Investigation of material behaviour in a squeeze flow geometry provides an important technique in rheology and it is relevant also from the technological point of view (some types of dampers, compression moulding). To our best knowledge, the squeeze flow has not been solved for fluids-like materials with pressure-dependent material moduli. In the main scope of the present thesis, an incompressible fluid whose viscosity strongly depends on the pressure is studied in both the perfect-slip and the no-slip squeeze flow. It is shown that such a material model can provide interesting departures compared to the classical model for viscous (Navier-Stokes) fluid even on the level of analytical solutions, which are obtained using some physically relevant simplifications. Numerical simulation of a free boundary problem for the no-slip squeeze flow is then developed in the thesis using body-fitted curvilinear coordinates and spectral collocation method. An interesting behaviour is expected especially in the corners of the computational domain where the stress singularities are normally located. Unfortunately, numerical results reveal some fundamental drawbacks related to the physical model and its possible improvement is discussed at the end of the thesis.