Minimizing NO_x and dust emissions from pellet-fired biomass boilers by optimization of the combustion

Anne Mette Frey*[1], Anders Hastrup Jensen[1], Morten Gottlieb Jespersen[1], Anders Pødenphant[1]
Kim Gregersen[2], Jannich Hansen[2], Jesper Krøger Lemme[2]
*[1]Danish Technological Institute, Kongsvang Alle 29, DK-8000 Aarhus C, Denmark *contact: amf@dti.dk, +4572201273*
[2]NBE production Kjeldgaardsvej 2, 9300 Sæby, Denmark

Introduction

When converting from fossil fuels to sustainable biomass energy sources an obvious choice of technology is to use biomass boilers. Ensuring low emissions of particles and NO_x are of crucial importance to avoid or reduce environmental end health damaging compounds to be released. This will be evaluated by intelligent control of the boiler to obtain ideal combustion conditions. Furthermore, a more intelligent control would have the advantage of making regulation easier in real life applications according to heat demand determined by both external factors as weather condition as well as internal factors such as the end-users requirements to room temperature.

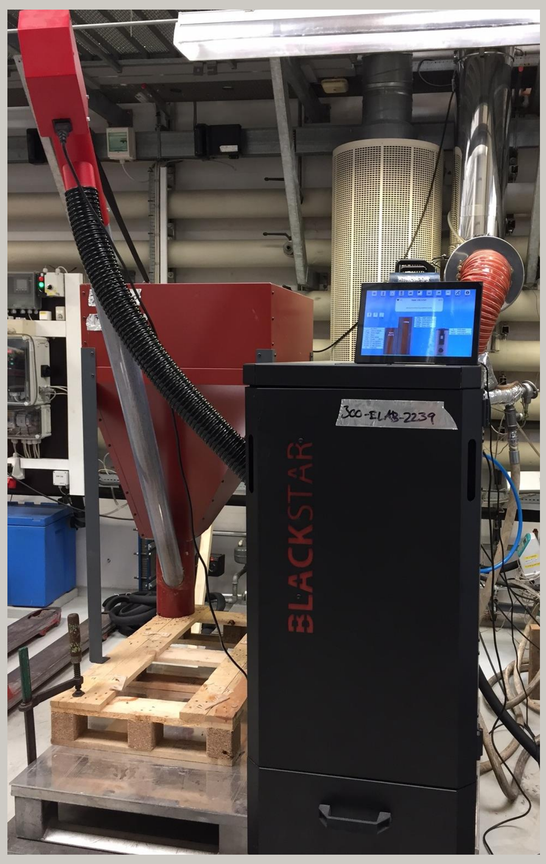
Aim

In the project 'Intelligent Burner' the impact of important parameters to obtain optimal combustion in boilers with low emissions are investigated:

- Regulation of air
- Addition of pellets
- Effect of insulation material of the fire chamber

On this poster the latter is presented with a focus on the impact of isolation of the burner with ceramics and vermiculite. Special focus is on obtaining:

- Low particle emission (dust)
- Low NO_x emission



Methods

Five different wood pellets A-E are examined by combustion in a "Blackstar biomass boiler" with isolation of the burner itself using respectively, vermiculite, s; and ceramic material, k. A, B, C and E are produced of softwood, while D is of hardwood. A, C, D and E are 6 mm pellets, while B is an 8 mm pellet.

Table 1. Selected chemical and combustional properties of wood pellets. Remaining conditions related to combustion are kept constant

	As	Ak	Bs	Bk	Cs	Ck	Ds	Dk	Es	Ek
CO_2 @10% O_2 [mg/m³]	13.5	13.1	13.8	13.8	12.9	12.9	13.3	13.6	13.1	13.1
CO [mg/m³]	122	113	818	659	182	155	421	364	166	189
NO_x [mg/m³]	145	142	198	195	151	150	213	216	258	267
OGC [mg/m³]	7	6	16	16	6	6	8	7	8	10,3
Dust [mg/m³]	22	21	53	50	24	23	55	54	27	26
Effect [kW]	15	15	15	15	15	15	15	15	15	15
N [mg/kg]	400	400	780	780	480	480	990	990	1180	1180
Net calorific value [MJ/kg]	19.2	19.2	18.7	18.7	19.1	19.1	18.4	18.4	19.1	19.1
Ash [%]	0.3	0.3	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3

Results

NO_x and dust emissions from the different pellets (A-E) using different isolation materials (s, k) are displayed in *Figure 1*:

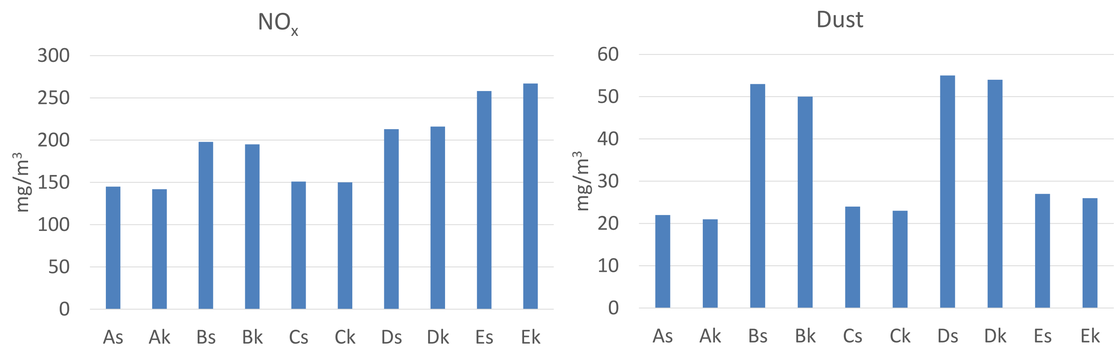


Figure 1. NO_x and dust emissions from various wood pellets (A-E) and different isolation materials, vermiculite (s) and ceramics (k)

The differences in emission levels of dust and NO_x are related to the wood pellets used, whereas for the individual wood pellet there is no significant difference between the isolation materials. Dust emissions are lowest for 6 mm pellets made of softwood.

A linear correlation exists between NO_x and the nitrogen content in the fuel, *Figure 2*. The offset suggest that thermic NO_x contributes to the total emitted NO_x in a constant way under the experimental conditions in this study (between 25-50% of total NO_x depending on the pellet).

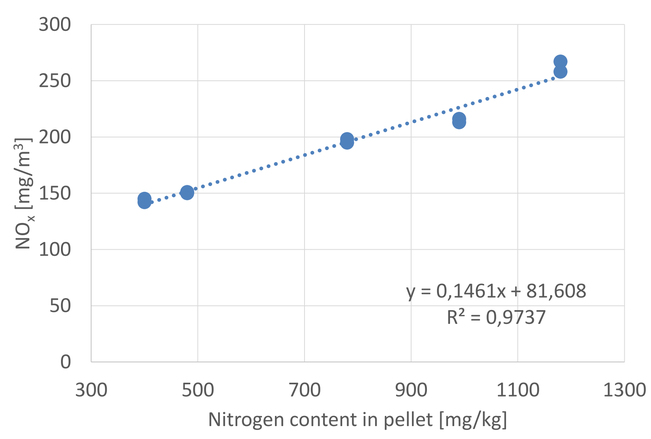


Figure 2. NO_x emission vs. nitrogen content in the wood pellets

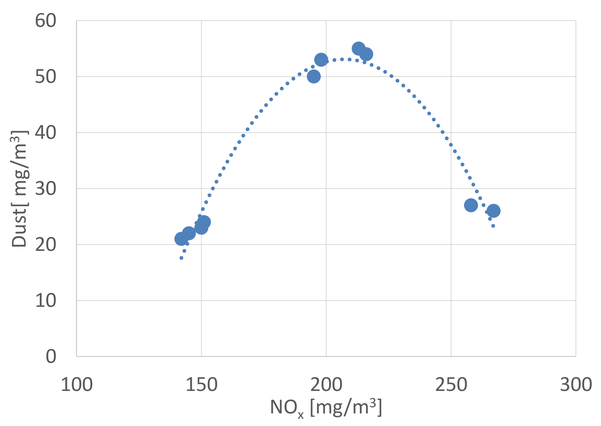


Figure 3. Dust emission vs. NO_x emission from combustion of various wood pellets using different isolation material

No apparent correlation seems to exist between NO_x and dust emissions, *Figure 3*. Both parameters have to be optimized in further improvement of the boiler e.g. by optimization of the air regulation. Dust emission is expected to be dependent on the amount and composition of salts in the wood pellets.

Conclusions and perspective

- A linear correlation exists between nitrogen content in wood pellets and NO_x emissions, suggesting that thermic NO_x contribution is constant.
- Isolation of the burner using different materials seems to play a very limited role for emissions as long as it is well-isolated.
- No clear correlation exists between extent of NO_x emission and dust emission, meaning that multifunctional optimization will have to take place in the remaining project by improving combustion by regulation of e.g. air and fuel supply.

Future investigations and optimizations will be directed not only toward best possible combustion during type tests but also under real life applications. A load cycle test will be developed to simulate yearly performance.

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