Electrode system design for an electrostatic precipitator for pyrolysis gases

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Keywords: electrostatic precipitator, pyrolysis gas, electrode system, corona discharge stability
Associated conference topics: 1.5, 1.7
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The scope of the study is the design of an electrode system for an electrostatic precipitator (ESP) for pyrolysis gases. In the focus of the work are the results of the tests of different electrode systems, being used in space charge and conventional ESPs, which are applied for reduction of particulate emissions from the air flow, loaded with oil mist, and from pyrolysis gases.

Two space charge ESPs are tested. The 1^{st} space charge ESP includes a set of nozzles (Fig. 1), in which the HV needle electrodes are axially installed. A grounded collector is maintained downstream the electrode system in direction of air flow. The generation of corona discharge ensures electrostatic condensation, coagulation and precipitation of oil mist.

The 2^{nd} space charge ESP includes grounded mesh electrodes, which are enveloped with a grounded collector. The HV star-form electrodes are installed on the HV rods, which are axially maintained inside every mesh electrode (Fig. 2). The use of HV rods with star-form electrodes simplifies the maintenance and adjustment of the HV electrodes in the grounded ones. Air flow, which is loaded with oil mist, flows orthogonal to the mesh electrodes into the grounded collector.

The conventional ESP includes a tube grounded electrode and HV star-form electrodes, installed on the HV rod inside the tube (Fig. 3). There are two gas flanges in the top and bottom part of the grounded tube, what ensures the possibility gas to flow downstream and upstream through the ESP. A part of the grounded electrode is manufactured in a form of tube-in-shell heat exchanger, which ensures cooling or heating of gas flow depending on the operation conditions. The electrode gap width in the 2^{nd} space charge and in the conventional ESPs is the same.

The experiments, carried out with the designed ESPs, confirm their high mass collection efficiency both for oil mist loaded air flow and pyrolysis gases.

In the space charge ESP, the use of high velocity nozzles allows compact design of the ionizing stage and the ESP itself for high gas flow rates. However, with the growing of gas flow rate, the quick increase of the pressure drop in the ESP is observed. The operation of the conventional ESP is characterized with the lowest values of pressure drop.

Figure 1. Electrode system of a space charge ESP with high velocity nozzles and HV needle electrodes

Figure 2. Electrode system of a space charge ESP with grounded mesh and HV star-form electrodes

Figure 3. Electrode system of a conventional ESP with grounded tube and HV star-form electrodes

The critical factor for corona discharge stability is the loading of electrode system (Fig. 1 and Fig.2), which strongly depends the corona discharge parameters, properties of oil and aerosol concentration in the gas flow. The loading with viscous substances changes electrode gap geometry and electric field distribution. At constant applied voltage, loading of HV electrodes reduces corona discharge current and provokes spark-over discharges, which decrease ESP collection efficiency. The constipation of grounded mesh electrodes increases pressure drop in the ESP. In the conventional ESP, the collected oil flows downstream the tube, excluding any constipation of the grounded electrode. The design of conventional ESP allows maintenance of a supplemental system for periodical cleaning of the grounded electrode.

The results of the tests are used for the development of a forthcoming electrostatically enhanced condensation system for pyrolysis gases.