



ESDU-SPC-M15-1

Sept.10: Mathematical modeling of asphaltenes deposition and removal in crude distillation units

Unamended
Issued October 2010

Mathematical Modeling of Asphaltenes Deposition and Removal in Crude Distillation Units

Fundamental Transfer processes
Sub-project C

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OBJECTIVES

Currently, fouling rates in a HXC are calculated using semi empirical “fouling threshold” models.

The objectives of our project (CROF-C) are:

- To investigate the **fundamental mechanisms** leading to deposition and removal.
- To **predict** the deposition and removal rates as a function of the relevant system parameters.
- To integrate information from other CROF sub-projects (A/B/D) and to **validate** the modelling predictions against their experimental observations CROF-E/F.

OUR APPROACH

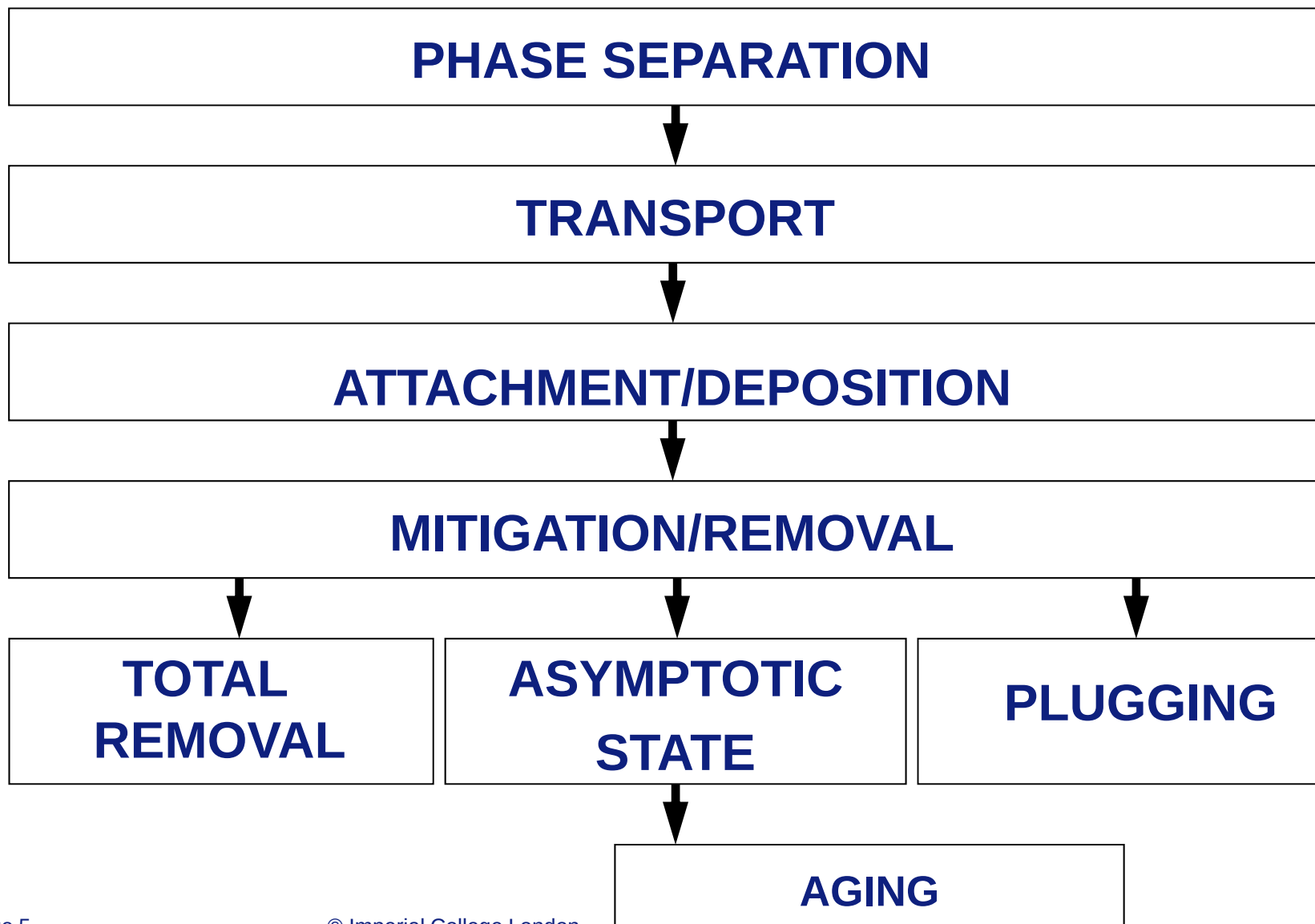
Accurate **predictions** and understanding of fouling composition, mechanisms of production, **deposition** and **removal** are needed

Empirical or semi-empirical correlations are currently used, with some fundamental understanding of physical, chemical, dynamic and mechanical processes involved

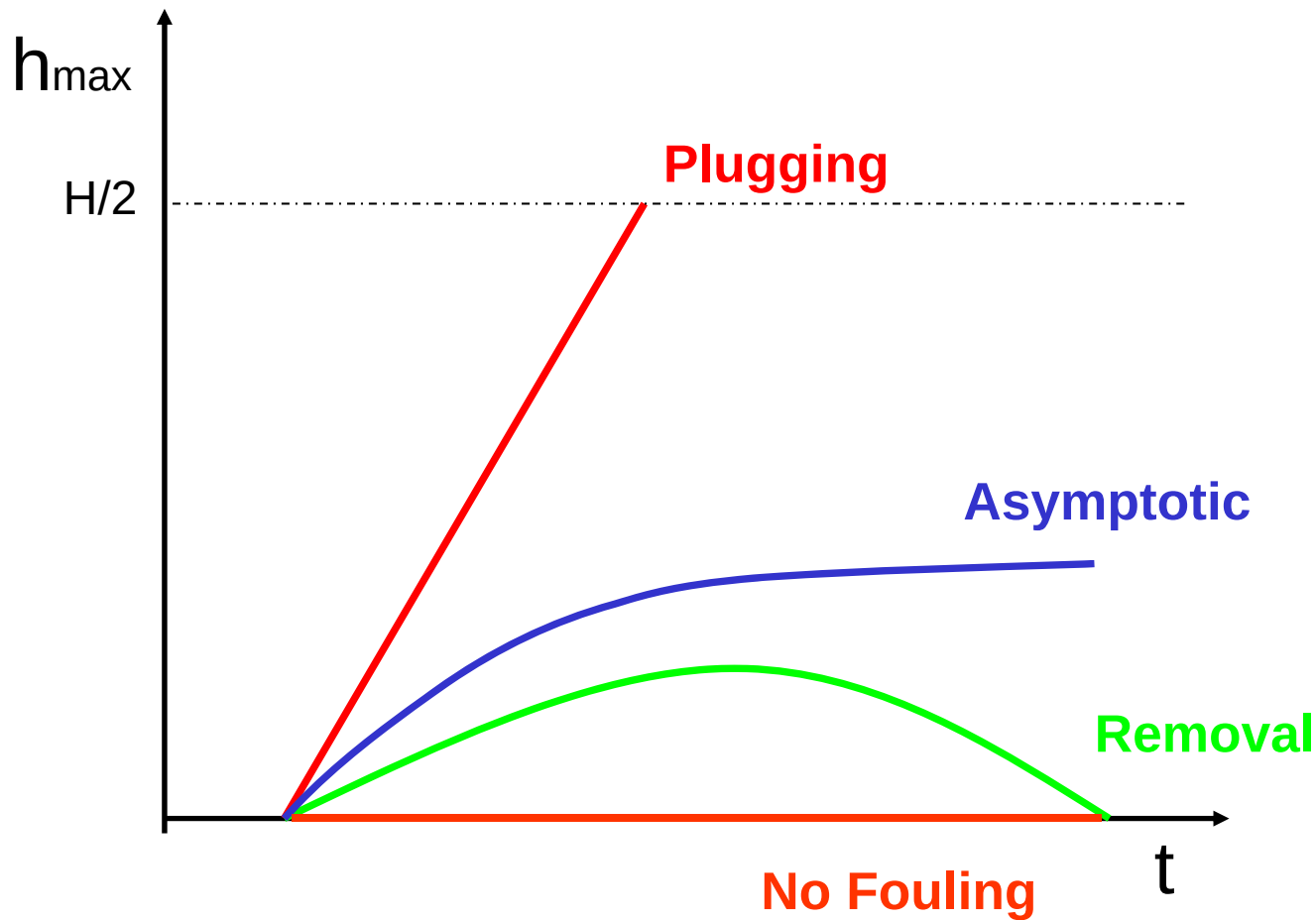
New approach combining:

- Mass, momentum, energy conservation
- Heat conduction
- Chemical equilibria

SEQUENTIAL EVENTS IN FOULING



POSSIBLE FOULING SCENARIOS

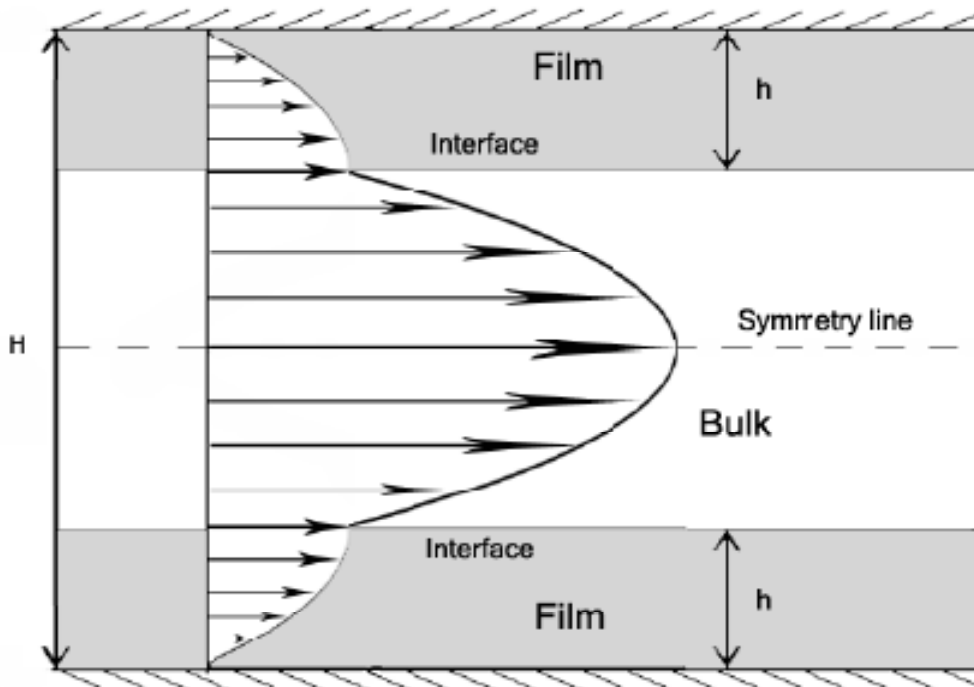


DNS SIMULATIONS METHODS

Diffuse Interface Method (DIM) by Ding et al. [2007]

PROPOSED MODEL:

- Viscosity of the wall layer is function of time (**AGING**)
- Multicomponent mixture phase separation (**DEPOSITION**)
- LAMINAR flow regimes (see LES simulations for turbulent flows)



- Incompressible
- Immiscible
- Viscosity ratio $\gg 1$
- Constant flow rate
- Wall: $T = T_w$
- Inlet: $T = T_{in} < T_w$

Geometry of the model

DNS SIMULATIONS

GOVERNING EQUATIONS

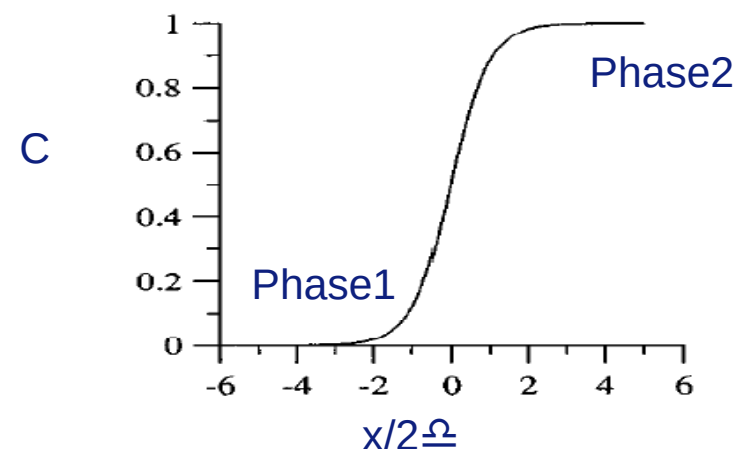
MASS, MOMENTUM, ENERGY conservation, C-H equation

$$\nabla \cdot \mathbf{u} = 0$$

$$\frac{\partial T}{\partial t} + \mathbf{u} \cdot \nabla T = \frac{1}{\text{Re Pr}} \nabla \cdot (\lambda \nabla T)$$

$$\rho \left(\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} \right) = -\nabla p + \frac{1}{\text{Re}} \nabla \cdot \left[\mu \left(\nabla \mathbf{u} + \nabla \mathbf{u}^T \right) \right] + f$$

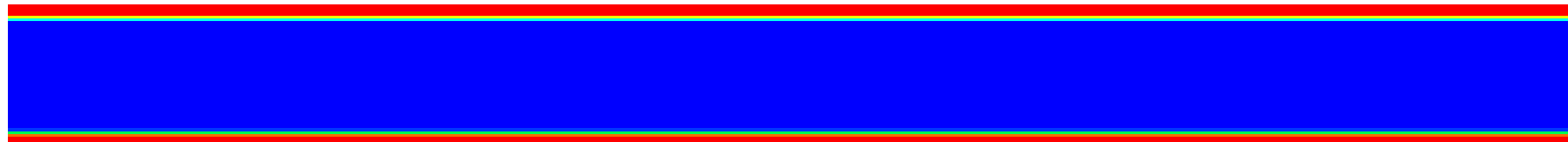
$$\frac{\partial C}{\partial t} + \mathbf{u} \cdot \nabla C = \frac{1}{\text{Pe}} \nabla \cdot (M \nabla \phi)$$



DNS RESULTS

NO AGING / NO DEPOSITION

$Re = 500$ $Pr = 5.435$ $Ca = 0.00865$
 $Ri = 0.1044$ $r_d = 1.5$ $r_v = 10$ $r_c = 10$ $\beta = 0.3$
 $D_s = \infty$ $\tau = \infty$ $n = 2$ $\alpha = 0$ $T_w = 1.5$



VOLUME FRACTION



TEMPERATURE