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LA EXPERIENCIA DE UTILIZAR OPENFOAM PARA ENSEÑANZA, INVESTIGACIÓN Y CONSULTORÍA INDUSTRIAL BASADA EN CFD

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Abstract. The objective of this presentation is to show the genesis of our group, which have been the major milestones that led to the decision-making in regards to the lines of research that we have followed and as in all of this plays a leading role the development that the group has had by the mere fact of taking as a methodological tool the suite OpenFOAM. We started in chronological order by mentioning the events that were happening, having begun to resolve cases of single phase flows in both compressible and incompressible laminar regime, adding in some way several turbulence models accepted by the community and the choice of the line of work on multiphase flows by a great need that has occurred coming from our national industry to understand and optimize their processes normally operating in these flow conditions. The presentation shows how the adoption of OpenFOAM has simplified a lot of work, delivers productivity thanks to the large diffusion of the knowledge gained through the existing international forums and by the fact that the whole group handles the same things on a daily basis. This in turn allows you to have international presence to the extent that one develops new applications, utilities and algorithms at the same time to debug the code through the detection of anomalies and the contact with the online service "bugtracker". There is also the way in which it is introduced in the postgraduate education by showing some examples that solve the students that come from the majority of research groups working in diverse areas and for which the computational mechanics is only a tool, because the focus of their researches are in another field of knowledge. Here are a few tools developed within the group both for emulation in Octave how OpenFOAM works as well as in debugger mode using gdbOF and a development interface or IDE based on QtCreator. Next some issues resolved for industrial applications using OpenFOAM are presented, in particular two recent projects, one on oil/water separation with skimmers tanks and another on atomization of liquid charge in a riser of a fluidized catalytic cracking (FCC) plant for YPF, currently Y-TEC. The idea is to show how these very challenging issues proposed by the industries promote research and thesis proposals, leaving as a future idea that of generating knowledge to propose new computational models that assist the daily work of our engineers in a better way and eventually resulting in innovative developments with intellectual property. Next a review of the main topics currently present in aour group is done, mostly generated by real world needs, as follows:

1) dynamic mesh manipulation (dynamicMesh),

2) simultaneous compressibles and incompressibles flow solvers (rhoPimpleFoam),

3) gas-solid multiphase systems model by Kinetic Theory Granular Flow (KTGF) with chemical reactions (twoPhaseEulerFoam + KTGF),

4) gas-liquid multiphase flow represented by separated interfaces (VOF), dispersed interfaces (mixture models) and its combination (interFoam, mixtureFoam and our own development called the mixture-extended version),

5) multiphase flow models with evaporation and condensation applied in subcooled nucleate boiling (twoPhaseEulerFoam),

6) primary and secondary atomization models (interDymFoam).

The first two topics come from developments that the group is doing on two innovative internal combustion engines platforms, one coming from Universidad Nacional del Comahue in Neuquen, patented by Sir Jorge Toth and Ezequiel Lopez, called MRCVC and the other from the private sector, the engine JLA, an opposed piston engine patented by José Luis Alonso and Carlos Juni.

The third item was proposed by Y-TEC to improve the process of refining gasoline in its FCC plant where the solid-gas system consists of air and steam mixed with solid catalyst that promotes the conversion of the atomized and vaporized liquid charge in various distillates. In addition, it could serve to resolve various issues that are presented in the steel-making industry where pneumatic transport of pellets and solid material feeding the steel furnaces is normally used. Also for environmental impact mitigation taking place inside and outside of store-buildings produced by the load operation scrap into furnaces, among others. The fourth topic responds to the need to improve the processes of separating oil and water, draft proposed by YPF to root of needs of the upstream sector today more revalued by the impact of secondary recovery, tertiary and the removal of the shale-oil. This item led the development of the doctoral thesis of Dr. Santiago Marquez. The fifth theme comes from the need to attend great detail models for the Nuclear Regulatory Authority (ARN) to audit the designs of national nuclear reactors that are put on leave or extend its useful life.

As a result of various agreements between CIMEC and ARN the group brings the coupled 0D/ 1D/ 3D thermohydraulic models which makes it possible to solve in great detail what happens inside the 3D reactor pressure vessel, inside their channels as a 1D model, as in the tank of the moderator and in their upper and lower plenums in 3D in computed in a coupled way receiving as external boundary conditions some information provided by a 0D model representing the rest of the whole plant, such as offers today Relap, Athlet, Cobra, etc. The sixth issue emerged as several needs, one of them from Y-TEC to evaluate the atomization produced by the injectors of liquid charge feeding the riser of the FCC as was mentioned earlier. The other need comes from the JLA engine development that by bench tests showed its better performance using gasoline direct injection (GDI). Another need arose from a proposal for a study of the impact of aerial fumigation on the population and the need to better regulate the activity. Obviously to this we can add the enormous interest in addressing this topic in the science being one of the challenges of the present decade.

In each of these issues there are some mathematical and numerical aspects in common that they can be noted, in particular issues related to the way in which OpenFOAM stabilizes their schemes in advection dominate problems looking for high-order accuracy and boundedness, critically important in applications that just mentioned before the evolution of the phases is followed. Another item that stands out is the P-V coupling tracking by Rhie-Chow interpolation and the manner in which the Pressure Implicit Spliting Operator (PISO) and Pimple(=PISO+Simple) are implemented on each of the above applications. Understanding these aspects and others is vital to use correctly the solvers and search for the necessary improvements for each application.

To finish, and as a separate chapter which deserves some mention is the development of Particle Finite Element Method 2nd Generation (PFEM-2) present in our group. During the last time we have become a part of the developers following the ideas of Prof. Idelsohn with some important progress published in several recent papers. The extension of PFEM-2 to the case of multifluids and multiphase flows always with the intention to accelerate the calculation times without damaging excessively accuracy gives the engineer a tool that is more tailored to your needs of design and selection of solutions.

In summary, the idea is to share this experience leaving message as the great potential that offers work on a platform like OpenFOAM since in addition to being widespread throughout the world, your license is available to the public remain attractive for our institutions often poor in budgets to deal with expensive commercial licenses. Being an open source code allows us to incorporate our knowledge inside the suite being ideal for scientific purposes, and having a hierarchy of capabilities which allow us to apply both in the teaching to an audience that is just beginning in the topic, such as the greater complexity that enfaces who does assistance to the social and productive environment.