Power and Energy Production from Waste and Biomass

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Abstract: - The paper presents the power and thermal energy production from burning waste and biomass. There were presented the actual results, for our country, concerning the conversion of wood waste into energy, regarding combustion efficiency and economic issues, considering the economic potential and environmental effects combined with the social one. There were considered low thermal powers, for a house heating and high thermal powers for residential district heating. The heating systems and the energy price represent a sensitive sector of the energy consumers’.

Key-Words: Biomass, Waste, Renewable energy, Power plant.

1 Introduction

The thermal and electric energy production with low prices is nowadays a challenge for the researchers, as well as for the producers. Conventional energy sources based on oil, coal and natural gas proved to be highly effective drivers for economic progress, but renewable energy sources such as biomass, waste, wind, solar or geothermal energy can also provide sustainable energy services. The use of renewable energy is expected to increase significantly motivated by the need to reduce fossil-fuel related to CO\textsubscript{2} emissions that contribute to the greenhouse effect, as well as by the decreasing reserves of these fossil-fuels. Biomass will be the most important source of renewable energy, as it is, not only suitable as fuel electricity generation, but also as the only source of renewable carbon. Romania has a rich forest capital totaling approximately over 6000 thousands hectares of forest, which means about 27% of the national territory.

To each European inhabitant correspond approximately 0.3 hectares of forest. With 0.28 hectares per inhabitant, Romania is under the European average. Economically and ecologically speaking, the branches resulted from cutting down the wood cannot be left in the forest and as well as the sawdust from the power saw, whose waste dumping contributes to water’s pollution. A quantity equal to 3245 mil.\textsuperscript{3}/year (in 2010) will result from the first wood processing, out of which about 0.440 mil.\textsuperscript{3}/year (13.5%) will turn to fire wood for inhabitants, this being useless and unprofitable because the rest of 2,805 mil.\textsuperscript{3}/year (86.5%) is practically thrown and causes important surroundings damages. Nowadays, in Romania, as in most countries of European Union, it is noticed a continuous reduction in using wood in private households for heating stoves. Unfortunately, the wood which costs about 20 Euro per metric tone (depending on its quality) is replaced by expensive fuels, first of all, by natural gas, but also by petroleum and liquid fuels. The final price will include VAT and transport charges [3].

2 Burning Wood Equipments

From wood waste it is possible to produce:
- Thermal energy for a household or an institution or business building.
- Thermal energy for a community, if the length of the thermal agent distribution network is small enough to limit the investment.
- Electric power up to 1-2 MW power for local use or for sale.

By turning the wood waste into sliver the price will rise with about 20%. Another way of using small wood waste is to turn them to briquettes or pellets. The pellets with maximum dimensions of 12 mm are made from sawdust.

The wood waste pellets can be used together with agricultural biomass pellets to feed the boilers previously tested for this purpose. From the point of view of their construction, the principal types of combustion equipment for wood waste are the following:
- boilers of low thermal power with direct combustion ($P_t \leq 70kW$)
- gasifying boilers of low thermal power with two stages of combustion ($P_t \leq 70kW$)
- boilers of average thermal power with direct combustion ($P_t = 70-170kW$)
- automatic boilers of high thermal power ($P_t \geq 170kW$).

In Fig. 1 it is presented a boiler of low thermal power with manual charging and direct combustion and fire grate. Depending on the construction of the fire grate, it is necessary to determine the size of solid fuel. It is possible to burn also a mixture of wood and coal or even agriculture waste. Manual charging takes place 4 to 6 times a day.

![Fig. 1: The boiler of low thermal power.](image1)

In Fig. 2 it is presented a gasifying boiler. This kind of gasifier is equipped with an air current channel for the superior combustion chamber where the combustion gas reduces on the lives embers bed formed at the lower part of the combustion chamber [2], [3]. The main gases resulted are: CO, H$_2$, CH$_4$ and N$_2$.

The combustion gases produced burn in the inferior combustion chamber with the air current from the secondary channel. Both combustion chambers are equipped with fire clay. So, it results a complete combustion with low ash content and low polluting emissions [5].

![Fig. 2: The gasifying boiler.](image2)

The disadvantage of this boiler consist in the growth of the boiler’s mass and the difficulties in turning it on, when it is first necessary to realize the live embers bed and then actually start the boiler.

In Fig. 3 it is presented a power plant with boiler of high thermal power and automatic fire grate. The environmental protection elements are indicated as well. The average or high thermal power boilers have the fire grate placed at the bottom. The combustible matter, like wood slivers or any other wooden or agricultural biomass, brought at the size requested by the feeding system, is introduced.

![Fig. 3: The power plant with boiler of high thermal power.](image3)
directly on the grate of the combustion chamber. As presented above, the combustion system of these categories of combustible met in district boilers, make use of the most usual fire grates, like slope/stride grate and rolling chain grate. In both cases, the air current is introduced under the grate and then goes upward through the grate’s slits and combustible layer. It is important to specify that when sawdust is burning, the way of feeding the fire is completely different from the other wood waste. The sawdust can be continuously introduced at the bottom of the furnace (using a worm gear feeder). The sawdust is drawn by the adequate insufflated air from the admission area into the combustion area. As a rule, the primary air current is insufflated exactly in the admission area of the sawdust in the furnace and the secondary air current from the middle of the furnace upward. So, the admission area of the sawdust is usually bordered by an air box with several admissions channels of the primary air.

A first efficient revaluation of the wood waste could be achieved by giving up burning the waste in stoves, which have a very low efficiency and by bringing it in steam generating stations using this combustible matters for heating households and public institutions, agricultural farms or business buildings.

The thermal power of such a heat station is between 30–170 kW. The investment for a 30 kW heat station, with all the necessary auxiliary equipment is about 3000 Euro, including the chimney. In addition to this are the investments for an adequate depositing of solid fuel and for the central heating elements, including the distribution network pipes. The gasifying boilers involve for starting and working, complex operating works which need special trained staff. When the electric power generation from wood waste is also estimated, the whole system will be equipped with an eolian turbine and with photoelectric cells. During summer time the boiler could be stopped and warm water would be produced by solar panels [1], [6].

The increase of electric power entails upon the gas generation and internal combustion engine system or steam generator and steam turbine system. For the power stations of average and high thermal power the investments could be placed between (0.33÷0.45) mil. Euro/MWt. The setting up of a high thermal capacity power station has to consider a special grouping of the users to decrease the investments for the thermal agent distribution network pipes. At power levels over 6 kWt, electric power generation may also be considered [4].

### 3 The Characteristics of Waste

For a better evaluation of the necessary equipment for burning or some other use of wood waste, it is necessary to know the physical and chemical composition.

In Tab.1 are presented the most important energetical characteristics of the wood waste.

<table>
<thead>
<tr>
<th>Wood waste</th>
<th>Ash, %</th>
<th>Moisture content, %</th>
<th>Low heat value, MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawdust</td>
<td>0.1-0.4</td>
<td>40-50</td>
<td>8.4-10</td>
</tr>
<tr>
<td>Bark</td>
<td>0.5-0.7</td>
<td>15-75</td>
<td>3-17</td>
</tr>
</tbody>
</table>

The physical composition of waste includes also:
- the density of waste
- the moisture(humidity) content.

The wood waste density depends of geographic place, season and stoking lasting. The moisture content of wood waste expresses usually like moisture mass per mass unit of dry or wet material. The method of measuring the wet mass expresses the moisture of sample like percentage of the wet material mass, but the dry mass method expresses the wet of sample like percentage of the dry material mass.

The moisture content is expressed in the equation below

\[
W[\%] = \frac{a - b}{a} \times 100
\]

where:
- \(W\) - the moisture content,
- \(a\) - the initial sample mass,
- \(b\) - the sample mass after drying process.

The knowledges about chemical composition of solid waste are important for the evaluation of alternative processes or recuperation options. If the wood waste are used as combustible the most important properties are:
- the elemental initial state analysis,
- moisture (105°C/h loss),
- the volatile matters (supplementary loss when heating at 950°C),
- mineral noncombustible mass or ash (after combustion residue),
- fix coal (the coke combustible substance),
- the temperature of ash fusion,
- the anhydrous state composition: C (carbon), O (oxygen), H (hydrogen), N (nitrogen), S (sulphur), A (ash),
- low heat value,
- organic chlorine.
The typical inactive residue and energetic values of wood waste may be converted as follows:

\[
\frac{kJ}{\text{kg(dry basis ash)}} = \frac{kJ}{\text{kg(thrown out residue)}} \left( \frac{100}{100-\% \text{ash} - \% \text{humidity}} \right)
\]

(2)

The experiments were made with a mixture of wood shavings and sawdust from beech and fir which proofs had the density of 100g/cm³. There were two proofs dried for two weeks in the laboratory and tested after. The results of the test are shown in the Tab. 2, the elemental technical analysis of wood waste [7].

Tab. 2: The results of the test.

<table>
<thead>
<tr>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essence of wood</td>
<td>beech + fir</td>
</tr>
<tr>
<td>Ash</td>
<td>1.66%</td>
</tr>
<tr>
<td>Humidity</td>
<td>7.23%</td>
</tr>
<tr>
<td>Volatile matters</td>
<td>73.60%</td>
</tr>
<tr>
<td>Carbonic residue</td>
<td>19.17%</td>
</tr>
</tbody>
</table>

The chemical analysis of that mixture was:

\[ C_i = 46\% , \quad H_i = 6\% , \quad O_i = 38\% , \quad N_i = 0.3\% , \quad W_i = 8\% , \quad A_i = 1.7\% \]

The low heat value was: \( Q = 15791 \text{kJ/kg} \).

4 Conclusions

The wood waste is recommended to be used for production of energy because it could represent a combustible substitute of fossil-fuels especially in the small communities and district area plants.

The cost of thermal energy produced by a plant with the thermal power of 5MW and the maintenance costs could rise to 60lei/Gcal.

References