INVESTIGATION OF THE SOLID WASTE OF A SMALL TOWN FOR THE PRODUCTION OF RDF

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Abstract
It is well-known that Hungary is poor in energy sources; therefore the country must rely on imports, particularly from the expensive hydrocarbons. However a considerable part of the municipal solid waste with significant chemical energy forwarded to landfills, because of the absence of incinerator capacities. From the municipal solid waste a valuable fuel can be generated with different technologies and this fuel can be suitable to provide one part of the thermal energy demand of a small town.

One aim of the research group of the University of Miskolc is to develop an energy supply model for the small and medium size towns, based on the locally available biomass and solid waste. This energy can be suitable for the substitution of the fossil fuels, especially the very expensive natural gas.

Within the framework of the research, the amount and the composition of the waste from a chosen town were measured by questionnaire, and in situ waste analysis. In this study the experimental data from the waste analysis are shown and compared with results of other towns. The possible treatment technologies for this waste are also discussed.

We give a review of the briquetting possibilities of the fuel to be produced, the main combustion technical characteristics of the pellets originated from waste – using former experimental results –, and the pellet behaviour during combustion is also mentioned.

1. Introduction

In Hungary quasi 5 million tons of municipal solid waste (MSW) is generated. About 75% of this waste deposited in landfills [5]. The treatment of the residual from the selective waste collection (the medley) is required, in order to save landfill capacities by reducing the weight and stabilizing the waste. On the other hand, energy can be obtained from the waste in form of refuse derived fuel (RDF).

At University of Miskolc during the research work, in order to substitute the fossil fuel based heating systems, a small town, Csernely was chosen for a sample town. Csernely has 830 inhabitants. The technologies able to convert municipal solid wastes (MSW) into alternative fuel were investigated. By application of the proper technology the residual waste can be divided into two parts, one fraction with high calorific value, and suitable for energetically purposes, and another fraction, a compost-like stabilitate or compost like organics (CLO). The most widely used treatment method is the mechanical biological treatment (MBT).
One of the first steps of the research work is to determine the amount and the composition of the waste, generated at the sample town. A comparison is given with the former results from another small town in relation to waste composition. The experimental data of a burning analysis carried out with a fuel, generated from MSW are also shown.

2. Waste processing technologies

Waste treatment
The strict rules in the field of environmental protection, prescribe the environmental friendly treatment of the MSW. The waste management of the European Union based on a hierarchical priority scheme (Figure 2) [8].

Based on the predictions the volume of the waste will increase in future [4]. One aim of the Second National Waste Management Plan – operating until 2014 – is to reduce the amount of the deposited waste below 60%. This more or less means:
• raising up the selective collection rate;
• the biologically degradable components have to be processed;
• and not least the rate of energetically utilization has to be increased.

It is important to mention that under the current legislations, the amount of the biodegradable waste at landfills is not allowed to be more than 35% by mass, correlated to the deposited amount in 1995.

Considering the international experiences, it can be only partially achieved; therefore the thermal utilization can be the complete solution.

The following methods are recommended [4]:

1. energetic utilization of the medley waste from the residual waste collection in waste incinerators;
2. after mechanical-biological pretreatment, thermal utilization of the RDF in waste incinerators or by gasification
3. after mechanical-biological pretreatment, thermal utilization of the RDF with high caloric value in cement factory or in coal-fired power plants.

MSW treatment technologies
The mechanical processes in order to produce RDF from the municipal solid wastes are known for at least 20–25 years. The biological stabilization was carried out in order to decrease the moisture content of the biodegradable part of the MSW, and for the production of a higher quality fuel. Today this complex treatment technology for the waste from the residual collection, consist of the combination of the mechanical, biological and thermal processes [3]. The general flow sheet of the mechanical biological waste treatment technology can be seen in Figure 3.

![Figure 3: MBT technology in general](image)

MBT technology in Hungary
In Hungary essentially two ways of MBT treatment are common. After comminution and metal separation, the municipal solid waste is subjected to biological treatment, and in this
case after the biological separation the coarse product of the drum screen is the useful fraction for energy purposes. In Hungary Győr–Sashegy Waste Treatment Centre and the Felső-Bácska Waste Management Ltd. are the examples for this technology [1, 2].

The other way is when after the comminution and metal separation, only the fraction below 80–100mm of the municipal solid waste is subjected to biological treatment. In this case, the energetically useful product is generated partly from the fraction larger than 80–100mm – separated in the beginning of the technology –, and on the other hand the upper fraction from the biological treatment followed by screening. The waste treatment centre of Green Bridge Region Ltd. in Kerepes, Ökörtelerk Valley adopted this kind of technology [1, 2].

Refuse derived fuels generated from the MBT technology are purchased by power plants, and cement plants, but the gasifier plants and pyrolysis plants are also mean a potential market for these products [6].

3. Waste analysis of small town

From the point of view of the supply of the planned heating system it is important to know the quantity and quality of the arising MSW in Csernely.

The small specific waste amount is typical for small town (ca. 250 kg/a/inhabitant, against the big cities 450–550 kg/a/inhabitant). It can be explained with the smaller consumption (circumstance of inhabitants, private produced food), and the private composting and combustion of the waste.

The expected amount of waste can be obtained by multiplying the number of inhabitants and the specific waste amount. The weekly amount in Csernely: 830 inhabitant×250 kg/a/inhabitant/52 week/a = 3990 kg/week.

_Determination of quantity and utilisation of waste through questionnaire_

The aim of the research work is to produce different fractions with high caloric value from MSW. In the given period a comprehensive public survey was made in the chosen small town (Csernely). The quantity and the fate of MSW (collecting, comminution) were determined by our questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>43. How much MSW arise in a week in your household? (one standard bucket is 10 litre, one big dumpster is 110 litre)</td>
<td>✐ 99 – don’t know ✐ 0 – don’t answer</td>
</tr>
<tr>
<td>44. Ratio of MSW used for heating purposes in autumn and winter:</td>
<td>✐ 1–0 % ✐ 2–25% ✐ 3–50% ✐ 4–75% ✐ 5–100% ✐ 9–don’t know ✐ 0–don’t answer</td>
</tr>
</tbody>
</table>

Figure 4: Questions related to the MSW
The weekly arising amount of MSW was determined by the answers for the questionnaire: 17950 l, it means 88 l/household. The mass of that is 3590 kg (average bulk density: 0.2 kg/dm³) which corresponds with the calculated amount.

**In situ waste analysis**

We wanted to determine the amount and composition of the arising wastes with direct analysis. According standard the waste must be emptied from the collecting vehicle, and so sampled. In our case it was not possible, because the vehicle collects the waste weekly (Wednesdays) from many settlements, so the waste from different settlements is mixed.

There were two possible alternatives for the composition analysis of waste according to standards MSZ 21420-28 and 29:

**ALTERNATIVE 1:** Collection of the sample (300–500 kg) to be analysed from randomly chosen households.

**ALTERNATIVE 2:** Collection of the full weekly waste amount in Csernely, and take the sample (300-500 kg) from it.

The waste analysis was carried out according to Alternative 2. The wet composition data are shown in Table 1 and Figure 4, where the total combustible fraction is the sum of 2–8 fractions, the total non combustible contains 9–12 fractions.

**Table 1**

<table>
<thead>
<tr>
<th>Material composition, categories, [% m/m]</th>
<th>Csernely</th>
<th>Szuha</th>
<th>Szuha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Inhabitants</strong></td>
<td>830</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>09. 2011</td>
<td>05. 2009</td>
<td>06. 2007</td>
</tr>
<tr>
<td><strong>Mass of sample [kg]</strong></td>
<td>341</td>
<td>415</td>
<td>452</td>
</tr>
<tr>
<td>1. Bio</td>
<td>34,34</td>
<td>39,00</td>
<td>27,29</td>
</tr>
<tr>
<td>2.-3. Paper, Cardboard</td>
<td>7,63</td>
<td>4,05</td>
<td>11,61</td>
</tr>
<tr>
<td>4. Composite</td>
<td>0,66</td>
<td>1,49</td>
<td>1,01</td>
</tr>
<tr>
<td>5. Textile</td>
<td>1,55</td>
<td>2,76</td>
<td>2,59</td>
</tr>
<tr>
<td>6. Hygienic</td>
<td>1,45</td>
<td>3,69</td>
<td>4,32</td>
</tr>
<tr>
<td>7. Plastic</td>
<td>9,38</td>
<td>14,88</td>
<td>13,70</td>
</tr>
<tr>
<td>8. Combustible</td>
<td>2,78</td>
<td>1,94</td>
<td>2,30</td>
</tr>
<tr>
<td>9. Glass</td>
<td>3,96</td>
<td>3,63</td>
<td>4,83</td>
</tr>
<tr>
<td>10. Metal</td>
<td>1,49</td>
<td>3,48</td>
<td>1,86</td>
</tr>
<tr>
<td>11. Non combustible</td>
<td>8,42</td>
<td>2,01</td>
<td>4,52</td>
</tr>
<tr>
<td>12. Hazardous</td>
<td>1,25</td>
<td>1,00</td>
<td>1,17</td>
</tr>
<tr>
<td>&lt; 20 mm</td>
<td>27,08</td>
<td>22,07</td>
<td>24,80</td>
</tr>
</tbody>
</table>
Date of analysis: 27 Sept 2011.
Place of analysis: Csernely
Origin of sample in the case of Csernely: from randomly chosen households

It can be seen that the waste of Csernely contains less combustible part and more fine fraction and non combustible, than the waste of Szuhá. Table 1 shows that the ratio of packaging material (plastic) is significantly less than in Szuhá, the non combustible (predominantly demolition waste, detritus) exceeds the values of reference small town. We should take in account this differences by the estimation of yield of high caloric values fraction.

4. Combustion technical properties

During an earlier experiment the high caloric value fraction of MBT and it’s mixture with woodchips and paper were used to produce pellet (diameter: 14 mm) for heating by the Vertikál Zrt’s flat die pelletiser [7].

Regarding to its elastic behaviour the waste had to be run over the technology twice in order to receive pellets with proper strengths. The main combustion technical properties are shown in Table 2.
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Figure 6: Pelleting plant technology in Polgárdi [6]

Table 2

<table>
<thead>
<tr>
<th>Pellet composition</th>
<th>Water</th>
<th>Ash</th>
<th>Volatile</th>
<th>C</th>
<th>H</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated MSW</td>
<td>15.33</td>
<td>12.88</td>
<td>63.55</td>
<td>60.09</td>
<td>7.47</td>
<td>0.96</td>
</tr>
<tr>
<td>Treated MSW and wood</td>
<td>16.16</td>
<td>12.84</td>
<td>61.55</td>
<td>55.50</td>
<td>7.10</td>
<td>0.78</td>
</tr>
<tr>
<td>Treated MSW and paper</td>
<td>13.81</td>
<td>13.56</td>
<td>57.60</td>
<td>53.50</td>
<td>6.97</td>
<td>0.94</td>
</tr>
</tbody>
</table>

The measured data during combustion experiments are shown in Table 3. (FLEXICO HUNGARY Halmaj Kft., 40 kW heating power, regulation by frequency modulator, screw fed pellet furnace).

Table 3

<table>
<thead>
<tr>
<th>Pellet composition</th>
<th>Treated MSW</th>
<th>Treated MSW and wood</th>
<th>Treated MSW and paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{max}$ [°C]</td>
<td>1024</td>
<td>920</td>
<td>985</td>
</tr>
<tr>
<td>CO [ppm]</td>
<td>628</td>
<td>595</td>
<td>605</td>
</tr>
<tr>
<td>CO$_2$ [% v/v]</td>
<td>13.8</td>
<td>12.4</td>
<td>12.8</td>
</tr>
<tr>
<td>O$_2$ [% v/v]</td>
<td>8.8</td>
<td>9.6</td>
<td>9.2</td>
</tr>
<tr>
<td>NO$_x$ [ppm]</td>
<td>680</td>
<td>567</td>
<td>590</td>
</tr>
<tr>
<td>[kJ/kg]</td>
<td>19 622</td>
<td>16 533</td>
<td>19 062</td>
</tr>
</tbody>
</table>
On the grounds of Table 3 we can consider the CO value was significantly under the for wood heating enabled value, NOX content was higher with an order of magnitude compared to standard pellet combustion. MSW pellet has odour after long time storage, so it is not recommended to distribute as public fuel. It can be used close to the place of production for heat energy supply of small town.

5. Summary

It can be seen that the waste of Csernely contains less combustible part and more fine fraction and non combustible as the waste of Szuha. Table 1 shows, that the ratio of packaging material (plastic) is significantly less than in Szuha, the non combustible (predominantly demolition waste, detritus) exceeds the values of reference small town. We should take in account this differences by the estimation of yield of high caloric values fraction.

It can be declared based on the measured data that it would be rewarding in the future to collect the waste possibly together with other small towns if possible. This waste can be suitable for heating purposes with a proper furnace after treatment. It would be possible to produce heat with a proper furnace after treatment. So could be new workplaces established, but the planning of this system requires further examination. By the estimation of yearly amount of high caloric value product the low combustible content of MSW compared to reference small town should be take in account. It is necessary to carry out a winter waste analysis, due to fluctuation and seasonality of composition. It is possible to produce combustible RDF from MSW. The economic safe and ecologically friendly pellet production requires further research activity.

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REFERENCES