

The Effect of Biomass Feedstock Type and Process Parameters on Achieving the Total Carbon Conversion in the Large Scale Fluidized Bed Gasification of Biomass

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The large-scale production of liquid biofuel based on fluidized bed gasification of biomass and Fischer-Tropsch synthesis process requires high amounts of biomass, which in Finland is primarily forestry-based. The total carbon conversion achieved in the gasifier, operating at temperatures below 1000 °C, depends mainly on the reactivity of solid char residue. The reactivity of the char residue is affected by temperature, partial pressures of the reactants H₂O and CO₂ and product gas components H₂ and CO, which inhibit the reactivity. The inorganic ash forming material catalyzes the char gasification reactions, and it can create problems due to sintering.

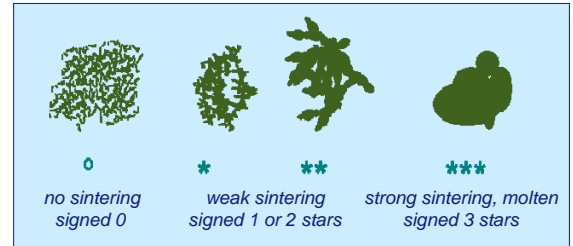
The tests were carried out in a pressurized thermogravimetric apparatus. Reactivity was expressed as instantaneous reaction rate. Ash sintering degree was detected on the residue under stereomicroscope after the test.

VARIABLES

- Biomass type: like barks, spruce, pine, birch, aspen
- Temperature, pressure, product gas composition

CONDITIONS

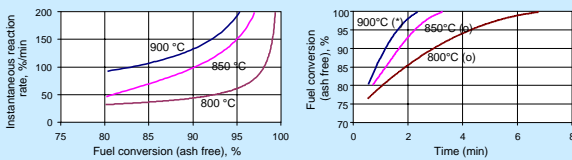
- Temperature: 800 - 900°C
- Pressure :1 bar - 20 bar
- Gasifying medium: 100 vol-% steam; 70 vol-% steam with 30 vol-% H₂; 100 vol-% CO₂; 70 vol-% CO₂ with 30 vol-% CO and a gas mixture containing all the gas components



Classification of ash sintering degree under microscope.

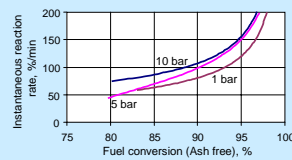
RESULTS

Temperature



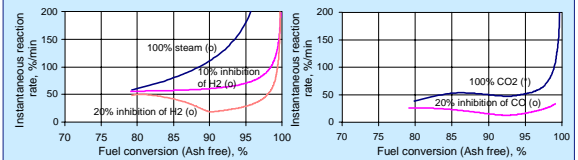
Steam gasification reactivity of spruce bark at various temperatures and in 5 bar pressure of steam: The instantaneous reaction rate as a function of fuel conversion and the fuel conversion as a function of time (right). o ** indicate ash sintering (see Fig. above)

Pressure



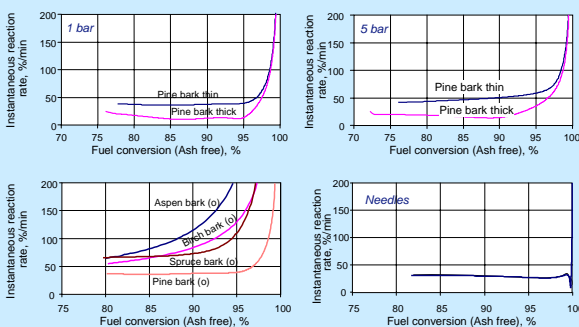
The steam gasification reactivity of spruce bark in various steam pressures at 850°C.

Product gas inhibition



Inhibition effect on gasification of spruce bark by adding H₂ into steam, and CO to CO₂ at 850°C and 5 bar pressure (total) with increasing concentrations of H₂ (2 bar steam, 0.5 bar and 1 bar H₂, respectively, the rest nitrogen) and CO in CO₂ (2 bar CO₂, 1 bar CO and the rest nitrogen) (right).

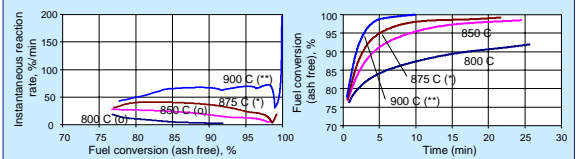
Biomass



Steam gasification reactivity of thin and thick pine bark in 1 and 5 bar steam pressures at 850°C.

Steam gasification reactivity of barks and needles (right) in 1 bar steam at 850°C.

o ** indicate ash sintering (see Fig. above)



The gasification reactivity of spruce bark in the gas mixture containing 1.5 bar steam, 1 bar H₂, 1.25 bar CO₂, 0.75 bar CO and 0.5 bar N₂ (total pressure 5 bar) at various temperatures.

o ** indicate ash sintering (see Fig. above)

CONCLUSIONS

- Reactivity of biomass char increases with temperature, which is obvious.
- Increase of pressure does not necessarily mean increase in reactivity.
- Reactivity of different biomasses, and also different parts of biomass may vary, such as thin pine bark had more than 5 times higher reactivity than thick pine bark, and lower than spruce bark.
- In general, ash sintering ranged from none to weak, in some cases the sintering was stronger at high pressure than at low pressure at the same temperature.
- Reactivity in the gas mixture including all the gas components was lower than in 100% steam, increase in temperature increased the reactivity significantly but in higher temperatures, ash sintering was detected.