10th World Congress in Computational Mechanics, 8-13 july 2012, São Paulo, Brazil

TWO-PHASE WATER-OIL FLOW IN POROUS MEDIA USING HIGH PERFORMANCE TECHNIQUES

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In this paper, we gather some experiences performing serial and parallel simulations solving two phase flows in porous media problems where we always tried to overcome CPU barriers represented mainly by the solution of a linear system of equations. We present a parallel implementation of a node centered edge-based finite volume formulation (EBFV) to simulate the immiscible and incompressible fluid flow of oil and water in petroleum reservoirs. The main variables are pressure and saturation. The former, is the major bottleneck in CPU usage during simulation and the target of our efforts to get a more efficient code. Our first attempt to get faster simulation results comes from the FVM formulation used to discretize the PDE which produces three intermediate matrices to obtain the final matrix. How to operate these matrices led us to two different approaches to get better solver convergence rate: a matrix-free like and a defect-correction approaches. Since the classical IMplicit Pressure Explicit Saturation (IMPES) formulation spend more than 90% of CPU time solving only the pressure equation, we used an edge based modified IMPES to avoid too many solver calls which dramatically reduces the overall simulation time. This strategy works well as far as the velocity field varies slowly throughout the simulation implying that the saturation field can be updated several times before the pressure and the velocity fields have to be updated.

To reproduce large scale problems (over 1 million of degrees of freedom) we made use of a distributed mesh refinement procedure to reach the desired mesh size. We used an open source mesh manager library which distributes among p processes a finite element mesh generated in a sequential generator. Then, each process starts the subdivision of its elements keeping a consistent numbering for all nodes lying on partition boundaries. Despite the fact that the work has been published before, here, we give a deeper insight treating heterogeneous and anisotropic porous media in large scale simulations using parallel computers of distributed memory. More complex situations like these will give us a better understanding of the effectiveness of the MIMPES approach as well as the robustness of the pressure equation solved by the defect-correction or matrix-free like approach.