UNDERSTANDING THE START-UP- KNOWLEDGE TRANSFER FROM BED MATERIAL TESTING AT CHALMERS TO THE OPERATION OF THE GOBIGAS GASIFICATION UNIT

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ABSTRACT: The operation of industrial sized plants is often based on experience and the operational window is usually narrow, around an optimum operational point. To get to that optimal point, the plant is designed for, it needs to go through a cumbersome start-up. In case of the 30MW gasification unit at the GoBiGas plant, one of the major hurdles during the commissioning of the plant was to control and limit the amount of tar produced from the gasifier. The high tar loads which clogged the raw gas cooler were preventing the standard operation to be attained, as olivine which is used as a bed material active towards tar decomposition had to undergo an in-situ activation. In principal two main activation mechanisms are considered, ash incorporation and structural changes due to heat treatment under red-ox conditions.

1 INTRODUCTION

The operation of industrial sized plants is often based on experience and the operational window is usually narrow, around an optimum operational point. To get to that optimal point, the plant is designed for, it needs to go through a cumbersome start-up. In case of the 30MW gasification unit at the GoBiGas plant, one of the major hurdles during the commissioning of the plant was to control and limit the amount of tar produced from the gasifier. The high tar loads which clogged the raw gas cooler were preventing the standard operation to be attained, as olivine which is used as a bed material active towards tar decomposition had to undergo an in-situ activation.

In principal two main activation mechanisms are considered, ash incorporation and structural changes due to heat treatment under red-ox conditions.

2 MATERIALS AND METHODS

To support the commissioning, a series of start-up experiments was performed at the Chalmers 2MW dual fluidized bed gasifier, each of them lasting for 100 hours of operation. The system was filled with around 3.5 tons of fresh bed material and operated at stable conditions at 820°C, 300kg_{fuel}/h and 160kg_{steam}/h. Tar was sampled with the SPA method and analyzed by GC-FID. Helium is added to the fluidization steam to the gasifier and is used to quantify the gases and tar in yields based on kg dry fuel. Permanent gases were measured by means of a micro-GC (Varian 4900). Including the trace of helium (0,2vol%) used to quantify the gases and tar in yields based on kg dry fuel. The performance of the gasification was assessed by means of gas yields, tar yields and carbon conversion. By variation of the chosen bed material different hypotheses regarding the activity of olivine were tested; calcium layer formation around the particles, iron migration to the surface and release or incomplete absorption of potassium.

Silica sand, bauxite, and olivine where chosen as test beds as they display different composition regarding their main phase, their initial reactivity and consequently the reactivity regarding ash components. On one side of the range silica sand represents a pure alkali getter, bonding the potassium chemically (1, 2) and is initially inert. In contrast, bauxite is rich in alumina with a small iron content and is a conditional alkali getter that is able to release adsorbed alkali to the surrounding gas phase (3, 4). Olivine, a magnesium silicate based material is a limited alkali getter with a content of 7% Fe2O3.

3 RESULTS AND DISCUSSION

As known from literature an increase in activity can be observed over time for bed materials, while this effect was negligible for sand (not shown) the effect was quite strong for olivine and Bauxite (Figure 1). Overall the tar yield decreased by 40 percent for olivine and 45 for bauxite respectively. Both bed materials in activated state exhibit a tar concentration and composition that allows for trouble free operation of a raw gas cooler as employed in the GoBiGas gasifier.

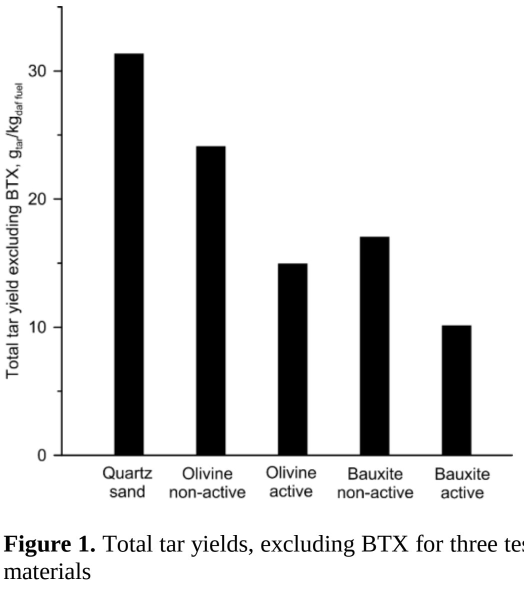

Figure 1. Total tar yields, excluding BTX for three tested materials

As reported by Marinkovic et.al. (5) the activity of olivine was not affected linearly by dilution with silica sand, as expected from heterogeneous catalyzed processes. Instead the entire activity disappeared already by a blending in 10% of silica sand. Dilution with olivine in contrast resulted in a dilution effect corresponding to the ratio of aged and fresh material.

By investigation of retrieved bed materials from before and after the blending olivine and bauxite with sand respectively a shift in the distribution from potassium becomes apparent. As seen in figure 2 potassium is dispersed evenly over the entire cross-section of the bauxite particles initially. After blending with silica the bauxite particles are cleared of potassium and instead stable potassium silicates are formed (Figure 3). As the bauxite applied contains some percentage of silicon itself some potassium remains in form of potassium alumina silicates. The reaction on the change in bed material composition is almost immediate and is reflected in the tar concentrations and composition as well as the gas composition.

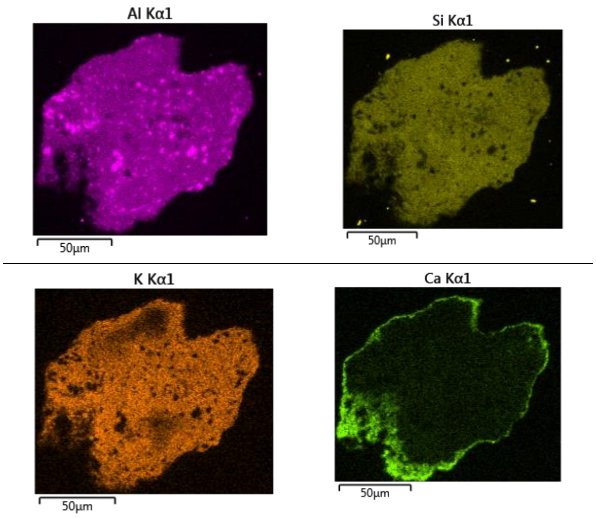

Figure 2. SEM/EDX image of bauxite particle enriched by ash elements

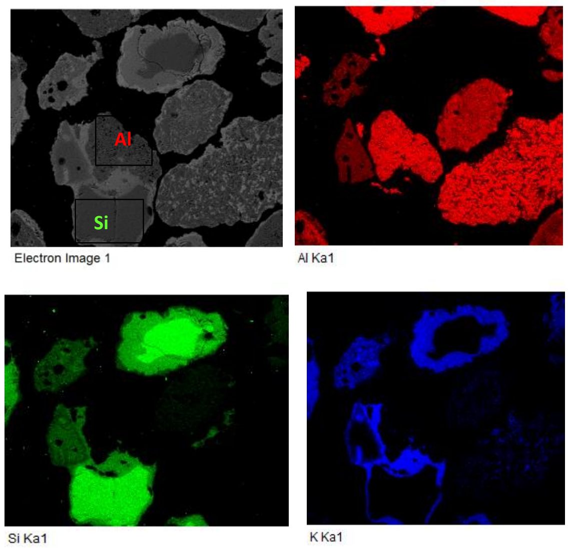

Figure 3. SEM/EDX image of the bauxite - quartz sand mixture

Potassium is well known as a potent catalyst in gasification and has been utilized in catalytic coal gasification (6) by impregnating Illinois coal with around 15 wt% of potassium carbonate.

Testing the hypothesis of potassium being the active component 3.5 kg of potassium carbonate were injected into the loop seal leading into the Chalmers gasifier. The effect was an immediate and lasting decrease in tar level by 20% as shown in figure 4. Based on 3 tons of bed material circulating through the system this amount results in a concentration of potassium carbonate around 0.1%. The full effect of this treatment became apparent after addition of some sulfur to the bed as the tar level dropped to one third of the initial level.

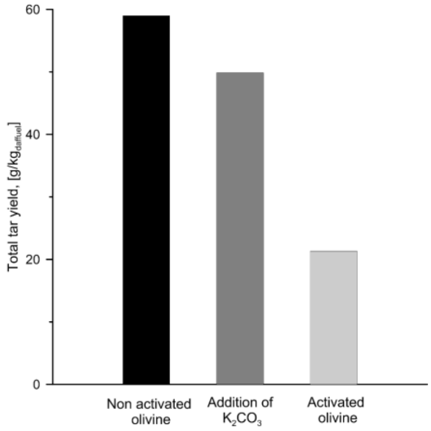

Figure 4. Total tar yield including Benzene and one 1-ring in g/kg_{fuel} before, after K2CO3 addition, and after K2CO3+S addition

5 CONCLUSIONS

Concluding on the importance of potassium in the system, a lack of ash content in the fuel utilized at the GoBiGas gasification unit was identified as the source of trouble (5). The yield of tar was efficiently decreased by adding potassium-salt to activate the olivine that is used as bed material.

The activity of "catalytic" bed materials olivine and bauxite undergo a transformation with time where added silica wipes out the positive effects and the addition of potassium leads to immediate activity. Strong impact can be attributed to volatile potassium species. Consequently, a relevant part of the catalytic property of those bed materials is a homogeneous catalytic effect of potassium in addition to heterogeneous catalytic effects of the particles and the surrounding ash layer.

Based on that not only good particle gas contact, but as well appropriate conditions for aforementioned homogeneous gas phase reactions should be considered in gasification reactor design. Furthermore, materials applied in gasification should be chosen accordingly (bed materials, additives and fuel). In that way tar formation can be controlled in terms of yields and oxygenated and reactive tar components can be avoided.

6 REFERENCES

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7 ACKNOWLEDGEMENTS

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