Proceedings of CHT-15
ICHMT International Symposium on Advances in Computational Heat Transfer

May 25-29, 2015, Rutgers University, Piscataway, USA

CHT-15-166

INTEGRAL TRANSFORMS FOR CONVECTION-DIFFUSION IN MULTISCALE COMPLEX DOMAINS

Renato M. Cotta [*§], Diego C. Knupp[**], and Carolina P. Naveira-Cotta[*]
[*]Mechanical Engineering Dept. (PEM) & Nanoengineering Dept. (PENT)
COPPE/UFRJ, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
[**]Instituto Politécnico, Universidade do Estado do Rio de Janeiro, IPRJ/UERJ, Dept. of Mechanical Engineering and Energy, Nova Friburgo, RJ, Brazil

[§]Corresponding author: cotta@mecanica.coppe.ufrj.br

ABSTRACT The Generalized Integral Transform Technique (GITT) is described for solving convection-diffusion problems defined in physical domains with subregions of multiple materials and scales. With the aid of a single domain reformulation strategy, that treats the multiregion problem as a single domain with space variable coefficients, the subregions transitions are incorporated into one single eigenvalue problem for the proposed eigenfunction expansions. Therefore, the eigenfunctions spatial behaviors are responsible for recovering the local information in each subregion, thus avoiding cumbersome domain decomposition schemes, while the transformed ordinary differential equations system handles the temporal behavior of the solution. The GITT itself is employed in the solution of the eigenvalue problem with space variable coefficients, by adopting a simpler auxiliary eigenvalue problem for the eigenfunction representation, resulting in a matrix eigenvalue problem that is readily solved. An integral balance approach and a coordinates transformation procedure are also illustrated to improve the convergence behavior of the eigenfunction expansions, while offering explicit accounting for the space variable coefficients. An example is provided that deals with heat transfer in a microchannels network embedded in a macro-sized substrate that participates in the overall thermal process. The convergence characteristics of the integrals transforms solution is more closely examined and critically compared against numerical results from a commercial CFD software system. Finally, the extension of the approach to time variable domains is also introduced, in the form of space and time dependent coefficients in the single domain reformulation, followed by the integral transformation process based on a time-dependent eigenvalue problem.