geoconvention
Calgary • Canada • May 15-17 2023

Multi-scale numerical method for multiphase flow in fractured reservoir

Hong Li[1], He Tian[2], Yu Peng[1], Fan Liu[1], Yujie Zhao[1], Han Yan[1], Yichun Luo[1], Guoxin Liu[1]

[1] Sulige Project Management Department, CNPC Chuanqing Drilling Engineering Company Limited

2 Shale Gas Research Institute, PetroChina Southwest Oil & Gas Field Branch

Summary

In order to improve the computational efficiency in the numerical simulation of fractured reservoir, the advanced multi-scale numerical calculation method (multi-scale restriction smoothed basis method, MSRSB) combined with projection-based embedded discrete fractured method (pEDFM) was used to characterize complex fractures, and the seepage law under the condition of multiphase flow was obtained. The accuracy of the model was verified by comparing the fine-scale and multi-scale simulation results. At the same time, because the multi-scale method was solved on the coarse grid domain, the number of calculated grids was greatly reduced and the calculation speed was increased. It is very important and useful for numerical simulation of complex fractured reservoir. This paper provides an efficient method for simulating multiphase flow in fractured reservoirs and points out potential problems that have been overlooked in previous studies.

Method/Workflow

Four fractures were developed in a 10×10m^2 reservoir area. The pressure boundary on the left side of the reservoir was 10MPa, and the pressure boundary on the right side was 1MPa. The reservoir original saturated gas. Therefore, the water flowed into the reservoir under the action of pressure difference. Set the number of coarse grids for the matrix to 30×30, which means the number of the grid for matrix was 900 and the number of the fine grids for matrix was 10,000. The number of coarse grids for fractures was set to 4. Then the MSRSB and pEDFM methods were coupled to calculate the model. In order to explore the influence of coarse grid division on simulation results, the results of different matrix coarse grid (50×50, 30×30,10×10) were compared.

Results/Conclusions

As shown in Figure. 1, the basis function in the four fracture grid domains is the key in multi-scale numerical simulation, through which fine-scale solutions can be obtained. Figure. 2 shows the comparison of fine-scale and multi-scale results under the premise of the same physical model. In this case, the coarse grid is 30×30. It shows that the multi-scale result can guarantee the accuracy under the premise of reducing the amount of calculation. At the same time the water was quickly rushing along the fractures. Figure. 3 shows the comparison of results with the coarse grid of 50×50 and 10×10 under multi-scale solution. The result of 50×50 also guarantees the accuracy, but the result of 10×10 has obvious error. This shows that when using multi-scale method, we should also pay attention to the influence of coarse grid division on the simulation accuracy. On the premise of ensuring the simulation accuracy, there may be an optimal coarse grid division scheme.

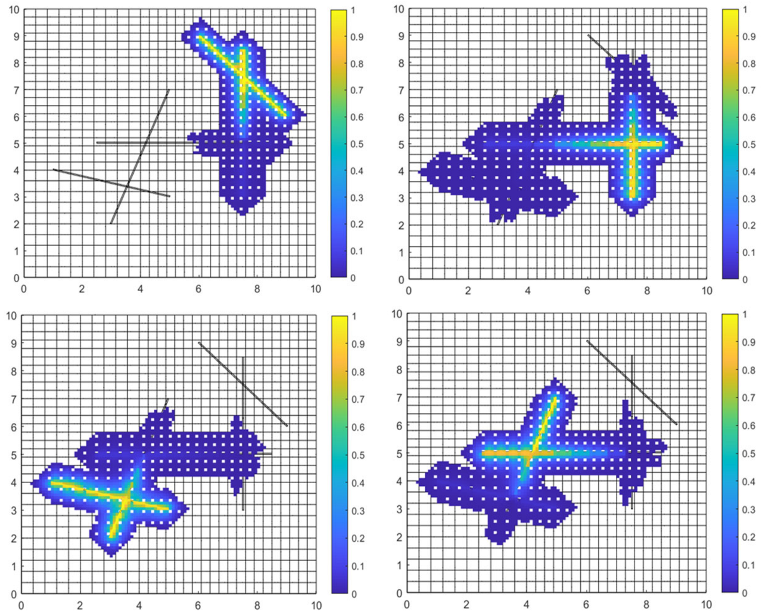
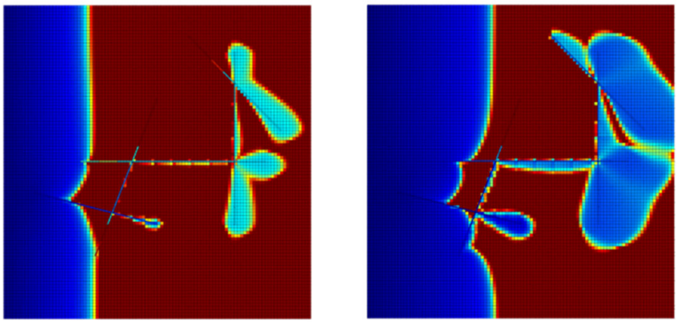
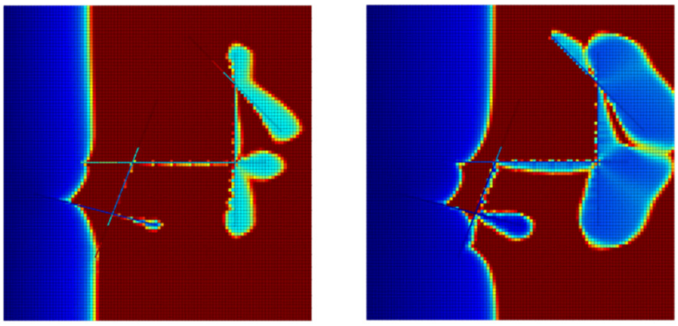


Figure.1 Basis functions in fractures

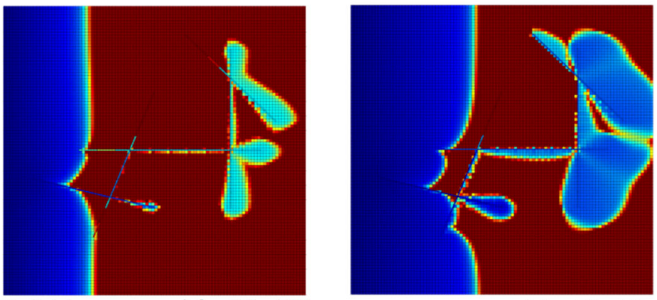


T=3d (fine-scale) T=5d (fine-scale)

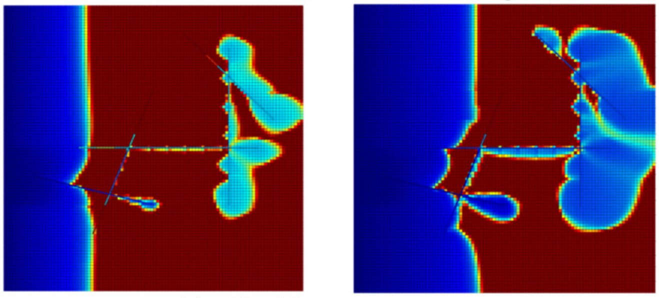


T=3d (multi-scale) T=5d (multi-scale)

Figure.2 Fine-scale and multi-scale saturation distribution Diagram (coarse grid: 30×30)



T=3d (coarse grid: 50×50) T=5d (coarse grid: 50×50)



T=3d (coarse grid: 10×10) T=5d (coarse grid: 10×10)

Figure.3 Fine-scale and multi-scale saturation distribution Diagram (coarse grid: 30×30)

References

Hong Li, 2022, Numerical simulation of fractured tight sandstone gas reservoir and its application. China University of Petroleum (Beijing).

Shah S,Møyner O,Tene M, et al, 2016. The multiscale restriction smoothed basis method for fractured porous media (F-MsRSB)[J]. Journal of Computational Physics, 318: 36-57.

Tene M,Bosma s B M, Alkobaisi M S. et al, 2017. Projection-based embedded discrete fracture model (pEDFM)[J]. Advances Water Research, 105:205-216.

Olorode O, WangB, Rashid H U, 2020. Three-dimensional projection-based embedded discrete-fracture model for compositional simulation of fractured reservoirs[C]. SPE Journal, 25: 2143-2161.

Møyner O, Lie K A, 2016. A multiscale restriction-smoothed basis method for high contrast porous media represented on unstructured grids[J]. Journal of Computational Physics, 30446-71.