Modeling strategy of IR lamps with integrated reflector used in the slurry powder impregnation process of composite tapes

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Abstract. This study proposes a modelling strategy to simulate the heating stage during the production of thermoplastic composite tapes. Impregnation using a slurry powder technique with carbon fibres and PEKK (Polyether-ketone-ketone) requires a heating step, achieved with an infrared (IR) oven, to evaporate the water and melt the polymer powder. These phenomenon are highly temperature dependant justifying the need to characterise heat transfer within the infrared oven.

In the literature, most of the models refer to clear lamps with Lambertian emission. The case of tubular lamps with coating on the back-side (i.e. integrated reflectors) presented Figure 1 then needed to be investigated. The reflector greatly modifies the lamps spatial emission, so a single emissivity and temperature assumption is no longer sufficient. Here we propose an adaption of the basic radiosity method to predict emission without explicitly accounting for a reflector in terms of radiative exchange. Inverse analysis was used to characterise the emission of these lamps. An IR camera (FLIR SC325, [7.5-13] µm) was used to perform measurements on the back surface of a heated ABS (Acrylonitrile butadiene styrene) plate for which radiative as well as thermophysical properties are known form previous in-lab research works[1]. Temperature distribution results were transferred into the commercial software – COMSOL Multiphysics® - to estimate model parameters: filament temperature and an emissivity distribution function.

The IR oven, as well as multiple IR lamps, also includes ceramic planar reflectors and glass plates. The optical properties of these components were measured using a Fourier-transform infrared spectrometer. Then, along with the lamp model, these properties were used in a heat transfer model of the infrared oven, again using commercial FEM software, to compute temperature distribution inside an ABS sheet. The results of this simulation were compared to experimental data, obtained while heating an instrumented sample inside the IR oven, in order to validate the numerical model.

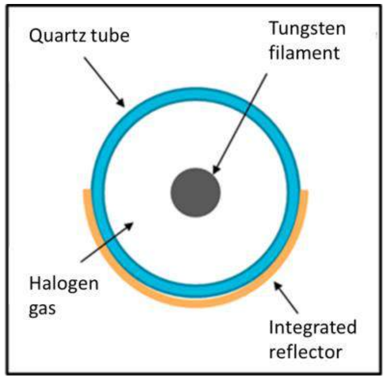

Figure 1: Cross section of an Infrared lamp with an integrated reflector

[1] S. Andrieu, “Etude expérimentale et numérique du chauffage infrarouge de plaques thermoplastiques pour le thermoformage,” Paris, ENMP, 2005.(In french)