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Hot treatment and upgrading of syngas obtained by co-gasification of coal and wastes

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ABSTRACT

Nowadays there is a great interest in producing energy through co-gasification of low grade coals and waste blends to increase the use of alternative feedstocks with low prices. The experimental results showed that the viability of co-gasification to process such blends and that by the right manipulation of coal and biomass or waste blends, syngas treatment and upgrading may be simplified and the cost of the overall process may be reduced. Blends of three different coal grades (sub-bituminous coal from Puertollano mines, South African bituminous coal and German brown coal) with two different types of biomass (pine and olive oil bagasse) or polyethylene (PE) were co-gasified. Blend co-gasification showed to be beneficial to reduce the negative characteristics of some coals, such as the high ash and sulphur contents, especially of Puertollano coal. Syngas obtained by these blends was hot cleaned and undesirable syngas components (tar, NH_3 and H_2S) were measured along the hot treatment tested, which proved to be suitable to treat syngas produced by a wide range of feedstocks. Different routes for syngas cleaning were analysed to reduce unsuitable components to values required by most common end-uses. The results obtained showed that the type of feedstock to be gasified is a key outcome on initial syngas composition, affecting greatly syngas cleaning needs, its application and the economic viability of the overall process.

1. Introduction

Gasification is an effective process to obtain a synthetic gaseous fuel from carbonaceous materials. This gas is usually named as syngas, because besides being used for energy production, it may also be converted into synthetic fuels either liquids (ethanol, methanol, gasoline, gasoil) or gaseous such as: dimethyl ether and SNG (synthetic natural gas). Gasification may also act as a pre-combustion carbon capture technology, as syngas may be converted into a CO_2 stream ready for storage and into a hydrogen rich fuel. Gasification has high efficiency, low negative environmental impact and produces a gas with a wide range of applications [1].

Gasification was first developed for coal and it has also been widely studied for biomass conversion into syngas. The need of using low grade coals and wastes for energy production has led to the study of carbonaceous material co-gasification, especially blends of coal with biomass and wastes, with the aim of using existing installations to process coal with diversified feedstocks.

Besides the feedstock diversification, co-gasification of coal and biomass has the advantage of decreasing the use of fossil fuels and of reducing CO_2 emissions, due to biomass carbon bio origin [2]. Biomass or other wastes with lower mineral contents than coal might also dilute the negative characteristics of some coals, like lower volatile matter contents, high ash content and high contents of S, N, halogens and heavy metals. Hence, the technical and economic viability of low grade coal gasification might be increased. However, the choice of the wastes to use should be carefully done, to decrease the negative bearing of some coals and avoid additional problems during syngas cleaning and upgrading processes.

The formation of undesirable compounds like: H_2S, HCl, NH_3, alkali metals, particulates and tar has been studied by several authors during gasification and co-gasification processes [1–11]. Syngas desulphurization, both during gasification and during syngas cleaning procedures was reviewed by Meng et al. [2] and Cheah et al. [5] who analysed several types of sorbents based on zinc, copper, iron, calcium, manganese, and ceria for syngas desulfurization. Mid- to high-temperature sulphur sorbents for desulphurization of biomass and coal-derived syngas were also studied by Ohtsuka et al. [6], namely TiO_2-supported $ZnFe_2O_4$ sorbent. Different sorbents have also been studied by Dooley et al. [7] and Cheah et al. [8]. Xu et al. [9] reviewed recent developments on catalysts for tar and ammonia abatement and Ohtsuka et al. [6] also studied new catalysts for the decomposition of 2000 ppm NH_3 in a syngas at 750 °C. Ni-based catalysts have shown high activities for tar and ammonia decomposition, especially when used as secondary catalysts [3,10]. However, better performances in ammonia conversion have been obtained with several precious metal catalysts on modified zirconia (Rh, Ni, Pd, Ir, Ru, and Pt) as reported by Rönkkönen et al.

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