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NUMERICAL VALIDATION OF A κ-ω-κ_θ-ω_θ HEAT TRANSFER TURBULENCE MODEL FOR LOW PRANDTL NUMBER FLUIDS.

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In ordinary fluids with $Pr \sim 1$ it is well known that a two equation turbulence model with a constant turbulent Prandtl number $Pr_t \sim 0.85$ is usually sufficient to correctly predict heat transfer in fully turbulent flows. On the contrary, in heavy liquid metals the simple hypothesis of constant Pr_t cannot reproduce experimental data and the turbulent Prandtl number Pr_t has to be introduced as a function of state variables. In this work we introduce a four parameter turbulence model that may improve heat transfer prediction in fully developed heavy liquid metal flows. The turbulent heat flux transport equation is solved algebraically and an expression for the thermal eddy diffusivity α_t is obtained. This quantity depends on the thermal and dynamical time scales of turbulence and their ratio. A four parameter turbulence model κ-ϵ-κ_θ-ϵ_θ for low-Prandtl number fluids has been already presented by the authors with satisfactory results. The main problem of the κ-ϵ models is the stability of the system since ϵ is a function of κ on the boundary. The introduction of the κ-ω system allows to calculate directly the time scale of turbulence as $\tau = \omega^{-1}$ and to achieve a more stable and robust solution near the wall. Numerical results are obtained by using an in-house code with a standard finite element implementation of Navier-Stokes equations coupled with the four parameter turbulence model. The code allows multiple refinement of the mesh in order to improve the solution and to correctly impose the boundary conditions with a near-wall approach. Results from simulations of fully developed turbulent flows of heavy liquid metals are reported for the plane and cylindrical geometries, in particular for the heat transfer between a wall heated with uniform heat flux and the liquid metal flow. The results are compared with DNS data when available and with experimental heat transfer correlations for the prediction of the Nusselt number in order to evaluate the turbulence model.

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