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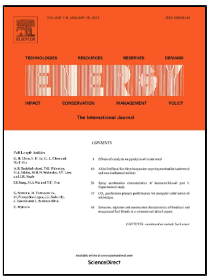

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Heat Pipe Based Municipal Waste Treatment Unit for Home Energy Recovery

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Abstract

A heat pipe based pyrolysis chamber has been developed and tested as an efficient, cost effective and space saving municipal waste treatment unit. The performance of the chamber was evaluated based on the temperature distributions inside the chamber, its electricity consumption and the chemical characteristics of the final pyrolysis products (bio-chars and pyro-oils) obtained from the process and validated by three test runs. In all the three tests, the type of waste treated was municipal waste obtained from households. In addition, special cases of challenging waste configurations, such as mixed domestic plastics and PVC are reported. The chemical analysis of the pyrolysis and the ash residues from the municipal solid waste showed no toxic elements in their composition. The main component of the char was calcium, the fluid oil obtained from the initial stages of pyrolysis had a similar composition to that of water, while the dense oil produced during the final stage of the process showed traces of iron and a potential composition match to commercial additive oils. The chemical analysis of the chars and ash obtained from the mixed domestic waste showed no toxicity for the mixed plastic char but a potential toxicity of the PVC char due to the existence of lead and chlorine. Calculations regarding the coefficient of performance (COP) of the heat pipe based pyrolysis unit indicated that the COP decreased with the increase of moisture content of the waste stream. For 0% moisture content in the waste stream the COP of the unit was 9.4 and the carbon footprint of the unit was 0.0782 kg CO_2e per kg of treatment. On the other hand, for a maximum moisture content of 100% the COP was 0.53 and the CO_2 emissions were 0.3873 kg CO_2e per kg of treatment.

Introduction

The term municipal solid waste (MSW) refers to waste materials discarded by a typical household, such as food, paper, plastics, metals, glass, ceramics, textiles, garden waste and other miscellaneous everyday materials. The total waste generated from households in England in 2013 was more than 21.5 million tonnes, with the average yearly waste production per person being 403 kg [1]. The key principle of European and UK waste legislation is the hierarchy of waste management options, where the most desirable option is to prevent waste production in the first place and the least desirable to dispose of the waste to landfill with no recovery of either materials or energy [2].

Table 1 describes the typical composition of the MSW found in UK households for 2011.

The chemical composition of each waste category is as follows:

Paper products

Cellulose fibre is the main constituent of paper products, while additional ingredients may be used to change the appearance and texture of the paper. For example, to produce the glossy paper of magazines,