Advanced Cyclone Systems

EMISSION CONTROL

CASE STUDY

AVISABOR | ESTARREJA, PORTUGAL | MARCH 2015

Hurricane MK system for PM Emission reduction on a 3MW$_{th}$ biomass boiler (12.500m^3/h at 240ºC)

FOREWORD

Advanced Cyclone Systems, S.A. (ACS) designed and supplied a Hurricane cyclone system type MK for particulate matter abatement from the flue gases of a new 3MW$_{th}$ biomass boiler. The boiler was installed at **Avisabor – Indústria Agro-Alimentar**, S.A., a Poultry production and slaughterhouse for meat commercialization. Avisabor is owned 100% by Grupo Lusiaves SGPS, SA, one of the largest players of the poultry and agri-food sector in Portugal, with a business turnover around 300M€.

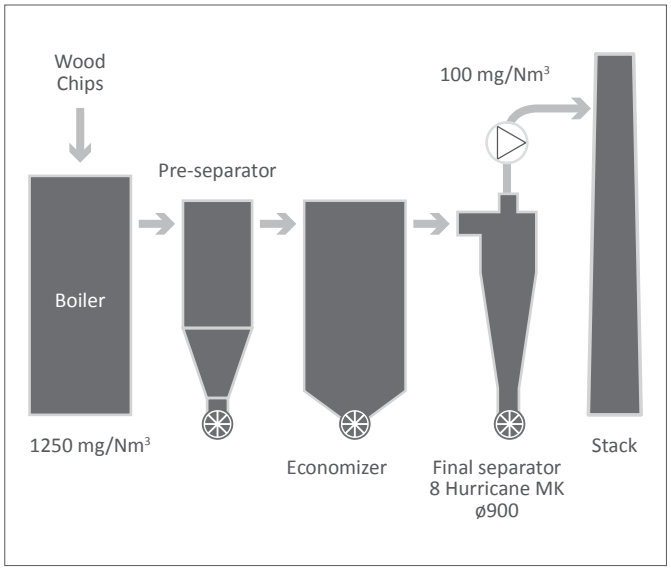

Fig. 1 - Process diagram

IDENTIFYING THE PROBLEM AND SOLUTION

The new boiler was manufactured by Flucal – Fluidos e Calor, Lda (http://www.flucal.pt/), who has a business partnership with ACS, for the flue gas treatment. The boiler, model APV 230 was fueled with wood chips, to produce 4 ton/h of steam at 10 Bar.

The goal was to reduce PM emissions (estimated on the design phase around 1250 mg/Nm$^3_{dry}$ at 11% O_2) , by a factor of around 13, down to <100 mg/Nm$^3_{dry}$ at 11% O_2, which is inferior to the general Emission Limit Value (ELV) in Portugal for PM (150 mg/Nm$^3_{dry}$at 11% O_2). Considering the usual silice content on the fly ashes from wood chips combustion, ACS designed a first step separation (SD pre-separator), an then, after the economizer, the final separator (hurricane MK). A simple flow diagram is shown in figure 1. In addition to the fact that the pre-separator is prepared to eliminate the coarser and more abrasive particles with lower velocities, thus less wear, the main goal was to avoid the abrasive particles reaching the final separator, and therefore increasing its life.

In order to design the most efficient system for this case, simulations were done, using a typical particle size distribution (PSD) of the fly ashes (Fig. 3) from ACS's database, taking that the boiler was being manufactured. ACS then designed the pre-separator, a single SD cyclone Ø1000, and a final separator comprising 8 numerically optimized hurricane MK cyclones Ø900 installed in two batteries.

THE AGGLOMERATOR CYCLONE

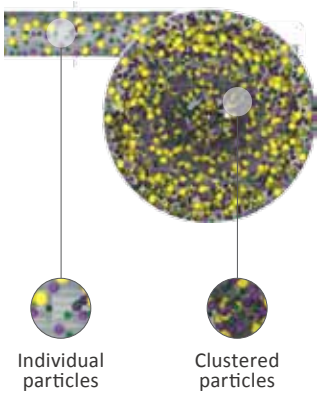

Fig. 2 – Agglomerator Cyclone

Hurricane cyclones are patented numerically optimized cyclones. Hurricane geometries maximize powder collection for each different application, while minimizing reentrainment and keeping pressure drop at reasonable levels. These cyclones are the output of nonconvex nonlinear problems formulated and solved after years of work in partnership with the Faculty of Engineering of Porto.

In 2014, a better understanding of agglomeration has allowed ACS to develop a completely new line of cyclone geometries, different from any other in the world: the **Hurricane MK**. It was obtained by combining stochastic numerical optimization with ACS (Particle Agglomeration in Cyclones (PACyc) model - (Chemical Engineering Journal 162 (2010) 861–876).

Emissions of these cyclones can be as low as 30 mg/Nm³ for many industrial processes.

DESIGN BASIS

- Fuel **[Wood chips]**
- Fly ash particle size distribution **[Fig.3]**
- Approximate actual flow rate (m^3/h) **[12 500]**
- Normalized flow rate (Nm^3/h_{dry}) **[6 318]**
- Gas flow temperature (ºC) **[240]**
- Moisture content in gas (%H_2O v/v) **[5]**
- Inlet concentration considering 11% O_2 (mg/Nm^3) **[1 250]**

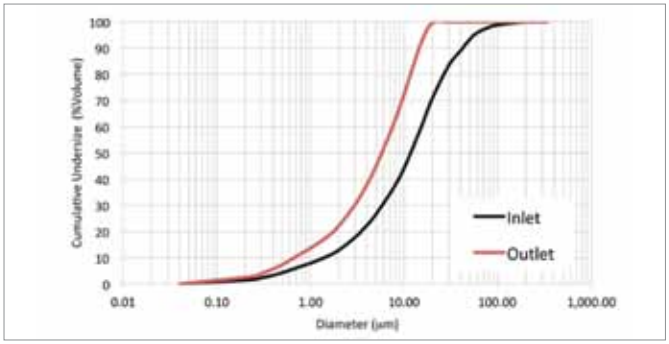

Fig. 3 - Particle Size Distribution (PSD) used in PACyc simulations

SYSTEM SPECIFICATIONS | EMISSIONS

- Guaranteed maximum emissions at 11% O_2 (mg/Nm^3) **[100]**
- Expected emissions considering 11% O_2 (mg/Nm^3) **[42]**
- Verified emissions considering 11% O_2 (mg/Nm^3)* **[34, 42, 81, 83]**
- Expected total pressure drop (KPa) **[2]**

*Combustion was with 14,5% O_2 when measurements were taken

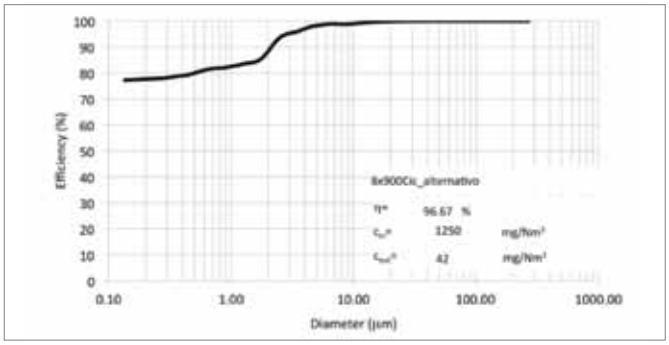

Fig. 4 - PACyc Predicted Grade Collection Efficiency

GENERAL ARRANGEMENT

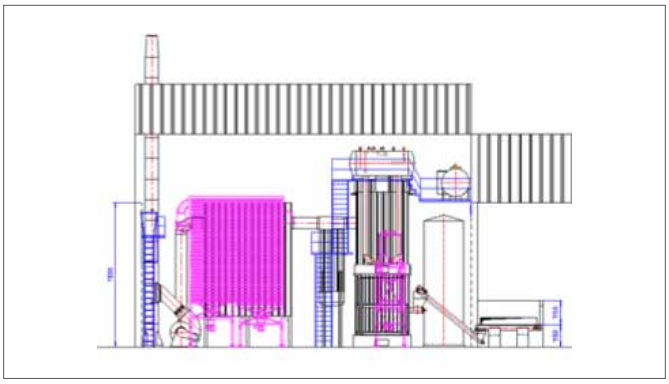

Fig.5 – General arrangement of the Hurricane cyclone system

Fig. 6 – Look of the stack at normal boiler operation

CONCLUSIONS

Despite heavily corrected for O_2, results confirmed that the Hurricane MK securely achieves PM emissions under 100 mg/Nm^3. On April 2015 several PM emissions measurements were done and results varying from 34 to 83 mg/Nm^3 at 11% O_2, thus confirming the achievement of the ELV with a very simple equipment: significantly lower investment costs when compared with ESPs (approximately 50% lower) and lower maintenance and operating costs when compared to Bag Filters (from 70% to 90% lower).