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Heat transfer spray model: An improved theoretical thermal time-response to uniform layers deposit using Bessel and Boubaker polynomials

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ABSTRACT

This study presents temperature profiling theoretical investigations in a pyrolysis spray model. Calculations are based on heat transfer equation resolution in cylindrical coordinates. Boundary conditions are taken into account in the resolution algorithm at different stages.

1. Introduction

Spray pyrolysis is a powerful and very low cost technique to synthesize varieties of thin films from several materials. In the last decades, many models [1,8] have been established in order to predict deposited material composition and behaviour.

Eslamian et al. [1] proposed, i.e., a mathematical model based on Boltzmann equation numerical solution for the transition regime with the continuum based governing equations. This model was successfully tested on submicron zirconium particles, prepared by spray pyrolysis. The model presented by Grader et al. [2] was rather based on particle and gas temperatures alterations during the spraying process, and tried to explain the incomplete reactions obtained under particular conditions. Other models were mainly based on numerical and empirical simulation [3–8].

In this paper, we propose an analytical solution to the heat equation. The studied model is a vertical gas–solution spray depositor under the presumption of a uniform deposited layer. The boundary conditions are introduced at the final solving stage by the mean of polynomial expansions, essentially Bessel polynomials [9–11] and Boubaker polynomials [12–16].

2. The uniform layer model

In the presented model, the targeted glass layer is a 2.0 cm × 2.0 cm × 0.2 cm parallelepiped sample fixed on a wide heating bulk. The bulk is maintained at constant temperature T_b. The efficient targeted zone for the study is limited to a 2.0 cm – diameter, 0.2 cm – thick cylinder (of glass sample). This means that the deposited layer would be spread out on this cylinder (Fig. 1).

If we then place the point A on the z-axis (Fig. 2), the problem can be considered as a cylindrical one, in which the thickness of the solution deposited (h) would be the height of the cylinder along +z-axis from the origin O (Fig. 2); and the thickness of the targeted glass layer (H) would be the height of the cylinder to the $-z$-axis from the origin (i.e. $z = -H$ at the lowest point of the cylinder).

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