Reduction of fine particle emissions from small scale wood chips combustion boiler by use of compact electrostatic precipitator

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Wood combustion in small scale combustion facilities is responsible for emissions of fine particles which are associated with various diseases. The chemical composition of generated particles, their size distribution, number and mass concentration strongly depends on combustion conditions, fuel quality and varies from the design of the combustion device. Fine particles emissions are strongly associated with increased mortality and cardiovascular diseases, so there is an increasing need for reduction of particle emissions into the atmosphere.

The purpose of the current work is the study of the reduction of fine particle emissions from the small scale wood chips combustion boiler by use of the novel form space charge electrostatic precipitator. The long-term experimental studies (over 1000 h) were carried in the Karlsruhe Institute of Technology. The test facility consisted of a 100 kW wood chips boiler (Fa. HDG Bavaria). For control of fine particles emissions from the exhaust gases a novel form CAROLA© space charge electrostatic precipitators (ESP) were applied. The ESPs are designed by the CCA – Carola Clean Air GmbH.

The exhaust gas from the boiler was delivered into the ESPs. During the tests the gas flow velocity and temperature, exhaust gas composition and particle mass concentration (measured by the corresponding equipment from Fa. Wöhler) and particle number concentration (measured by the Scanning Mobility particle Analyser (SMPS), Fa. TSI) were controlled. Among this were measured current-voltage characteristics of the electrostatic precipitators for different operation conditions, power consumption for corona discharge and total power consumption of the ESP, including the cleaning of the ionizer and collector stages. By the long-term measurements were also defined particle mass and fractional collection efficiencies of the ESPs and the stability of operation was observed.

The compact pilot electrostatic precipitator (fig.1) consists on grounded housing with high voltage ionizer and two grounded brush-electrode collectors. Particles are charged in the DC negative polarity corona discharge and further charged particles are precipitated in the brush-electrodes under the influence of space charged effects. At the test facility the precipitators are operated at gas temperatures up to 200 °C and gas flow rate up to 150 m³/h. The maximum value of applied voltage is 20 kV with operation corona current round 1 mA depending on particle number concentration and exhaust gas composition. The size of the precipitator (LxWxH) is 750x360x920 mm.

The use of new approaches to the design of the high voltage insulator and the system for isolator protection, effective cleaning of the ionizer and collector stages ensures stable operation of the ESP by different combustion conditions.

Figure 1. CAROLA electrostatic precipitator

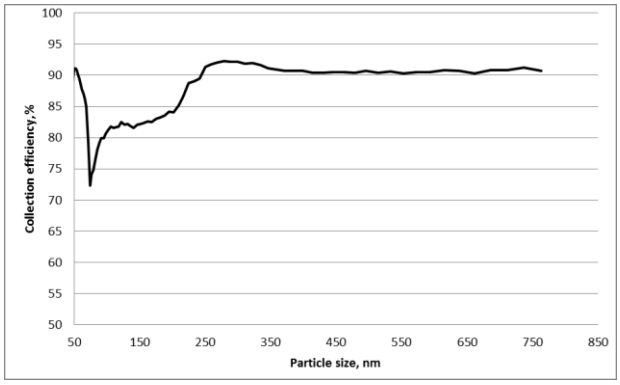

Figure 2 Fractional collection efficiency of the pilot electrostatic precipitator

The long-term observation of the simultaneous operation of the wood combustion boiler and the ESP has shown that the precipitator does not disturb the operation of the boiler.

The use of novel ESP's decreases particle mass and number concentration. The mass collection efficiency of the electrostatic precipitators is in-between 70% to 90% depending on combustion conditions.

The fractional collection efficiency for particles with size 100-250 nm is in-between 80% and 90%, increasing >90% for particles larger than 250 nm (fig.2).