

# Combustion characteristics of moist woody biomass in a grate boiler



**Narges Razmjoo\*, Sven Hermansson\*\*, Michael Strand\***

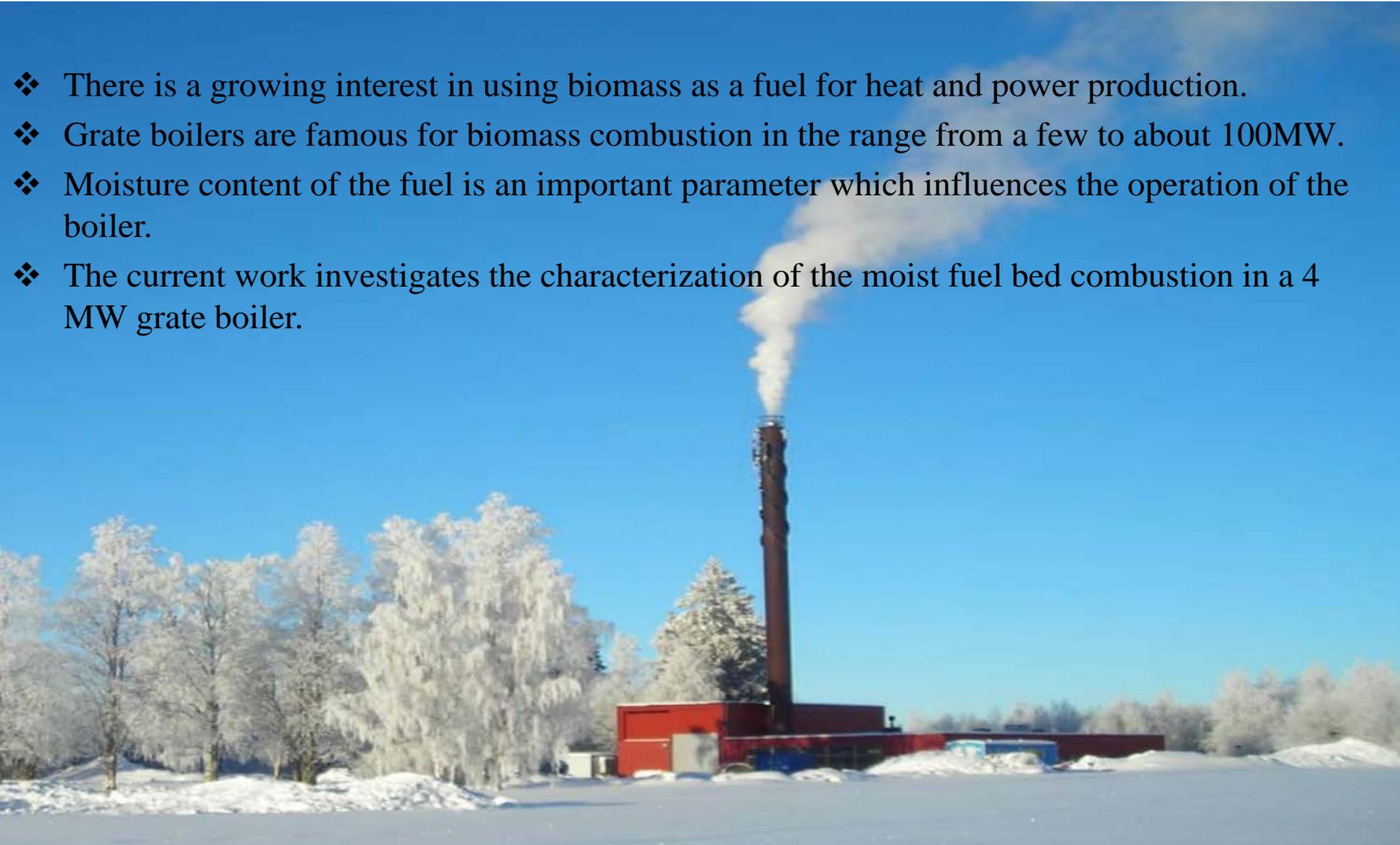
\*Department of Built Environment and Energy technology, Linnaeus University, Växjö, Sweden

\*\*Department of Energy Technology, SP Technical Research Institute of Sweden, Borås, Sweden

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# Introduction

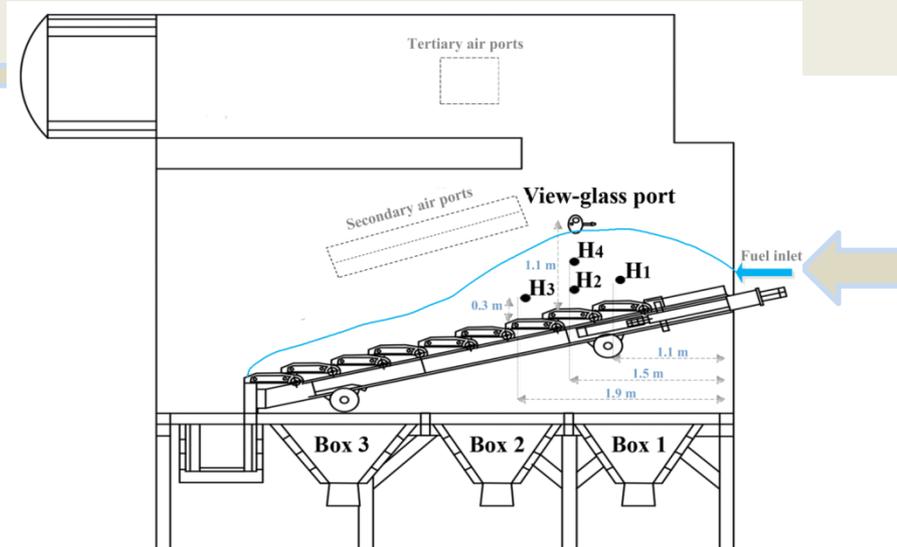
- ❖ There is a growing interest in using biomass as a fuel for heat and power production.
- ❖ Grate boilers are famous for biomass combustion in the range from a few to about 100MW.
- ❖ Moisture content of the fuel is an important parameter which influences the operation of the boiler.
- ❖ The current work investigates the characterization of the moist fuel bed combustion in a 4 MW grate boiler.



# Test facility

- 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 moist 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.

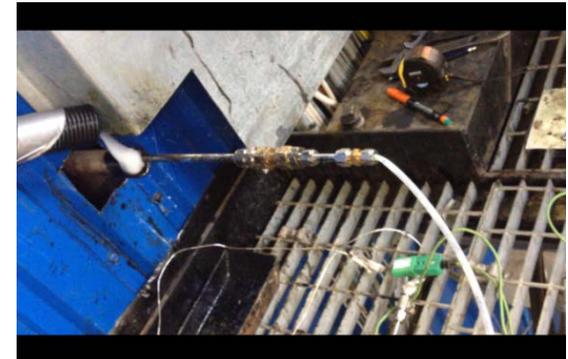
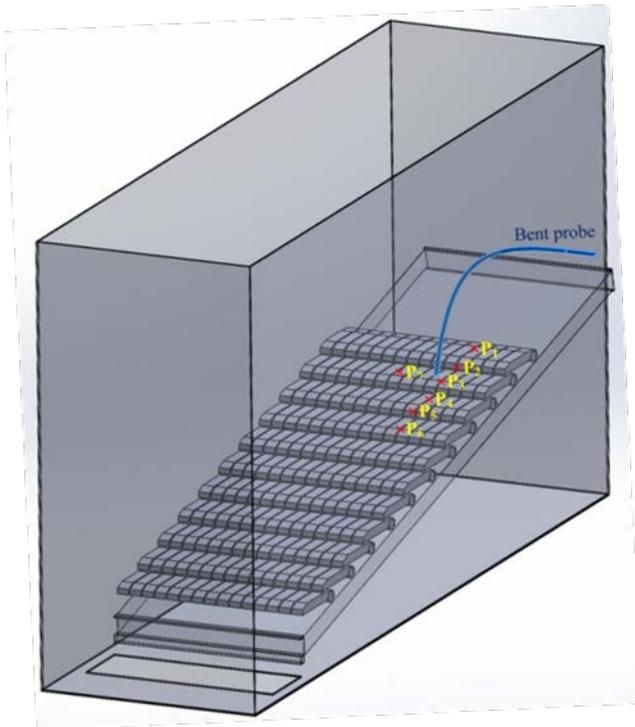
District heating system



Primary air

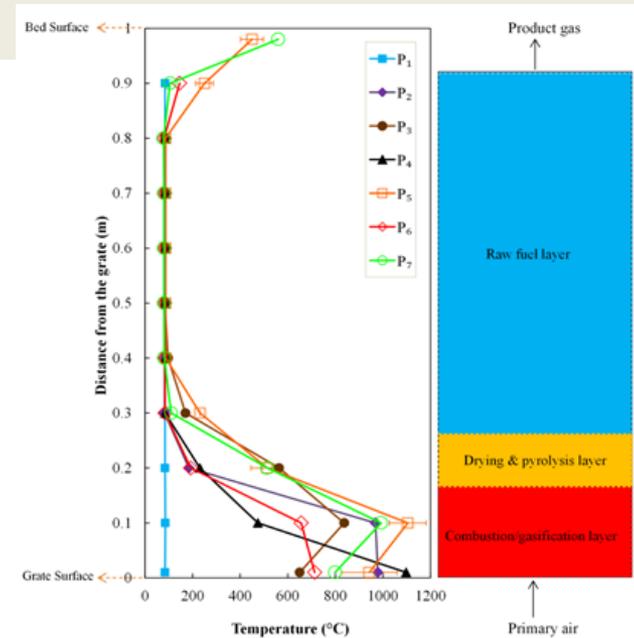
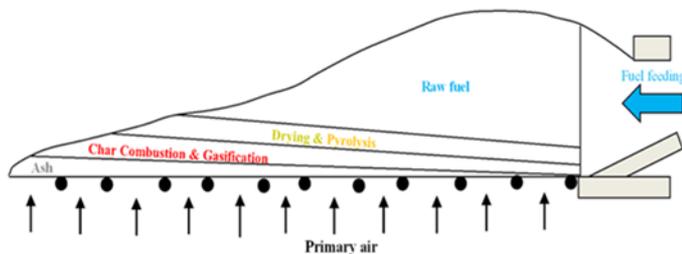
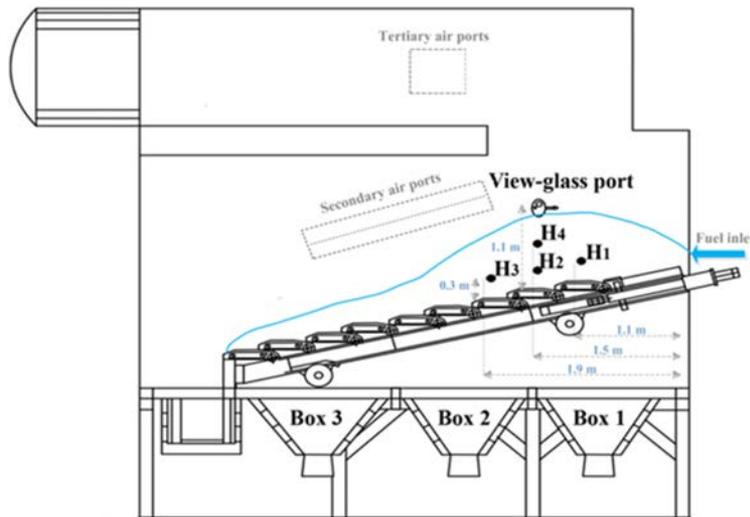
# Methodology

- ❖ Local temperatures and concentrations of gases ( $\text{NO}$ ,  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{O}_2$ ) were measured in the highly moist fuel bed through different ports.
- ❖ The sample gas passed through a gas conditioner to avoid condensation of water vapor and tars inside the measuring instruments. The dry gas was then sent into two IR-analysis spectrometers.
- ❖ Besides, the moisture content of the fuel bed was measured with NIR spectroscopy, in the fuel mix before it was fed into the furnace. The moisture content of the fuel is decreased from about 56 wt% to 40 wt%.
- ❖ The flue gas moisture was measured with FTIR spectroscopy. The moisture content of the fuel can be calculated from the flue gas moisture content, primary air flow, and elemental composition of the fuel.



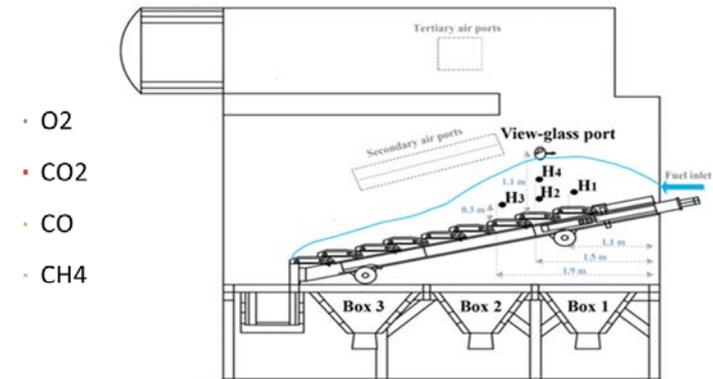
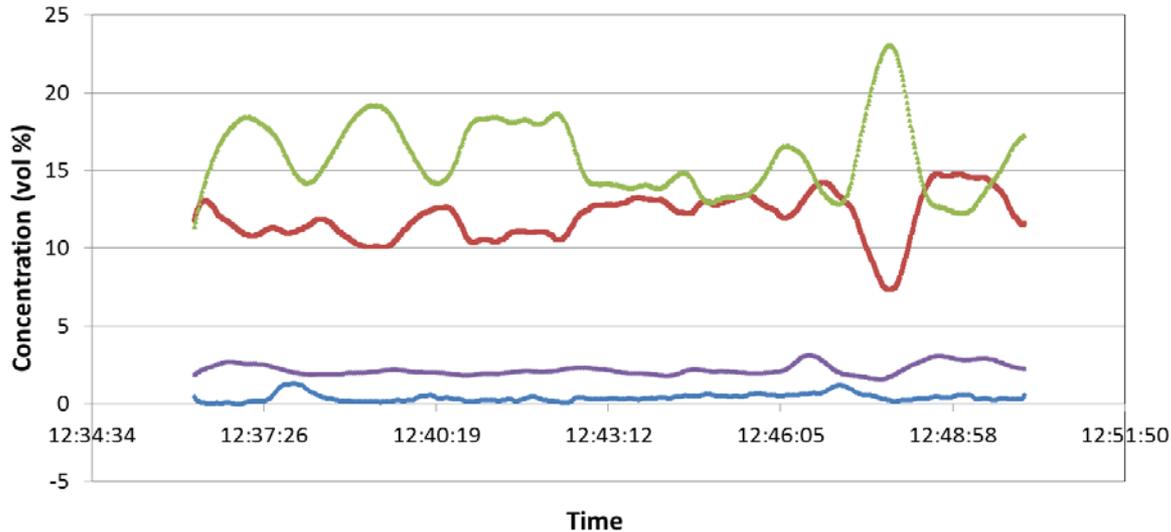
# Results

- ❖ 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).
- ❖ The high temperatures within a layer of about 0.1 m from the grate surface shows that intense combustion takes place close to the grate surface.
- ❖ Appropriate grate material and configuration should be considered to avoid its deterioration at such high temperatures.



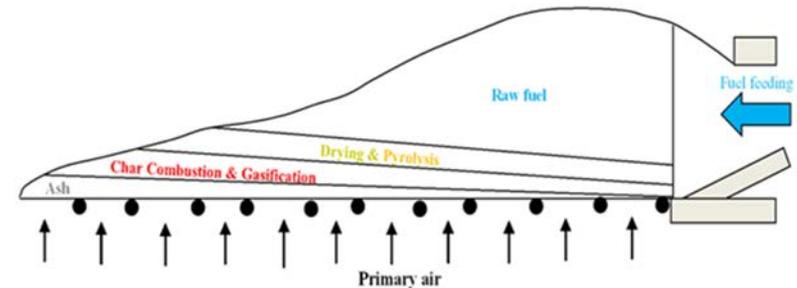
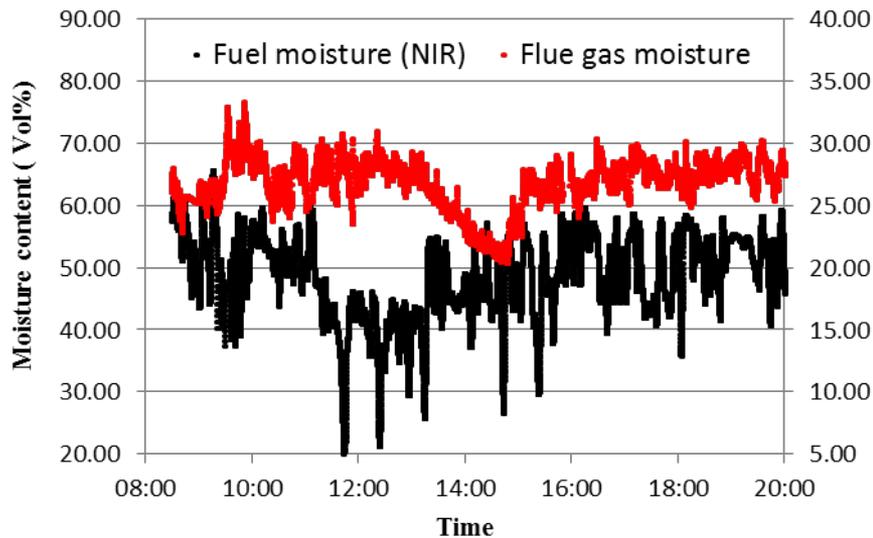
# Results (Inbed gas measurements)

- ❖ Gas concentrations (about 20 min): CO (15-20 Vol%), CO<sub>2</sub> (10-15 Vol%), CH<sub>4</sub> (2-3 Vol%), O<sub>2</sub> ~ zero concentration.
- ❖ The gas concentrations confirm the combustion, occurring at the bottom of the bed.
- ❖ Fluctuations in the gas concentrations correspond to the fuel feeding and grate movement cycles.



# Results (moisture measurements)

- ❖ There is about two-hour delay time in the response of the moisture content change in the flue gas, which shows that online moisture measurements through flue gas measurement is not possible in such a case.
- ❖ This behaviour is line with the proposed combustion pattern inside the moist fuel bed.



# Conclusions

- ❖ There is a combustion zone located close to the grate surface and appropriate grate configuration and material should be considered to avoid its deterioration.
- ❖ High concentration of CO and low concentration of Oxygen (close to zero) is in line with the temperature measurements.
- ❖ Moving grate furnaces can be operated with a thick and extended layer of raw and wet fuel being formed on top of the fuel bed.
- ❖ Online moisture measurements cannot be applied by measurements of the flue gas moisture content, since it has a long response delay.

*Thanks for listening*