Successful combustion of fast pyrolysis BioOil produced from forest residue

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Among the many potential uses for fast pyrolysis BioOils produced from biomass residue, spray combustion in furnaces, kilns and other industrial combustion equipment is most readily available. The steep rise in fossil fuel prices and the search for clean, renewable energy sources that can be used in existing equipment with little modification are strong drivers to put this greenhouse gas (GHG) neutral fuel and the necessary technology into the market place. This paper describes the successful combustion of fast pyrolysis BioOils produced by the BioTherm process of DynaMotive from coniferous white wood and bark.

The natural temptation is to treat BioOil as a hydrocarbon oil and to attempt to use burners designed for these conventional fuels. The three major stages of spray combustion of hydrocarbon liquids are atomisation, evaporation and combustion. Early in the heating process pyrolysis liquids undergo large changes in properties, particularly viscosity, and initial chemical reactions. This significantly modifies the atomisation and combustion behaviour. A closer analogy is found in the behaviour of coal-liquid mixtures (CLM). The CANMET Energy Technology Centre (CETC) previously carried out extensive work on CLM, including nozzle design and testing. An external mixing two-fluid atomising nozzle, developed for CLM combustion, was selected for tests using BioOil . The nozzle is of simple construction and is combined with the proper quarl to promote recirculation of hot gases.

The tests were performed in the CETC pilot-scale flame tunnel furnace, which is capable of burning pulverised solid, liquid or gaseous fuels, using a variety of burner designs. It has a simple cylindrical configuration, 4.25 m long and 1 m internal diameter, to facilitate the study of combustion aerodynamics. A refractory lined section at the front end, 1 m long and 0.8 m internal diameter, facilitates burner ignition. There is a continuous access slot along the furnace axis to allow probing. It is designed for a thermal input of 2.5 GJ/h, with stack oxygen of 3 to 5%. Combustion air is provided to an annulus around the burner, with adjustable swirl. There is the capability to preheat both the atomising air and combustion air. The liquid fuel feed system has a heated daytank, a Moyno pump, and a fuel preheater.

BioOil was provided by DynaMotive Technologies Corporation. It was produced using the BioTherm process from three feedstocks: 100% coniferous white wood, 70% coniferous white wood and 30% coniferous bark, and 100% coniferous bark. The fuel had less than 0.5% of both ash and nitrogen. The moisture content varied from 23% (100% white wood) to 33% (100% bark), with the gross calorific value ranging from 19.86 MJ/kg to 14.50 MJ/kg.

Combustion testing covered two full days (16 hours cumulative combustion time) with seven steady operating conditions obtained. The firing rate varied from 50 kg/h to 95 kg/h, or from 1.1 GJ/h to 1.9 GJ/h. The stack O_2 level was maintained below 6%, and CO was below 100 ppm for each of the seven flames. The ratio of atomising air to fuel was adjusted to give a stable flame. These flames were narrow, approximately 2 m long, highly luminous with very high heat release rates. There was no preheating of the atomising air. Preheating the combustion air was necessary for the 33% moisture BioOil.

Stable flames were obtained with fuel feed temperatures of 50ºC and 40ºC. The fuel was not filtered; there was only a strainer with opening size comparable to the fuel nozzle tip opening. No coking or plugging of the nozzle tip was observed, and the pressure in the fuel feed line remained constant at each feed rate.

These tests have demonstrated that fast pyrolysis BioOil burns very well with the CLM nozzle, even at 33% moisture content. The control of the flame is obtained through the atomising air flow. Little preheating and no filtering were needed for the fuel. The optimum firing conditions will be developed in future nozzle testing and development.