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Modeling of the Heat and Mass Transfer in Fluids through Thermal Pollution in Pipelines

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Abstract : Introduction: Determination of the temperature field inside a fluid in motion has many practical issues, especially in the case of turbulent flow. The phenomenon is greater when the solid walls have a different temperature than the fluid. The turbulent heat and mass transfer have an essential role in case of the thermal pollution, as it was the recorded during the damage of the Thermoelectric Power-plant Oradea (closed even today). Basic Methods: Solving the theoretical turbulent thermal pollution represents a particularly difficult problem. By using the semi-empirical theories or by simplifying the made assumptions, based on the experimental measurements may be assured the elaboration of the mathematical model for further numerical simulations. The three zones of flow are analyzed separately: the vicinity of the solid wall, the turbulent transition zone, and the turbulent core. For each area are determined the distribution law of temperature. It is determined the dependence of between the Stanton and Prandtl numbers with correction factors, based on measurements experimental. Major Findings/Results: The limitation of the laminar thermal substrate was determined based on the theory of Landau and Levice, using the assumption that the longitudinal component of the velocity pulsation and the pulsation’s frequency varies proportionally with the distance to the wall. For the calculation of the average temperature, the formula is used a similar solution as for the velocity, by an analogous mediation. On these assumptions, the numerical modeling was performed with a gradient of temperature for the turbulent flow in pipes (intact or damaged, with cracks) having 4 different diameters, between 200-500 mm, as there were in the Thermoelectric Power-plant Oradea. Conclusions: It was made a superposition between the molecular viscosity and the turbulent one, followed by addition between the molecular and the turbulent transfer coefficients, necessary to elaborate the theoretical and the numerical modeling. The concept of laminar boundary layer has a different thickness when it is compared the flow with heat transfer and that one without a temperature gradient. The obtained results are within the margin of error of 5%, between the semi-empirical classical theories and the developed model, based on the experimental data. Finally, it is obtained a general correlation between the Stanton number and the Prandtl number, for a specific flow (with associated Reynolds number).

Keywords : experimental measurements, numerical correlations, thermal pollution through pipelines, turbulent thermal flow
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