Controllability of HCl and SO_2 release in a grate-fired Waste-to-Energy furnace

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Reducing boiler corrosion and preventing emissions are two main challenges in state-of-the-art Waste-to-Energy (WtE) installations. Industrial practice indicates that grate-fired WtE installations could strongly benefit in this regard from further improvements in their combustion control systems (De Greef, 2023). So far, however, only a limited number of studies (i.e., Birgen, 2021; De Greef, 2016; Meynendonckx, 2022) was dedicated to the influence of combustion control conditions on the release of HCl and SO_2 from waste in grate-fired furnaces. The presented research therefore aims at unravelling the relation between chemical compositions of combustion gasses generated and physical combustion control settings applied, to finally establish thermochemically more advanced combustion control in WtE installations.

To reach this goal, process data from an industrial grate-fired WtE installation are analyzed in three steps. First, qualitative patterns are identified in time-dependent data, which can yield relations between concentrations of HCl and SO_2 in the combustion gas, on the one hand, and physical conditions in the waste layer provoked by combustion control, on the other hand. Second, the impact of the combustion control on the physical conditions in the waste layer are analyzed. Finally, the findings from the first and second step are brought together, to correlate combustion control conditions with the HCl and SO_2 concentrations observed.

For the first step, it can be observed that the amount of SO_2 released per ton of waste tends to vary with the primary airflow through the waste bed (Figure 1a), whereas HCl is released from the waste in a complementary way (Figure 1b). The latter observation is new compared to Meynendonckx (2022), who already related the release of HCl to the temperature of the primary air.

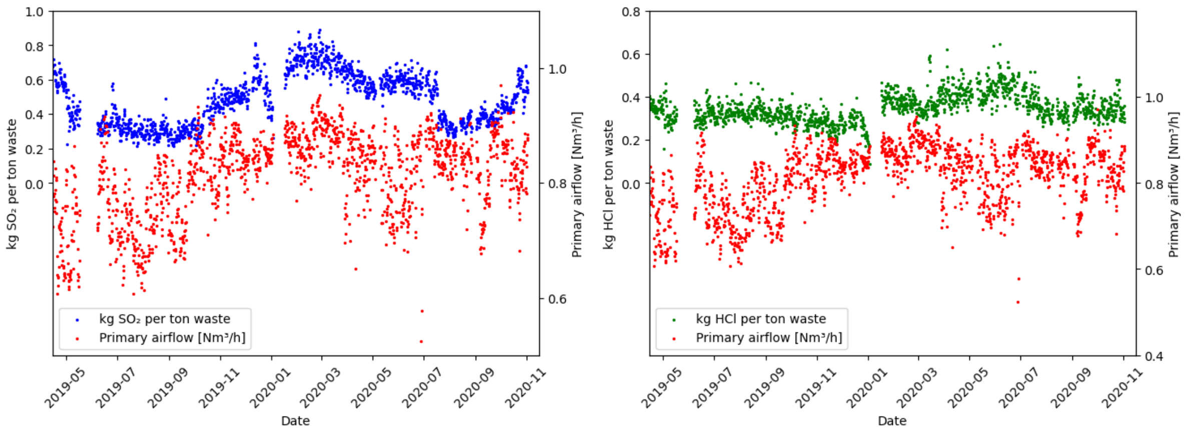

Figure 1. Time series graphs of: (a) primary airflow and emission of SO_2 per ton waste and (b) primary airflow and emission of HCl per ton waste.

An example of the second step shows the relation between the pressure drop and the primary airflow in the waste bed (Figure 2). The data are clustered according to two different setpoint values for waste layer thickness on the grate. The action of the combustion control causes a linear relation between the primary airflow and the pressure drop established in the waste layer by dynamic adaptation of the primary airflow. This way, different conditions for thermal decomposition occur in the waste layer throughout the entire period studied. Based on packed-bed reactor theory, these conditions can then explain the variability in the HCl and SO_2 release as observed.

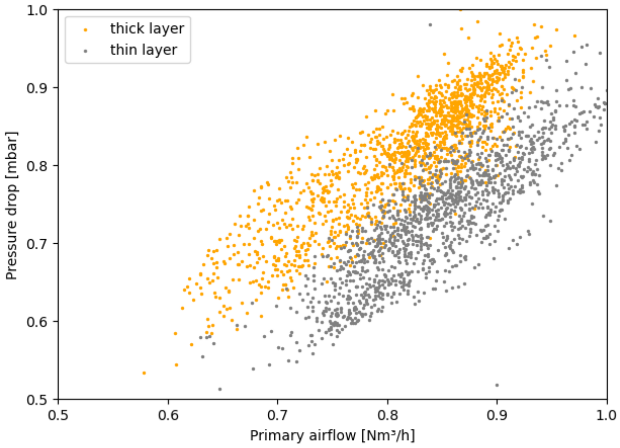

Figure 2. The relation between primary airflow and pressure drop in the waste layer caused by the combustion control.

Selected results of the third step of the data analysis are shown in Figures 3a and 3b, e.g., regarding the release of SO_2 from a thick waste layer and of HCl from a thin waste layer, respectively. The data are clustered according to waste layer thickness and pressure drop (i.e., the equivalent of primary airflow in this analysis step). As can be noticed in Figure 3a, the release of SO_2 from a thick waste layer increases with increasing pressure drop for a single class on the horizontal axis (i.e., comparable waste layer thicknesses). The release of HCl from a thin layer, however, decreases with increasing pressure drop. In comparison with De Greef (2016), the first observation is similar, whereas the second observation is different.

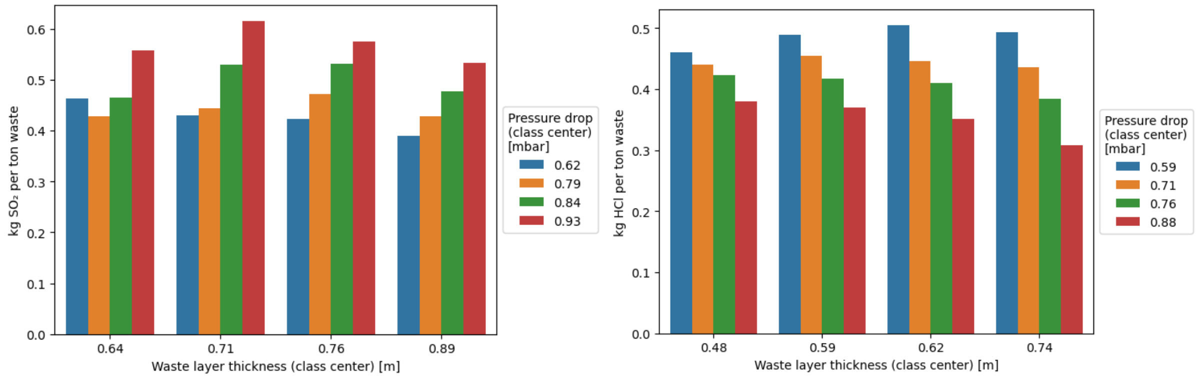

Figure 3. The release of (a) SO_2 from thick waste layers and (b) HCl from thin waste layers, as function of pressure drop and relative waste layer thickness.

In conclusion, the release of HCl and SO_2 in grate-fired furnaces is related to variable physical conditions in the waste layer due to actions of the combustion control system. Although qualitatively in agreement with established packed-bed reactor theory, findings from this study have not been reported before in literature. They are however important to develop new insights for improved thermochemical combustion control to further reduce the impact of operational problems related to boiler corrosion and emissions in WtE installations.

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