ABSTRACT

The determination of temperature distribution and the estimation of exit temperatures during the thermal energy transfer between the two fluid streams in the heat exchangers are of indispensable task to analyse the performance of the heat transfer systems. Hence, many researchers developed several mathematical models to estimate the exit temperatures in the heat exchangers through the determination of temperature distributions. This dissertation presents the steady state behavior of the heat transfer processes through fractional differential equations in the two different thermal equipments, which are widely used in many industrial applications.

The steady state behaviour of heat transfer process in the single pass cross flow plate-fin type of heat exchanger with constant specific heat of the fluids is analysed. The governing linear system of energy transfer equations are solved using the differential transform method and the closed form series solutions are identified. The proposed series solution predicts the temperature distributions of the hot and the cold fluids and determines the effectiveness of the heat exchanger. The introduction of the temperature dependent transport properties particularly the specific heat is considered as a linear function of temperature, which converts the governing energy equations into nonlinear, are crucial in the study of heat transfer in the advanced materials. Further, the fractional derivatives are introduced in the nonlinear energy balance equations in order to analyse the irregular temperature distribution in the heat transfer process.

The fractional system of nonlinear energy balance equations incorporating the temperature dependent specific heat are solved and the closed

form series solutions are identified for the temperature functions using the fractional differential transform method. The convergence of the series solutions is well established using Cauchys criteria. Further, the temperature distributions of the heating fluid and the working fluid are determined and the effectiveness of the single pass shell and tube heat exchanger is estimated. Due to the importance of multi fluid heat exchangers in the industry, the heat transfer process in the single pass cross flow three fluid plate fin heat exchanger is analysed and the closed form series solutions to the system of the three linear fractional energy equations are proposed.

Using the series solutions of temperature functions, the temperature distribution and the exit temperatures of fluids are determined and the effectiveness of the heat exchanger is estimated. Throughout this research, the chaotic behaviour and the pre local temperature distributions in the heat transfer process are observed for various values of fractional parameter and the irregularity in the temperature distributions are statistically validated by using the testing of hypothesis. Moreover, the effect of temperature dependent specific heat are also investigated through closed form series solutions and it is observed that the temperature gradient decreases as the specific heat increases.

The “Tarig Projected Differential Transform Method” a hybrid method, is proposed to solve the linear and the nonlinear fractional differential equations. The computational efficiency of the methodology is illustrated by solving sufficient number of numerical examples that often arises in the heat transfer problems. The non local behaviour of the heat transfer process is studied through fractional derivatives using the new hybrid technique.