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A validated tool for thermal design and the forecasting of behavior of composite materials exposed to high thermal loads

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Abstract

A tool for the virtualization and prediction of thermal behavior of composite materials exposed to fire has been developed. The software, called *"3D FireSimulator",* is an interface running above a standard finite element program with a heat transfer module.

The 3D FireSimulator (3DFS) is based on the research carried out by the LIR-Infrared Lab of the Universidad Carlos III de Madrid (Spain) on heat propagation phenomena [1] in composite materials under load of fire [2]. 3DFS models the thermal behavior by means of the thermal parameters change with temperature and degradation states which have been previously determined by the LIR-UC3M by infrared non-destructive testing (IR-NDT), including the flash method techniques [3].

The 3D FireSimulator can be used by industrial designers, researchers, product developers and scientists interested in detailed descriptions of the thermal behavior of composite materials in fire. The 3DFS has modeling tools for the simulation of heat transfer mechanisms involved in both fire tests and medium to high temperatures conditions, including conduction, natural and forced convection and radiation. The simulations study the thermal behavior throughout the time in three-dimensional systems.

The high level of detail provided by these simulations allows optimizing the design and operating conditions on devices and processes influenced by heat transfer. An important part of the high temperature accuracy provided by the program is based on having, precisely, the thermal parameters of each material (conductivity, specific heat, emissivity ...), temperature dependent by means infrared nondestructive techniques [4].

3DFS results have been empirically validated, with less than 7% of deviation, comparing modeled results with experimentally obtained measurements.

Keywords*: Fire, composite materials, virtualization, simulation, thermal parameters*

Results

Introducing the type of material, its geometry, the maximum temperature and the shape of the flame and the time of fire exposure, some of the results that can be obtained are shown in the figures below:

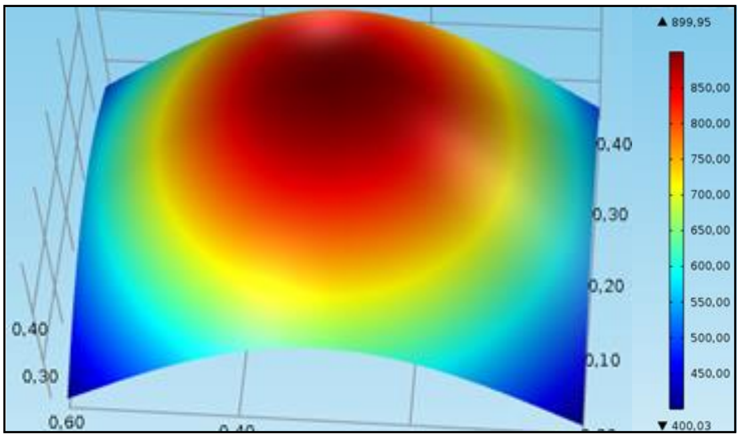

Figure 1: *Simulated flame in order to virtualize the fire experiments. Shape and maximum temperature of the flame can be modify by the user*

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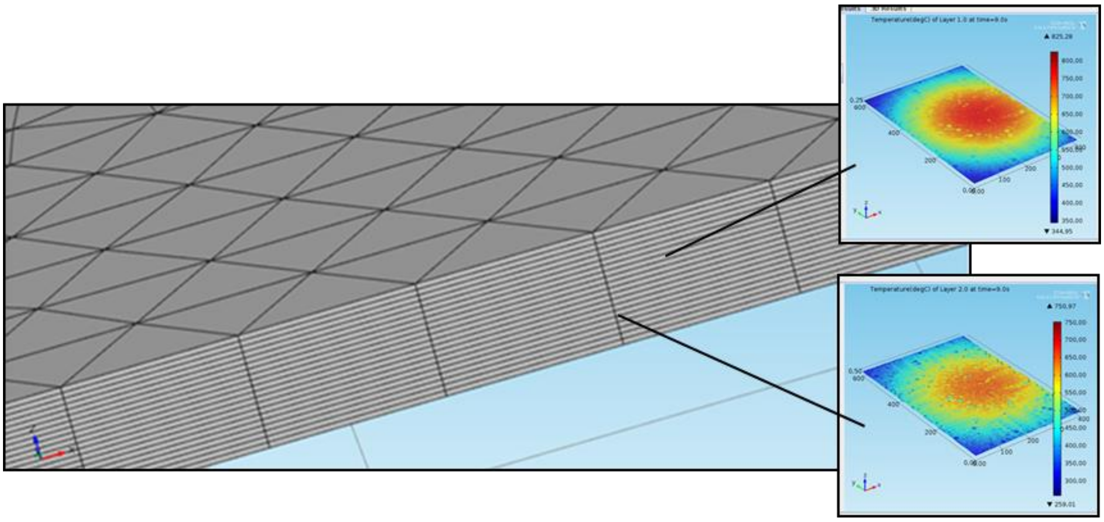

Figure 2: *Detailed information of every layer of the material. In every three-dimensional point and in every time*

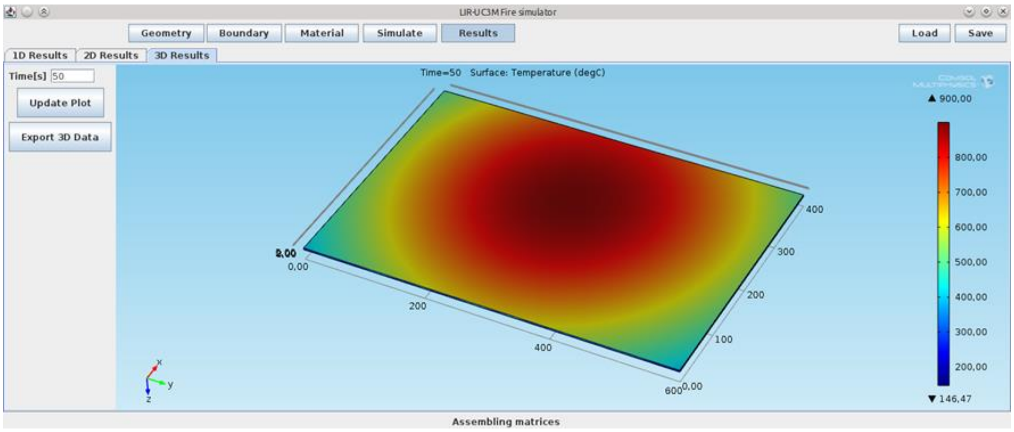

Figure 3: *Three-dimensional analysis of the thermal behavior of the material*

References

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