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Visit to Cranfield University, UK
UK Fluids Network Short Research Visit: Trip Report

2nd July – 13th July 2018

Project Summary

The application of Computational Fluid Dynamics (CFD) to multiphase flow problems in the oil and gas industry is important to the design and operation of the drilling, production and transport processes involved [1,2,3]. The co-existence of solid, liquid, and gaseous phases warrants the formulation and implementation of high-fidelity CFD models for the process description in an annular wellbore. Hence, the onset of critical phenomena such as particle deposition and droplet evolution from the gas-liquid interface [4,5] during underbalanced drilling operations can be adequately predicted. Considering the relatively similar CFD-related research done at Cranfield to that of my PhD project, establishing meaningful communication to explore collaboration potential was paramount; and this was facilitated by the UKFN–SRV funding scheme.

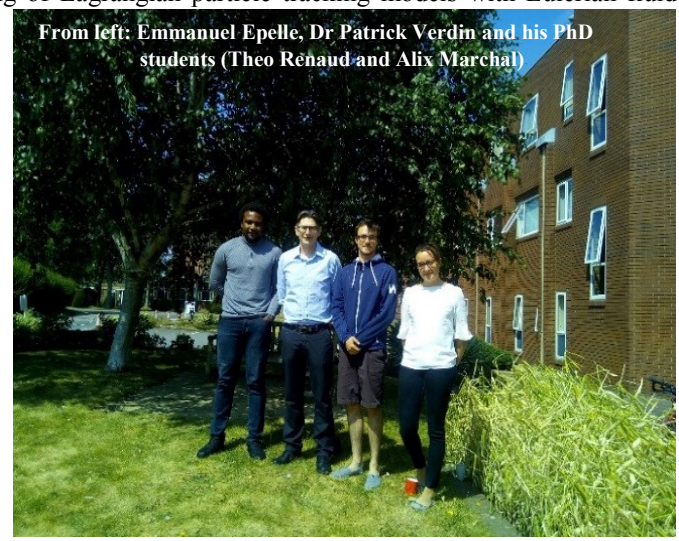
Visit Outcomes

In order to gain a well-rounded knowledge of the work done in the research group at Cranfield, group presentations were organised by Dr Patrick Verdin, during which my work was also presented. Although collaboration interests are at this point purely computational, a visit to the multiphase flow lab (by Dr Liyun Lao) gave me an experimental perspective to some aspects of my work. Relevant experiments carried out by other researchers in the group could constitute possible model validation studies in the future.

Qualitative model inspection of my current case study was carried out by Dr Verdin, after which some valuable insights were provided to some of the challenges faced. One of which was the prediction of the onset of particle deposition in an annulus during wellbore cleaning operations. This was followed by discussions on the limitations and implementation challenges of several droplet evolution criteria in literature for annular flow conditions [5,6]. However, there is a clear possibility to extend these proposed models to stratified flow and also slug flow conditions in an annular wellbore for which these criteria are currently scarce.

As part of my accomplished tasks during the visit, the Volume of Fluid (VOF) model in ANSYS FLUENT™ 17.1 was applied to describe the gas-liquid motion and capture the interface between both phases during underbalanced drilling. The effects of liquid flow rate and gas injection rate on the nature of the produced interface were analysed in a horizontal annulus. With the motion of the gas and liquid phases described, we began investigating the suitability of existing CFD coupling methodologies in literature, with open source and commercial codes which implement the Discrete Element Method (DEM) and the Dense Discrete Phase Model (DDPM). What interaction forces to include (drag, lift, pressure gradient, turbulent dispersion and virtual mass forces) and how they should be included, were some of the points discussed. This is essential to describe particle collision, entrainment and deposition phenomena in the annulus. Result validation after more CFD and CFD-DEM simulations is crucial and will be facilitated by data availability and further technical contribution (code development) from Cranfield. If successful, this could form the basis for a peer-reviewed journal article submission.

The research discussion towards exploring common collaboration goals is still ongoing, since my return to Edinburgh. The insights gained on the coupling of Lagrangian particle tracking models with Eulerian fluid models and the criteria for particle evolution and entrainment phenomena in a horizontal annulus, will be very useful for implementation in my PhD project. There is also room for a joint proposal submission with my supervisor (Dr Dimitrios Gerogiorgis) who is also in touch with Dr Patrick Verdin.


From left: Emmanuel Epelle, Dr Patrick Verdin and his PhD students (Theo Renaud and Alix Marchal)

My research prospects have certainly been elevated via the UKFN–SRV funding scheme, and my visit to Cranfield University. Through this visit, I have maintained good communication with other staff and graduate students at Cranfield University, who could remain throughout my whole career.

Literature references

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