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MIXED FINITE ELEMENT MODEL IMPLEMENTATION FOR A PETROLEUM RESERVOIR SIMULATION

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In this work a simulation of a petroleum reservoir using FreeFEM++ v 3.21-1 is done with a two phase (water and oil) incompressible and immiscible flow. The rock is assumed to be porous and immovable. For the pressure equation, Mixed Finite Elements such as Taylor Hood and Raviart Thomas, which are convergent not only for pressure but also for velocity were used. Different kinds of boundary conditions such as Velocity (Neumann) and Bottom Hole Pressure (Robin) were used. Local mass conservation is improved using an additional term in the weak formulation proposed by Masud et al. related to Least Squares Finite Element Method (LSFEM) [1].

For the Saturation equation, which is hyperbolic in its nature, two methods are used: A Modified Method of Characteristics with Adjusted Advection (MMOCAA) [3], which improves the global mass conservation compared to the traditional MMOC. The other one is the Galerkin Finite Element Method using a non-linear artificial viscosity [4].

Two numerical tests were performed: one using a uniform permeability and the other using layer 85 of the Model 2 – SPE10 [5] as geostatistical permeability. This Upper Ness formation is a challenge for the simulations due to its high heterogeneity and bimodality. Watercut curves and instantaneous fields showing evolution of variables (pressure, velocity and saturation of water) are presented as numerical results of this work. More similarity is achieved to the watercut curve show in reference [6] using the artificial viscosity, although both methods (MMOCAA and Galerkin) respect the global mass conservation.

REFERENCES

[1] A. Masud and T. J. R. Hughes. A stabilized mixed finite element method for Darcy flow. *Computer methods in applied mechanics and engineering* (2002). Vol. 141 pp. 4341-4370.

[2] Zhangxin Chen, Guanren Huan, and Yuanle Ma. *Computational Methods for Multiphase Flows in Porous Media*. SIAM, 2006.

[3] J. Douglas Jr, F. Furtado and F. Pereira. On the numerical simulation of waterflooding of heterogeneous petroleum reservoirs. *Computational Geosciences 1* (1997) 155–190

[4] C. Chueh, N. Djilali and W. Bangerth. An h-adaptive operator splitting method for two-phase flow in 3D heterogeneous porous media. SIAM Journal of Scientific Computing.Vol. 35, No. 1, pp. B149–B175

[5] M.A. Christie, Heriot-Watt U, and M.J. Blunt. Tenth SPE comparative solution project: A comparison of upscaling techniques. SPE Reservoir Simulation Symposium, 10:308–317, 2001.

[6] L. Jiang and I. D. Mishev. Mixed Multiscale Finite Volume Methods for Elliptic Problems in Two-phase Flow Simulations. ArXiv e-prints. 2011.