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Biomass combustion technology development – It is all about chemical details

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Abstract

Biomass fuels differ in many ways from the conventional fossil fuels used in combustion processes, such as coal. They often have high moisture contents, lower heating values, and a variety of minor constituents, such as chlorine, sulfur, phosphorus, nitrogen, and a variety of ash-forming metals. These special properties of biomass fuels cause several challenges, but in many cases also provide advantages, to their use in combustion processes. Design of the combustion devices and choice of their operating parameters are very dependent on the detailed properties of the biomass fuel or fuels to be used. Often these challenges are connected to the fate and chemistry of the many minor constituents or impurities of the fuels. This paper reviews some of such chemical details related to biomass combustion that are important to take into consideration in the use of biomass combustion processes. The focus of the paper is in large, industrial scale combustion technologies for biomass and biomass derived waste fuels, either in district heating or also power production. Areas discussed are biomass particle conversion and biomass char oxidation reactivity, nitrogen and sulfur reactions in furnaces, superheater fouling and corrosion due to biomass ashes, low-temperature corrosion, and bed sintering in fluidized bed furnaces. The advances in understanding chemical details of biomass combustion have strongly contributed to the development of more reliable and efficient boiler technologies. Unresolved challenges are still connected to simultaneous combustion of several different biomasses and interaction of fuel ashes in such applications.
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Keywords: Biomass; Nitrogen oxides; Sulfur oxides; Corrosion; Defluidization

1. Introduction

The use of low-grade fuels such as various biomasses is increasing rapidly as an alternative to conventional fossil fuels. Biomass can be defined as organic matter derived from living, or recently living organisms. In this paper we specifically deal with biomass which is used, or planned to be used, in potential combustion or energy conversion processes. Biomasses are often inexpensive energy sources with a low greenhouse gas footprint. On the other hand, their utilization is connected with a number of technical challenges.

The qualities and properties of biomasses vary a lot. Biomass has less carbon, more oxygen and

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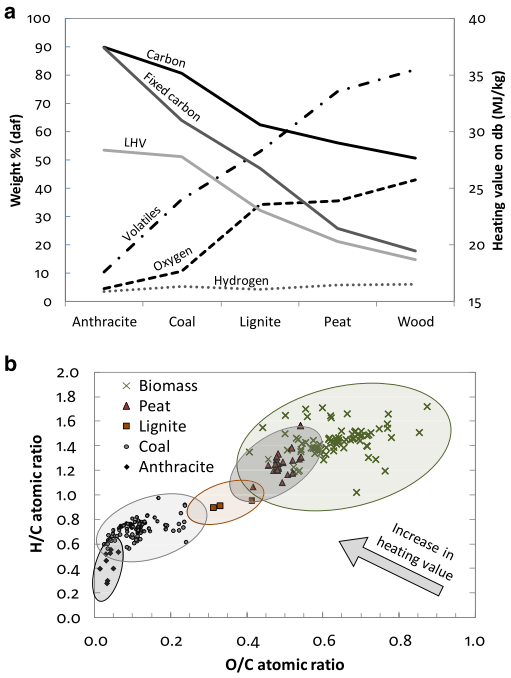

Fig. 1. (a) Properties for various types of solid fuels (daf, dry ash free basis; db, dry basis), (b) van Krevelen diagram of various fuels.
The figures are based on data from [1,2].

a lower heating value than coal (see Fig. 1). The volatile content is considerably higher and the fixed carbon content is lower for biomass compared to coal. Further, biomasses often have high moisture contents. Many challenges are related to the minor constituents or impurities contained in these fuels. Biomasses have a variety of minor constituents, such as chlorine, sulfur, phosphorus, nitrogen, and a variety of ash-forming metals (Fig. 2). These special properties of biomass fuels cause several challenges to their use in combustion processes. One key point is to combine/select fuels so that problems associated with various elements are eliminated. For example, fuels with high potassium and chlorine contents may lead to problems with fouling and corrosion, however, these problems may be solved by co-firing fuels with high sulfur content. Design of the combustion devices and choice of their operating parameters are very dependent on the detailed properties of the biomass fuel or fuels to be used. Often these challenges are connected to the fate and chemistry of the many minor constituents or impurities of the fuels. Figure 3 summarizes some of the chemistry related challenges in biomass combustion. Some of these challenges are similar to the ones in combustion systems using conventional fuels such as coal or even oil. However, in biomass combustion the phenomena and solutions needed may be very different. The chemical compositions of the biomasses influence the extent and severity of the problems illustrated in Fig. 3.

Solving or controlling of the problems shown in Fig. 3 requires a good understanding of the chemical behavior of the minor constituents and impurities of the fuel during the combustion process and in the flue gases. Consequently, research around problems caused by the minor constituents in the biomasses and waste derived fuels has been intense the past ten years all over the world. This paper discusses some of such chemical details related to biomass combustion that are important to take into consideration in the use of biomass combustion processes. The focus of the paper is in large, industrial scale combustion technologies for

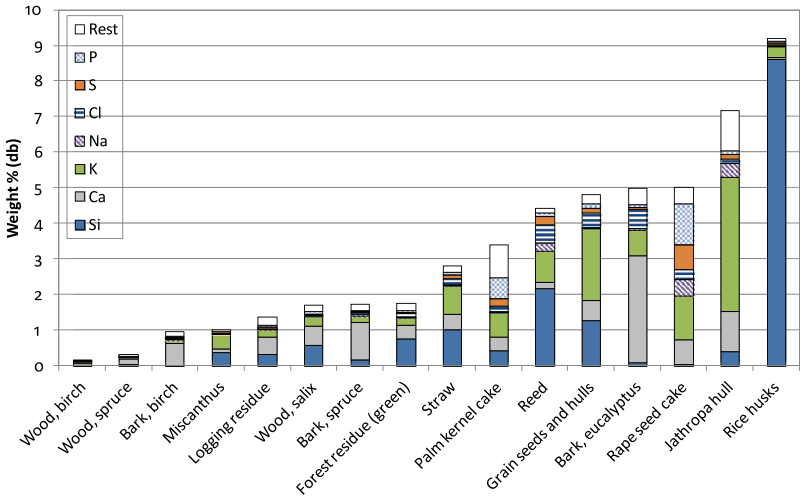

Fig. 2. Ash forming elements in various biomass fuels (db, dry basis).
Based on data from [1].

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