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

NUMERICAL SIMULATION OF THE REACTING FLOW FIELD IN A ROTARY KILN

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Key words: *Rotary kiln, Turbulence, Low-Mach, Combustion, RANS, LES.*

Rotary kilns are one of the primary components in the cement industry and are employed to provide the adequate conditions to convert raw materials into cement clinkers [1]. This process demands a lot of energy not only to sustain the endothermic reaction controlling the clink formation, but also to assure a high temperature environment appropriate for the process. The energy source of the system is the combustion heat-release of the fuel supplied to the free board. The heat is transferred to the bed material by conduction, convection, diffusion and radiation allowing the inititiation of the chemical reactions. Long residence times for the solid materials are needed to assure certain level of quaility for the product leading to high energy consumption rates [2]. Further understanding of the thermo-chemical processes is essential to improve the efficiency of the system and to reduce the energy consumption.

Modelling all the physical phenomena taking place in rotary kilns is still a challenge, although some efforts have been reported in the literature [1, 3, 4]. The physical processes go from radiation, heat transfer, coal devolatilization, homogeneous volatile combustion, heterogeneous char reaction and particle dispersion in a rotating configuration. The interactions among all the physics is highly complex and the wide range of length scales of the problem require large computational resources for which High-Performance Computing is required.

The present study aims at providing some understanding of the reacting flow field within the rotary kiln using modern RANS and LES models. The numerical equations are obtained using a finite element approximation of the low Mach number equations, accounting for variable density flows with strong thermal effects coupled to reduced chemical kinetic models for hydrocarbon combustion. The computational cases correspond to a full kiln geometry of 50 m length, in which the effects of different operating conditions are analysed. The fuel is supplied by an annular injection ring, while the air is injected through several holes surrounding the fuel nozzle. Details of the geometry and mesh are shown in Fig. 1. The analysis accounts for the gas phase in a high-resolution domain allowing to compare steady (RANS) and unsteady (URANS and LES) simulations. The effects of kiln rotation and the capability of different turbulence models to predict the main flow features will be addressed in detailed. Sample results of the non-reacting flow are presented subsequently in Figs. 2 and 3.

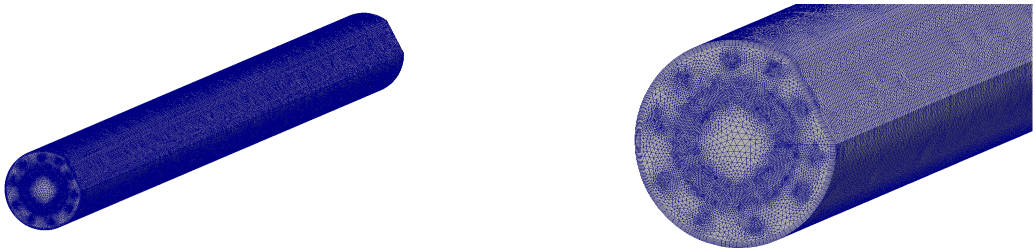

Figure 1: Computational domain (left) and zoomed view of the inlet (right).

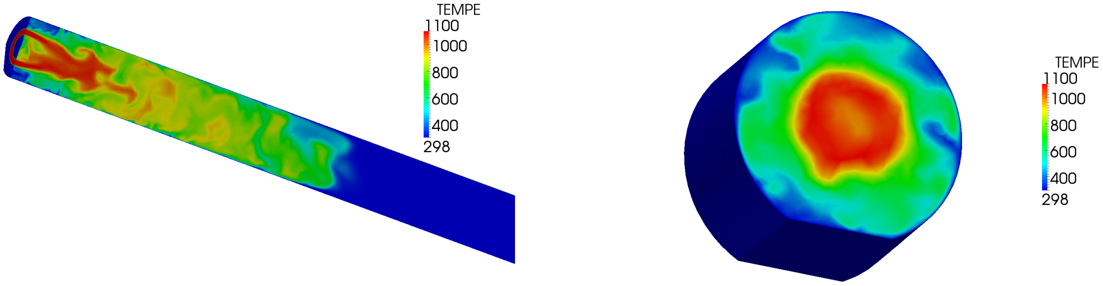

Figure 2: Temperature contour after hot injection on the streamwise (left) and spanwise sections (right).

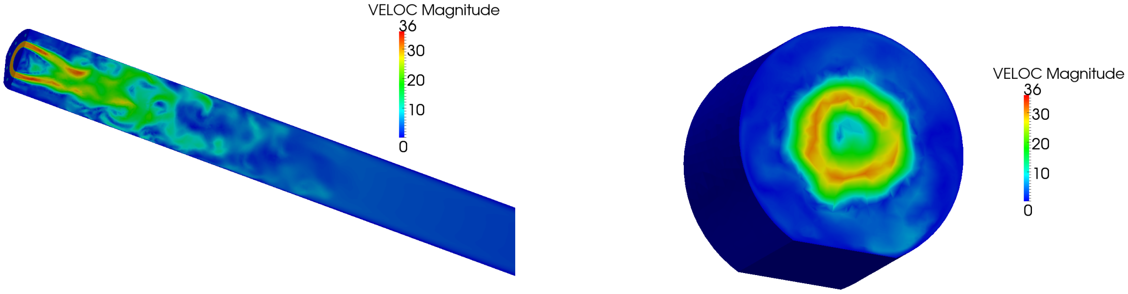

Figure 3: Velocity contour after hot injection on the streamwise (left) and spanwise sections (right).

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