INTRODUCTION TO BIOMASS COMBUSTION AND GASIFICATION

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1. Abstract

In this chapter a brief summary of biomass firing technology is given. The general properties of biomass fuels are summarised and some of the difficulties that can occur in biomass combustion are described.

2. Introduction

Biomass has been the primary energy source for humankind until about 100 years ago when the 'oil age' started. Today fossil fuels are the dominating source of energy with about 2/3 of the global energy supply. However, growing awareness of the threat from climate change due to build-up of greenhouse gases in the atmosphere and the possibility of a peak followed by a decline in fossil oil production has led to a renewed and strong interest in biomass fuels. In some countries in the world, e.g. Sweden and Finland, biomass is already more important than fossil fuels except for transportation purposes. In Sweden the biomass share of energy supply to the industry is actually larger than that from oil, coal and natural gas combined and the total energy supply from biofuels is larger than 100 TWh[1]. On a global scale biomass provides about 14% of the worlds primary energy supplies and has the potential to provide about 50% during the next century (IEA Bioenergy, http://www.ieabioenergy.com/IEABioenergy.aspx).

Although biomass is a renewable resource, the use of biomass as a fuel is not automatically sustainable. For sustainability one must also ensure that forests and fields are properly managed from an environmental point of view and that the harvesting does not exceed the growth rate in the long term. Some of the major stakeholders in the world has created the Forest Stewardship Council (FSC) that has developed ten principles about responsible stewardship that will lead to a sustainable forestry :

1. Compliance with laws and FSC principles
2. Tenure and use rights and responsibilities
3. Indigenous peoples' rights
4. Community relations and worker's rights
5. Multiple benefits from the forest
6. Assessment of environmental impact
7. Management planning
8. Monitoring and assessment of management impact
9. Maintenance of high conservation value forests
10. Responsible management of plantations

[1] "Energy in Sweden 2006 – OH-pictures", Official Statistics for Sweden, Can be downloaded from: http://www.energimyndigheten.se/web/biblshop.nsf/FilAtkomst/Elaget06_oh_eng.pdf

The FSC also issues certificates to companies who want to show that they work according to the FSC rules and principles. This then presumably leads to environmentally appropriate forest management that ensures that the harvest of timber and non-timber products maintains the forest's biodiversity, productivity and ecological processes. There are also social and financial goals for the FSC about which one can learn more on the organisation's website http://www.fsc.org/en.

Biomass can broadly be divided into woody and non-woody biomass. Woody biomass is usually subdivided into softwoods (evergreen trees with needles) and hardwoods (broad-leefed trees that shed their leaves every autumn). The density of hardwoods is generally higher than for softwoods. An important characteristic of woody biomass is that fibers are reinforcing the trees in the lengthwise direction and as a result it becomes quite costly to fractionate woody biomass into fine particles. A special class of woody biomass is bark which is spongelike. Bark contains more resin and ash than stem wood. Common forms of woody biomass fuels are 'hog fuel' (mill residue of bark, chips and fines of a wide size range), whole tree chips, saw fines, sander dust etc. In the Nordic countries the wood is often refined into pellets with a well controlled moisture level, ash content and combustion behaviour. Some examples of non-woody biomass that can be used as fuel are agricultural residues (e.g. straws, stalks, husks and pits), manure and tall grasses (e.g. switchgrass and reed canary grass). Peat is a special case of non-woody biomass for which the debate is active whether it is a renewable or fossil fuel. Some advocates prefer to use the term 'slowly renewable', whereby it is meant that over a period of about 600 years the peat grows back. This discussion is important since peat can be used as an additive that reduces ash related problems, e.g. slagging, fouling and corrosion of superheater tubes.

3. Biomass fuels

3.1. Composition

Biomass fuels have properties spanning a wide range in many respects. The data in Table 1 shows examples of some important biofuels. However, it should be noted that the values in the table are indicative and that a wide variation within each category is possible as a result of different growing conditions and pre-treatment technologies.

Notice, the very wide range in the total ash content in Table 1 which is one factor that affects the combustion behaviour significantly. Besides the total fraction of ash in the fuel it is important to know the ash properties. One very important property is the ash melting point that influences the severity of slagging in the fuel bed and fouling of heat transfer surfaces. Typical ash melting temperatures are in the range 800 - 1200ºC. It is very important to handle the biofuel cleanly since already very small levels of contamination with e.g. sand or gravel can lower the melting temperature of the ash with several hundred degrees. This often leads to severe operational problems, e.g. complete sintering and loss of fluidisation in fluidised beds[2]. As a general rule, lower quality fuels need more sophisticated (usually larger-scale) combustion systems that can accomodate the large variations in ash melting point that usually follows with low quality. For the same reason, in small scale systems (e.g. domestic heating systems) the demands concerning fuel quality and homogeneity must generally be high.

[2] Öhman, Marcus, "Experimental studies on bed agglomeration during fluidized bed combustion of biomass fuels", Doctoral dissertation, Umeå University, ISBN 91-7191-646-6, 1999