Development of electrostatically enhanced condensation system for pyrolysis gases

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The development of a multi-stage electrostatically enhanced condensation system (EECS) for pyrolysis gases is in the focus of the study. The EECS includes tube-in-shell cooling modules, connected into a row (Fig.1). The 1st module becomes hot gases from the pyrolysis reactor at temperature of about 500°C. The pyrolysis gas is in step-mode cooled in the forthcoming modules, via the circulation of heat transfer fluid (HTF) through the heat exchangers. The last module has to be operated at HTF temperature of about 0°C. The multi-stage EECS can be extended with an additional electrostatic precipitation module, applied for protection of the downstream measurement periphery from the loading with oil.

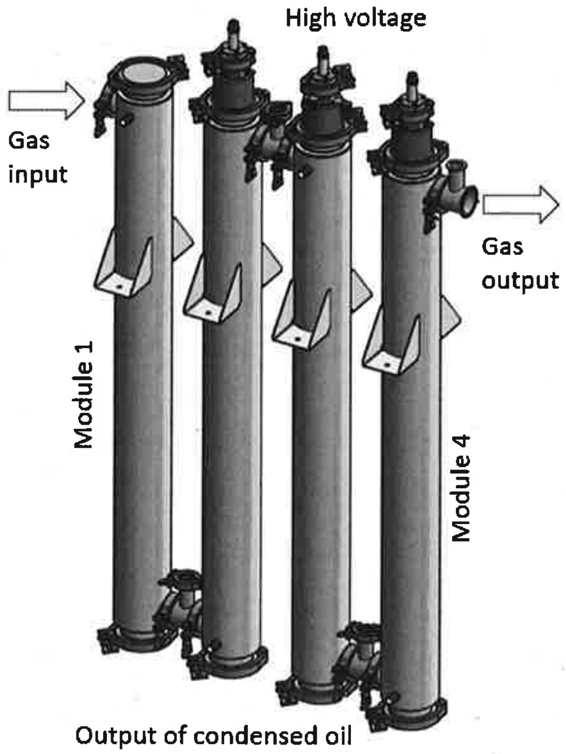

Figure 1. Electrostatically enhanced condensation system (EECS)

Passing through the EECS system, hot pyrolysis gases are cooled, what results in oil mist condensation and fractionally collection in the EECS modules. To enhance these processes, the EECS 2nd, 3rd and 4th modules are equipped with corona discharge ionizers, installed axially inside the tube-in-shell heat exchangers. Each ionizer consists of a high voltage (HV) insulator and a HV rod, which penetrates through the HV insulator. The HV rods are connected to the HV power supply units, respectively. Via applied special design approaches, the HV insulators are protected against the loading with pyrolysis oil. The HV rods are axially installed in the tubes, and HV star-form electrodes are maintained on the HV rods orthogonal to the lateral wall of each tube module.

The corona discharge operational parameters are the key factor for effective and stable operation of the EECS. Among long-term operation stability of the developed EECS, the knowledge of corona discharge characteristics is important for the development of the corresponding control procedures, which have to be applied for variable operation conditions.

In the study, the attention is concentrated on the phenomena, which take place during pyrolysis gas cooling and condensation in corona discharge field. The governing equations, which describe the generation of corona discharge, are discussed and analysed, focusing on the defined electrode system geometry. The corona discharge electric field intensity, onset, spark-over and operation voltages, as well as corona discharge currents and power consumption are discussed.

The corona discharge suppression phenomenon, which depends on the interplay between the mutual position of HV and grounded electrodes, gas properties and particle concentration in the gas flow, are highlighted. The results are recommended for the development of the procedures, necessary to control applied voltage, depending on the gas temperature and particle concentration in the gas flow.

The study includes the analysis of the influence of pyrolysis gas temperature on corona discharge current-voltage characteristics. The temperature dependence of corona discharge power consumption is reviewed. The influence of the electrohydrodynamic phenomena, such electric wind, on the enhancement of heat transfer in the EECS system, is analysed.

The results of the theoretical and analytical studies should be compared with experimental data from the laboratory EECS system, which is in plan to be put in operation and tested being installed downstream the pyrolysis reactor.

The scaling of the EECS system is the next step of the forthcoming study.