ROUMANIAN ACHIEVEMENTS IN BIOMASS COMBUSTION FOR ENERGY PURPOSES

Ionel PÎŞĂ, Lucian MIHĂESCU , Prisecaru TUDOR, Gabriel NEGREANU

UNIVERSITY POLITEHNICA OF BUCHAREST, Romania.

Rezumat. Lucrarea prezintă unele cercetări şi realizări româneşti referitoare la obţinerea de energie din arderea biomasei lemnoase şi agricole. De asemenea sunt prezentate tehnicile de ardere a biomase şi principalele tipuri de cazane (($\leq$ 1 MW_t)) pentru încălzirea rezidenţială şi districtuală. Au fost cuantificate, prin coroziune, influenţa arderii biomasei asupra transferului de căldură şi a impactului asupra mediului.
Cuvinte cheie: biomasă, ardere, coroziune, instalaţii.

Abstract. The paper presents some Romanian researches and achievements regarding wood and agricultural biomass energy conversion. Also, it's presented the combustion techniques of biomass and the main type of boilers ($\leq$ 1 MW_t) for residential and district heating. It was quantified the influence of the biomass combustion, by corrosion, against the transfer heating surfaces and the impact to the environment.
Keywords: biomass, combustion, corrosion, fuel supply installation.

1. INTRODUCTION

According to environmental rules and regulations, the biomass is perceived as a carbon dioxide emitter, during combustion only the recently fixed carbon being delivered in atmosphere. The use of unconventional fuels for heat and electricity is a constant goal for the experts working in the energy domain. Moreover, in order to reduce the advantage of natural gas combustion technology, a lot of improvements have been made to the fuel supply installations of small and medium size boilers burning solid biomass.

The most attractive biomass wastes for combustion technologies are those resulted from forestry and agriculture, according to their qualities (physic and chemical characteristics, low calorific value) and available quantities. The present paper is focused on wooden and agricultural biomass combustion in order to obtain heat for residential heating and hot water preparation. In Romania are available some quantities of biomass for energy purposes, presented bellow:

- Straw (from wheat, rye, barley, etc.) ....3,000,000 t/year;
- Corn stalk…………..…..14,000,000 t/year;
- Sunflower stalk............................1,500,000 t/year;
- Wooden wastes (sawdust, chips, bark)……………..14,000,000 m^3/year.

In the last decade, several low and medium size biomass boilers have been conceived and designed in Romania, harmonizing the existent international concepts with specific national fuel characteristics. These boilers provide hot water to residential buildings (individual houses and blocks of flats), greenhouses, workshops and small administrative and commercial buildings, both in gravitational circulating system and pumped one. In the furnace are burned different biomass fuels such as sawdust, wood chips with humidity lower than 40 %, and agricultural waste (straw, corn stalks). Next step is to obtain steam, in order to expand it in a steam turbine/generator unit and generate electricity supported by the green certificate mechanism.

2. BOILER DESCRIPTION

The unit is a steel welded construction made from two different subsystems: the furnace and the heat exchanger, connected additionally to the fuel supply and control system. In order to clean the internal surfaces and extract large pieces of slag or unburned material, the furnace is provided with an operational door. The horizontal (or vertical) heat exchanger is composed of iron tubes immersed in water, and connected to the two tubular plates that confine the smoke rooms. According to the desired thermal output and overall efficiency, the iron tubes can be disposed on 1, 2, or 3 flowing paths, for the heat transfer improvement. On the interior, the furnace is padded with refractory bricks, while its exterior is insulated with refractory cement and glass wool then covered with painted steel sheets. Outside is installed the ash container.

In figure 1 are presented the main components of the biomass boiler:

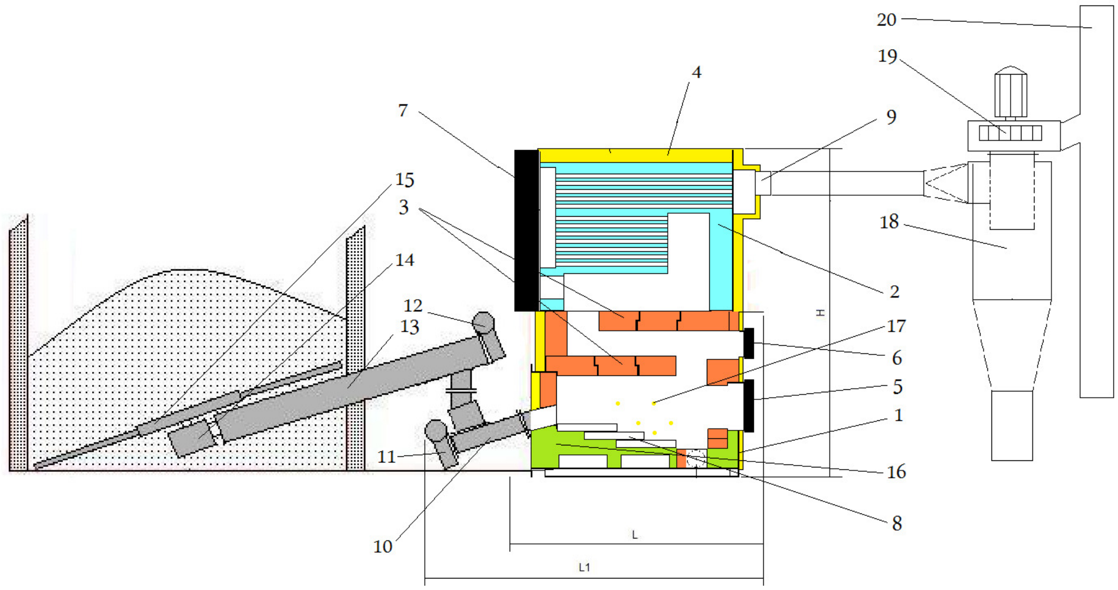

Fig. 1. Main parts of the biomas boiler

1- furnace; 2- heat exchanger; 3- double vault of refractory cement; 4- wool glass insulation; 5- door for grate cleaning; 6- door for vault cleaning; 7- door for heat exchanger cleaning; 8- mobile grate; 9- flue gasses exhaust;10- worm-screw supplier; 11- first motor-gear transmission; 12- second motor-gear transmission; 13- worm-screw supplier from the storage; 14- reducing extractor; 15- pan extractor; 16- primary air; 17- secondary air; 18- flue gasses cleaning cyclone; 19- flue gasses fan; 20- chimney.

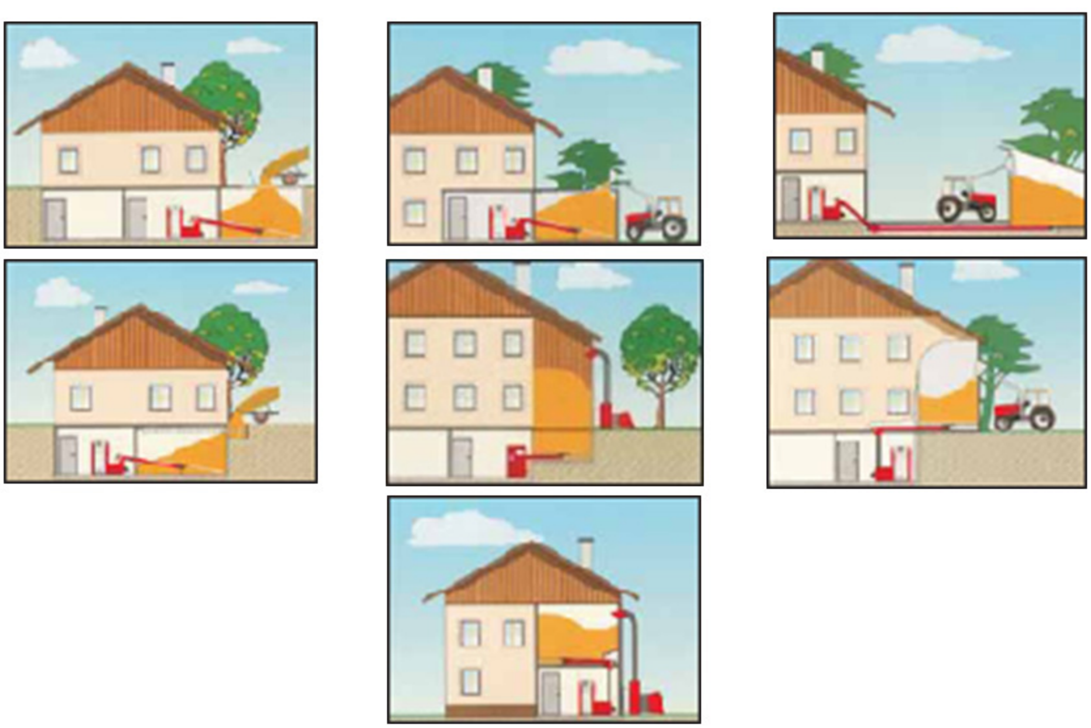

Fig. 2. Different locations of the biomass storage

Inside the furnace is placed the mobile grate, made from high temperature resistant iron and powered by a motor-gear trough a rack-cogwheel system. The fuel is handled by a worm-screw supplier powered also by a motor-gear transmission (there are a different system for straw and sawdust, for example). During combustion, the necessary air is taken from the fan and conducted to the furnace by means of control valves, in order to ensure the needed air excess coefficient. An effective safety device is represented by a thermostatic valve connected to the pressurized water network, that automatically opens when the temperature increase at the bottom of the worm-screw supplier, even in the absence of the power source. The main electric panel of the boiler contains the switches for the motors and all the protections in use. In figure 2 are shown some installing oportunities for the fuel storage.

3. BOILER AUTOMATIC OPERATION

Adapting the boiler for automatic operation refers especially to the fuel an air supply, according to desired thermal output. For the fuel supply, the worm-screw supplier is needed. Its efficiency is related to external diameter, channel length and height. All these dimensions are correlated to the quality of the fuel and the mass-flow required by the thermal output. When the worm-screw supplier is blocked by the pieces of biomass, the protection stops the motor-gear transmission and alerts the operator to open the door and extract these pieces.

Fig. 3. View of an air distribution box

Concerning the air intake, this operation is done by the distribution box. Primary air is blow under the grate (with cooling role too), while the secondary air cools the furnace and ensure the volatile combustion. If needed, tertiary air is injected, for cooling purposes. In figure 3 is presented an air distribution box installed on the boiler. Next step is to redesign the distribution box in order to introduce the air in the furnace in fractions, for reducing NO_x emissions.

volatilization and condensation reactions are significant in the process of biomass co-firing;

The control of hot water temperature is fully automatic and is performed by the control system placed in the electric control panel. The fuel mass-flow rate is not constant ad depends on fuel granulation, humidity, and the required thermal power. When the temperature achieves the desired value, the control system stops the air fan, decreasing the air injection.

The combustion is inhibited, thus the thermal output decreases too. In consequence, the water temperature diminishes, and a thermocouple starts the air fan. Then, the combustion reappears. This discontinuous mode of control ensures an optimal combustion, and rational fuel consumption, in the range of 30…100 % thermal outputs. The whole chain fuel-air-flue gasses-hot water-ash disposal is automatic controlled. The main performances of these boilers type are:

- Net efficiency ……………..….83 – 87 %;
- Heat release rate per unit furnace area…………………....450 – 600 kW/m^2;
- Allowable heat release rate……………...……..300 – 400 kW/m^3;
- Excess air ratio (end of furnace)…………………..…..…1.3 – 1.5;
- Flame temperature ……..…. 650 – 780 °C;
- Lower heating value…………………...…14 – 18 MJ/kg;
- Heat loss with unburned carbon ………………………..0.5 – 1.5 %;
- Automation level …………….95 – 100 %;
- CO concentration (at O_2 = 7%)……………………..1200 - 1800 ppm;
- SO_2 concentration (at O_2 = 7%)……….……………...……5 - 10 ppm;
- NO_x concentration (at O_2 = 7%)……………………...……25 - 40 ppm.

4. INFLUENCE OF BIOMASS COMBUSTION ON THE BOILER RELIABILITY

The behaviour at high temperatures and the chemistry of resulted ash for biomass combustion are major problems to be considered in designing and operating energy equipment. The results of experimental researches have revealed that type of fuels are the main parameters that contribute to aerosol formation during biomass combustion, aerosols that have a substantial contribution in ash deposits formation and corrosion development. The high content of chlorine and alkaline metals from agricultural biomass (particularly wheat straw) suggests that the deposits formations by

The high content of silicon dioxide (SiO_2) and low calcium (Ca) determined in the ashes, along with a lower content of potassium (K) contributed to the lack of occurrence of the phenomenon of agglomeration/melting, as confirmed by the temperature values of low fusion of ash. Experimental research results indicate synergism between oxidation process and alkali compounds of ash from biomass, an effect that helps in case of lower temperature of combustion to the appearance of corrosive processes. Temperatures developed in the process proved to be too small for the formation of protective oxide layers on metal surface but large enough to release alkali metals. This shows that the process of volatilization, condensation and nucleus of the alkali in biomass combustion is inevitable. When burning biomass it's possible to generate sodium or potassium chloride. These products have a strong corrosive impact on the furnace or on the iron tubes. Moreover, at straw combustion, the hot slag is settling on the grate's bars, even if the grate has a self-cleaning mechanism. In order to maintain in operation a constant value of the overall heat transfer coefficient, several technical measures have been promoted.

5. CONCLUSIONS

In order to ensure a constant fuel supply, the most recent biomass boilers are equipped with a worm-screw supplier, electronically controlled by the measured oxygen value in the flue gasses. In such manner, the fuel mass-flow rate is automatically adjusted;

The oxygen percentage is controlled bi means of the same transducer as the case of the sequential fuelling boilers. The amount of biomass is also controlled stopping and the starting the worm-screw;

The main goal is to maintain a constant concentration of oxygen in the flue gasses of 7%;

Using this automatic control of the combustion, the boiler efficiency increase with 5 – 10 %. In these conditions, the CO fraction also diminishes, and the smoke at the chimney exhaust is less visible;

The impact of the biomass combustion on the internal surfaces of the boiler is more significant than the coal combustion. Large quantities of tar and slag are deposing on the grate and on the refractory internal surface of the furnace. Thus, frequent cleaning actions should be manually performed.

REFERENCES

[1] C., Rădulescu, Gh., Lăzăroiu, I., Pîşă, ş.a. -*Resehes on the Negative Effects Asseessment (Slugging, Clogging, Ash Deposits) Developed at the Biomass-Coal Co-Firing.* Enviromental Engineering and Management, Vol. 9, No.1, January/February 2010, pg. 17-25 (2010)

[2] I., Pîşă, C., Rădulescu, Gh., Lăzăroiu, G., Negreanu -*The Evaluation of Corrosive Effects in Co-Firing Process of Biomass and Coal*. Environmental Engineering and Management Journal, Vol.8, No.6, November/Decembre 2009, pg. 1485-1490 (2009).

[3] N., Antonescu., R., Polizu -*Valorificarea energetică a deşeurilor*. Editura Tehnică, Bucureşti, 352 pag.(1988)