Computational fluid dynamics modeling of struvite precipitation

Bernardas Jankauskas[1]; Dr Gavin Tabor[1]; Dr Daniel Jarman[2]
University of Exeter[1]; Hydro International[2]

stream
The Industrial Doctorate Centre for the Water Sector

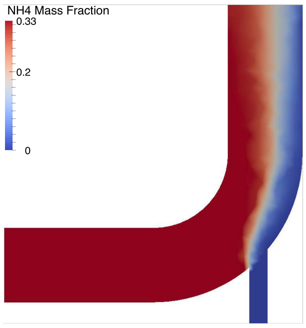

Fig 1. – Final ammonium mass fraction distribution in the domain.

Why Struvite?

Struvite is a magnesium, ammonium, phosphate mineral. If wastewater is saturated well enough with Mg^{2+}, NH_4^+, $H_nPO^{3-n}_4$ ions - there is an increased chance for spontaneous precipitation of struvite. This of course is a huge problem, as crystal layer then clogs up the pipes.

$$Mg^{2+} + NH_4^+ + H_nPO_4^{3-n} + 6H_2O \rightarrow$$
$$\rightarrow MgNH_4PO_4 \cdot 6H_2O + nH^+$$

Eq.1 – struvite reaction[2]

On a positive note - it is known that struvite works as a slow release fertiliser. For that reason it is more efficient than conventional substances and is an attractive economic opportunity.

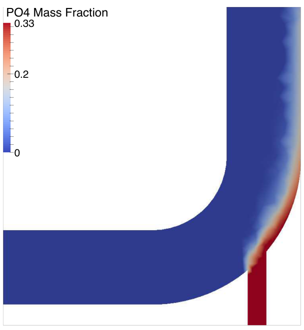

Fig 3. – Final phosphate mass fraction distribution in the domain.

Introduction

Currently it is estimated that there is only 100 years of phosphorus left[1] for mining. Phosphorus is one of the main fertilizers used; without it the agricultural industry would suffer and possibly couldn't exist at the scale that it is now.

This challenges us to think out of the box and find more innovative solutions of producing phosphorus. Luckily, there is a significant amount of phosphorus found in wastewater, it is highly important that we start using this source. Therefore, wastewater treatment facilities are now being designed with that goal in mind.

Fig 5. – Visualisation on youtube.

Further work

In the near future population balance equation (PBE) modeling will be implemented to the current setup.

Settling velocity will also be added to the model as we aim to apply this method to one of the products of Hydro International.

References

[1] Driver, J, Lijmbach, D, Steen, I 1999, 'Why Recover Phosphorus for Recycling, and How?', *Environmental Technology*, 20:7, 651-662, DOI: 10.1080/09593332008616861
[2] Le Corre, KS 2006, *Understanding Struvite Crystallisation and Recovery.*, Ph.D thesis, Cranfield University

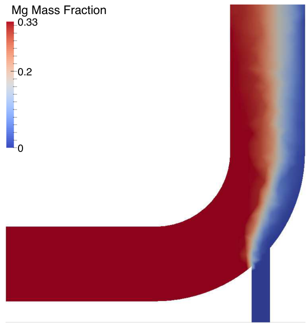

Fig 2. – Final magnesium mass fraction distribution in the domain.

Computational model

We start formulating our computational fluid dynamics model by first implementing a scalar transport formulation:

$$\frac{\partial (Y_i)}{\partial t} + \nabla \bullet (\vec{v} Y_i) = -\nabla \bullet \vec{J}_i + S_i$$

$$S_i = \pm k_{arr} \prod_{j = \text{ reactants}} Y_j$$

Eq.2 – a generic scalar transport equation.

At the moment the transport is chosen to be irreversible, i.e. the transported species do not dissolve.

The current model gives expected mass transfer, which is shown in the figures and visualisation.

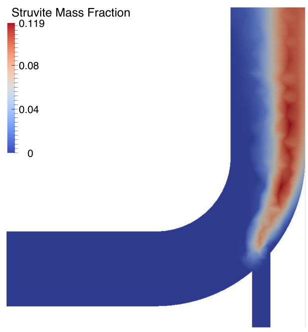

Fig 4. – Final struvite mass fraction distribution in the domain.

www.stream-idc.net

www.exeter.ac.uk

www.hydro-int.com

www.epsrc.ac.uk

Bernardas Jankauskas
Address: Harrison Bldg, Rm110, University of Exeter N Park Rd, Exeter, Devon EX4 4QF;
Email: bj255@exeter.ac.uk

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