Abstract

The concept of nanofluidity was reported since the middle of the 18th century. The practical applications of nanofluids have become possible latter, after the development of nanotechnologies. A nanofluid is a dispersion of nanometer-sized particles in a base liquid, resulting an alteration of some properties such as density, viscosity and heat transfer capability. Nanofluids have proven to be suitable for improving the heat transfer but, are successfully used in other important field as transportation, electronics or biomedicine.

In order to analyze and improve the heat transfer in real devices, the complete flow field must be studied, because it controls the energy transport processes and heat exchange. To achieve this goal, the study of the entropy generation is important.

The entropy generation minimization can be used to enhancement the heat transfer in different applications, since the entropy generation quantifies dominating dissipative or conductive effects within the flow field.

The mathematical concept of fractional calculus involves non-local derivative/ integral operators which can be applied to study of complex physical systems in which the memory effects are not negligible.

In the present thesis, have been studied several problems of convective flows of nanofluids with different initial and boundary conditions taking into consideration power-law and exponential memory effects.

Firstly, we studied the natural convection flows of a nanofluid over a vertical isothermal plate with thermal radiation. The model is described by fractional differential equations with time-fractional Caputo derivatives, so the memory kernel is of power-law type. Wright functions and their fractional derivatives are employed to obtain the solution of the studied problem. It is found that the enhancement of the heat transfer is obtained for the memory parameter close to 1.

The second problem is referring at the natural convective flows of fractional

water-based nanofluids over a time-exponential accelerated vertical plate with uniform heat flux and heat source. The mathematical model is based on the Caputo-Fabrizio time fractional derivative with exponential non-singular kernel. Two types of the effective thermal conductivity and two types of dynamic viscosity as well as different shapes of nanoparticles are considered. The differential equations for the thermal boundary layer thickness and velocity boundary layer thickness are obtained and integrated. The influence of the memory parameter on the fluid behavior and on the thermal boundary layer thickness was analyzed.

Magneto-hydrodynamic free convection flows of nanofluids near a vertical non-isothermal plate with heat source are also studied. The plate has a time-dependent translational motion in its plane. Time-fractional Caputo derivatives are used to describe the memory effects. Some particular cases such as, mechanical and thermal shock on the plate, isothermal plate which is moving with constant velocity, or the time-ramped plate velocity and time-ramped plate temperature are studied. Using two types of nanofluids, namely copper-water nanofluid and titanium oxide-water nanofluid, a comparison between fractional nanofluids and ordinary nanofluids has been made. It is found that the heat transfer can be improved by varying the fractional parameter.

Entropy generation due to fractional Couette flows in a rotating channel with time-exponential heating on the walls is studied in the last part of thesis. Time-fractional Caputo-Fabrizio derivatives are used to describe the mathematical model. Exact analytical solutions for the velocity and temperature fields are obtained with the Laplace and finite sine-Fourier transforms. A numerical method for the time-fractional Caputo-Fabrizio derivative is developed and used to determine the fluid temperature. The influence of the fractional parameter on velocity components, temperature and entropy generation was studied. It is found that transient parts of the velocity components are strongly affected by the memory effects. Temperature field and the local volumetric rate of entropy generation are significantly influenced by the fractional time-derivatives. Analyzing the influence of the fractional parameter on the dimensionless number of the entropy generation and on Bejan number, it is found that the entropy generation can be decreased by reducing the value of the memory parameter.