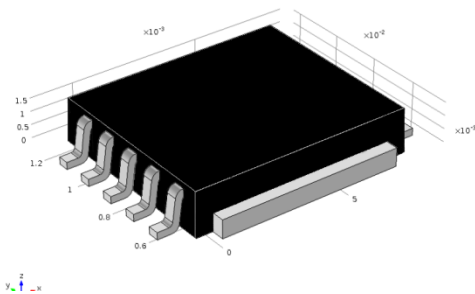
*“... Apps mark a **revolutionary page** in the history of mathematical **modeling** and numerical simulation: these specialized and **user-friendly tools bring the power of numerical simulation to a larger group of users...***”

“... people with no prior experience from FEA or mathematical modeling can access, exploit, and benefit from analysis...”

*“...simulation apps can create **more business opportunities with customers**. Beyond simply providing them with a technical report, you are also supplying them with an interactive tool...they can use to investigate the problem on their own ...”*



FROM MODEL TO APP



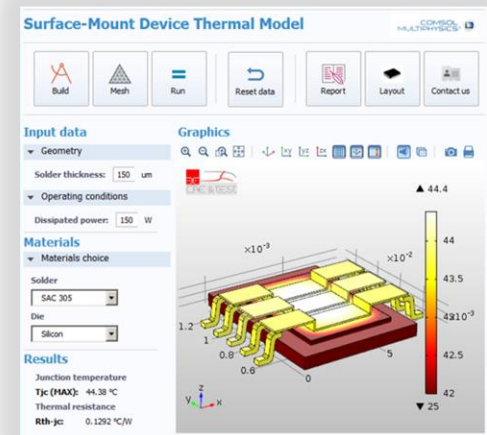
*Extract from COMSOL Press Release «Simulation Apps Pave New Frontier for Virtual Prototyping of Surface-Mount Devices»
<https://www.comsol.com/press/news/article/3231/>

➤ What is a COMSOL App?

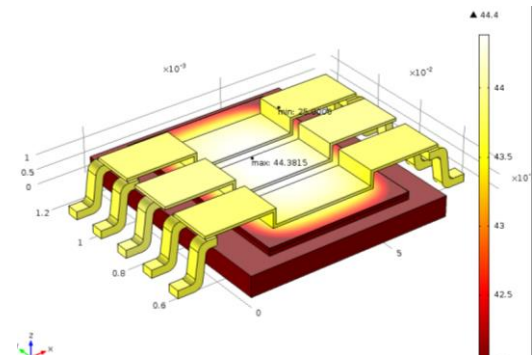
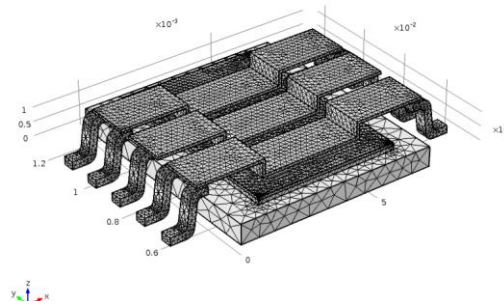
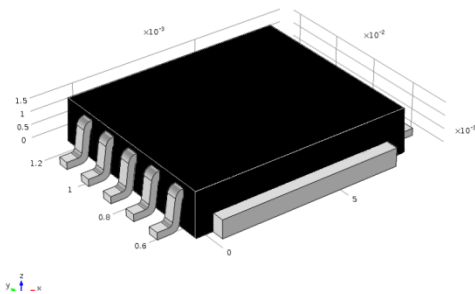
- Customized GUI allowing users to carry-out parametrical simulations without build models

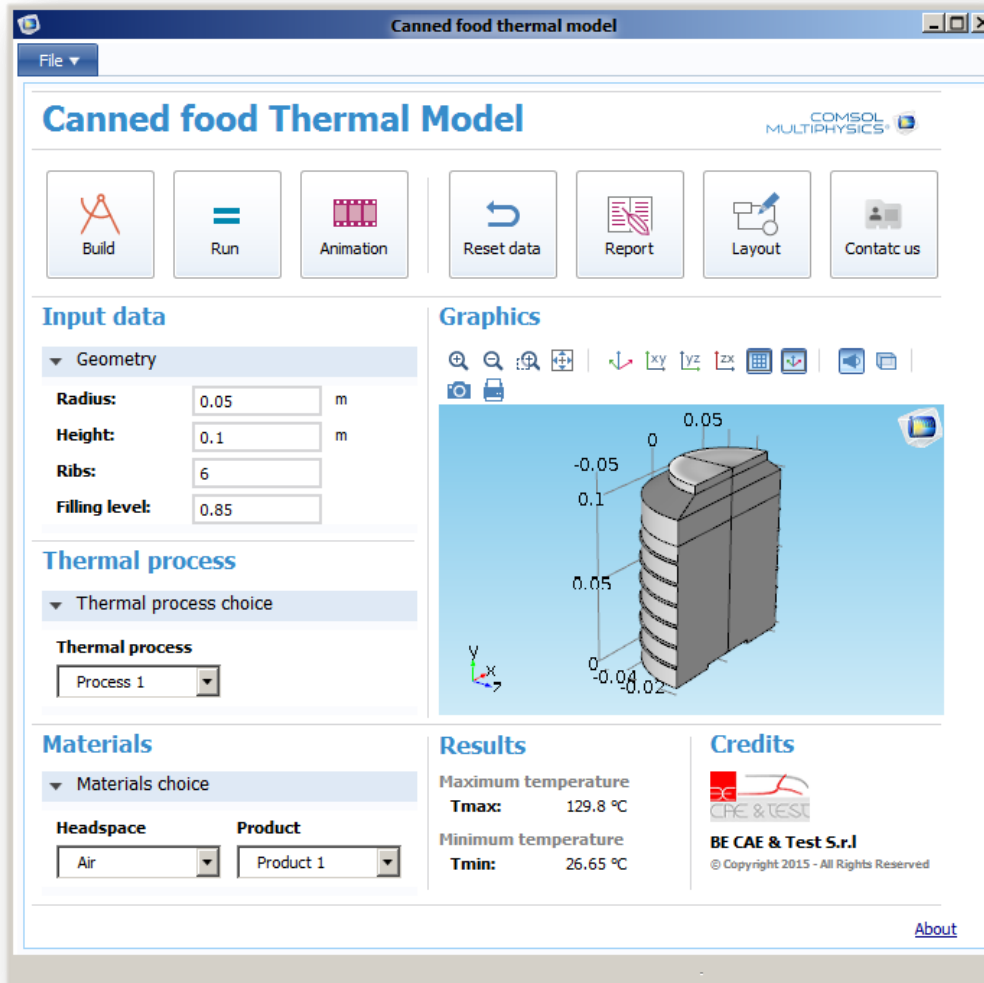
➤ Which kind of «parametric» analysis?

- **Geometrical**
- **Constitutive:** materials, assumption (i.e. plasticity model in structural analysis, flow regime in fluid dynamics, ...)
- **Funcional:** any operational or working condition
- **Derived value:** any value derived from FE dependent variable solved (i.e. a thermal flux from temperature solution in thermal analysis)
- ...



FROM MODEL TO APP

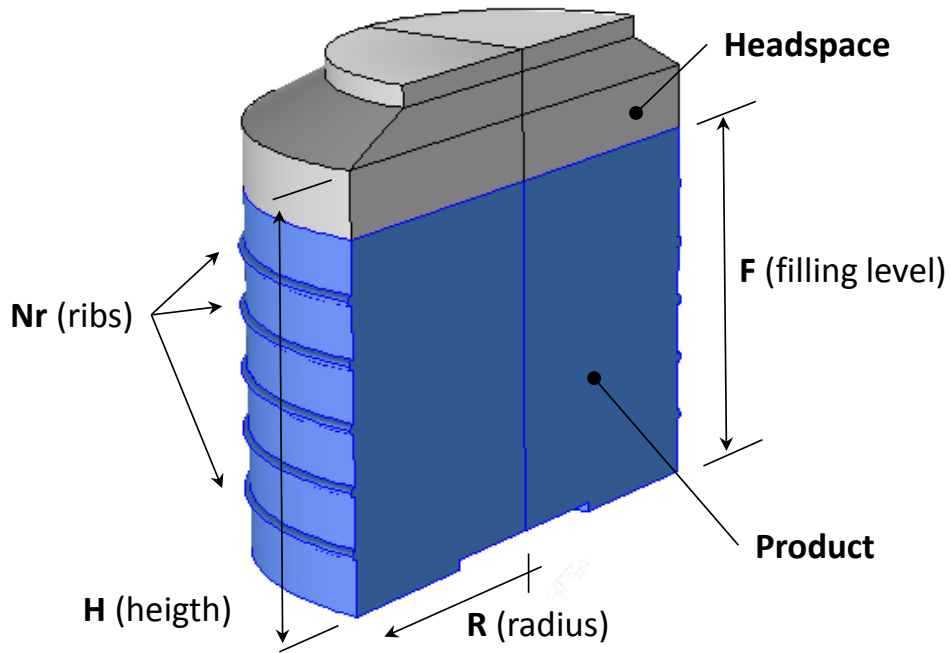




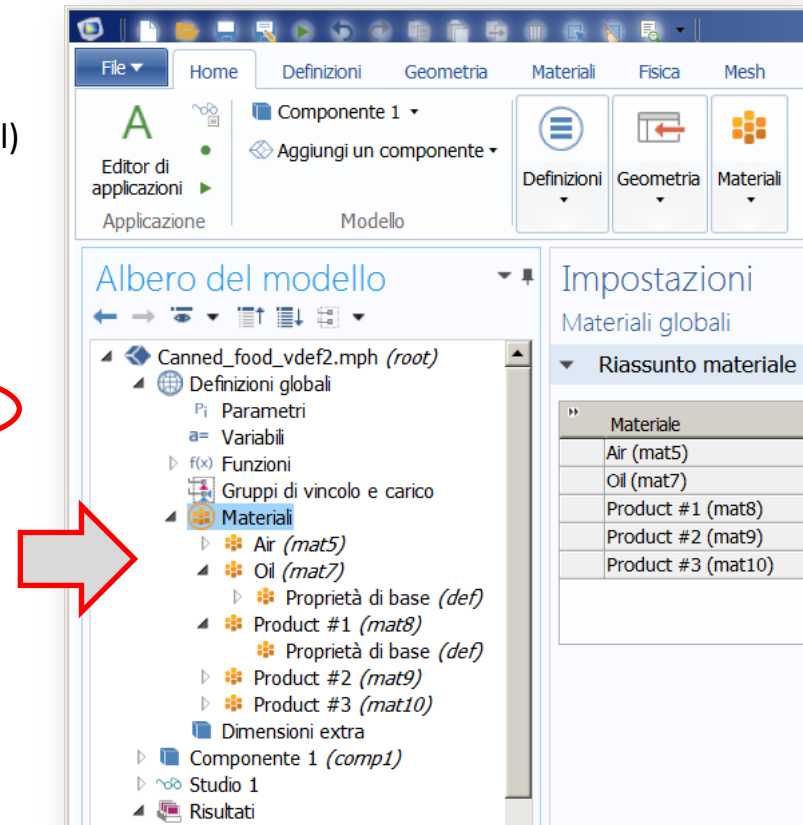
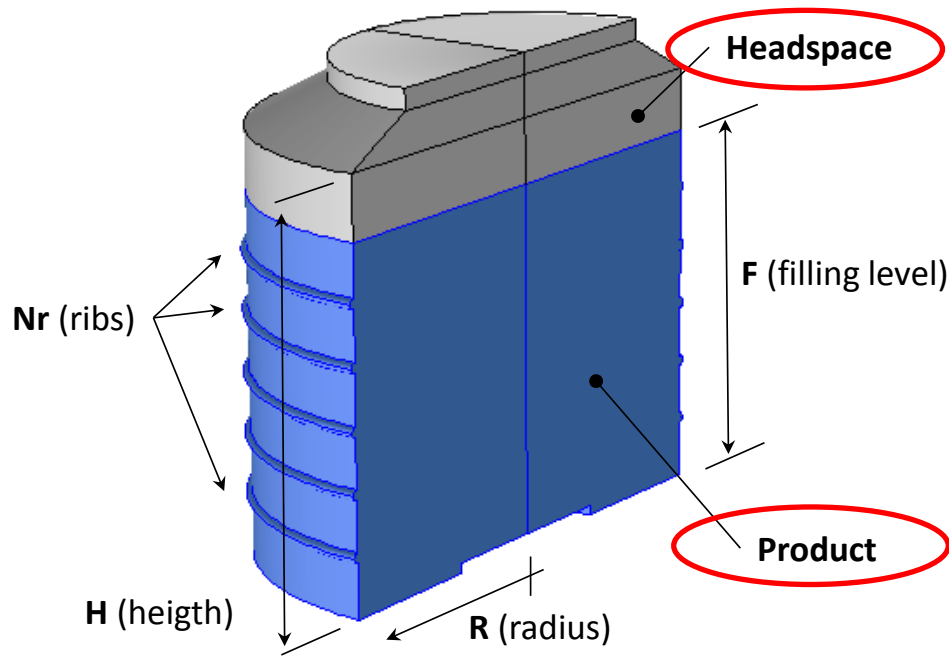
FOOD THERMAL TREATING

- “Food thermal treatment”: procedures for **destroying micro-organisms by the application of heat**.
- Numerical model allowed **simulating the heat transfer during a given process** implemented for food sterilization.
- It is needed a flexible tool allowing modification of **product type, quantity, shape of tray, type of heating cycle,...**
- Some specific quality indexes for the process need to be computed in **post-processing analysis**.

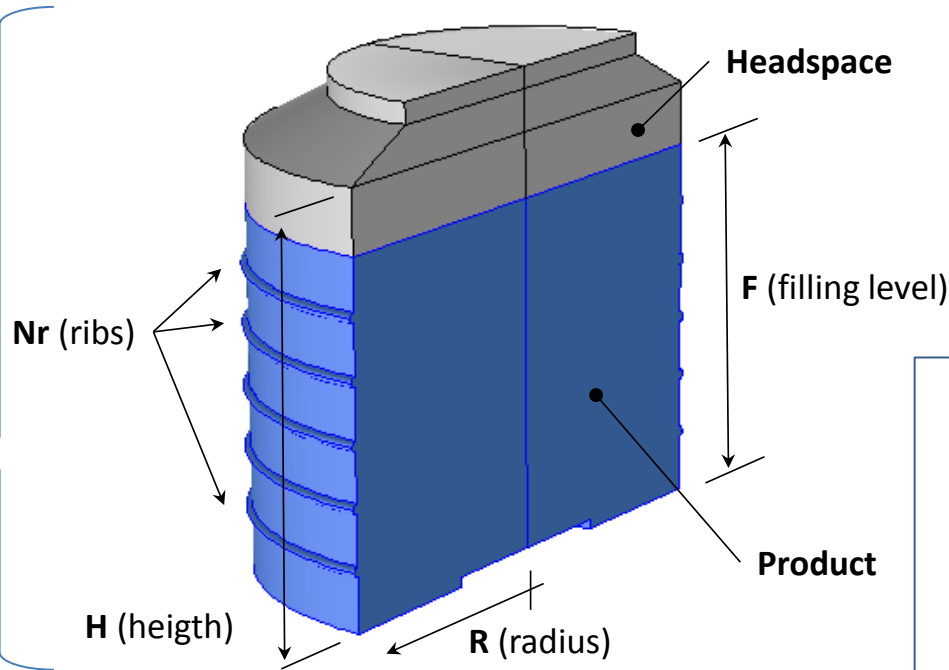
A parametric geometry...



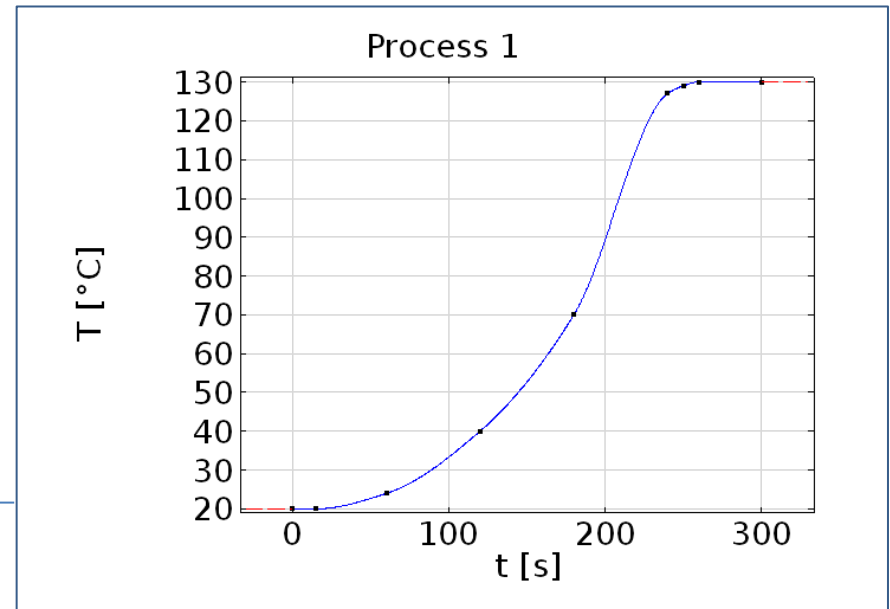
Customized libraries for material choice: “canned food (product)” and “headspace”



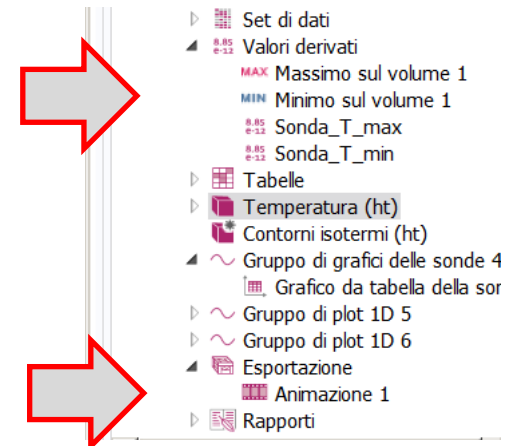
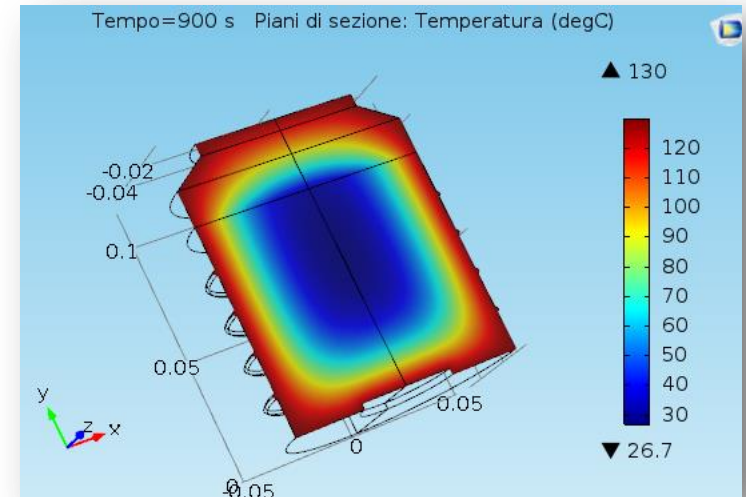
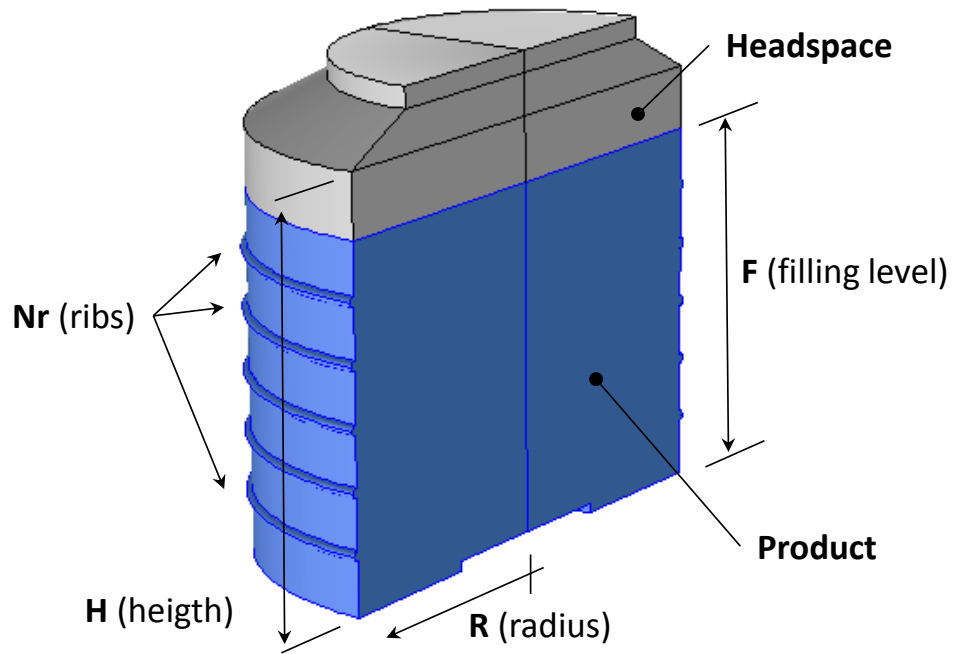
Choice of applied thermal process (retort temperature)



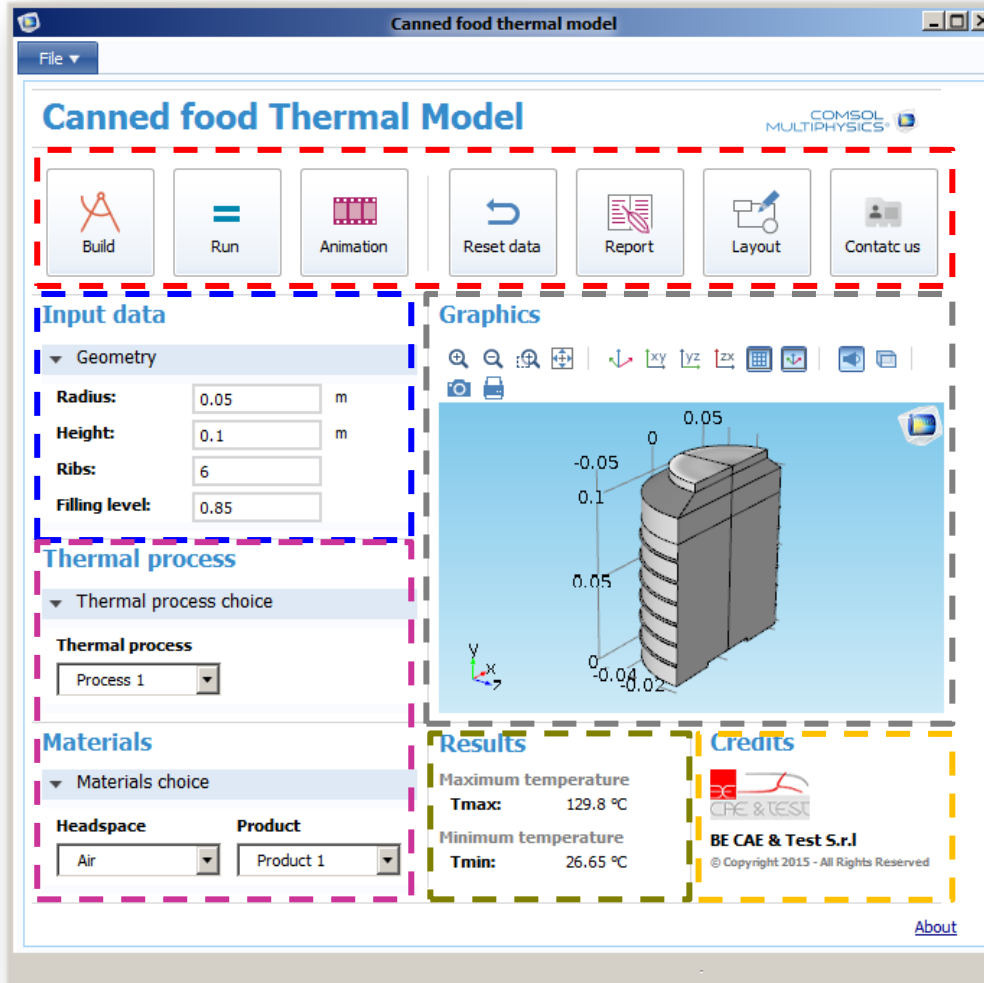
Boundary condition on "external" surfaces



Post-processing: thermal maps, animation of transient analysis, probe values...



Graphical interface built by using some of the Form Editor features



- ← Action button
- ← Input field
- ← Combo Box
- ← Graphics
- ← Data Display
- ← Picture / text

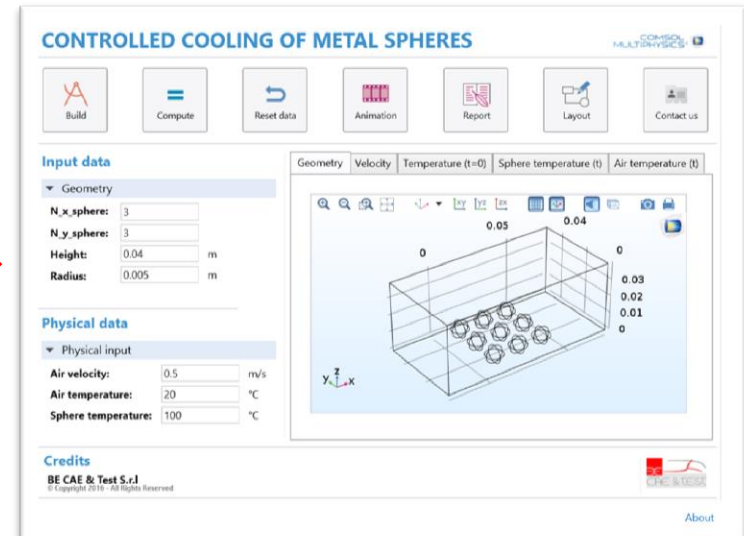
SIMULATION OF HEAT TREATING PROCESSES

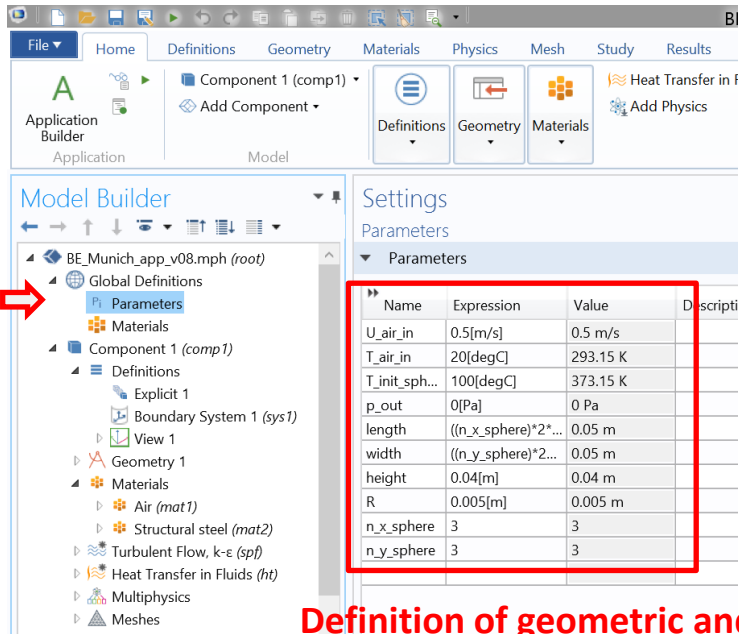
- Optimizing the heating/cooling equipment.
- Monitoring the time evolution of the pieces “core” temperature as a function of :
 - Size;
 - Constituting material;
 - Relative position of the pieces in the cooling equipment;
 - Magnitude of the cooling forced flow.

This kind of study can be carried out by **three steps**, setting different boundary conditions and physical variables coupling from one step to another:

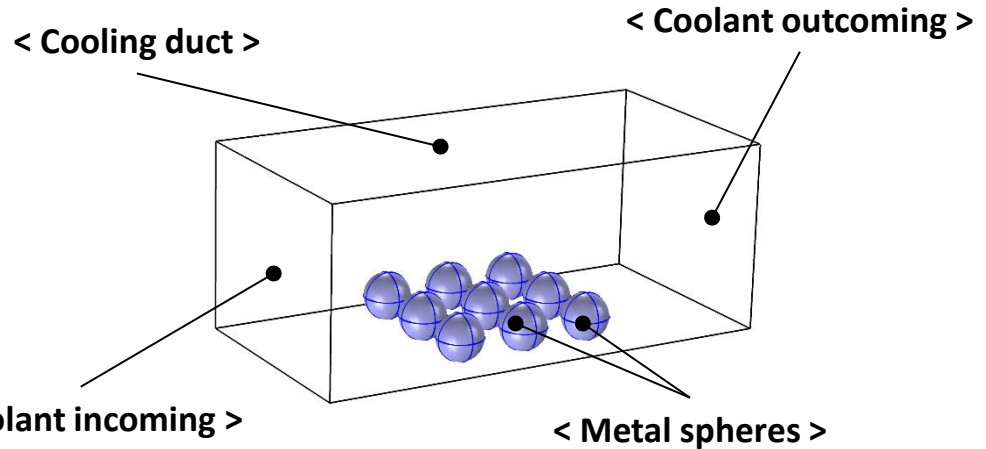
1. **Fluid dynamical** solution of the **permanent velocity field**;
2. **Steady thermal simulation** of temperature distribution at cooling process beginning;
3. **Transient thermal analysis** during the cooling process.

Build an App for managing a sequence of computational steps to be run by using different physical settings



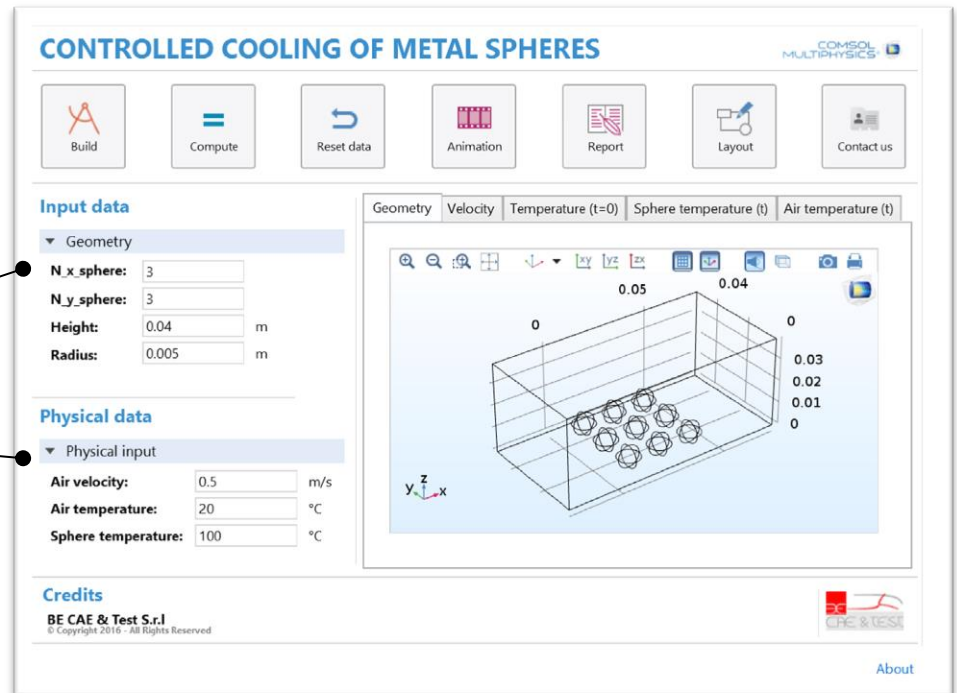


Definition of geometric and process parameters



Parametric» analysis

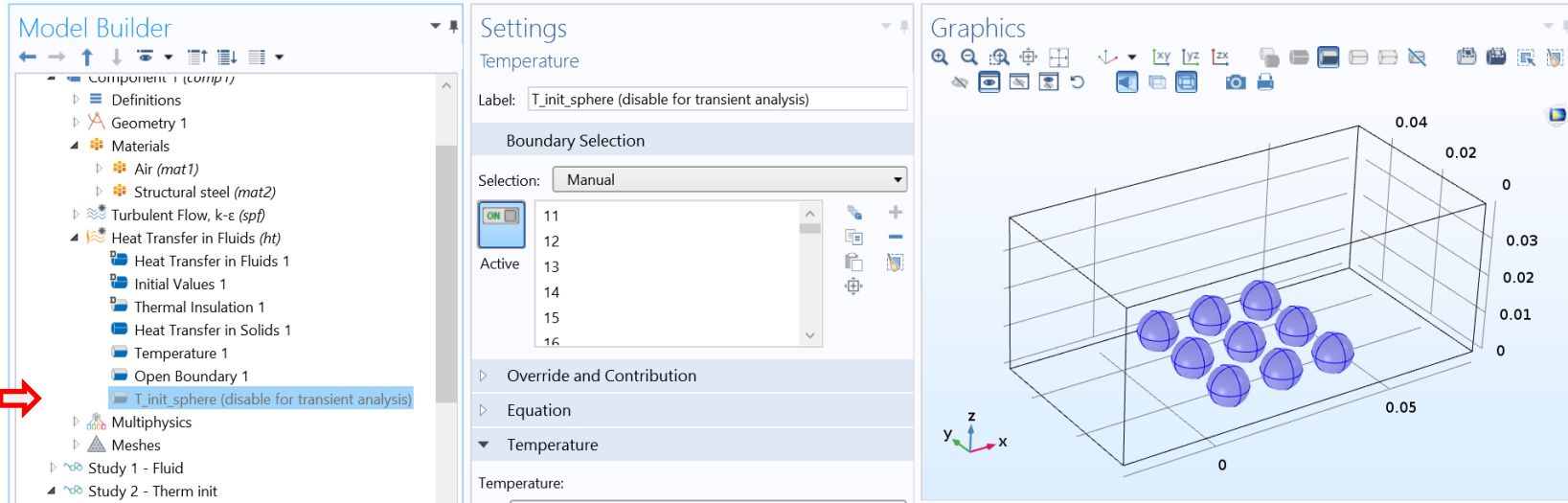
- **Geometrical** (spheres number and dimension, duct dimensions)
- **Functional** (Coolant flowrate and temperature, initial spheres temperature)



**Definition of probes
(parametric also)**

Parametric» analysis

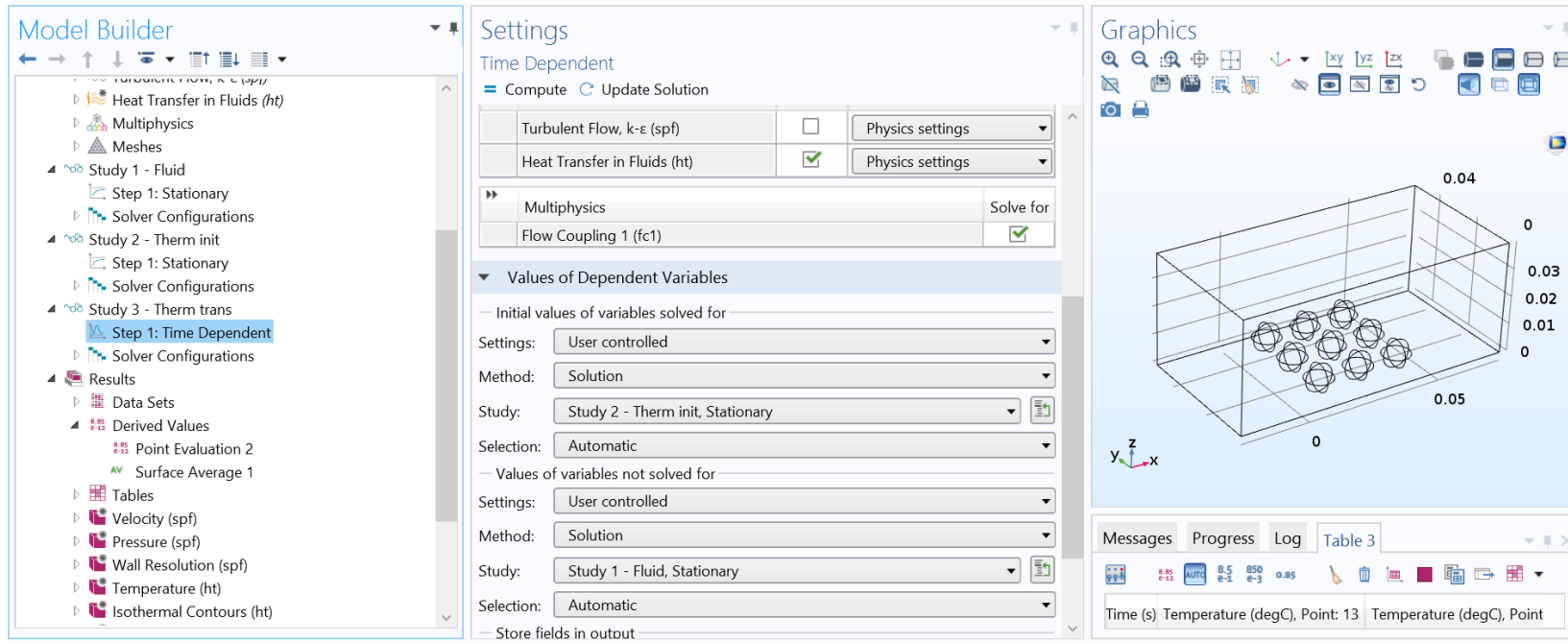
- **Derived values** (time-evolution of the «core» temperature for each sphere, time-evolution of the average temperature of out-flowing air)



The screenshot displays the COMSOL Multiphysics interface with three main panels:

- Model Builder:** Shows a hierarchical tree of components. A red arrow points to the 'T_init_sphere (disable for transient analysis)' entry under the 'Temperature' node.
- Settings:** Shows the configuration for the 'Temperature' boundary condition. The label is 'T_init_sphere (disable for transient analysis)'. The 'Boundary Selection' is set to 'Manual', and a list of active boundaries (11-16) is shown.
- Graphics:** Shows a 3D visualization of a rectangular domain with several blue spheres inside, representing the metal sheres. The axes are labeled x, y, and z, with numerical values indicating the domain dimensions.

Physics setting
 (Specific BC are used for computing specific initial thermal states exploited as initial solution for transient analysis)

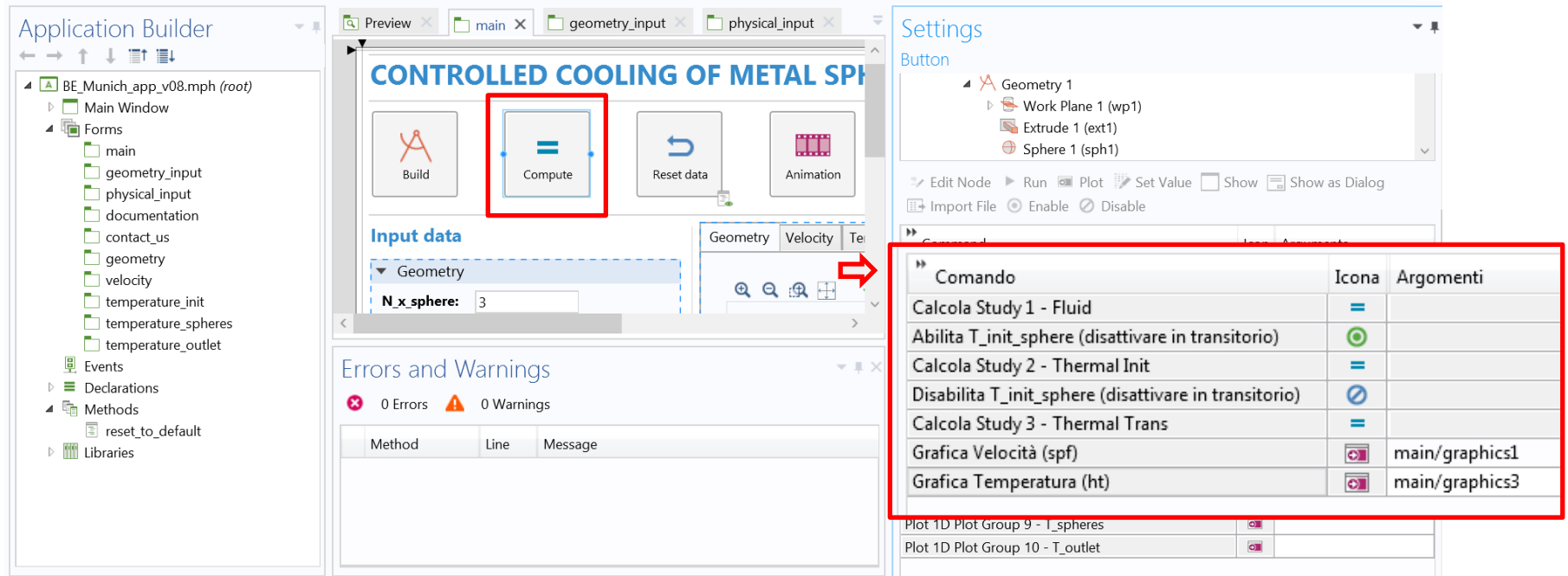


«Manual» work-flow by using the embedded model:

- Run < Study 1 – Fluid > for solving the velocity and pressure fields
- Set (enable) specific BCs (surface spheres temperature)
- Run < Study 2 – Therm init > to get a specific thermal state (or distribution) at the initial time
- Disable specific BCs (surface spheres temperature)
- Run < Study 3 – Therm trans > to perform the transient analysis

**Waiting for
solution**

**Waiting for
solution**



The screenshot displays the COMSOL Application Builder interface for a model titled "CONTROLLED COOLING OF METAL SPHERES". The interface is divided into several sections:

- Application Builder (Left):** Shows a hierarchical tree of the application structure, including folders for "Main Window", "Forms", "Input data", "Events", "Declarations", "Methods", and "Libraries".
- Preview (Center):** Displays the application's user interface. It features a title bar, a toolbar with "Build", "Compute", "Reset data", and "Animation" buttons, and an "Input data" section with a "Geometry" dropdown and a text input field for "N_x sphere" set to "3". The "Compute" button is highlighted with a red box.
- Settings (Right):** Shows the configuration for the application. It includes a "Button" section with a tree view of the application's components. Below this is a table of commands, which is highlighted with a red box.

Comando	Icona	Argomenti
Calcola Study 1 - Fluid	=	
Abilita T_init_sphere (disattivare in transitorio)	🟢	
Calcola Study 2 - Thermal Init	=	
Disabilita T_init_sphere (disattivare in transitorio)	🟡	
Calcola Study 3 - Thermal Trans	=	
Grafica Velocità (spf)	📊	main/graphics1
Grafica Temperatura (ht)	📊	main/graphics3
Plot 1D Plot Group 9 - T_spheres	📊	
Plot 1D Plot Group 10 - T_outlet	📊	

«Manual» work flow by using the embedded model:

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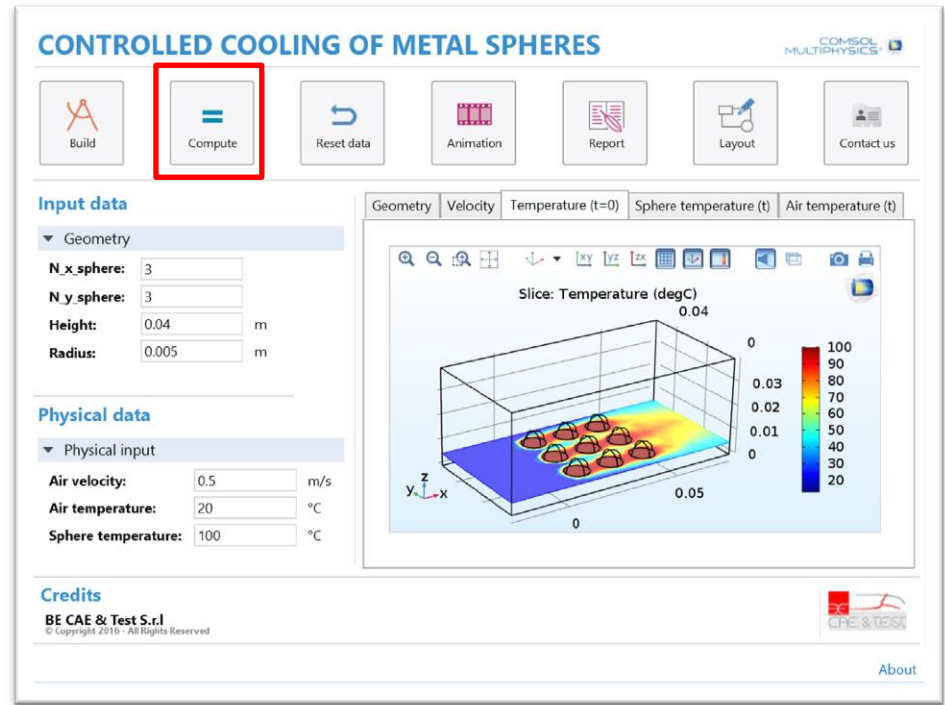
➤ **The Application Builder allows to EXECUTE a «work-flow» of commands by a single «action button»**

«Manual» work flow by using the App:

- Click the «Compute» button



FROM MODEL TO APP



CONTROLLED COOLING OF METAL SPHERES

Build Compute Reset data Animation Report Layout Contact us

Input data

Geometry

N_x_sphere: 3
N_y_sphere: 3
Height: 0.04 m
Radius: 0.005 m

Physical data

Physical input

Air velocity: 0.5 m/s
Air temperature: 20 °C
Sphere temperature: 100 °C

Geometry Velocity Temperature (t=0) Sphere temperature (t) Air temperature (t)

Slice: Temperature (degC) 0.04

0 100
90
80
70
60
50
40
30
20

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About

«Manual» work flow by using the embedded model:

- Run < Study 1 – Fluid > for solving the velocity and pressure fields
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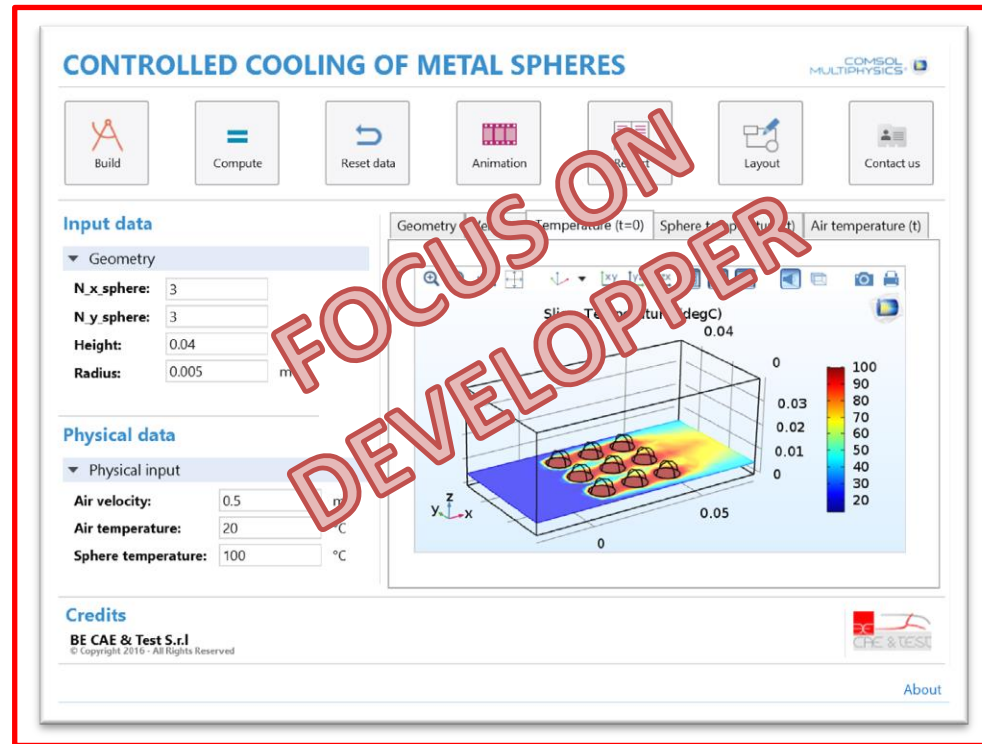
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