Green carbon as coal substitute in the blast furnace

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Sub-Area 2.1: Process Analysis and Simulation

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Introduction

European iron and steel industry has already set the course to reduce its CO_2 emissions drastically by shifting to new production technologies. [1] This shift – along with the ensuing need for appropriate renewable fuels – is going to take decades. Thus, a change to renewable fuels at existing blast furnaces is a vital transitional solution. Injection of bioreductants, i.e. special biochar, (see Fig. 1) is considered to almost instantly enable a 20-40 % reduction of blast furnace CO_2 emissions. [2]

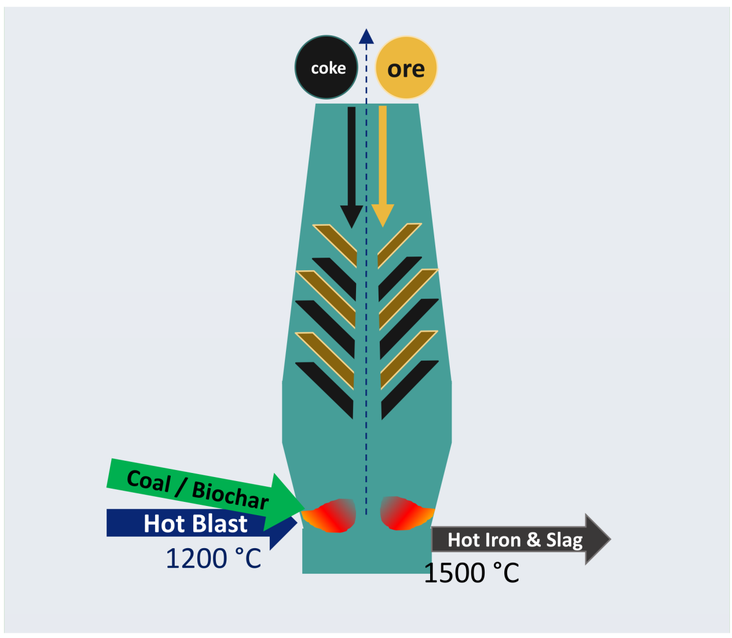

Fig. 1: Blast Furnace process with pulverized coal/char injection

Objectives

- Defining a preparation strategy for bioreductants
- Evaluating implications on the blast furnace process
- Assessing bioreductant substitution strategies with a combined understanding of pyrolysis and blast furnace to pinpoint a “most promising strategy”.

Economic Assessment

In the production of this injection “bioreductant” the pyrolysis severity is a decisive aspect. Chemical composition and particle and bulk characteristics can be improved. Equally, the specific costs of the bioreductant increase with increased severities as the solid yields drop.
By linking pyrolysis results and blast furnace reduction and heat demand with fuel and emission costs, a most beneficial pyrolysis severity can be deduced.

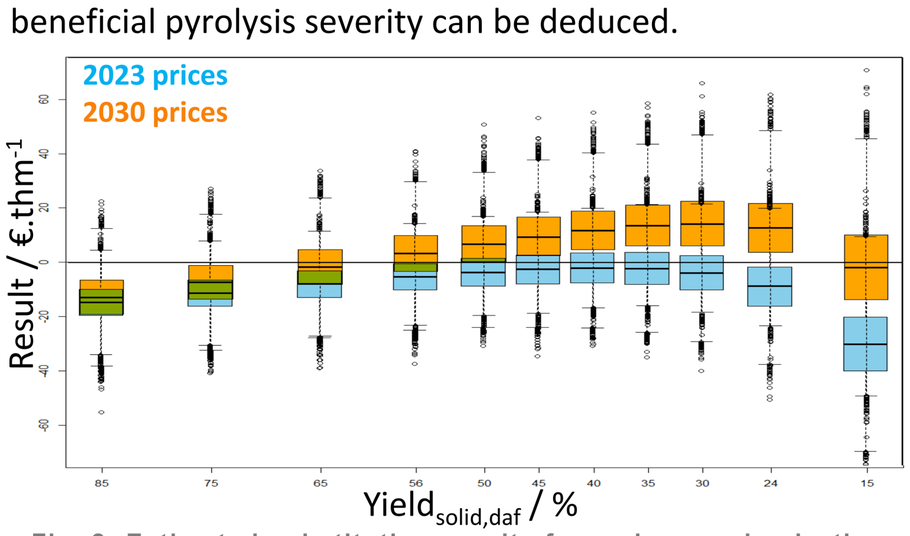

Fig. 2: Estimated substitution results for various carbonization intensities (positiv value signifies cost advantage for the bioreductant substitute)

Fig. 2 shows results for two reference years. This analysis shows that the likelihood of an economic advantage of bioreductant usage is expected to be high already within the present decade. Most advantageous pyrolysis severities are expected to be between 30 and 40 % $yield_{solid,daf}$.

CO_2-Reactivity

The CO_2–reactivity is a decisive indicator for the use of biochar in the blast furnace. The two stages of coal gasification are pyrolysis in the first step and gasification of the char in the second. The pyrolysis step involves heating samples of coal and biochar in a nitrogen environment. Next, the environment is changed from nitrogen to carbon dioxide, and the reactivity is assessed. [3] The process of gasification involves the Boudouard reaction, in which the carbon from the coal reacts with carbon dioxide and is converted into carbon monoxide. [4]

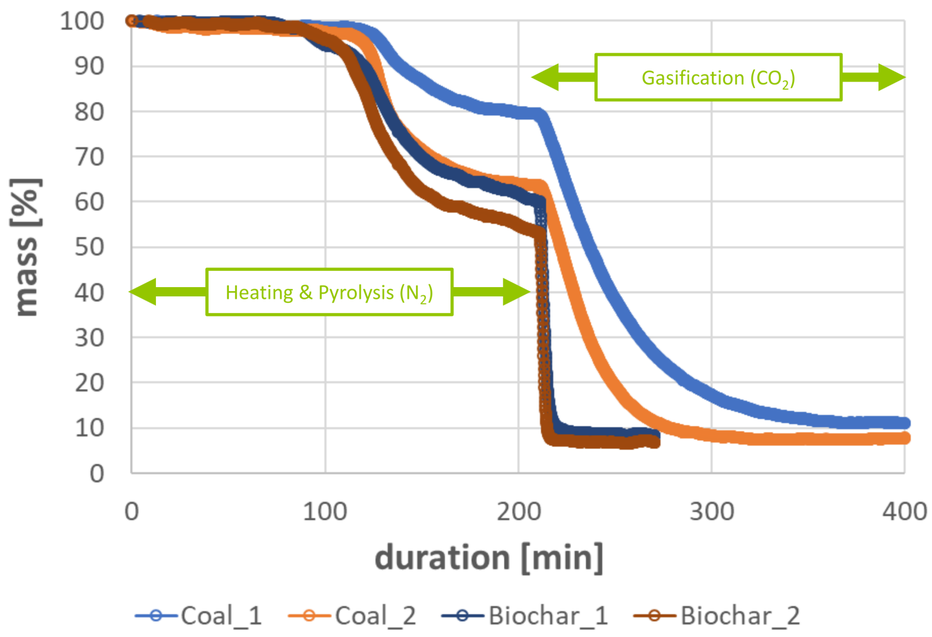

Fig. 3: Reactivity of coal types and biochar types towards CO_2 measured on a TGA (NETZSCH STA 449 F3 Jupiter)

Thermogravimetric analysis can be used to measure gasification processes. A measurement of this kind, which plots mass loss against duration, is illustrated in Fig. 3.
The noticeable mass loss during pyrolysis is caused by the release of volatile matter. The biochar samples lose a significant amount of mass after switching to carbon dioxide, whereas the coal samples take longer to convert. Because it converts considerably faster than coal, biochar is far more reactive than coal. Biochar can therefore be used as blast furnace injectant to reduce the consumption of coal due to its high reactivity. [5]

Further activities

By incorporating a better understanding of the volatile compounds’ behavior – either in the carbonization process or after blast furnace injection – an improved decision on most suitable carbonization parameters is expected. In the long run, options for the usage of pyrolysis condensables other than for thermic purposes shall be evaluated.

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