

ANALYTICAL SOLUTION OF POLYMER SLUG INJECTION WITH VISCOUS FINGERING

S.A. Abdul Hamid and A. H. Muggeridge, 2018

Department of Earth Science and Engineering, Imperial College London

INTRODUCTION

- Why use polymer in enhanced oil recovery (EOR)?
 - Increase injected water viscosity – improve oil sweep
 - Increase oil recovery
- A better solution: inject polymer as a slug, followed by chase water
 - Reduced cost as less polymer used
- The problem: fingering between chase water and polymer slug may occur (FIGURE 1)
 - Need to ensure slug integrity while minimising the polymer size

FIGURE 1

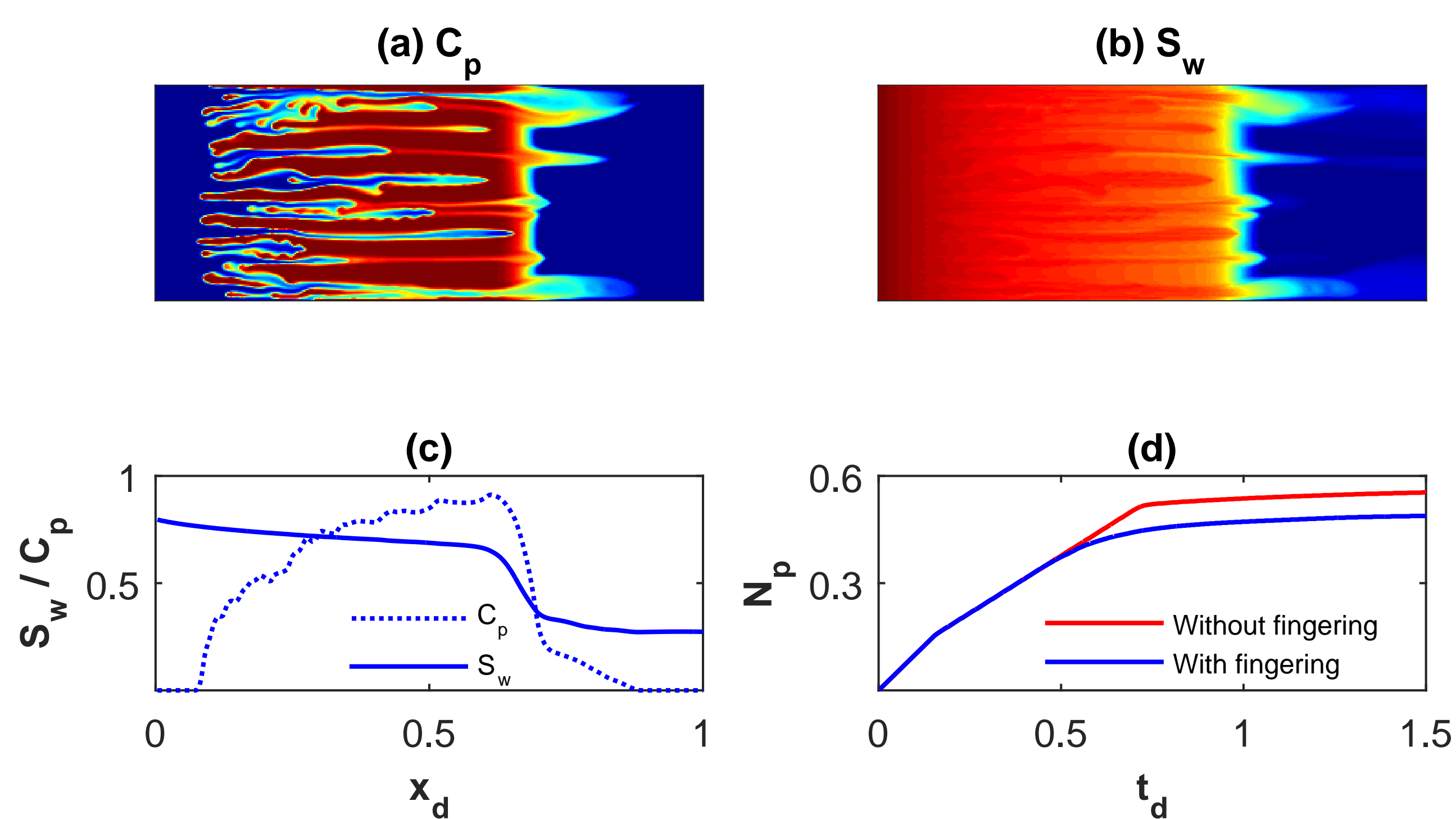


Illustration of the chase water fingering into a polymer slug and destroying the slug integrity. (a) Map of polymer concentration; (b) Map of water phase saturation; (c) Average water saturation between the injector and the producer from (a) and (b); (d) Oil recovery curves.

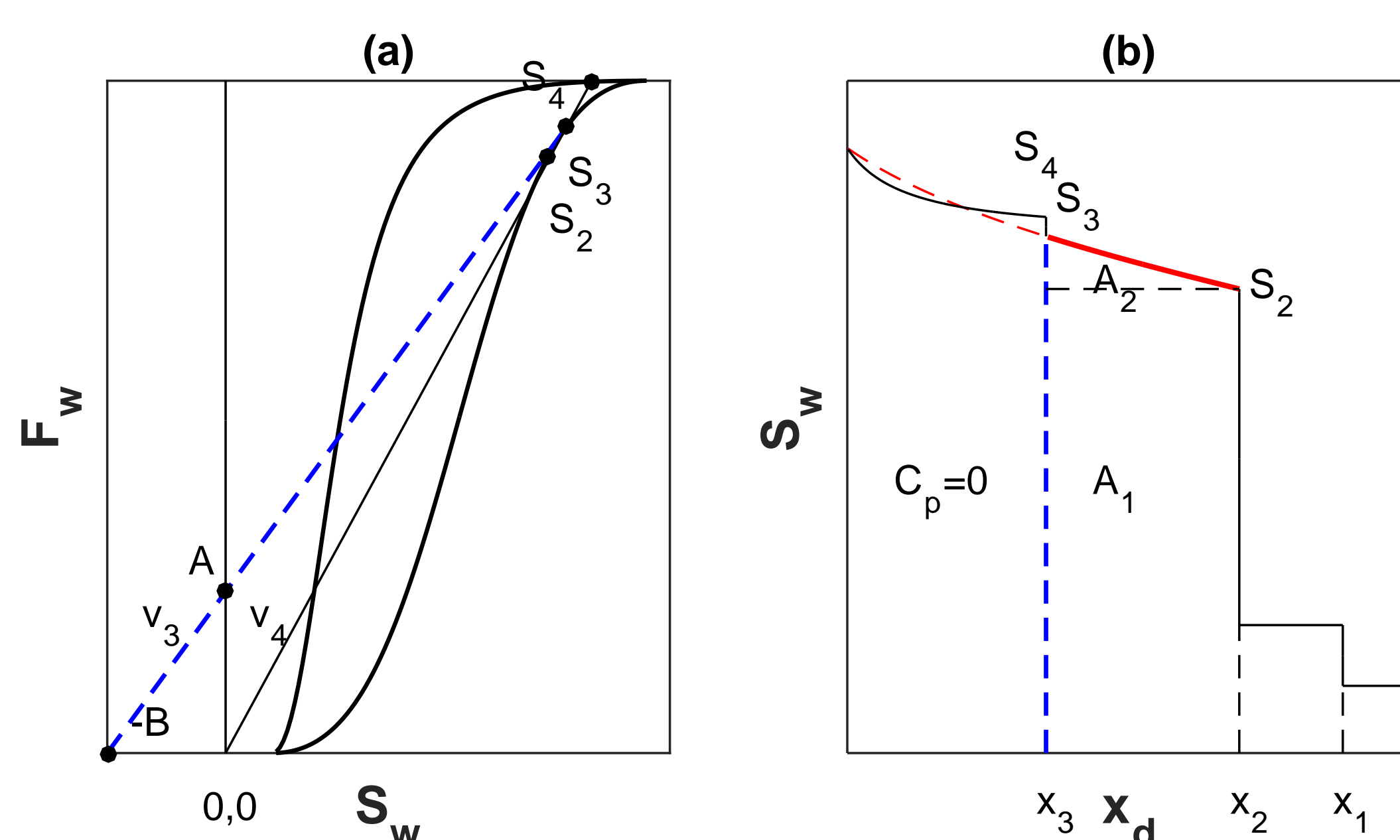
OBJECTIVE

- Develop 1D analytical model to predict the breakdown of the slug

METHODS

- Semi-analytical model:
 - Perform Buckley-Leverett type analysis (method of characteristics) to track the slug rear assuming no fingering (FIGURE 2)
 - Incorporate fingering using Todd-Longstaff empirical model

FIGURE 2

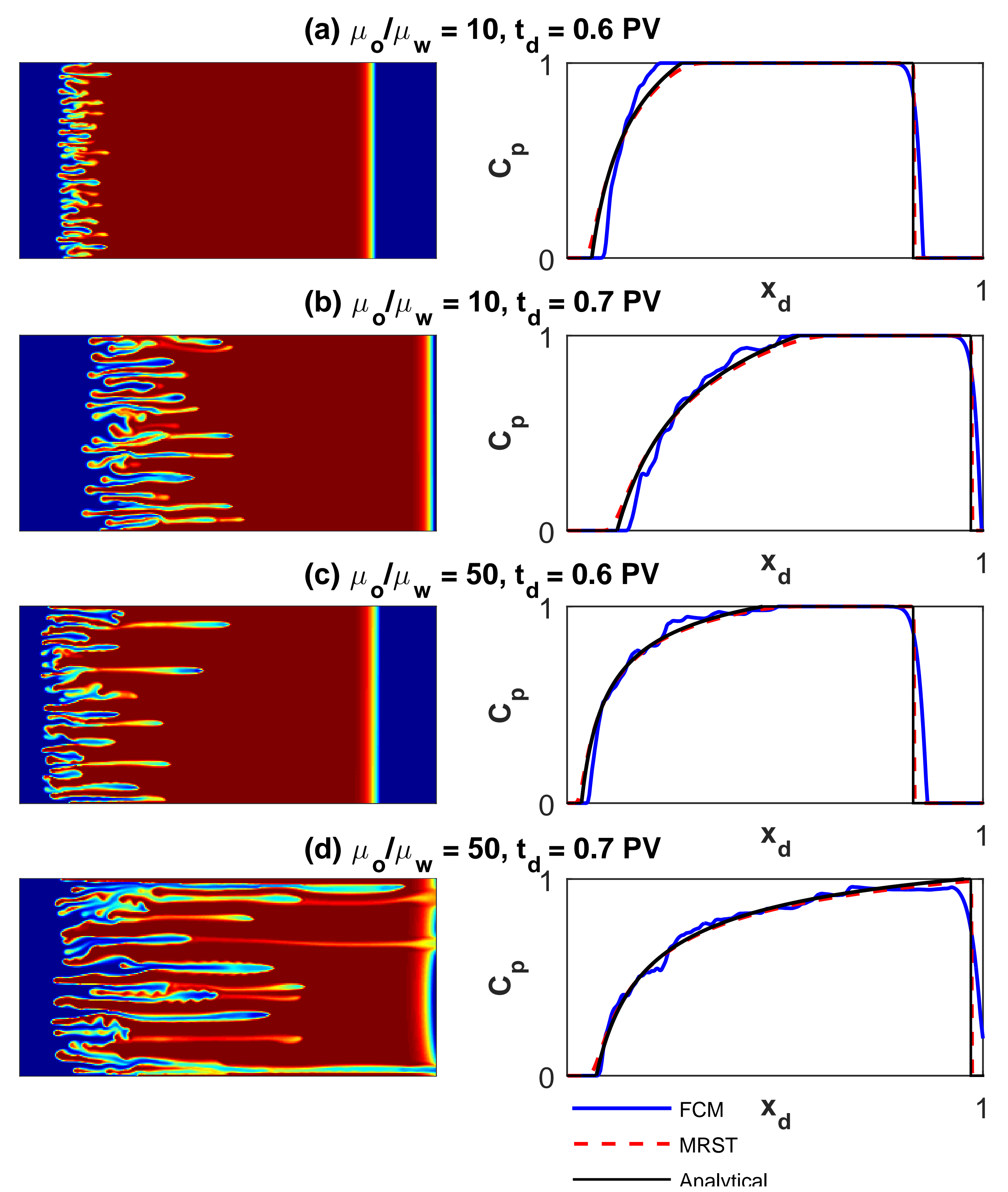


1D solution for polymer slug injection. (a) Fractional flow curves for water-oil and polymer-oil; (b) The position of slug trailing edge.

RESULTS

- Validation against (FIGURE 3):
 - Black-oil simulator (MRST)
 - High resolution first contact simulator (FCM)

FIGURE 3

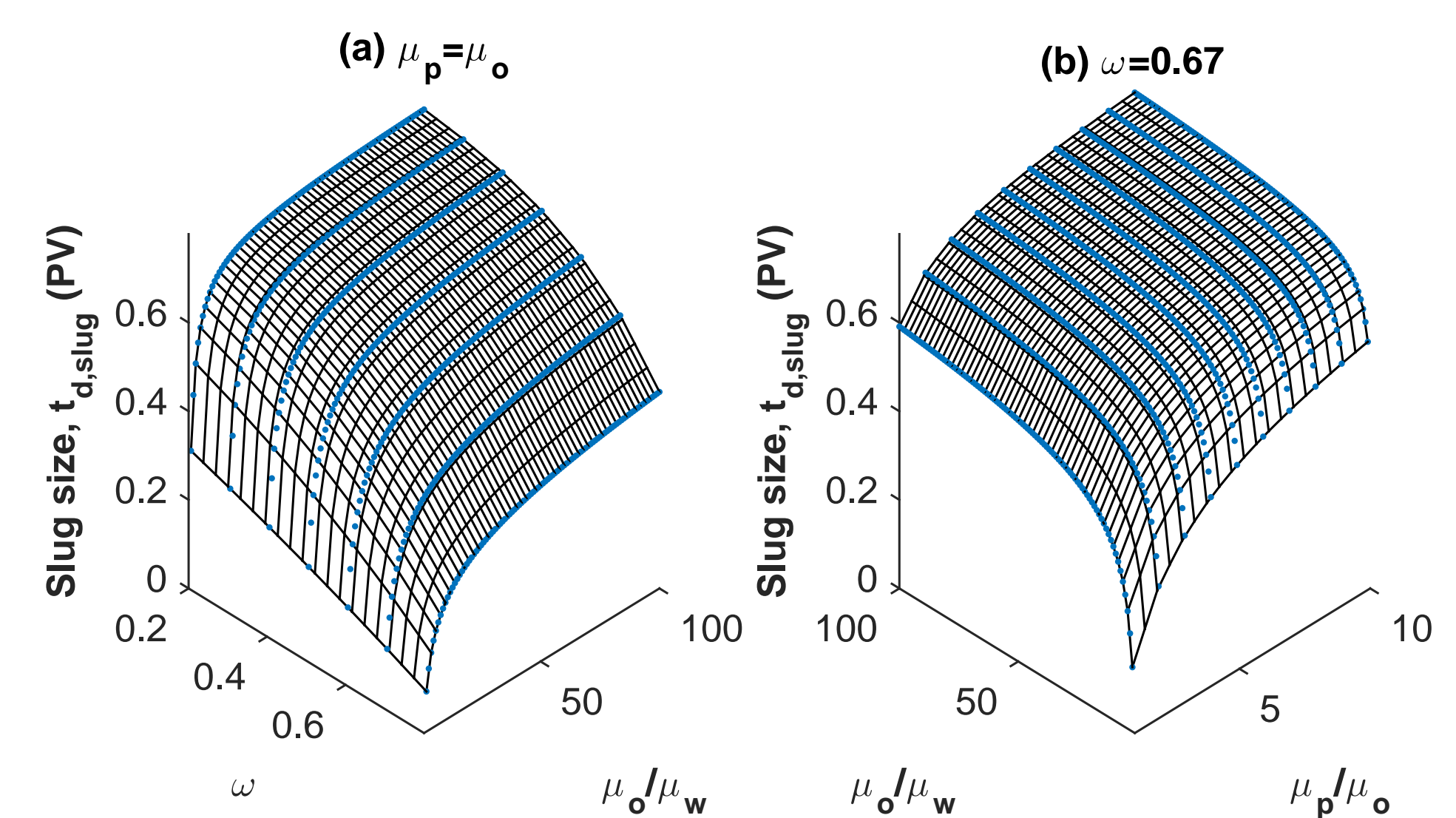


Comparison between FCM simulator, MRST and analytical model, showing that the new analytical model can predict the development of the viscous fingers into the trailing edge of the slug.

APPLICATIONS

- Quick estimation of the minimum polymer slug size (FIGURE 4)
 - Potentially very useful during EOR screening studies.
- Need a large slug size in most cases

FIGURE 4



Optimum slug size as a function of ω (Todd-Longstaff tuning parameter) and viscosity ratios.

REFERENCES

S.A. Abdul Hamid and A. H. Muggeridge (2018). "Analytical solution of polymer slug injection with viscous fingering". In: *Computational Geosciences* 22.3, pp. 711–723.