

Approximate Solution of Imbibition Phenomenon in Heterogeneous Porous Media using Optimal Homotopy Analysis Method

Shreekant P. Pathak

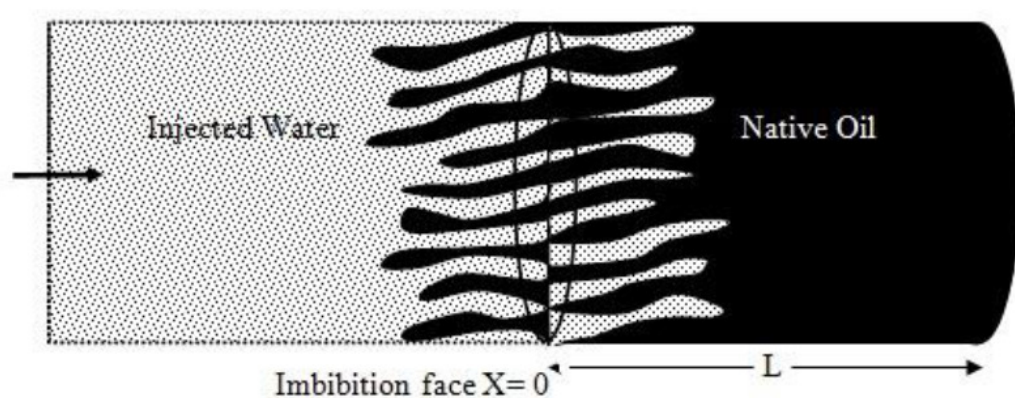
M. B. Patel Institute of Technology, Vallabh Vidyanagar, India

Email: sspathak.mbit@edu.in

INTRODUCTION & AIM

- ▶ Imbibition is displacement of oil by water in porous media.
- ▶ Important in secondary oil recovery.
- ▶ Heterogeneous media has irregular pore geometry.
- ▶ Objective: Analyze counter-current imbibition using OHAM.

PHYSICAL MODEL



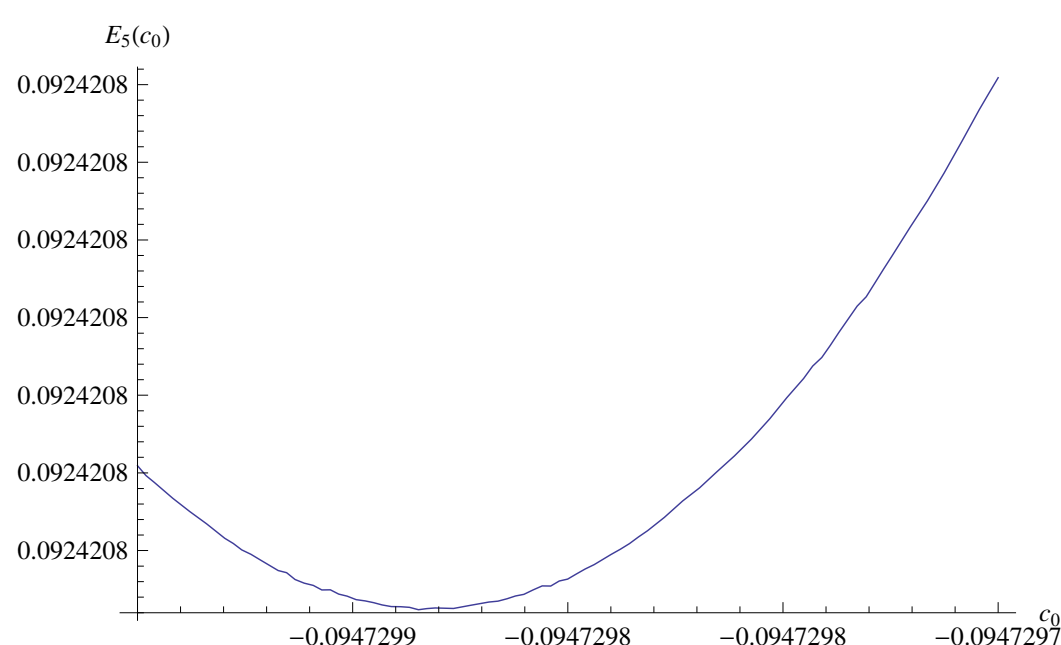
MATHEMATICAL MODEL

Darcy's law for two-phase flow:

$$V_i = -\frac{k_i}{\mu_i} K \frac{\partial p_i}{\partial x}, \quad V_n = -\frac{k_n}{\mu_n} K \frac{\partial p_n}{\partial x}$$

- ▶ Governing PDE derived for saturation
- ▶ Porosity depends on space and time
- ▶ Heterogeneous medium considered

GEOMETRY

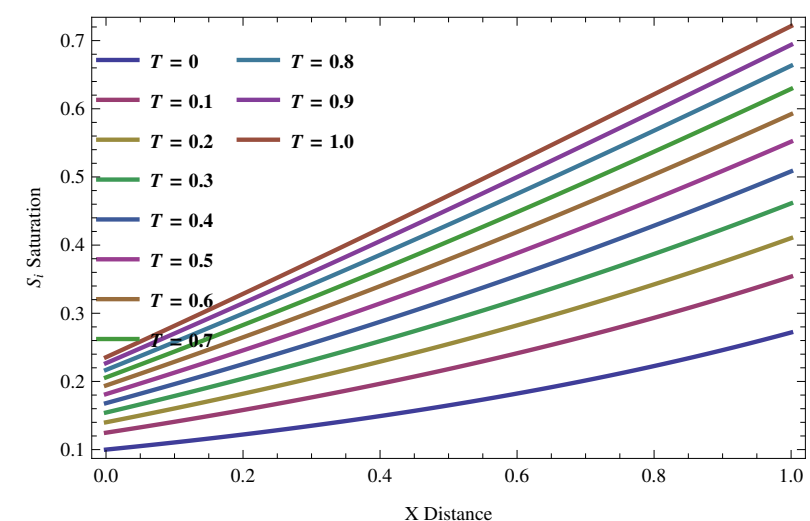


METHOD

- ▶ Optimal Homotopy Analysis Method (OHAM)
- ▶ Series solution obtained
- ▶ Convergence controlled by auxiliary parameter

RESULTS & DISCUSSION

- ▶ Analytical solution obtained for saturation
- ▶ Comparison between homogeneous and heterogeneous media
- ▶ Graphical interpretation shows:
 - ▶ Faster imbibition in homogeneous media
 - ▶ Slower penetration in heterogeneous structure



CONCLUSION

- ▶ OHAM effectively solves nonlinear imbibition model
- ▶ Heterogeneity significantly affects oil recovery
- ▶ Model useful for petroleum engineering applications

FUTURE WORK / REFERENCES

Future Work:

- ▶ Extend to fractured reservoirs
- ▶ Numerical simulation validation

References:

- Bear (1972) • Patel et al. (2013) • Vafai (2015)