A NOVEL POPULATION BALANCE MODEL FOR SUBSEA MULTI-PARALLEL PIPES SEPARATOR

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1. INTRODUCTION

Management of ever-increasing produced water is a critical issue for mature oil fields. Subsea separation using multi-parallel pipes (MPPS) is one viable solution to address this problem as it can reduce the load on topside facilities and gathering networks, allowing for increased production. Thus, this study develops a mathematical model for subsea Multi-parallel pipes separator. Population balance modelling is an indispensable part of the model to consider polydispersity in the system. Theoretically, the process consists of below phenomena.

Gravitational setteling/rising	➔	Kumar and Hartland (1985)
Binary droplet coalescence	➔	film drainage model
Interfacial coalescence	➔	film drainage model
Dense packed layer formation	➔	diffusion term

3. NUMERICAL ANALYSIS

- Simultaneous coupling of the two phases layers?
- Mass transfer between two phaseslayers? and the effect on the velocities

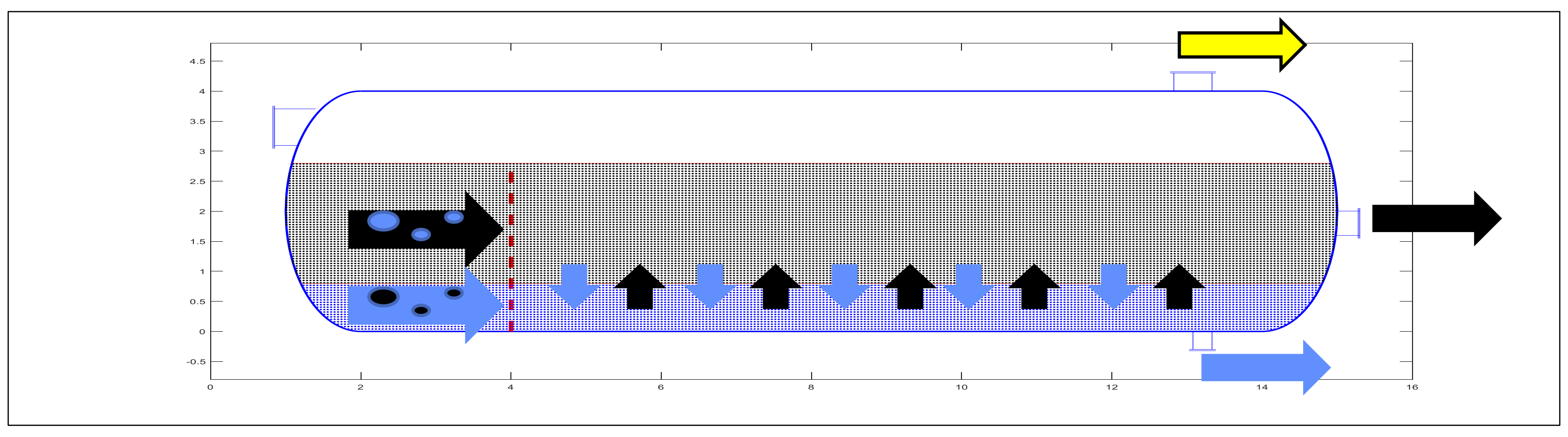

Fig.2. Schematic of the gravitational separator model

Internal Domain
- Spectral-element Orthogonal Collocation Technique
- Legendre Jacobi polynomials
- Grid size: 20 for no coalescence
- Grid size: 80 for coalescence

Spatial Dimension
- High resolution FVM (MUSCL)
- Reconstruction of the profile
- Equidistance cells
- Grid size: 40

Steady-state solver
Transient solver (adaptive Gear's Method)

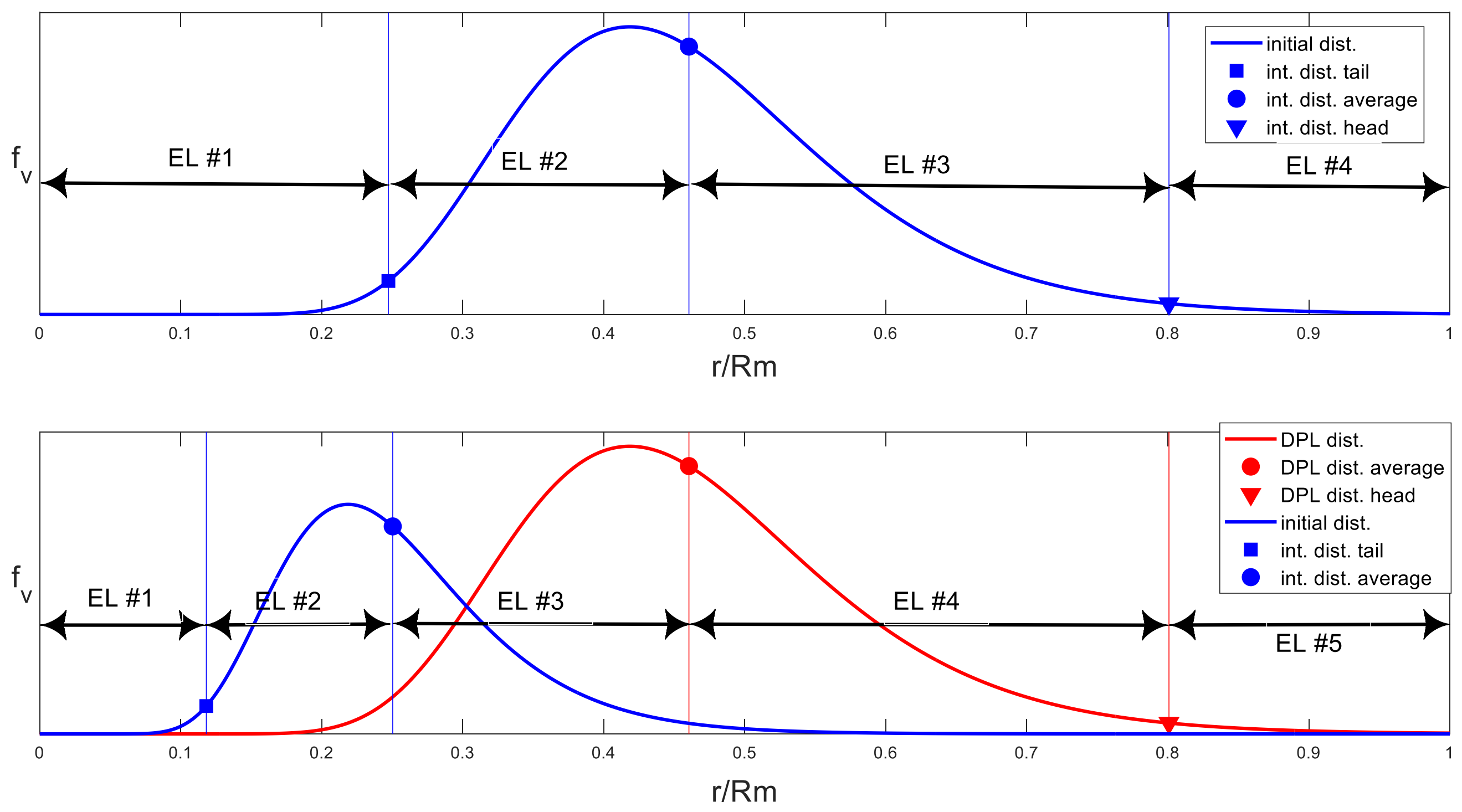

Fig.3. Spectral-element grid, top: system with no coalescence, bottom: coalescing system

5. CONCLUSIONS

The developed model can be readily used in designing the subsea separators by liking the characterization information obtained from the experiments to large-scale industrial designs. The model provides promise for performing scale-ups as well as improvements of the existing designs.

2. DENSE PACKED LAYER MODEL

A vertical diffusion term is considered to model the formation of dense packed layer. The maximum volume fraction of dense-packed layer is included in this term which can incorporate the physical restriction of max volume fraction at dense-packed layer.

$$D(r,z,t) = Cu_d(r,z)\left(\frac{\left(\phi_d(z,t)/\phi_{dpl}\right)^n}{\left(1-\phi_d(z,t)/\phi_{dpl}\right)^m}\right)$$

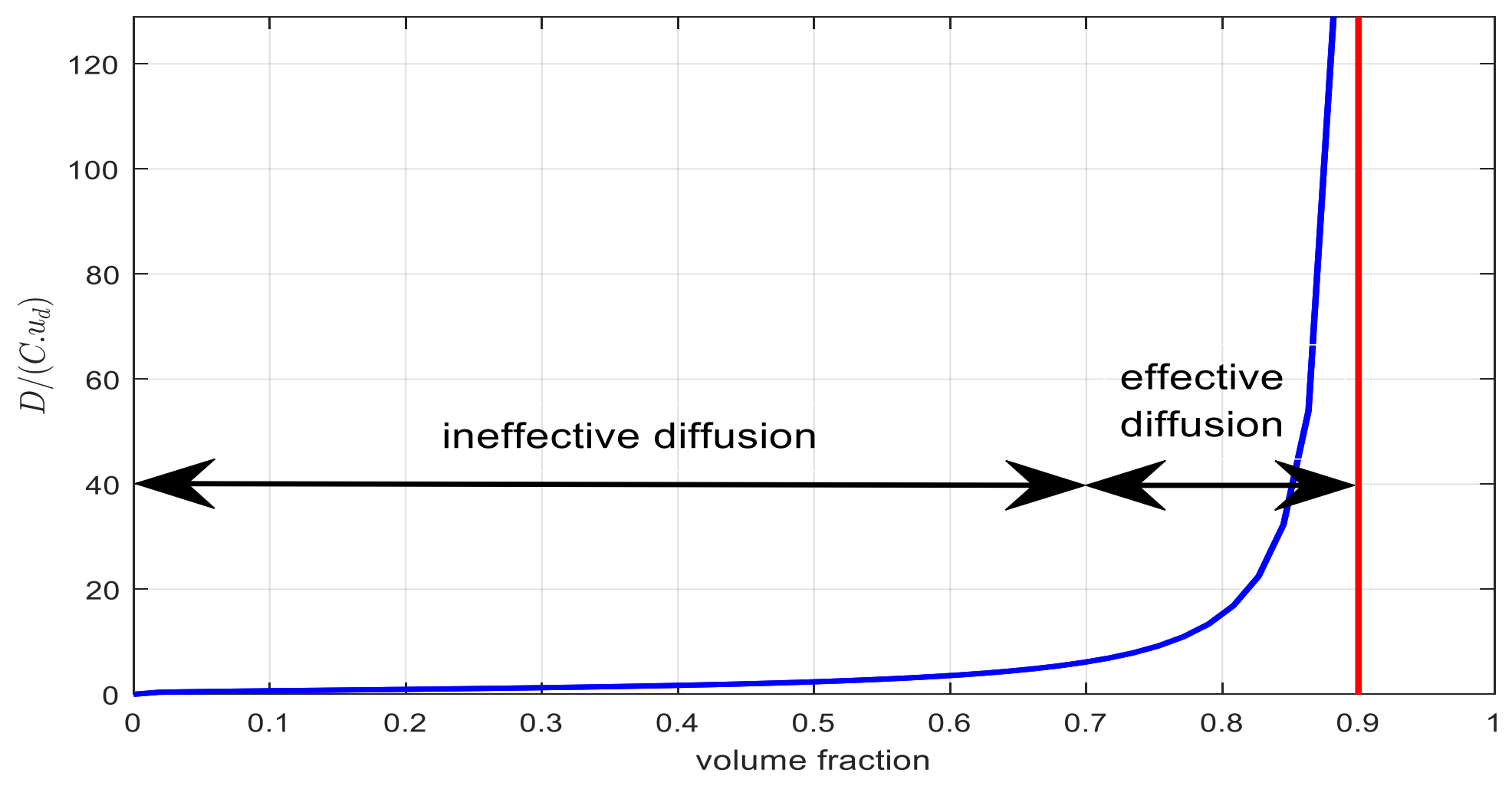

Fig.1. Vertical diffusion versus volume fraction

4. RESULTS

Several experiments were performed using a lab-scale multi-parallel pipes separator to study the effect of different volume fractions and flow rates.

Fig.4. Test Rig

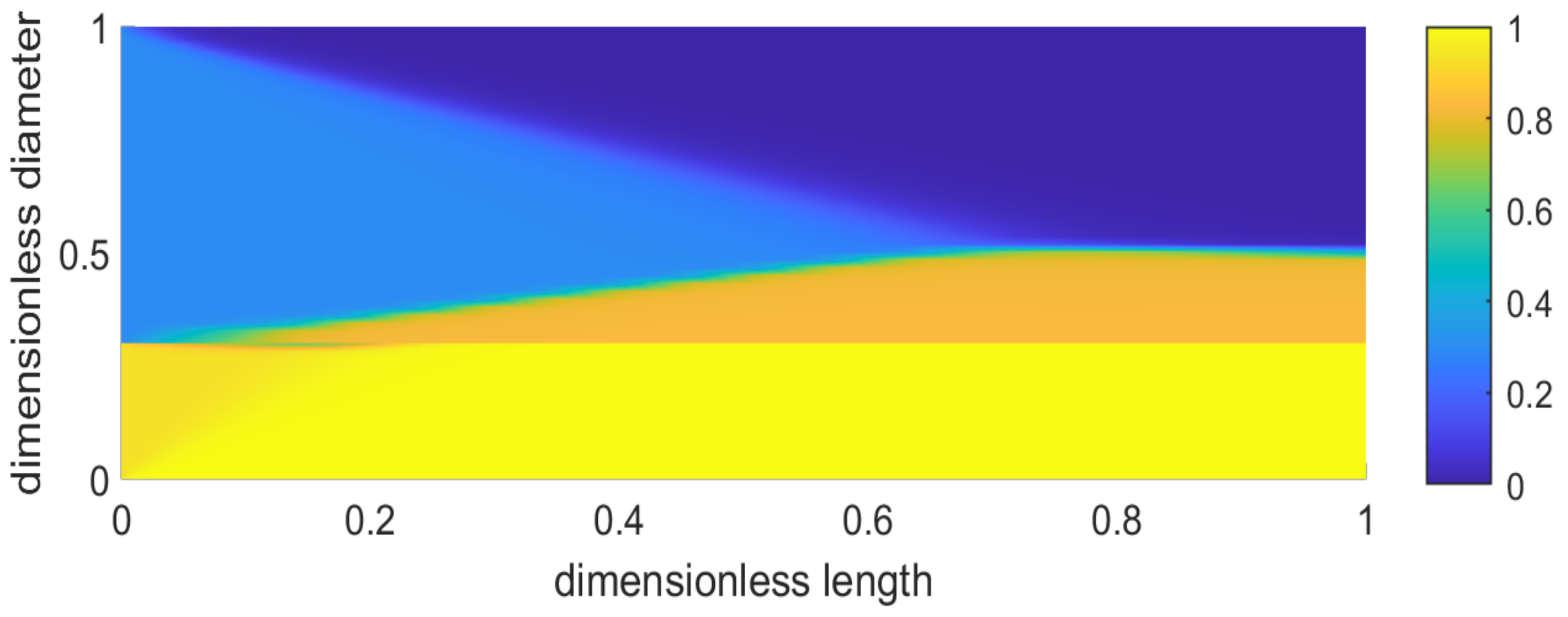

Fig.5. Water volume fraction colormap, inlet WC=50%, flow rate=500 L/min

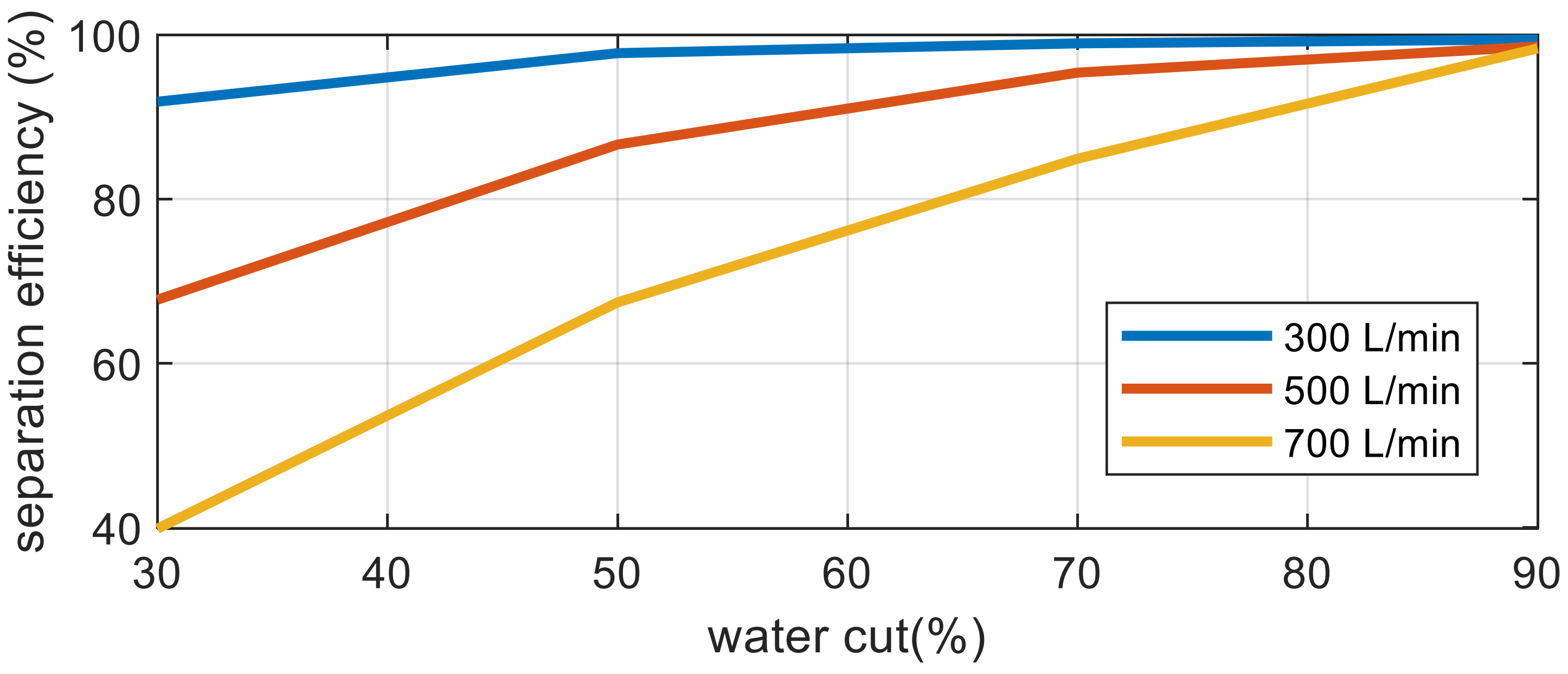

Fig.6. Effect of flow rate and water cut on the Separation efficiency

6. ACKNOWLEDGMENTS

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