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NUMERICAL ANALYSIS OF MULTIPHYSICS MODEL IN UNDERGROUND HIGH VOLTAGE CABLES

NATALIJA TUMANOVA, GERDA JANKEVIČIŪTĖ AND VADIMAS STARIKOVIČIUS

Department of Mathematical Modelling, Vilnius Gediminas Technical University

Saulėtekio av. 11, LT10223 Vilnius, Lithuania

E-mail: natalija.tumanova@vgtu.lt

We solve multiphysics problems, which arise in modelling of underground high voltage cables:

1. *Cables placed in ducts, ducts directly buried in soil.* The air circulation inside the plastic duct due to free convection is typical for such case. The velocity of convective transport of the heat in air regions is obtained by solving a coupled thermoconvection problem including the heat conduction problem and a standard Navier–Stokes model of the flow in air:

$$\nabla \cdot \mathbf{u} = 0, \tag{1}$$

$$\rho \frac{\partial \mathbf{u}}{\partial t} + \rho \mathbf{u} \nabla \cdot \mathbf{u} - \nabla \cdot (\eta \nabla \mathbf{u}) = -\nabla p - \rho \alpha \mathbf{g}(T - T^*), \tag{2}$$

$$\rho c \left(\frac{\partial T}{\partial t} + \nabla \cdot (\mathbf{u} T) \right) = \nabla \cdot (\lambda \nabla T), \tag{3}$$

   here $\mathbf{u}(x,t)$ is velocity of the flow, $\rho(x)$ is the mass density, $p(x)$ is the pressure, η is the dynamic viscosity, α is the thermal expansion coefficient, $T(x,t)$ is temperature, $\lambda(x)$ is the heat conductivity coefficient, $c(x)$ is the specific heat capacity.
   The heat transfer equation for solids similar to (3) is to be solved in cables and soil:

$$\rho c \left(\frac{\partial T}{\partial t} \right) = \nabla \cdot (\lambda \nabla T) + q_0 (1 + \alpha (T - T^*)) I^2, \tag{4}$$

   here $q(x,t,T)$ is the source function, and we also take into account a linear dependence of the resistance on temperature: T^* is the reference temperature and I is the electrical current.

2. *Heat and water transfer in porous medium.* The thermal properties of soil depend strongly on the moisture level. The accurate modelling of soil drying and changes in thermal conductivity due to the heating requires modelling of porous medium in the soil area. For the detailed model we refer to [1].

We observe some solution methods for solving problems related to multiple materials (solid/fluid) or coupled fields, including explicit coupling (segregated solvers), matrix-level and equations level coupling, which can be implemented in OpenFOAM [2] finite volume method software tool used in simulations. We also present some simulations results.

REFERENCES

[1] R. Čiegis, G. Jankevičiūtė, A. Bugajev and N. Tumanova. Numerical simulation of heat transfer in underground electrical cables. In: *Proceedings of the European Consortium for Mathematics in Industry, June 9 - 13, 2014, Taormina, Italy*, to appear, 2015.

[2] OpenFOAM http://www.openfoam.org