Bioreducer – Possibilities of bio-based materials in reduction applications

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GOALS OF THE PROJECT
One of the possibilities towards more sustainable steelmaking could be the partial replacement of fossil fuels with biomass-based energy sources. Before the introduction of biomass-based energy sources in metallurgical processes, several factors need to be evaluated. For Bioreducer project the following objectives were set:
1) Evaluate the availability and metallurgical properties of bio-based and alternative raw materials in Finland for use in metallurgical processes
2) Evaluate the thermochemical conversion technologies to produce bio-based reducing agents (solid, liquid and gaseous) from various biomass feedstock
3) Investigate the gate-to-gate (plant-wide) system impacts of biomass introduction to integrated steelworks
4) Assess the sustainability of biomass use in iron and steelmaking including environmental, economic and social aspects
5) Evaluate the reactivity and combustion behavior of biomass chars compared to fossil-based reducing agents

RESEARCH METHODS
Methods and tools used in the research include literature studies, laboratory experiments to determine the reactivity and the gasification behavior of chars, economic calculations, plant-wide modeling and simulations and life cycle assessment with HSC Chemistry, GaBi 5 and Factory simulation tool.

RESULTS
Availability assessment of biomass materials
According to vast literature review, it seems that there would be wide-range of suitable bio-based raw materials and products for blast furnace (BF) ironmaking. Raw material base could range from forest chips to tall oil pitch, by-product from crude tall oil distillation. Depending on the fossil reducing agent replacement ratio, the need for biomass (wood) could be substantial. According to blast furnace simulation studies, full replacement of pulverized coal injection with charcoal injection (50–200 kg/t hot metal) could be possible [1,2]. In the case of Ruukki steel plant in Raahie, this would mean at maximum annual charcoal need of 400 000 tons and around 2.7 Mm3 green wood need (e.g. forest chips) [3].

Thermochemical conversion technologies
Several thermochemical biomass conversion technologies were reviewed, which could be adopted to produce bio-based reducing agents with suitable chemical and physical properties for ironmaking.

Plant-wide modeling
In the Base case scenario coke and oil were used as reducing agents in BF, in the CC (charcoal) case 1, charcoal produced outside the system boundaries replaced oil injection in and in the CC case 2 charcoal produced inside the system boundaries replaced oil injection and part of the top-charged coke.

Experimental
Bio-based coals could replace small amount of top-charged coke or larger amounts of pulverized coal in blast furnace. In general, bio-based chars are more reactive than fossil-based chars.

CONCLUSIONS
The approach taken in the research is holistic in nature, providing overall picture of the challenges and possibilities related to biomass adoption in metallurgical industry. In the future several commercialization possibilities may exist in technology development as well as in new industry development.

References

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