A Study of Pyrolytic Oil from Sewage Sludge Using the Taguchi Method and Its Combustion Characteristics

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Abstract

Sewage sludge is the major urban waste generated from the wastewater treatment process and is also a kind of waste biomass. The traditional ways of disposing sewage sludge have several shortcomings. Nowadays, with the increase of the sewage treatment rate, the sludge volume rapidly increases and alternative methods of sludge management are highly demanded. In the study, the pyrolytic oil of sewage sludge is obtained using the Taguchi method. The feedstock is the typical dewatered sewage sludge from a wastewater treatment plant. The experimental results indicate that the maximum pyrolytic oil yield, 18.46% dry and ash free by weight achieved, is obtained under the conditions of 450 °C pyrolytic temperature, 60 minutes residence time, 10 °C/min heating rate and 700 mL/min nitrogen flow rate. The effective sequence of the parameters with regard to sewage sludge pyrolysis is the nitrogen flow rate, pyrolytic temperature, heating rate and residence time. In addition, the combustion performance parameters are evaluated from thermogravimetric analysis and the suspended droplet experimental system is also used to explore the combustion characteristics of sludge pyrolytic oil and heavy fuel oil. From the thermogravimetric analysis of sludge pyrolytic oil, the combustion performance parameters such as the ignition temperature, burnout temperature, flammability index and combustion characteristics index are calculated and compared with heavy fuel oil. Sludge pyrolytic oil has lower ignition and better combustion characteristics than heavy fuel oil. With the blends of sludge pyrolytic oil and heavy fuel oil, the maximum combustion rate, the flammability index and combustion characteristics index obviously increase. Sludge pyrolytic oil significantly enhance the combustion of heavy fuel oil especially in the mixture of 50 % sludge pyrolytic oil and 50 % heavy fuel oil. Finally, from the suspended droplet experiment, the ignition delay time increases with the percentage of sludge pyrolytic oil in the blend. At the ambient temperature of 600 ^{o}C, more volatile vapor will be released and the flammable mixture will be ignited to form a non-premixed flame wrapping droplets. During the combustion process for the droplet of sludge pyrolytic oil, the micro-explosion occurs continuously, but the droplet still maintains the appearance close to a sphere. The fuel combustion characteristics substantially follow d^2-law and it can be approximated by a straight line and the slope K, which represents the burning rate, is about 1.62 mm^2/s

Keywords: Sewage Sludge, Pyrolytic oil, Taguchi Method, Thermal gravimetric Analysis, Suspended Droplet Experiment