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Fine grain separation for the production of biomass fuel from mixed municipal solid waste

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ABSTRACT

The main goal of the project MARSS (Material Advanced Sustainable Systems) is to build a demonstration plant in order to recover a renewable biomass fuel suitable for the use in biomass power plants out of mixed municipal solid waste (MMSW). The demonstration plant was constructed in Mertesdorf (Germany), working alongside an existing mechanical–biological treatment plant, where the MMSW is biological dried under aerobe conditions in rotting boxes. The focus of the presented sorting campaign was set on the processing of fine grain particles minor than 11.5 mm which have the highest mass content and biogenic energy potential of the utilized grain size fractions. The objective was to produce a biomass fuel with a high calorific value and a low content of fossil (plastic, synthetic) materials while maximizing the mass recovery. Therefore, the biogenic components of the dried MMSW are separated from inert and fossil components through various classification and sifting processes. In three experimental process setups of different processing depths, the grain size fraction 4–11.5 mm was sifted by the use of air sifters and air tables.

1. Introduction

According to Article 5,2 c, the EU Landfill Directive demands the avoidance of biodegradable waste being landfilled by at least 65% (by mass) in comparison to the production of biodegradable waste in 1995 (EU, 1999). However, the European Environment Agency (EEA) states that several European countries do not yet meet the requirements (EEA, 2013). Many of these countries have rather just started deciding on whether or how to set up their waste management system. Although there already is a number of existing waste processing techniques available today, they are not always suitable for the specific circumstances existing in these countries (for further information see Cioranu et al., 2014).

Fig. 1 shows the main waste management systems and there relevance in the countries of the EU-28. It shows that in many eastern and southern Europe countries landfilling is still the main waste disposal method. Mechanical biological treatment (MBT) is prior to waste incineration in most European countries to condition landfill material (Eurostat, 2014). Some MBT processes focus on recovering energy by generating high calorific refused derived fuels (RDF). However, research of press releases of the last decades shows that waste and RDF incineration is poorly accepted in some EU-countries. Most likely, the incineration of bio-waste is more easily accepted by the population.

In order to provide an alternative to the existing waste management systems, the Life + demonstration project MARSS (Material Advanced Recovery Sustainable Systems) was designed.

A consortium of five partners from Germany, Italy and Spain (coming from industry and academia together with a medium-sized enterprise) have developed a joint project to build, test and monitor a demonstration plant in Germany to determine the most effective way to separate the biologic material from MMSW into a refined renewable biomass fuel commonly known as Refuse Recovered Biomass Fuel (RRBF) and reuse it as a source for energy production.

The goal is to produce a RRBF that reaches the market demands of purity together with a high calorific value, and complies with the demands of the EU Landfill Directive Art. 5 and Art. 6. If the processing is successful, greenhouse gas (GHG) emissions will be reduced by the substitution of fossil fuels as well as by avoiding biodegradable substances being landfilled and hence resulting in further reductions of emissions (for further information see also Rada et al., 2012; Velis et al., 2009). With small technical effort it is possible to add a processing plant module to an MBT technology to produce a biomass fuel.

The new demo plant will be built in Mertesdorf, near Trier, Germany, working alongside the existing MBT plant which

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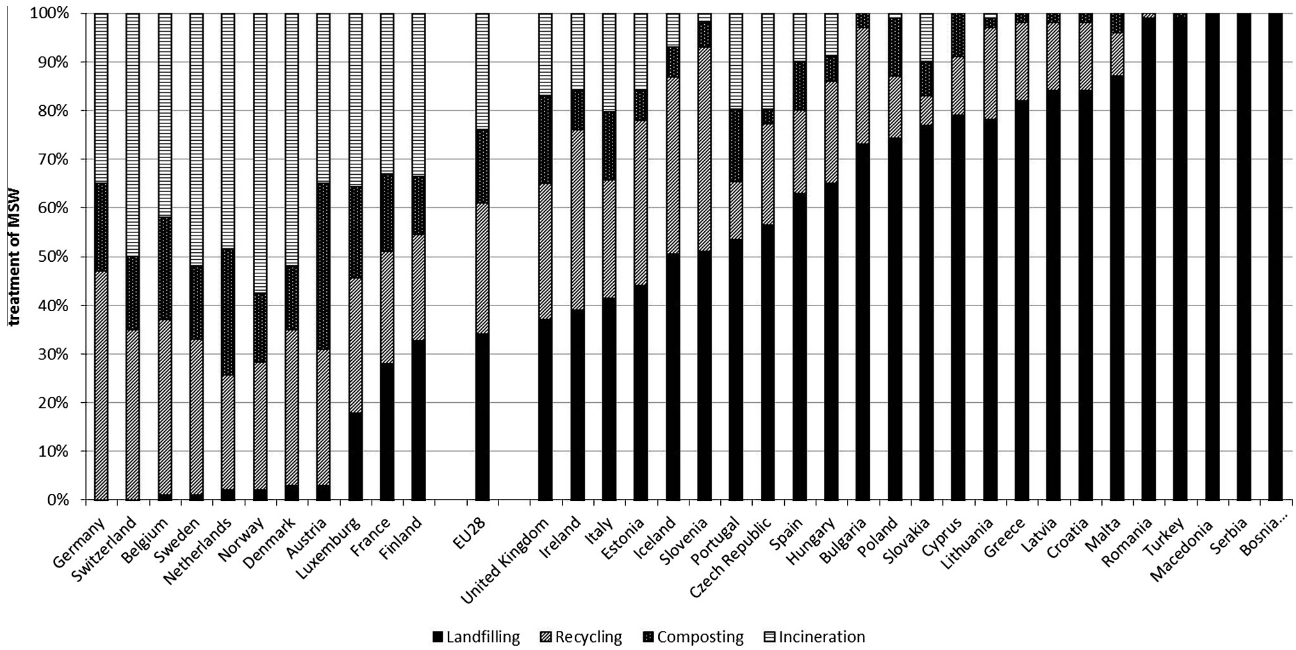

Fig. 1. Relevance of the main waste management systems in the EU-28 in 2012 (Eurostat, 2014).

employs the Herhof Stabilat Process®. In this process the MMSW (water content 45–50 M.%) is stabilized and dried through aerobic biological treatment steps to produce high calorific refused derived fuels (RDFs). Microorganisms which are present in the waste produce the heat to vaporize a majority of the water content (total mass loss by drying process: ~35%). The average water content of the dried material is about 10% by mass (Clausen et al., 2013).

Due to the fact that the majority of biogenic material is found in the fraction minor than 40 mm, only this material will be investigated in the MARSS Project regarding suitability to be used as a RRBF.

The Department of Processing and Recycling (I.A.R.) analyses the potential of the demo plant's input material and carries out sorting campaigns to produce RRBF out of dried MMSW of different grain sizes, for example minor than 11.5 mm (Clausen et al., 2013; Giani et al., 2014). With focus on the sorting, the results of these campaigns will be presented.

2. Materials and methods

2.1. Project concept

The demo plant was installed in the period between April and July 2014 and consists of the following main machine components:

- Sieving: one drum screen, two flip-flow-screens
- Density separation: one air sifter, one air table
- Metal separation: one overhead magnetic separator, one eddy current separator

The plant is designed to be partly mobile. The combination or maintenance of several conveyor belts and screens can thus be performed easily. This flexible modular plant uses a feed hopper that enables a reapplication of intermediate goods. Therefrom different processing cycles can be realized and finally be adapted to the fluctuations of the input material composition. One possible treatment process chain is shown in Fig. 2 and described as follows.

Using a bypass-system, the MARSS demonstration plant receives a separate stream of 10 t/h of the dried MMSW from the MBT plant. Within the demo plant treatment process the dried MMSW passes several sieving processes. The input material is first sieved at 40 mm using a drum screen. Following sieving processes, using flip-flow-screens at 11.5 and 4 mm, produce suitable grain-size bands (11.5–40 mm and 4–11.5 mm), which are needed for further density sorting in air sifters or air tables. For sifting, the ratio between the maximum and minimum particle size should not be more than 3:1 (Pretz and Julius, 2010). The light fraction of the density sorting processes and the material fraction 0–4 mm will be merged to a RRBF product.

In this publication, only the results of the sieving and the fine grain density separation tests are presented. The coarse grain density separation and the ferrous and non-ferrous metal separation will additionally be utilized within the demo plant.

2.2. Basic information and objectives of the I.A.R. test campaign

The dried MMSW input material composition and the potential of producing a RRBF was analyzed in previous test campaigns. Fig. 3 shows the average material composition of the MMSW minor than 40 mm and the distribution of the materials into fuel groups (Biogenic Carbon, Fossil Carbon, Mixed Carbon and Inert Material) according to Clausen et al. (2013). Therefore, the material was sieved at 10 mm as the fraction major than 10 mm was separated manually.

An analysis of the particle size distribution showed that almost half of the input material 0–40 mm is minor than 10 mm. Furthermore, due to Clausen et al., over 45% of the total input energy potential is present in the fraction 0–10 mm. For this reason, this fraction plays an important role for the production of a RRBF.

The 0–10 mm fraction can be characterized by the following: Due to its small particle size, the fraction minor than 10 mm cannot be separated manually. Information about the water content, the organic and inert content of this fraction can be provided analyzing the water content (DIN EN 14774) and the ash content (DIN 14775). The organic fraction consists of biogenic carbon as well as fossil carbon. Contents of fossil carbon can be estimated following the guidelines described in the "Methodological manual for