4th International Symposium on
Energy Challenges & Mechanics
- working on small scales

11-13 August 2015
Aberdeen, Scotland, UK

Modelling of turbulent flow over porous media using a volume averaging approach and a Reynolds stress model

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Accepted for publication on 14th March 2015

A computational efficient method for simulation of high-Reynolds number flow over porous media will be presented. The approach is based on volume and Reynolds averaging of the Navier Stokes equations. The additional terms in the momentum equations which appear as a result of volume averaging inside porous media are modeled with Darcy and Forchheimer terms. The modeling of turbulence is accomplished with a Reynolds stress model where the governing equations must also be modified inside porous media. Special attention is paid to the interface area between nonporous and porous regions. The transition from nonporous to porous regions is simulated with a discrete jump and therefore special relations are derived for the flow variables between the two interface sides. The conditions are based on an isentropic flow change for the mean flow variables and on jump conditions for several gradients.

The performance of the theoretical model is shown by evaluation of some test cases. The results are obtained with an established flow solver which was extended with the theoretical models. The main focus of the test cases is a channel flow where DNS-data serve as a benchmark. This rather simple case helps to understand the sensitivities of the different modeling parameters. Besides the generic channel case, a more realistic test case is shown which is incorporated by a wind tunnel model of a wing with porous trailing edge. The experiment supplies both, pressure data along the airfoil surface and PIV velocity fields at the trailing edge of the wing. Detailed comparisons against the numerical results help to classify the performance of the theoretical models.

Keywords: porous flow; volume averaging, jump conditions, Reynolds stress model