Technical University of Munich

Experimental investigations of nitrogen oxide emissions from biomass combustion employing selective non-catalytic reduction in a lab-scale grate firing reactor

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Motivation

Combustion of fuels play an important role in securing the power and heat demand in Europe for at least the near future. Biomass and biogenic residues are considered carbon-neutral alternatives when comparing to coal. However, biomass defines a wide range of different fuels, which posses different characteristics and different nitrogen contents. This leads to fuel-dependent nitrogen oxide (NO_x) emissions. Such emissions should be kept at a minimum due to the harmful contribution of NO_x in acid rain and smog formation [1].

Various methods are able to reduce such emissions, e.g. air-staging, fuel-staging, and selective non-catalytic reduction (SNCR). It is important to use cost-effective methods since biomass-based plants are mostly decentralised and smaller in scale. In this work, the effects of SNCR on emissions from biomass combustion (wood from pencil shavings) were studied in a lab-scale reactor by adding gaseous ammonia and performing flue gas analysis.

Experimental Set Up

The experiments were conducted at the grate-firing lab-scale reactor from BEST GmbH in Graz [2]. The reactor consists of a fuel tank, which delivers the fuel (pellets or chips) to the grate. The released flue gas goes from the combustion chamber, through an overpass to an electrically heated drop tube. The flue gas is then cooled down and released to the atmosphere (see Figure 1).

- Fuel: spruce pellets and wood pencil shavings pressed into pellets
- Measurements: flue gas analysis above the grate and after the heat exchanger (FTIR and NDIR) – marked points A ($NO_{x,0}$) and C (NO_x)

The reduction of NO_x through addition of gaseous ammonia was investigated – point B.

- Different ratios of ammonia to initial NO_x ($NO_{x,0}$) were investigated (β)
- Experiments were conducted for at least 30 minutes each

The residual oxygen in the flue gas was used to regulate the reactor.

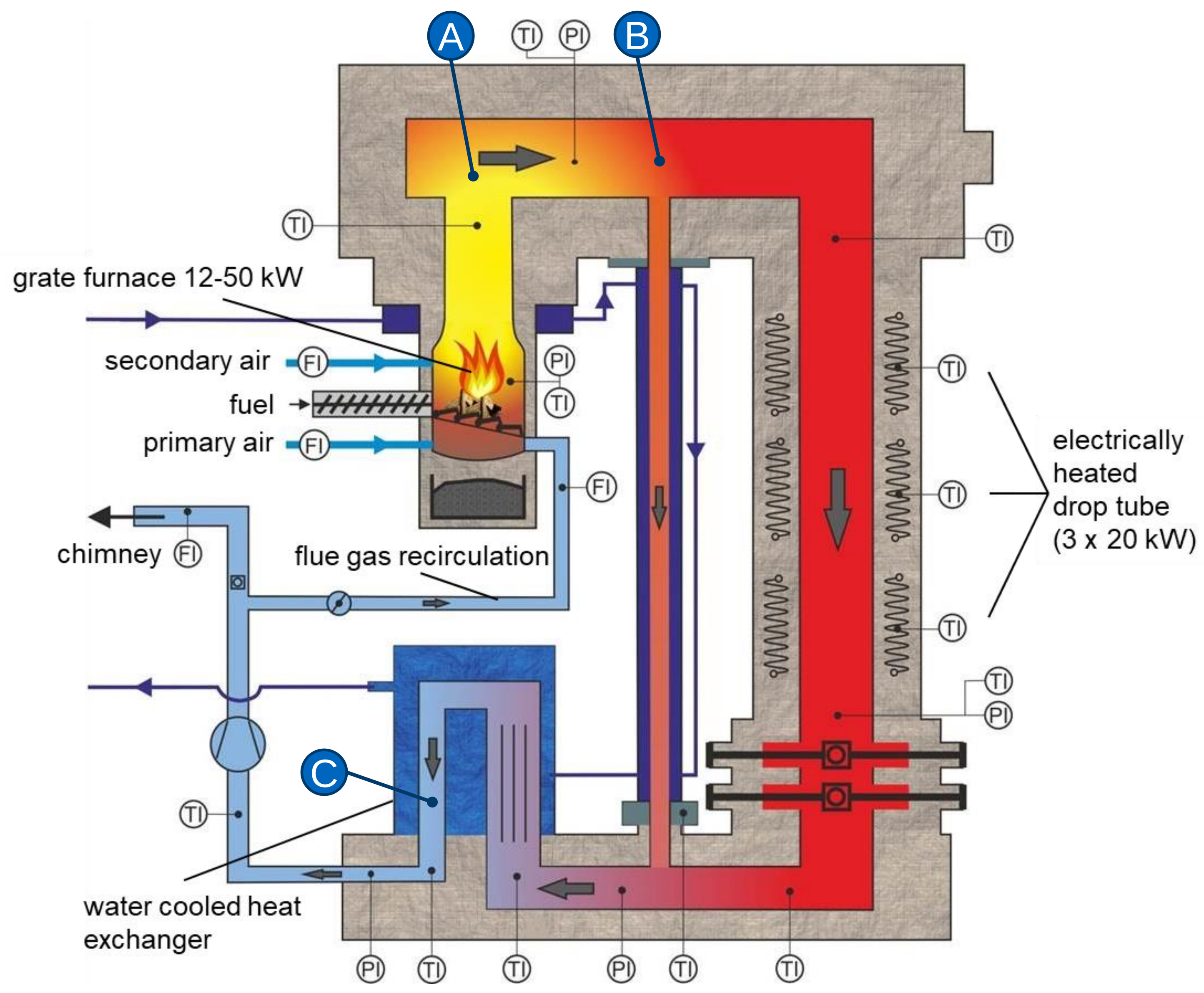

Figure 1: Scheme of the combined grate firing and drop tube reactor

Results

Elemental analysis of the fuels is shown in the table below:

	% daf					%		MJ/kg
Fuel	**N**	**C**	**S**	**H**	**O**	**w**	**a**	**HHV**
Spruce Pellets	1.21	53.68	0.24	4.78	40.09	6.64	0.33	19.05
Pencil shavings	1.01	55.94	0.47	5.55	37.04	6.93	0.35	21.19

- Combustion temperatures were strongly dependent on the air ratio and the overpass temperature ranged between 700 – 1030 °C
- Lower temperatures resulted from higher air ratio λ
- NO_x emissions (mostly NO) did not show a clear temperature dependency
- Addition of ammonia lead to a reduction of NO_x, with the ratio β playing a major role
- Raising ammonia quantity lead to a decrease in NO_x up to a point
- Higher temperatures reduced the effect of the SNCR
- Ammonia slip was only detected at high ammonia flows β>8

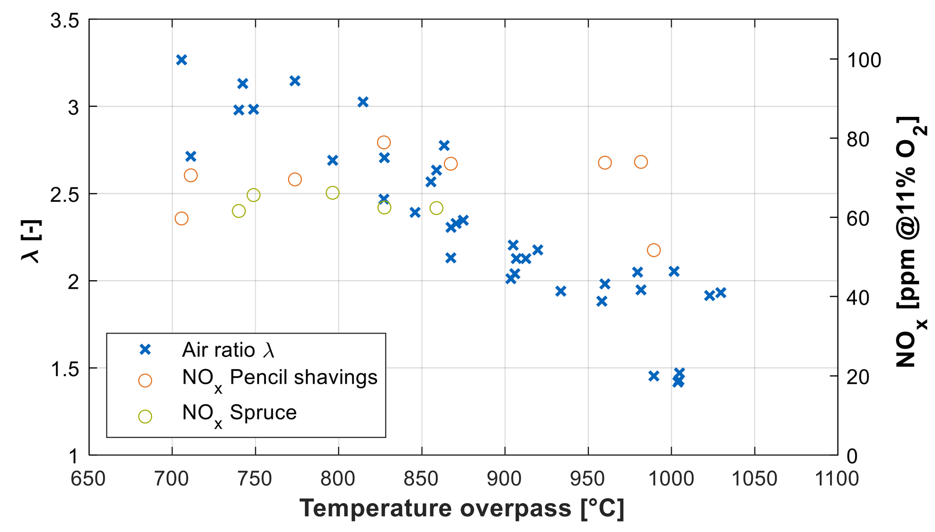

Figure 2: Temperature dependency on air ratio and NO_x emissions over the combustion temperature

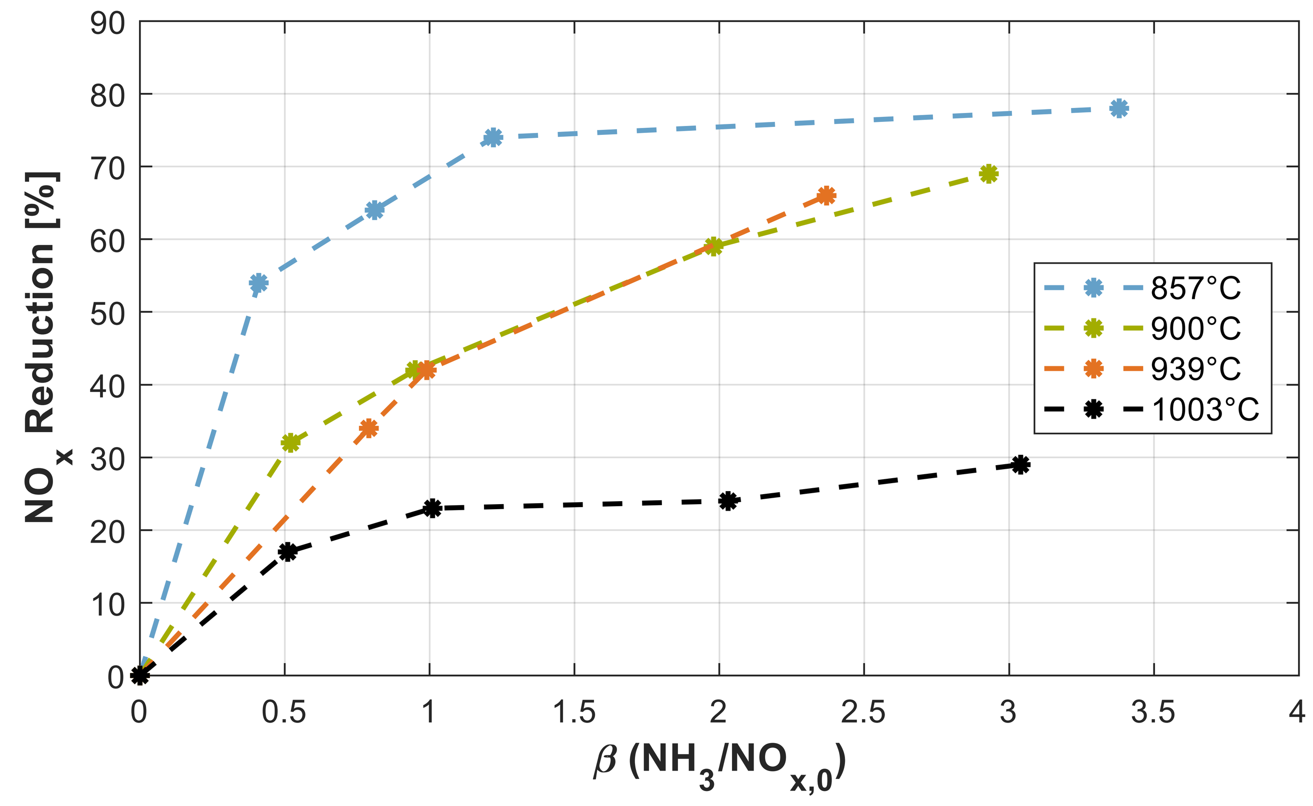

Figure 3 : NO_x reduction via SNCR (pencil shavings)

Conclusion

The results of the experiments show that the NO_x emissions were not temperature dependent for the investigated range. However, on the other hand, the effect of SNCR decreased with increasing temperatures. As a note, the effect of air ratio and temperature could not be decoupled from one another in this reactor configuration. Additionally, higher ammonia to initial NO_x ratios lead to increased reduction with a maximum being reached. High ratios lead to further costs and may cause ammonia slip, which is also harmful to the environment.

Low ammonia quantities applied at the correct temperature may reduce the NO_x in the flue gas enough to keep the emission limits and maintain costs at a minimum.

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[1] US Environmental Protection Agency: Integrated Science Assessment for Oxides of Nitrogen–Health Criteria.
[2] www.best-research.eu/de

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