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Screening of various low-grade biomass materials for low temperature gasification: Method development and application

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ARTICLE INFO

Article history:

Received 3 July 2014

Received in revised form

17 December 2014

Accepted 19 December 2014

Available online xxx

Keywords:

Biomass

Characterization

Gasification

Sludge

Waste

ABSTRACT

This work aims at identifying potential low-grade biomass fuels for a near future Danish CHP system encompassing pretreatment of these fuels by Pyroneer gasification for subsequent conversion of the gas in existing coal-fired boilers. The focus of the work is on development of a suitable screening method and the subsequent use of the method to identify promising – but currently unproven, low-grade biomass resources for conversion in Pyroneer systems. The technical assessment is conducted by comparing the results from a series of physical-mechanical and thermochemical experiments to a set of proven references. The technical assessment is supplemented by an evaluation of practical application and overall energy balance. Applying the developed method to 4 references and 18 unproven low-grade potential fuels, indicated that one of these unproven candidates was most likely unsuited for Pyroneer gasification, 5 of the candidates looked highly problematic, 5 of the candidates looked very promising and 7 of the candidates ranged in between the highly problematic and the very promising.

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1. Introduction

In Denmark, wood pellets are used more and more to substitute coal in existing Combined Heat and Power (CHP) infrastructure. This approach will decrease dependency on fossil fuels and greenhouse gas emissions in the Danish energy sector. However, the biomass resource is limited, and especially the high quality wood resource is stressed by increased utilization in small and large scale energy and material

systems around the world. To be able to continue the substitution of coal with renewable biomass, suitable conversion systems need to be introduced that can handle biomass resources of lower quality.

The Pyroneer gasification platform is such a system. The process is currently implemented in a 6 MW demonstration plant at Asnæs power plant in Kalundborg, Denmark, as well as in a 100 kW pilot scale plant at the Technical University of Denmark at Risø, Roskilde, Denmark.

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<http://dx.doi.org/10.1016/j.biombioe.2014.12.019>

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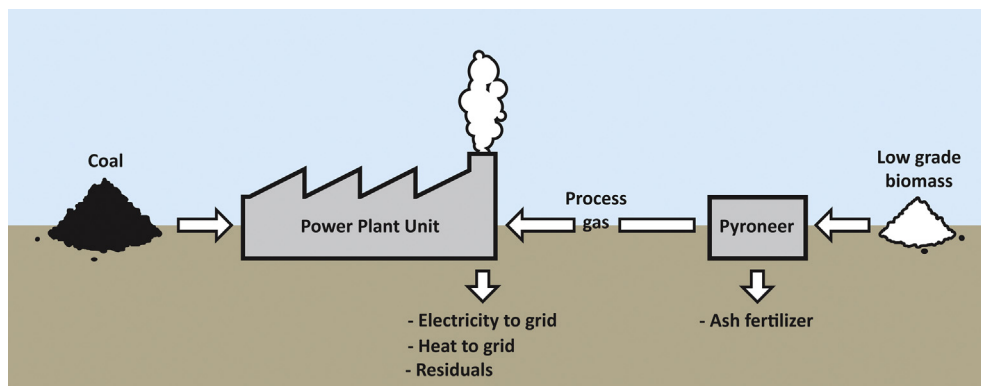


Fig. 1 – Integration of Pyroneer gasifiers in existing coal based energy infrastructure.

The technology is characterized as highly fuel flexible, robust and relatively inexpensive compared to other similar conversion platforms [1]. The integration of Pyroneer plants in existing coal based energy conversion infrastructure is illustrated in Fig. 1.

The reference fuel of the current generation of Pyroneer plants is straw – loose or in pellets, but the process has also been proven on even more problematic fuels like digested manure fibers and dried waste water sludge. The Pyroneer gasification process is a Low Temperature Circulating Fluid Bed (LT-CFB) gasifier. It operates at maximum temperatures of around 750 °C and thus largely avoids ash melting due to two related mechanisms [1–3]. First of all, due to the low operating temperatures, many common inorganic ash constituents like K, P and most Cl can be maintained in a solid state in the ash [3]. Secondly, the low temperature and reducing atmosphere prevent fast conversion of fixed carbon, and the ashes are therefore rich in carbon throughout the process. This mechanism has been studied by e.g. Kurkela et al., in 1996 and Skrifvars et al., in 1996 who describe a relation between the completeness of the fuel carbon conversion and the rate of ash deposit formation [4,5]. An illustration of the LT-CFB gasification concept is provided in Fig. 2.

The aim of this work is to develop a simple method for first hand screening of potential low-grade fuels for Pyroneer gasification systems as well as to test this method on a range

of biomass and waste resources of varying quality and origin. Characterization of various biomasses and wastes for use in gasification systems have been conducted previously in published literature. The method varies from study to study regarding the assessed conversion platform, the fuel characteristics and the biomass resources included. A short review study on the matter can be found in literature [6]. In the present work, it is attempted to provide a relatively simple method dedicated for initial screening and characterization of potential low-grade fuels for the Pyroneer LT-CFB gasification process.

2. Method

2.1. Selection criteria

A list of questions relevant for successful LT-CFB gasification was prepared to set guidelines for the experimental work. The questions were related to the preparation of the potential fuels as well as to the technical feasibility of the actual conversion. The list of questions was as follows:

- Is transportation/handling/feeding problematic due to low energy density per weight or volume?

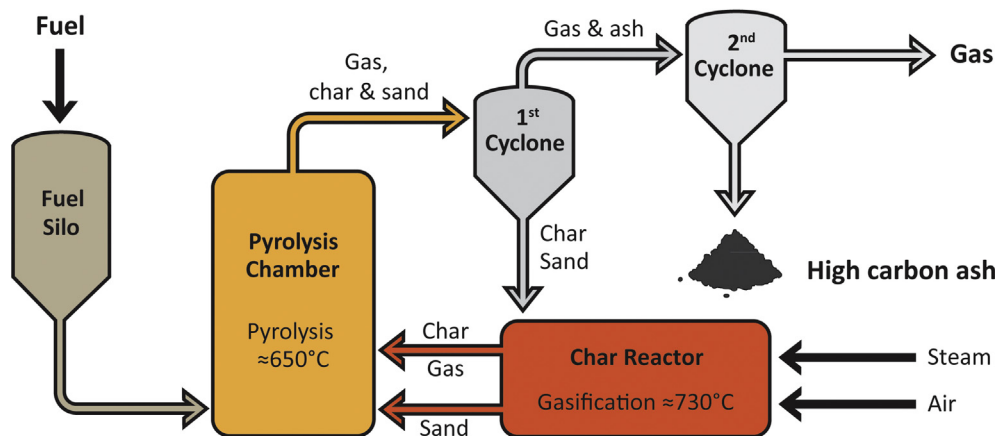


Fig. 2 – LT-CFB gasification flow sheet diagram.

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