CFD STUDY FOR GAS AND GAS-SOLID FLOWS IN HIGH-EFFICIENCY CYCLONES: COMPARISON BETWEEN A NEW DESIGN AND STAIRMAND TYPE

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Abstract— **Cyclones are equipments used for gas-solid separation in many applications at industrial level, however, they are considered low-efficiency devices and their design have been simplified to basic models without further improvements. This paper presents a numerical study by Computational Fluid Dynamics (CFD) for gas and gas-solid flows in two designs of High-Efficiency (H.E.) cyclones: the commonly known Stairmand cyclone and one proposed by López, Trujillo and Quintana (LTQ) that showed better performances according to preliminary calculations. The turbulence of the gas flow was obtained by the Reynolds Stress Model (RSM). The pressure and velocity fields of both geometries were analyzed. The results indicate that the proposed design has lower pressure drops and higher collection efficiency for the given operation conditions, allowing savings in operating costs.**

Keywords— **Cyclone separators, Gas-solid flows, Reynolds Stress Model, CFD.**

I. INTRODUCTION

Due to the low operating cost, the lack of moving parts and be adaptable to a wide range of operations, cyclone separators have application in many different industries: from processing of cement, coal and wood, through the manufacture of chemical and pharmaceutical products, and even in the refining of sugar (Hoffmann and Louis, 2004; Peres, 2002). For some time these have been considered low-efficiency devices, however by improving the technical requirements in design, starting with a good understanding of flow dynamics inside the separators, the performance parameters can be optimized and thus achieving better cost-effectiveness ratios.

Despite its apparent simplicity, the flow in a cyclone is complex: includes features such as vorticity and, in some cases, several annular zones of reverse flow which are not satisfactorily predicted by the confined vortex flow theories (Gimbun *et al.*, 2005;

Witt *et al.*, 1999). Moreover, the problem associated with the detailed mathematical modeling of flow profiles involves solving the tightly coupled nonlinear partial differential equations for momentum and mass conservation, which have no analytical solution and must be solved using discretization methods.

Simulation using Computational Fluid Dynamics (CFD), whose techniques convert the partial differential equations into a set of algebraic equations and solve these by iterative methods, emerges as a suitable and economical tool for understanding the complex flow dynamics within these devices and how it is affected by changes in the original design or operating conditions (Bernardo *et al.*, 2006; Patankar, 1980). The calculations can be used in a wide range of flows in order to decrease the need for experimental evidence, allowing predictive analysis in the design process and evaluation of industrial processes, reducing factors such as cost, risk and time (Ranade, 2001).

López *et al.* (2005) proposed new geometric configurations for three types of cyclones using existing correlations: LTQ high-efficiency, LTQ high-capacity and LTQ conventional. Nevertheless, given the nature of these empirical equations, there is not a theoretical foundation for validation, and that is in partly what motivates this work.

In this paper we present numerical simulations of gas and gas-solid flows for two models of high-efficiency cyclones: LTQ, comparing with the traditionally used Stairmand cyclone. The purpose is to obtain the velocity and pressure fields of both cyclones and to describe the trajectories of the particles within the two devices, in order to validate through a comparative evaluation of performance under given conditions, if LTQ cyclone design is operationally more economical.

II. MATHEMATICAL MODELING

Usually, the fluid flows are mathematically described by a group of partial differential equations: the continuity equation obtained from the mass balance, and