On existence analysis of steady flows of generalized Newtonian fluids with concentration dependent power-law index

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We study a system of partial differential equations describing a steady flow of an incompressible generalized Newtonian fluid, wherein the Cauchy stress depends on concentration. Namely, we consider a coupled system of the generalized Navier-Stokes equations (viscosity of power-law type with concentration dependent power index) and convection-diffusion equation with non-linear diffusivity. We prove the existence of a weak solution for certain class of models by using a generalization of the monotone operator theory which fits into the framework of generalized Sobolev spaces with variable exponent (class of Sobolev-Orlicz spaces). This leads us to the principal a priori assumptions on the model parameters that ensure the Hölder continuity of the variable exponent. We present a constructive proof based on the Galerkin method. Moreover, we discuss an extension of the result by the means of generalization of Lipschitz truncation method for the case when lower bound of the variable index does not "guarantee" the control of the convective term. By generalization we mean construction of Lipschitz approximations in the sequence of generalized Sobolev spaces, a difficulty we need to challenge in the case of not a priori known (c-solution dependent) variable exponents.

References

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