Experimental investigation of the primary combustion of woody biomass in a grate boiler

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Introduction

• There is a growing interest in using biomass as a fuel for heat and power production.
• Grate boilers are famous for biomass combustion in the range from a few to about 100MW.
• Most of the grate-fired biomass combustion applications are not perfectly optimized.
• The combustion pattern inside the fuel bed is of practical interest.
• The current work investigates the temperature and gas species distribution inside the fuel bed.
Fuel and Furnace Description

- A reciprocating grate boiler with maximum thermal capacity of 4 MW.
- The fuel was forest waste with a mixture of wood chips, bark and sawdust from sawmill.
- A stack of fuel is supplied on a grate (by a stoker) and moves lengthwise along the sloping and moving grate.
- The grate tumbles and transports fuel by reciprocating movements of the grate rods as combustion proceeds.
- The primary air is distributed from three wind-boxes into the combustor.
- Combustible gases leaving the bed upward mix with the secondary air and flue gas.
Experimental method

- Local temperatures and concentrations of gases (NO, CO, CO₂ and O₂) were measured in the fuel bed through different ports, at two different conditions.
- The sample gas passed through a gas conditioner to avoid condensation of water vapor and tars inside the measuring instruments.
- The dry gas was sent into two IR-analysis spectrometers.
Results (temperature)

The experts assume two completely different combustion patterns for grate combustion:

1. Ignition takes place on the surface of the bed by the heat of radiation, and the reaction front propagates downwards.
2. The ignition takes place close to the grate surface and the reaction front propagates upwards.

- The temperature was measured 8 times (P₁–P₈) from close to the grate upwards.
- The temperature close to the grate surface was about 200-1100°C within a layer of around 200 mm thick over the grate (the second pattern).
Results (gas concentrations)

- Oxygen (vol %)
  - **Condition A (4 MW)**
  - **Condition B (2 MW)**

- CO (vol %)
  - **Condition A (4 MW)**
  - **Condition B (2 MW)**

- NO (ppm)
  - **Condition A (4 MW)**
  - **Condition B (2 MW)**

- Lower NO in the stack gas (60 mg/ MJ)
- Higher NO in the stack gas (80 mg/ MJ)
Conclusions

- There is a combustion zone located close to the grate surface.
- High concentration of CO and low concentration of Oxygen (close to zero) is in line with the temperature measurements (in both conditions).
- Higher NO concentration in the fuel bed in case B, compared to case A, despite its lower value in the stack gas.
- These in-bed measurements are necessary to reduce the formation of NO at its source of formation.

Thanks for your attention