

# How Apps Can Support COMSOL Multiphysics® Users?

Petrone G. \*, Barbagallo C.

BE CAE & Test S.r.l., Viale Africa 170 - Sc.A, 95129, Catania, ITALY.

\*Corresponding author: Viale Africa 170 - Sc.A, 95129, Catania, ITALY; [giuseppe.petrone@be-caetest.it](mailto:giuseppe.petrone@be-caetest.it)

**Abstract:** Disposing of easy-to-use COMSOL Multiphysics® app to exploit FE-based simulations represents an important opportunity for people working in several industrial areas, from the electronics to the process engineering. In supplying consultancy services, Engineers at BE CAE & Test propose their Customers to use COMSOL Multiphysics® apps to run parametric models and carry-out predictive analyses (geometrical, constitutive and functional) for supporting decisional processes during the product/process development. Analysts in BE CAE & Test also use the Application Builder themselves to better manage or automate their own COMSOL Multiphysics® models.

**Keywords:** Application Builder, Thermal analysis, Manufacturing processes, Form Editor, Method Editor.

## 1. Introduction

The typical user of a simulation package is someone who holds a PhD or an MSc, and has several years of experience in modeling and simulation. He or she typically works as a scientist in the R&D department of a company or as an academic researcher. Because modelling methods are complex and typical simulation packages present many options, it is up to the user to employ his or her expertise to validate the model and the simulation. This means that usually a small group of simulation experts is servicing a much larger group of people working in product development or in production. Simulation models are oftentimes so complex that the person who implemented the model is the only one who can safely provide input data to get useful output. Hence, very often the use of computer modeling and simulation creates a bottleneck in product development, production, and education. In order to make it possible for this small group to service the much larger group, the Application Builder offers a solution. It enables simulation experts to create an intuitive and very specific user interface

for his or her otherwise general computer model – a ready-to-use application [1]. From this point of view, the Application Builder has revolutionized the concept of simulation. The engineer creating the application customizes the interface and controls input and output data that the user of the app will be allowed to manipulate. Apps are built by experts who include only the parameters relevant to the design of a specific device or process. The apps then make the simulation engineer's expertise available to everyone involved in the design and manufacturing processes across all engineering disciplines of a company. By enabling more people to access simulation in a company, product designs and processes can be improved efficiently and effectively. Two tools are integral to the Application Builder: The Form Editor and the Method Editor. The Form Editor is the platform for building apps and allows for easy creation of app's user interface through drag-and-drop capabilities. The Method Editor is used to extend app's simulation capabilities by providing a programming environment for use with Java code [2,4].

In the present paper, two demonstrative COMSOL Multiphysics® apps are presented. Both apps were built to monitor the internal thermal state (core temperature vs. time) of different products during specific thermal processes.

## 2. Application building

The GUI of the first app is shown in Fig. 1: it relates to a thermal process in a food engineering application. This app allows to simulate the transient heat transfer in canned food during a sterilization process for several geometrical and functional configurations. The cans geometry was integrally built in the COMSOL Multiphysics® environment, so that the app users can modify its cylindrical lateral-ribbed shape (radius, height, number of ribs). Because of the can is not totally filled by the food, the filling level is also allowed to be geometrically modified.

Before starting simulation, the retort thermal process can be selected, as well as the kind of product inside the can (material properties) and the material used to fill the headspace (air or oil). As result, the transient temperature distribution inside the can is available.

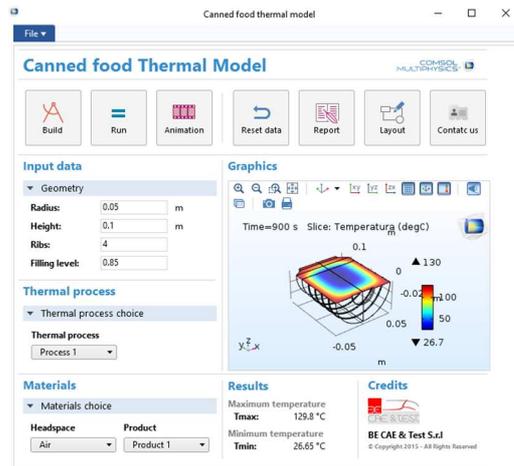


Figure 1. Canned food Thermal Model.

The GUI of the second app is shown in Fig. 2: it concerns an industrial cooling process for bearing metal spheres. In order to achieve specific material properties, a sudden cooling in forced flow is applied to the metal spheres. Simulation is based on a three-steps studies: the first one to solve the permanent fluid flow, the second one to achieve the initial thermal state, the third one to solve the thermal transient analysis. The number and dimension of the processed spheres can be setup by the app users, as well as the cooling channel dimensions, the magnitude and temperature of the forced cooling flow. Some methods were introduced in the embedded COMSOL Multiphysics® model in order to automatic switch between the enabled/disabled state for specific boundary conditions on the spheres surfaces during the different computational steps. Methods were also applied to manage the computational sequence of simulation. As result, the internal thermal state (core temperature vs time) of metal spheres is given.

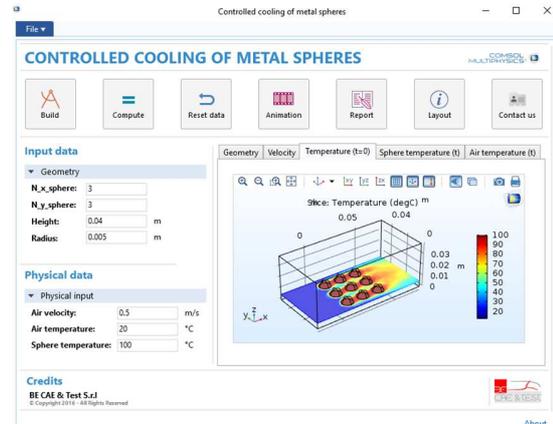


Figure 2. Controlled cooling of metal spheres.

The above mentioned apps were built-up using the Application Builder of COMSOL Multiphysics version 5.1. The proposed tools exploit several functionalities of the Application Builder, such as Action Buttons, Input Fields, Combo Boxes, Graphics and Data Display. Some features were implemented concerning global/local links for material definition, declarations, initial values and methods for manage strings in combo box application and global variable values assumed by specific probes. The steps of application building and implemented functionalities are presented in the following paragraphs [4].

## 2.1 Model layout

The layout of the can studied in the firstly presented app is shown in Fig. 3. It is mainly made by a headspace, filled with air or oil, and a remaining part, (shown in blue in Fig.3) characterized by several ribs and containing the product.

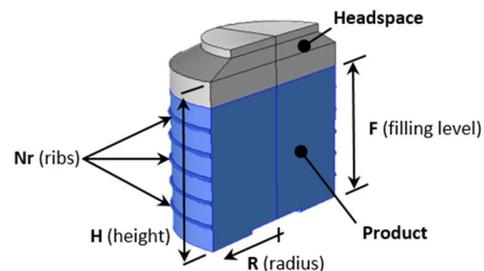


Figure 3. Layout of the studied can.

The layout of the numerical model studied in the second app is shown in Fig. 4. It is composed by a cooling duct in which several metal spheres are located.

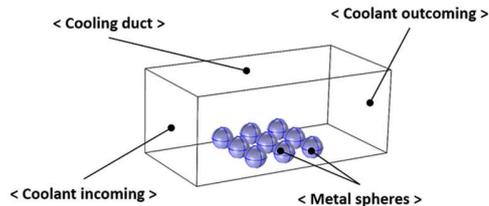


Figure 4. Layout of the second app numerical model.

## 2.2 Action buttons

In both apps, an action buttons tab was implemented. It displays the model and application actions that can be run by clicking a button in the application user interface [3]. In particular, we implemented some action buttons: Build, Run/Compute, Animation, Reset data, Report, Layout and Contact us.

Build button allows to show in the graphic window the updated geometry after setting geometrical properties in the suitable input field. Run/Compute button consents to compute the implemented study. Animation button permits to show an animation of transient thermal distribution. Reset data button permits to return to the default settings. Report button shows a resume of the performed simulation. Layout button shows information about geometry and materials of the studied mode. Contact us button shows the contacts of our company [4].



Figure 5. Example of action buttons tab.

## 2.3 Input fields

Input fields allow to manually set geometrical and functional/physical data. In the first app presented users can set radius and height of the can, the number of ribs and the filling level, as shown in Fig.6. In the second app, users have the possibility to choose the number of spheres and their dimension, to set the duct dimension, and to

set the air velocity, the air temperature and the initial temperature of spheres, as shown in Fig.7.

**Input data**

▼ Geometry

Radius:  m

Height:  m

Ribs:

Filling level:

Figure 6. Input fields of Canned food thermal model app.

**Input data**

▼ Geometry

N\_x\_sphere:

N\_y\_sphere:

Height:  m

Radius:  m

---

**Physical data**

▼ Physical input

Air velocity:  m/s

Air temperature:  °C

Temperature:  °C

Figure 7. Input fields of Controlled cooling of metal sphere app.

## 2.4 Combo boxes

In the Canned food thermal model app three combo boxes were implemented in order to allow the choose of the thermal process, the headspace material and the product. The thermal process was realized as an interpolation function tracing the evolution of temperature in time as shown in Fig.8.

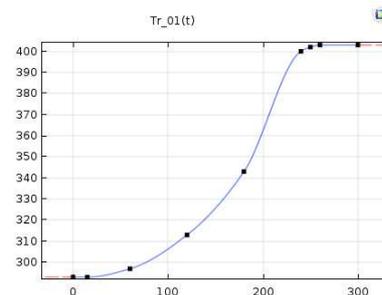
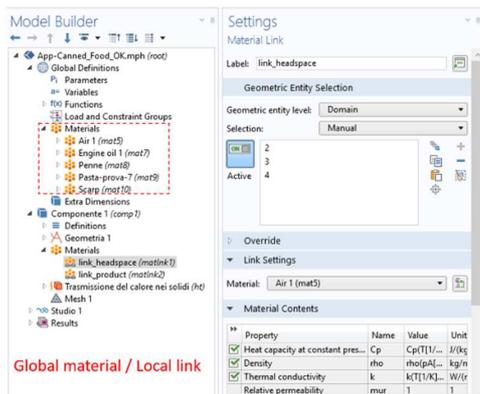


Figure 8. Example of thermal process.

The thermal process choice was implemented in the embedded model using global materials and a material link, as shown in Fig. 9. Each material

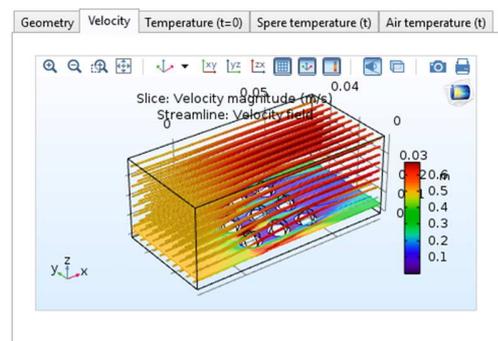
and thermal process are indexed with a string, where global variables are defined. For the global variables both an initial value and a choice list were associated. An event listens for changes to the value of the global variable, where the value is controlled by a combo box. When the value is changed, the local method implemented in the Application Builder permits to change material and thermal process in combo boxes [1].



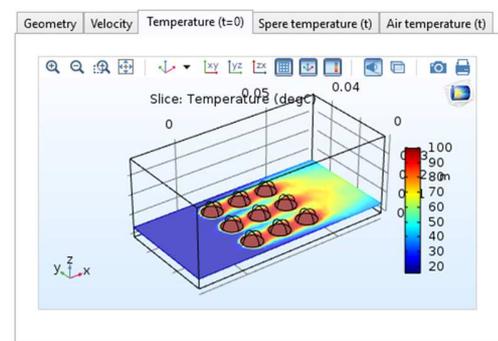
**Figure 9.** Global materials implementation for Canned food thermal model.

## 2.5 Data display

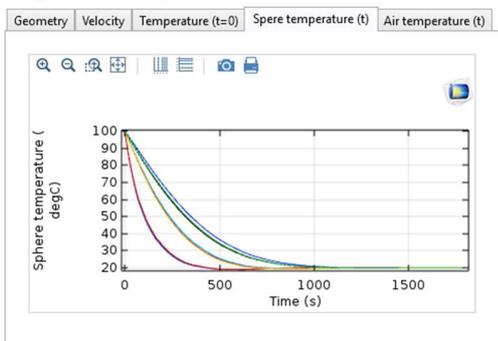
A data display object is used to display the outputs of implemented models. For the canned food thermal model the maximum and minimum temperature inside the can was obtained. This result is function of chosen thermal process and materials. In addition, the transient temperature distribution inside the can could be displayed in the graphic window, as previously shown in Fig.1. In order to do this, two probes were defined assuming as input the achieved thermal state. For the other app, the velocity field, the temperature distribution, the sphere temperature after cooling and outlet air temperature are obtained, as shown in Fig. 10-13.



**Figure 10.** Velocity field.



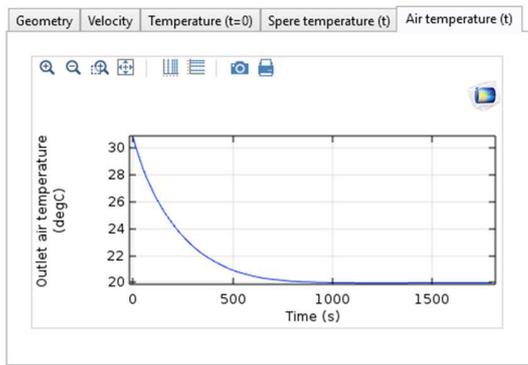
**Figure 11.** Temperature distribution.



**Figure 12.** Sphere temperature.

## 3. Exploiting APP by COMSOL Server

These apps built-up by BE CAE & Test were also live tested on COMSOL Server platform during specific events, showing the opportunity of exploiting it by a remote control through COMSOL Client and a web browser [4].



**Figure 13.** Outlet air temperature.

## 4. Conclusions

Two COMSOL apps were built up to monitor the internal thermal state of different products during specific thermal processes. That was obtained for several geometrical and functional configurations exploiting several available features of the COMSOL Application Builder. As result, the transient temperature distribution inside the can is available for the first app, and the flow field, the temperature distribution, the sphere temperature after cooling and outlet air temperature are available for the second one. The presented apps well show the opportunity of revolutionizing the concept of simulation for users, representing a competitive advantage in terms of organizational efficiency for companies.

## 5. References

1. COMSOL Multiphysics, *Introduction to Application Builder*, 2017.
2. COMSOL Multiphysics website, <http://www.comsol.com/release/5.1/application-builder>.
3. COMSOL Multiphysics website, <https://www.comsol.it/events/5771/analisi-termiche-e-termo-strutturali-con-comsol-lesperienza-di-be-cae-and-test/>.
4. G. Petrone, C. Barbagallo, A COMSOL APP for thermal analysis of electronic devices, *Proceedings of the COMSOL Conference 2015*, 14-16 October 2015, Grenoble, France (2015).