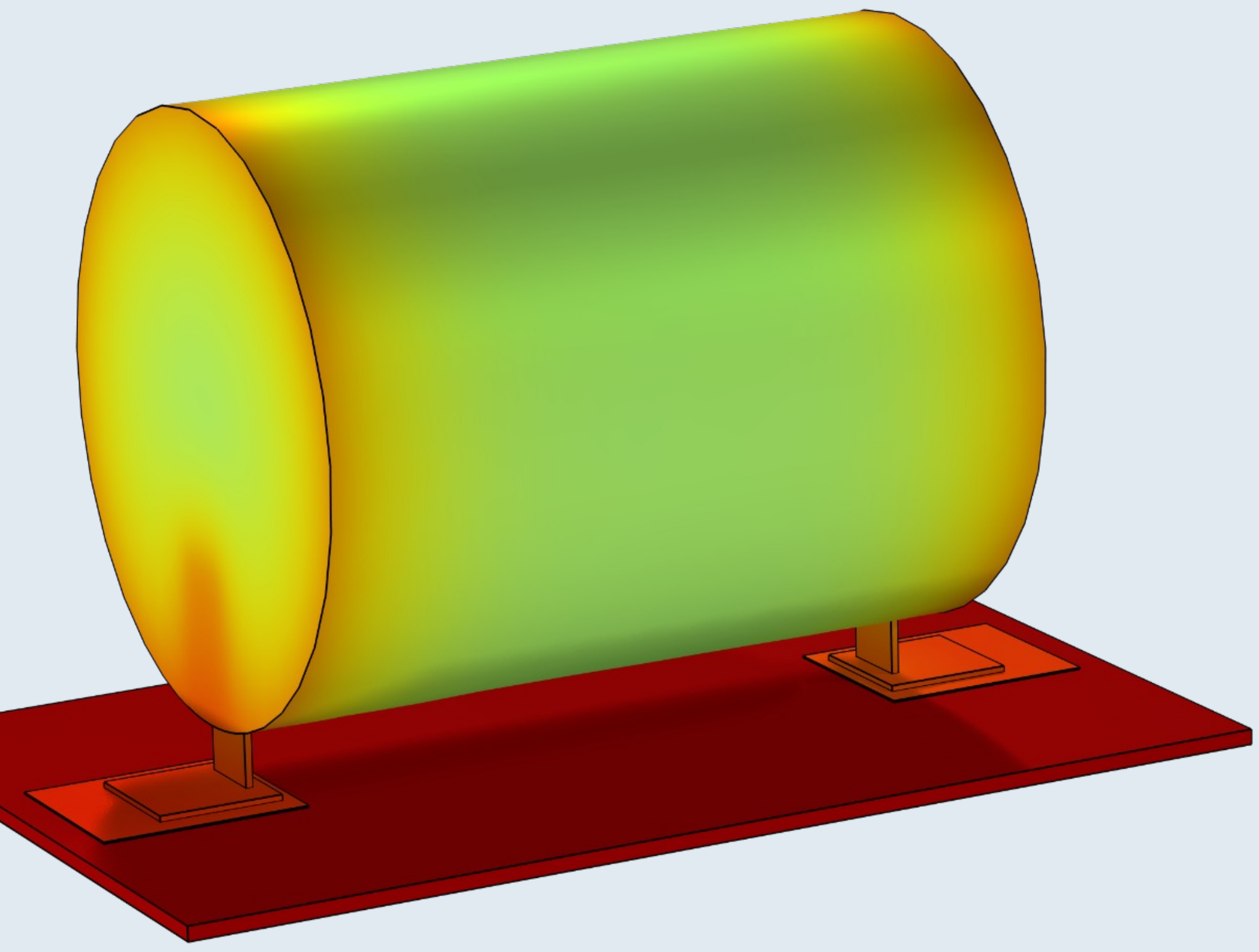

Quantifying the Convective Heat Transfer Coefficient in a Reflow Oven: A Numerical Approach

Numerical and experimental investigations on the reflow process of an electronic component are performed. The heat transfer mechanisms, such as conduction and convection, are simulated to predict the temperature distribution on the surface and in the middle of the component.

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Introduction & Goals

Reflow soldering is a widely used technique in electronics manufacturing that facilitates the precise and automated assembly of electronic components onto printed circuit boards (PCBs). This method is indispensable for the efficient production of complex electronic devices, ensuring their reliability and functionality. This work, through finite element analysis, aims to simulate the heat transfer mechanisms involved in reflow soldering to predict the temperature distribution on the surface and in the center of the component. To reach this goal, the surface heat transfer coefficient trend during convective reflow oven processes is determined using the Lumped Heat Capacity formulation. The numerical results were compared to the experimental ones.

FIGURE 1. Example of a reflow oven.

Methodology

The Lumped Heat Capacity formulation was used in order to determine the trend of the heat transfer coefficient $h(t)$ over time:

$$h(t) = \frac{\rho c_p V}{A_{surf}} \left[-\ln \left(\frac{T_{oven} - T(t)}{T_{oven} - T_{start}} \right) \right]$$

The trend of $h(t)$ was obtained from the value of T_{oven} and $T_{surface}$ of an aluminum block, taken by the experimental measurements. The method was validated comparing the simulated results with the experimental data. Then, using *h(t)*, the convective heat transfer of an electronic device inside the reflow oven was simulated .

Results

The temperature field of the entire element was obtained from a transient simulation. The heat transfer process occurs both through thermal convection with the external air and thermal conduction between the two different layers. In fact, it can be observed that the outer part of the element has a higher temperature compared to the central part, which is thus well protected from the high temperatures of the reflow oven.

The temperature values on the outer surface and inside the element obtained from the simulation were compared with experimental measurements obtained using two K-type thermocouples. A good agreement was obtained, with a maximum relative error of 7.2%.

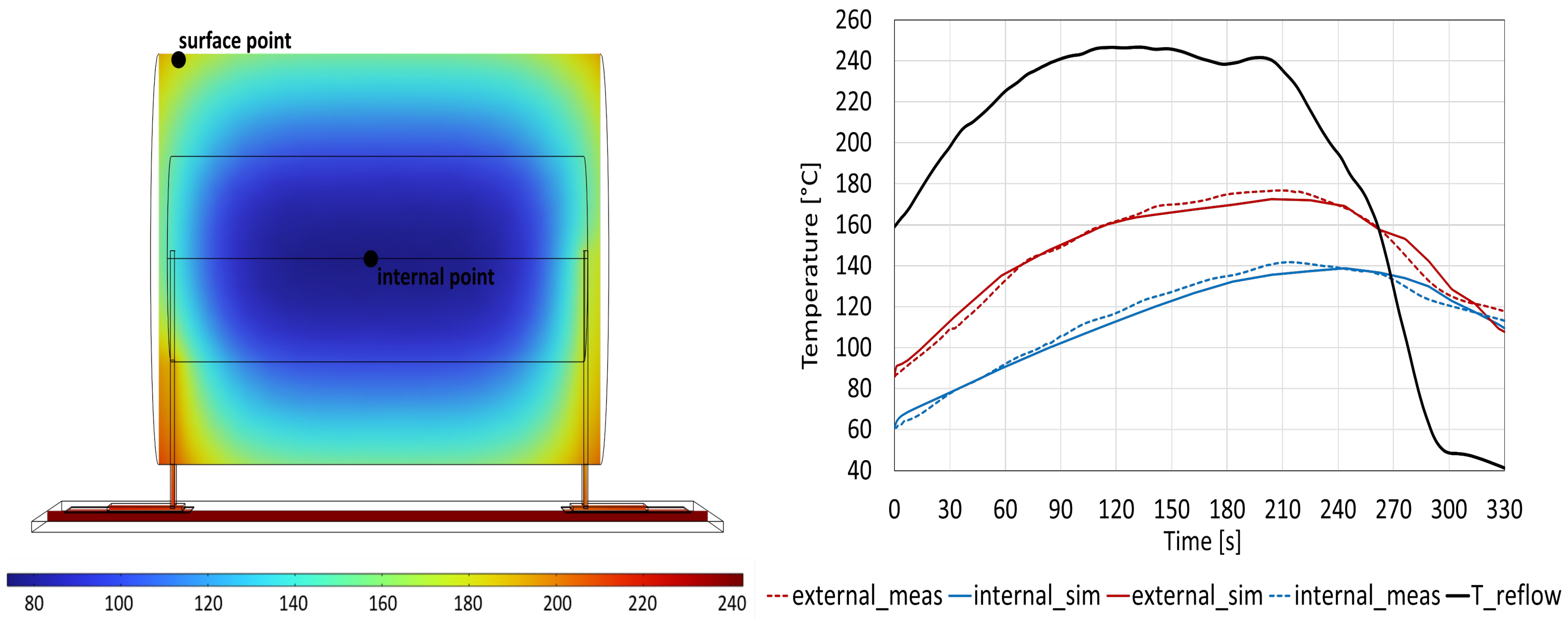

FIGURE 2. Left: Temperature distribution on the element. Right: Comparison of the numerical and experimental temperature trends of the external surface and of the middle of the element.

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