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HEAT TRANSFER DEPENDENT ORIFICE JET FLOW OF A THERMO-VISCOUS SHEAR-THINNING FLUID

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Non-Newtonian fluid properties can change the flow behaviour and the resulting flow topology significantly, even for low Reynolds number laminar flows. The prediction of the flow field is even more difficult when thermal effects come into play. In particular when high shear rates occur and different temperatures act on the fluid changing its properties symmetry breaking is an often observed flow phenomenon. A well known case, which is focal point of this study, is the laminar orifice jet flow of a thermo-viscous shear thinning fluid within a straight duct [1], [2]. Isothermal flows of newtonian fluids reveal a straight jet flow leaving the orifice, in contrast to isothermal non-newtonian fluid flows, which show a deflection of the orifice jet and complicated flow separation and attachment structures within the duct. In the present CFD study wall temperature dependent flow structures are investigated for the flow of a Carreau fluid through a duct with an orifice. The temperature dependence of the fluid viscosity is modelled by applying the standard Williams-Landel-Ferry (WLF) equation [3]. It is shown that thermal viscous shear thinning due to high shear rates and temperatures at the duct and the orifice walls leads to a significant decrease of viscosity of three orders of magnitude in the near-field of the orifice. Locally reduced viscosity can be used to control the jet flow behaviour. In the present simulation campaign thermal boundary conditions are varied over a wide range in order to derive relations between heat transfer, non-newtonian fluid properties and the behaviour of the orifice jet flow.

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