11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

PREDICTION OF CYCLIC COMBUSTION VARIABILITY IN INTERNAL COMBUSTION ENGINES VIA COUPLED 1D-3D LES METHOD

B. Roux[1]*, J. Bohbot[1], Q. H. Tran[1] and P. Sagaut[2]

[1] IFP Energies nouvelles, 1 & 4 avenue de Bois-Preau 92852 Rueil-Malmaison Cedex, France, benjamin.roux@ifpen.fr, http://www.ifpenergiesnouvelles.fr/
[2] Institut Jean le Rond d'Alembert, Université Pierre et Marie Curie, 4 place Jussieu, 75252 Paris Cedex 05, France, sagaut@lmm.jussieu.fr, http://www.dalembert.upmc.fr/

Key Words: *Internal combustion engine, Cyclic combustion variability, Large eddy simulation, System simulation, coupling, 1D, 3D.*

The increasing regulation constraints in terms of fuel consumption and pollutant emissions related to automotive traffic requires the development of innovative engine concepts. Among them, lean combustion and exhaust gas recycling are widely used and it has been shown that these techniques increase acyclic phenomena already present in the engine [1]. The cyclic combustion variability (CCV) leads to variations in the engine speed causing poor drivability, power loss and incomplete combustion raising pollutant emissions. Furthermore the extreme cycles limit engine operation and reduction of CCV would be beneficial to engine efficiency [2]. In this context, predictive simulations of cycle to cycle variations in the engine, are particularly interesting.

Recent works [3] have shown the capability of Large Eddy Simulation (LES) to predict cycle to cycle variations. They have also pointed out a lack of data for the definition of boundary conditions. System simulation or mono dimensional CFD have already been used to generate boundary conditions for engine simulations [4].
The objective of the present work is to develop an approach using LES to simulate in detail the complex reactive flow in the combustion chamber of an engine, while accounting for its interaction with the flow and acoustics in the complete engine system. We develop a coupling method between the AVBP software (dedicated to the study of the chamber and its close vicinity using LES) and the AMESim commercial system simulation code, which is able to describe the rest of the engine using 1D or/and system simulation. The middleware OpenPalm is used to couple these two codes for high performance computing. Three coupling methods, respectively based on exchange of primitive, conservative [5] and characteristic [6] variables across the interface, have been implemented. First, they have been compared in 1D/1D test cases (CD nozzle, shocktube and acoustic waves propagation). Then 1D/3D computation of an exhaust line have been carried out. Finally, the first calculation of a motored (without combustion) engine system will be presented and compared with the SGEmac [7] database dedicated to the study of CCV in spark ignited engines.

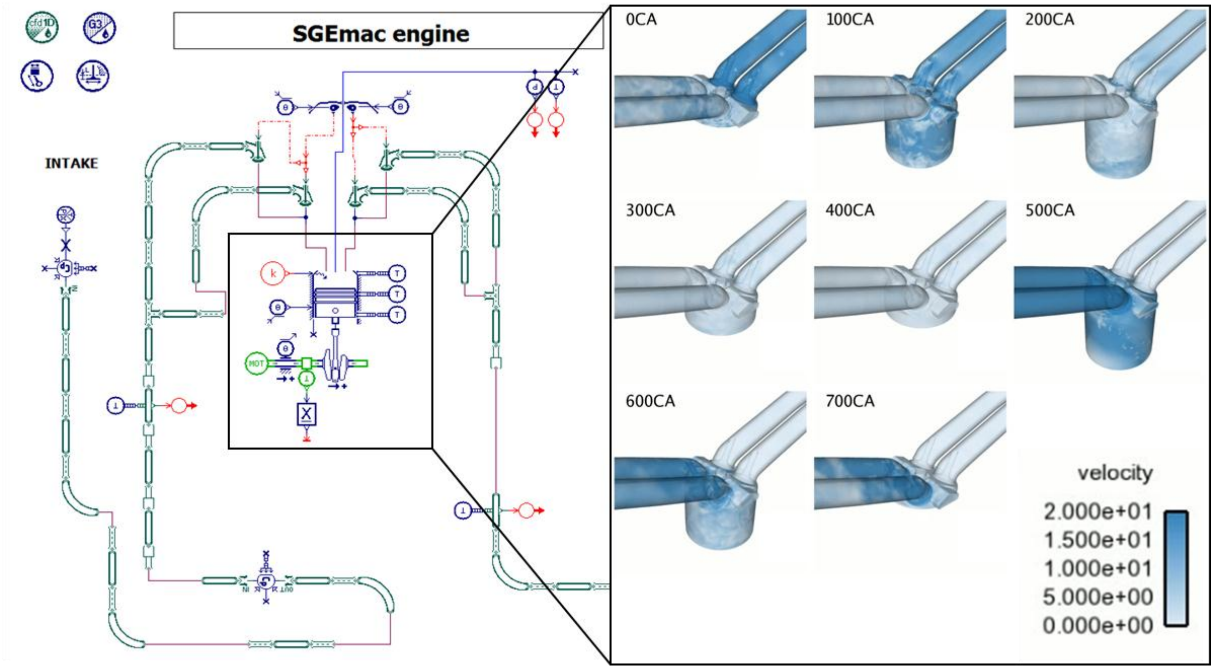

Figure 1: Left : AMESim 0D/1D sketch of the SGEmac engine. Right : Preliminary non coupled LES cycle of the motored SGEmac engine.

REFERENCES

[1] J. Heywood, *Internal combustion engine fundamentals*, McGraw-Hill, New York, NY, USA, 1988.

[2] N. Ozdor, M. Dugler, E. Sher, Cyclic variability in spark ignition engines, a literature survey. *SAE Technical Paper* 940987, 1994.

[3] O. Vermorel, S. Richard, O. Colin, C. Angelberger, A. Benkenida, D. Veynante, Toward the understanding of cyclic variability in a spark ignited engine using multi-cycle LES. *Combust. Flame*, vol. 156, no 8, pp. 1525-1541, 2009.

[4] C. Pera, C. Angelberger, Large Eddy Simulation of a motored single-cylinder engine using system simulation to define boundary conditions: methodology and validation. *SAE Technical Paper* 2011-01-0834, 2011.

[5] C. Chalons, P.-A. Raviart, N. Seguin, The interface coupling of the gas dynamics equations. *Quart. Appl. Math*, vol. 66, no 4, pp. 659-705, 2008.

[6] T. Poinsot, S.K. Lele, Boundary conditions for direct simulations of compressible viscous flow, *Journal of computational physics*, vol. 101, no 1, pp. 104-129, 1992.

[7] C. Lacour, C. Pera, An experimental database dedicated to the study and modeling of cyclic variability in spark-ignition engines with LES. *SAE Technical Paper* 2011-01-1282, 2011.