Towards improved solid-liquid separation in High Rate Activated Sludge systems by unravelling flocculation behaviour

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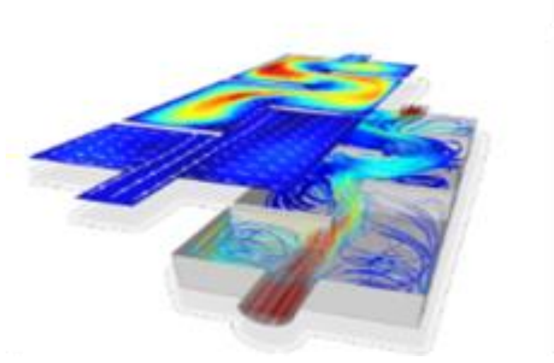
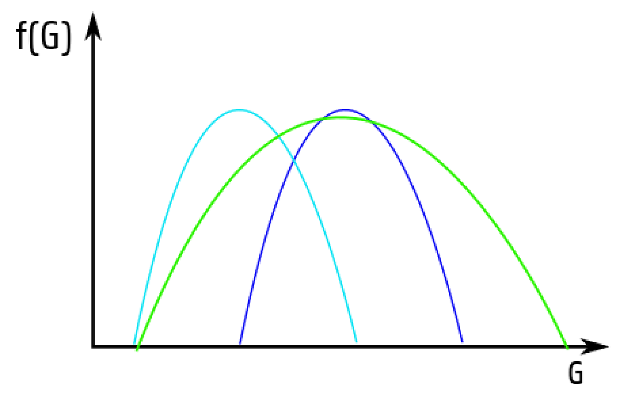
Introduction

- Many full-scale high-rate activated sludge (HRAS) systems, operated at short SRT and HRT, often suffer from poor settleability
- Sludge settleability is highly dependent on the floc characteristics (e.g. size, structure and density) determined by flocculation processes that take place in the specifically designed unit process prior to the solid-liquid separation process
- Current flocculation dynamic models do not accurately capture the interactions between fluid dynamics and floc formation processes in full-scale flocculators due to assumption of average shear rates
- Average shear rates can differ significantly from local shear rates (factor 10-100)

Computational Fluid Dynamics (CFD)





CFD allows to characterise the reactor fluid flow (L) and to predict the range of local velocity gradients to which flocs are subjected in the HRAS system (R), allowing to construct shear rate distributions

Using CFD to extend simple models

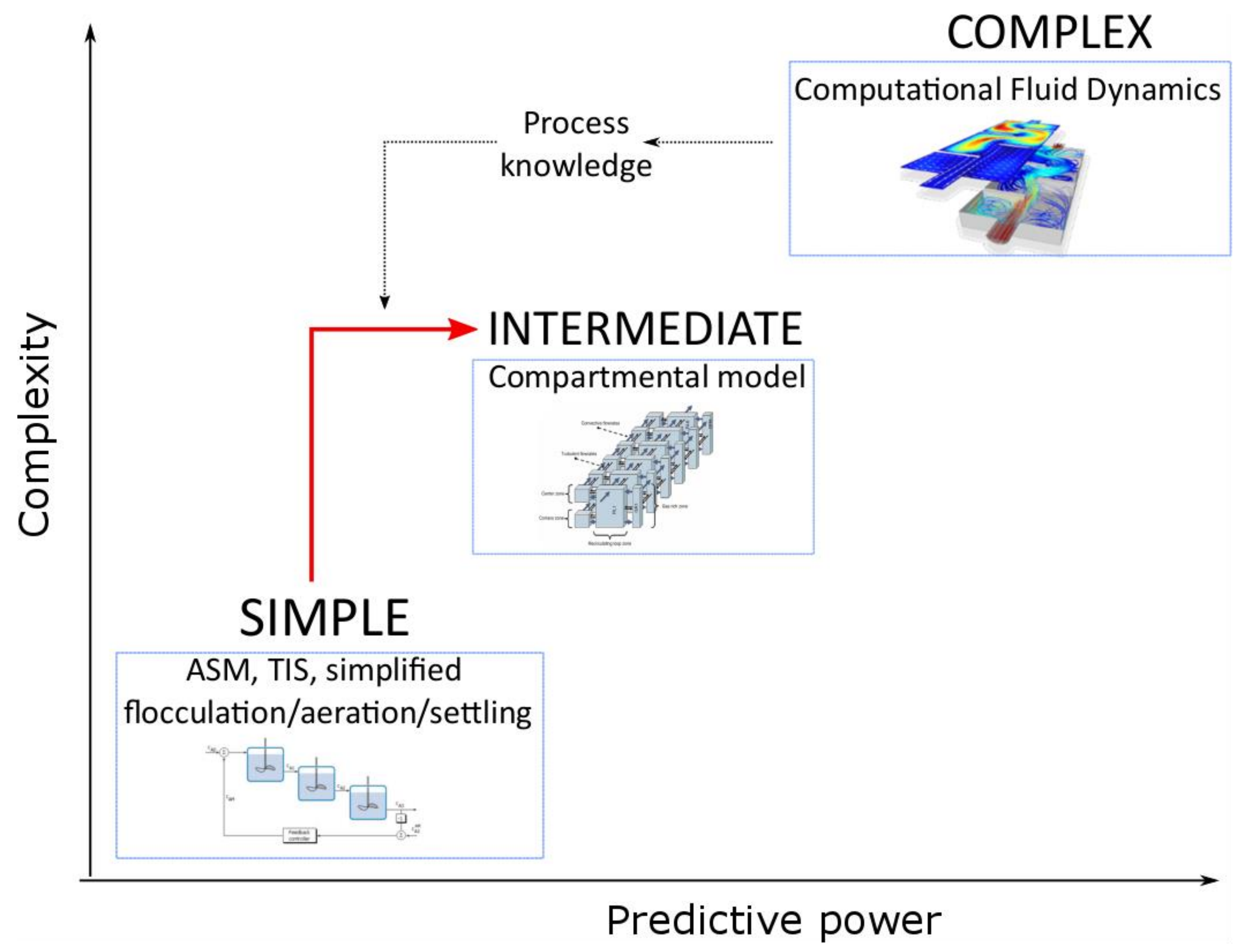
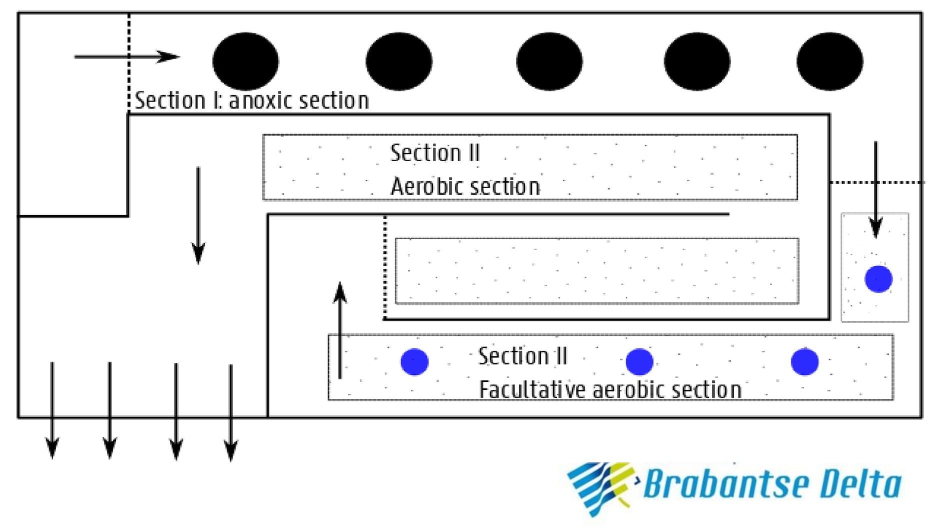


Illustration of the concept of using process knowledge gained by CFD-modelling to lift the predictive power of simple models, such as tanks in series (TIS) or Activated sludge models (ASM), to a higher level

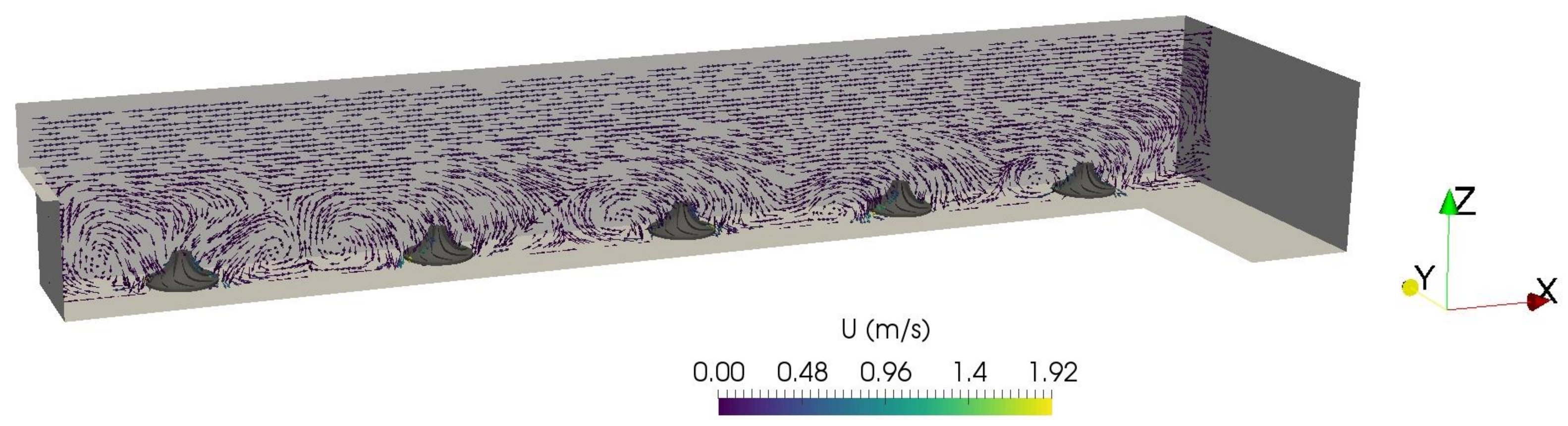
Case-study: HRAS-process at WRRF of Breda



Brabantse Delta

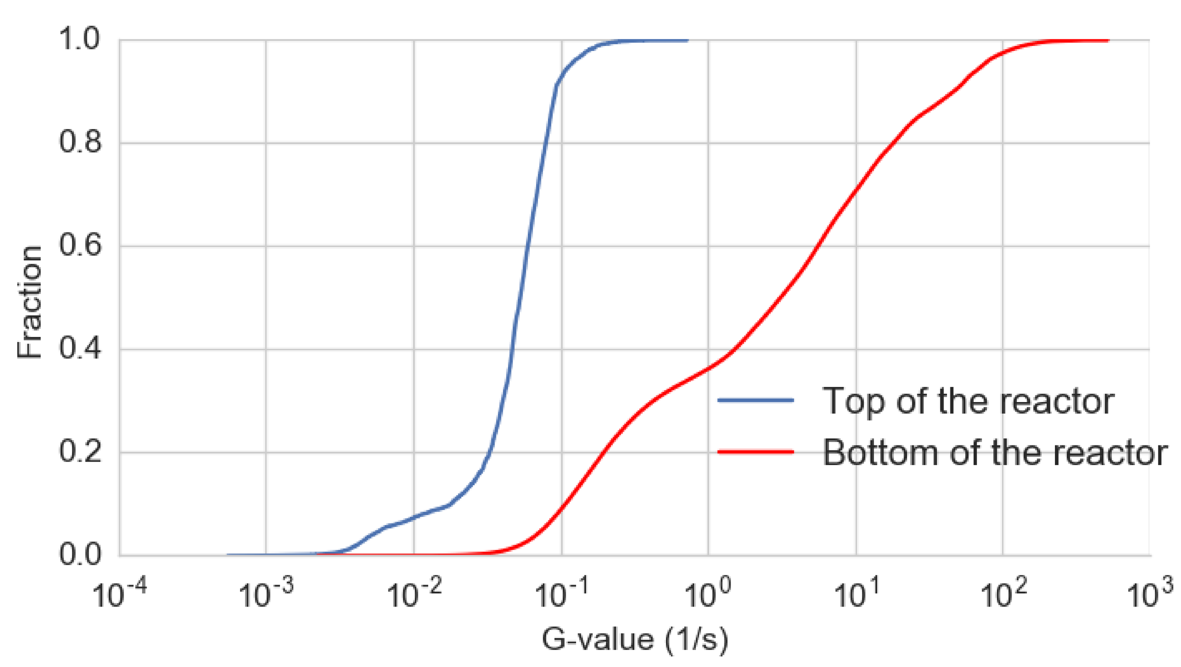
The reactor contains three zones: an anoxic zone (with hyperboloid mixers) to denitrify returned nitrate from the B-stage, followed by a facultative aerobic and aerobic zone to concentrate as much organic carbon as possible into a well-digestible sludge.

Mixture heterogeneity in anoxic section



Preliminary simulation results of velocity contours in the anoxic section. The flow field generated by hyperboloid mixers was modelled using the incompressible, steady-state RANS solver, with multiple MRF, and the k-epsilon turbulence model. Non-ideal mixing in the reactor is observed, even in areas close to impellers.

Local velocity gradients distribution



Difference between the distribution of velocity gradients G (1/s) in the top and bottom (mixture zone) of the reactor.

Conclusions

- Improving solid-liquid separation in HRAS systems requires a thorough understanding of the flocculation processes
- CFD allows prediction of the local velocity gradients
- Complex CFD models are computationally very demanding and thus not suitable in optimization studies.

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