There are plenty of experimental studies suggesting to model behavior of viscous materials as incompressible fluids with the viscosity depending on the shear-rate, the temperature and the mean normal stress (the pressure). In this thesis we investigate mathematical properties of internal unsteady three-dimensional flows of such fluids subject to Navier's slip at the boundary. We establish the large-data and long-time existence of weak solution provided that the viscosity and heat conductivity depend on the shear rate, temperature and the pressure in a suitably specified manner. Note that specific relationship however includes the classical Navier-Stokes equations and power-law fluid (with power law index r 2, r 2) as special cases.
The achieved results are based on two observation. First, although for smooth functions completely equivalent, in the context of weak solutions the formulation of the balance of total energy share better mathematical properties than the equation for the temperature, balancing the internal energy. Second, for evolutionary models, again in the context of weak solutions, Navier's slip boundary conditions are well suitable to defining the global pressure needed if the viscosity is pressure-dependent. Except for the special case, the Navier-Stokes equations, when one identifies the Navier-Stokes system with the evolutionary Stokes system, is open how to define the pressure globally for no-slip boundary conditions.