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Numerical study on heat transfer in aeronautical systems by CHT methods

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The purpose of this paper is to show the results of the application of the CHT method to an aeronautical configuration of interest. To perform these analyses the three heat transfer mechanisms, conduction, radiation and convection, were considered joining the solutions of the solid and fluid regions at the interface. Numerically, the two domains are treated separately in a first moment and then, at the end of each iteration, they are coupled by imposing the equivalence of the gradients. Conductive walls where the Fourier heat flux is considered only in direction normal to the wall, are used. The fluid domain is studied, instead, by a finite volume, implicit and second order accurate code. After a preliminary study carried out on a 2D square cavity, a new generation turboprop nacelle built with three different metallic materials has been taken into consideration. Particular attention has been paid to the thermal fields and the heat exchange rates achieved on the skin both in cruise (T_∞=253 −273 K; P_∞=72500 Pa) and in idle (T_∞=273 − 293 K; P_∞=101325 Pa). The results show how the CHT approach in the aerodynamic investigations can affect the aerodynamic predictions in not negligible manner. Indeed, the thermal conductivity plays a relevant role on the internal convective and radiative heat transfer on the single walls.

Keywords: heat transfer; conduction; radiation; convection; CHT; thermal conductivity

Nomenclature

κ = kinetic energy [$m^2\ s^{-2}$]
μ = dynamic viscosity [$N\ s\ m^{-2}$]
ε = dissipation rate [s^{-1}]
α = thermal diffusivity [$m^2\ s^{-1}$]
ε_r = surface emissivity
ρ = density [$kg\ m^{-3}$]
ν = kinematic viscosity [$m^2\ s^{-1}$]
τ = stress tensor [Pa]
T = Temperature [K]
p = pressure [Pa]
CHT = Conjugated Heat Transfer
k = thermal conductivity [$W\ m^{-2}\ K^{-1}$]

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