Simultaneous removal of soot and NO_x from biomass boiler fumes over catalytic sintered filter.

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Because of the global warming, due to the high greenhouse gases emission, and the limited resources of fossil fuels, the worldwide concern for the energy production from biomass combustion, has strongly enhanced. However, biomass combustion plant generates lot of pollutants too (Particle Matter $PM_{2.5}$ / PM_{10}, nitrogen and sulfur oxide, heavy metals …). Soot and NO_x (NO and NO_2), which from industrial small-scale boiler, are pollutants focused in this project. Since Directive 2010/75/EU of January 2014, the control of soot and NO_x emissions is more stringent, due to theirs harmful effects on the human health and environment, only for high power plants (Williams, 2012). However, in a near future, this will be extended on smaller biomass boiler (< 4 MWh).

Soot are carbonaceous aggregates with a size from tens to hundreds nanometer in aerodynamic diameter. They are emitted when the combustion is uncompleted, which are mainly due to combustion conditions poor in O_2. At the exhaust of combustion room, emitted particles are generally trapped by two different devices, inertial filtration (cyclone(s)) for the largest (PM_{10}) and then, porous filter media for the smallest ($PM_{2.5}$). There are several types of filter media, as bag filter, moving or fixed bed granular filter and rigid filter, which of various nature in function of their composition (ceramic, metallic), structure (fibrous, sintered, …) and geometry (candle, disc, …) (Heidenreich, 2013).

The most widely used technique for removing of only NO_x is the Selective Catalytic Reduction (SCR) over V_2O_5-WO_3 (MoO_3)/TiO_2 with NH_3, as reducing agent, and in excess of O_2. However, this SCR unit has to be located at the upstream particles filtration system, because it's efficient at a temperature range of 300°C to 400°C, and this brings such problem, as the deposition of dust on catalyst (Yang, 2011). Several studies have been performed over transition metals oxide from Mn, Fe, Cu, Co and Ni supported on high specific surface materials in order to reduce NO_x at lower temperature (< 200°C).

Rigid filter can be functionalized by the impregnation of a catalyst at his surface in order to remove simultaneously soot and gas pollutants, as NO_x. Several catalysts have been impregnated on various filters (Yoshida, 1989). However, the soot influence on NO_x reduction is always disputed.

In this work, several metallic functionalized sintered filters are prepared. Several transition metals (metallic or oxide) are deposited on the surface and on bulk of a metallic filters with various porosities. The main objective is to find an efficient catalytic filter to remove simultaneously soots and to reduce NO_x from small-scale biomass boiler, which require a compact and easy to use and maintenance cleaning system, at low temperature. The study will performed in two step, first at the pilot-scale and then at the industrial scale. This work will permit to study the influence of the nickel deposit on the filtration efficiency and to have a better understanding of the mechanism taking place at the interface catalyst-soot-NO_x.

The filter media in stainless steel or in bronze are prepared by Sintertech SAS-PORAL industry and the impregnation of catalyst is performed by PRODEC METAL society. Catalytic filters are characterized by mercury-porosimetry and SEM (Scanning Electronic Microscopy) in upstream and downstream of experiment on pilot to observe the influence of tests on porosity and metal deposit.

The experimental pilot consists of a heated stainless steel tube (interne diameter of 70 mm and long of 2 m). This allows working at temperature comprised between 100 and 400°C, which is measured over the tube by thermocouples. Functionalized filter is placed at the half length of the tube and the overpressure it induced is quantified by a pressure sensor. The pilot is feed with a mixture of gas and soot, whose is the closest of the real composition of fumes from biomass combustion. To determine the efficiency of filter, 3 analytical devices are used upstream and downstream of the filter: Analyzer HORIBA for NO_x and other gas quantification, Electrical Low Pressure Impactor (ELPI) for soot size distribution and a Tapered Element Oscillating Microbalance (TEOM) to have the weight concentration of soot emitted.

Two experiments are performed on each filter: with and without soot. The experimental tests are conducted at a temperature of 200°C, with a gas composition of 7% in O_2, 13.5% in CO_2, 2.5% in H_2O, 0.05% in NO_x (500 ppm), the remain in N_2 and about 4E+08 part/cm^3 with a mode around 0.1µm.

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