INTEGRAL APPROACH OF THE TRANSIENT CONVECTIVE HEAT TRANSFER OVER A PLATE EXPOSED TO A TEMPORAL VARIATION OF HEAT FLUX

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More recent works Rémy[1], Polidori[2], Padet[3], and al., deals with unsteady or steady forced convection over a flat plate. By contrast, most of the existing studies and derived correlations relate to an uniform and constant (in time) heat flux or temperature on the plate. Therefore, the present study presents a mathematical model of the unsteady convective heat transfer when arbitrary flux densities in time are imposed. This allows the analysis of the heat transfer characteristics associated with a constant laminar parallel flow over a negligible thickness plate. Transients are induced by a temporal flux step change on the interface solid fluid. The purpose of this work is to get new data in addition with other previous contributions listed in the references [1-9].

The modelling approach is based on the 4th order Karman Pohlhausen polynomials for fluid velocity and temperature profiles within the boundary layers. The boundary conditions were used to derive the coefficients of the polynomials. As a result, the profiles are adaptive for more situations and coupled at the contact surface. Thermal properties were kept constant for the fluid. The fluid continuity and momentum equations were thus independent of thermal conditions and allowed the computation of the hydrodynamic boundary layer thickness, otherwise constant in time since the flow is steady. Because the thermal boundary layer was considered thinner than the hydrodynamic boundary layer, the model is valid for fluids of Prandtl numbers greater than about 0.7.

Energy conservation equation in the fluid was used together with the velocity and temperature profiles to derive the system governing equations. It was assumed that the thermal boundary layer is space and time dependent.
This governing equation was integrated by use of the integral method. Results were obtained for different combinations of heating and cooling phases. These cases were chosen due to their wide applications in the engineering fields and as limiting cases as well. Temporal variations of the thermal boundary layer thickness and the contact surface temperature allowed determination of the transient variations, as well as Nusselt number or convective heat transfer coefficient. Figures 1 and 3 show the imposed heat flux forms and figures 2 and 4 illustrate the unsteady wall temperature response at the interface $y = 0$.

These two cases studied here, show a problem of convective heat transfer corresponding either to a situation of partial fluid heating or partial fluid cooling.

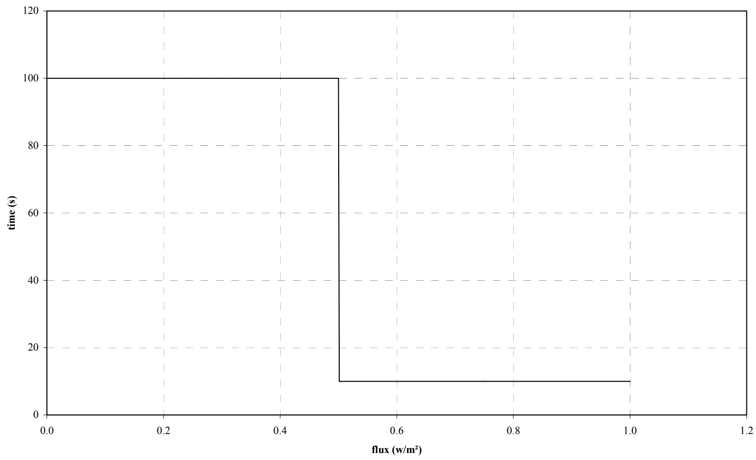

Fig. 1: Imposed heat flux density (flux form n°1).

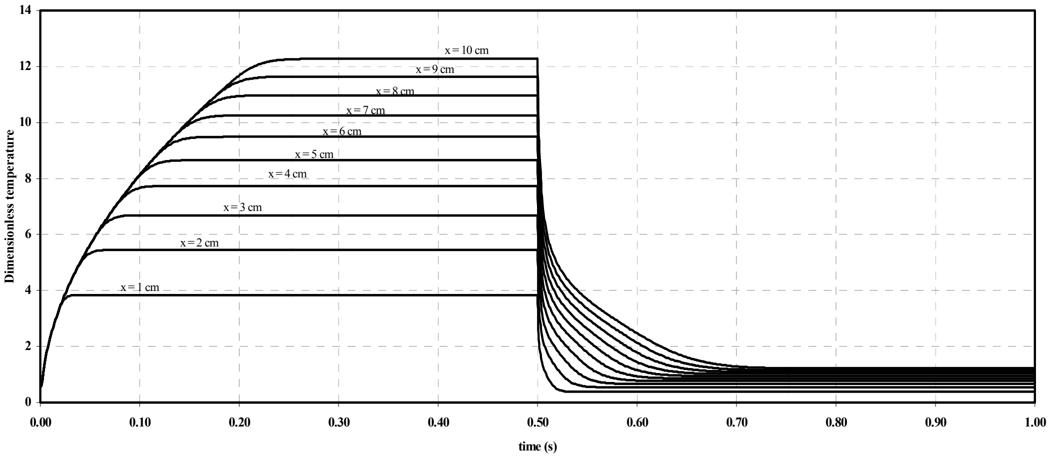

Fig. 2: Dimensionless temperature along the wall. Response for the flux form n°1.

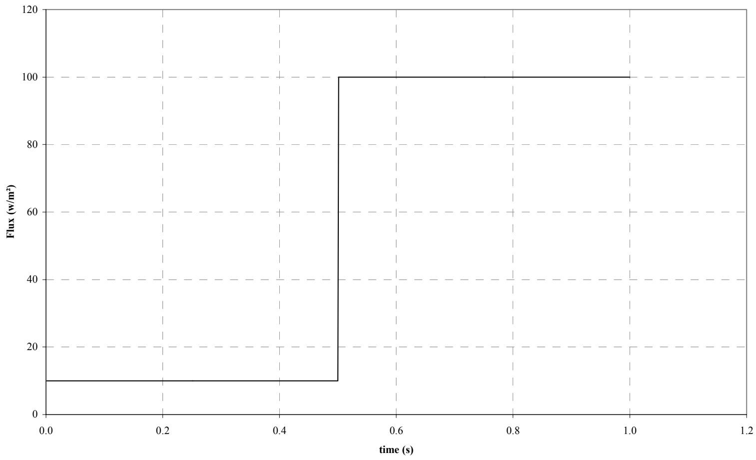

Fig. 3: Imposed heat flux density (flux form n°2).

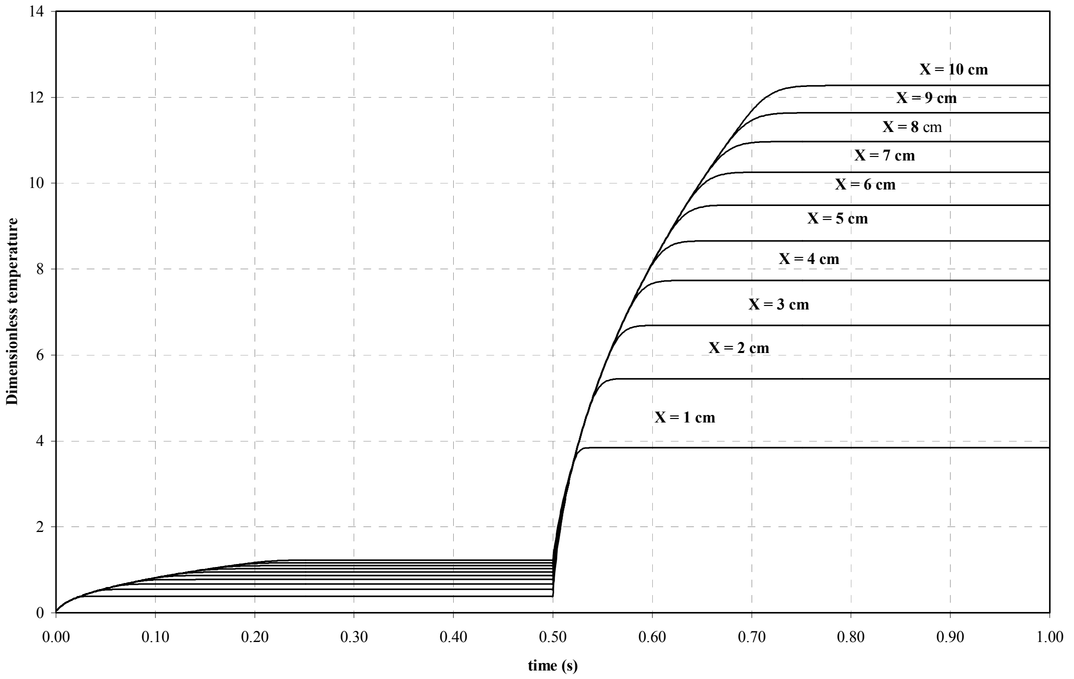

Fig. 4: Dimensionless temperature along the wall. Response for the flux form n°2.

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