Post-doctoral proposal 2006:

Direct numerical simulation of particulate flows with heat transfer

In the Oil and Gas industry, many situations are representative of particulate flows : cutting removal in drilling operations, sand management in production, dispersed hydrates transportation in pipeline, ... Particles may be of arbitrary shape and the fluid itself may exhibit non-Newtonian properties. The comprehension of these complex flows is of primary importance at the fundamental level for the researcher and at the practical level for the engineer to contribute to the improvement of industrial methodologies.

To gain more knowledge of these flows, one possible approach consists in studying accurately the solid/solid and fluid/solid interactions at the particle level. IFP has been developing for a couple of years a numerical code to simulate particulate flows in which the level of description is the particle, which implies that our approach may be regarded as a direct numerical simulation. The numerical tool is based on the coupling of a purely granular code named GRAINS2D/3D with a standard Finite Element fluid solver. The coupling is achieved thanks to the use of the Fictitious Domain method which is particularly well suited to the free motion of bodies. One asset of our approach relies on the Discrete Element Method adopted in GRAINS2D/3D that is able to handle particles of almost arbitrary shape (at least polyhedral or convex) and the detection of the numerous multi-body collisions. The contact laws for the description of the solid/solid interactions are based on a soft spheres model.

At the present time, IFP owns a 2D version of the coupled code. This code has been validated with success and is able to simulate the motion of up to a few thousands particles in a flowing fluid. However, the simulations are highly demanding in terms of computation time. We are currently working on the extension to 3D flows and the upgrade to a full parallel version of the 2D code to enhance the computation capabilities towards the simulation of large numbers of particles (from a few tens of thousands to a few hundreds of thousands), but this is not the objective of the present post-doc proposal.

The post-doctoral position is oriented towards the comprehension of these complex flows. The work program is divided is three main tasks :

- the improvement of the adopted numerical methods in terms of accuracy and efficiency,
- the extension to heat transfer,
- the validation of the code based on comparisons with experimental data (sedimentation of particles in a non Newtonian fluid, start up of a bed of settled particles in a pipe, ...)

Since the whole software platform is developed in C++, further developments are expected to be achieved in this oriented object language with the adequate method of analysis based on the use of UML and Design Pattern.

This is a one-year postdoctoral position, available at the Fluid Mechanics Department of the Petroleum French Institute (Institut Français du Pétrole). It will start as soon as it is filled. Only international (i.e. non French) applications will be considered.

The right candidate must have completed a PhD and should have a strong background in Fluid Mechanics and Applied Mathematics, as well as good C++ programming skills and experience in scientific computing. Basic knowledge in rheology is a plus but is not required.

In addition, the candidate is expected to be have good communication skills in English (or French) and the ability to write articles and technical reports in English. We forecast to write 1 to 3 articles to be published in international journals.

IFP is a mixed private/public research institute working in the oil and gas field and located in Rueil Malmaison, 10 miles west of Paris. It offers a stimulating working environment with efficient computing facilities and a competitive salary (~2200 euros/month net).

Contact : Anthony Wachs (anthony.wachs@ifp.fr)
Institut Français du Pétrole
1&4 avenue Bois Préau
92 500 Rueil Malmaison
Tél : +33 1 47 52 63 67
Fax : +33 1 47 52 70 02