GASIFICATION EXPERIMENTS ON HERBACEOUS BIOMASS

P. Tóvári[1] and V. Madár[2]

[1] Hungarian Institute of Agricultural Engineering
Tessedik Sámuel u. 4., Gödöllő, H-2100, Hungary
Tel.: +36 28 511-611; E-mail: tovari@fvmmi.hu

[2] Termo-Energo-System Ltd
Tamási Áron u. 3., Vásárosnamény, H-4800, Hungary
Tel.: +36 45 570 192; E-mail: madar.viktor@gek.szie.hu

Abstract: Due to the large amount of fuel present in the gasification device and to the complex and sudden reactions it is difficult to monitor the processes taking place in the device with measurement methods. For this reason a laboratory measurement system had to be developed to promote the modeling of the chosen, examined herbaceous and woody biomass fuels' gasification and oxidation processes.

Keywords: Biomass conversion, gasification, pyrolysis

INTRODUCTION

The utilization of biomass gasification and the internal combustion engine in decentralized combined heat- and power plants is a good solution. On lower performance levels better efficiency and electricity/heat ratio characterize these plants, in contrast to other, combustion based, combined heat- and power generating technologies. Small scale combined heat- and power biomass gasification plants have high specific electric output, while the specific heat output is low. Therefore this technology offers a good base to promote the process of developing the Hungarian biomass based gasification model.

Several experimental devices can be found in specialized literature which can be used to conduct pyrolisis experiments both among service of close-to-service conditions, but in most occasions these solutions are relatively costly. Whereas only a limited amount of information can be found in specialized literature on the application of herbaceous fuels, a laboratory measurement system had to be developed in order to measure parameters of these materials in connection with ash melting temperature and slag formation, since these phenomenons has major importance regarding the gasification device's lifetime.

METHOD

After revising the specialized literature and the available measurement data the following developments were made on the measurement system in order to decrease the uncertainty of the measurement.

Our goals:

- Adjustable reactor heating
- Application of highly stable scale
- Calibrated temperature and mass sensing
- Model scale measurements (20-30g)
- In order to promote constant measurement
    - the fuel feeding and the removal of leftovers must be solved
    - the scale's measurement range must ensure two or three measurements without disassembling the furnace
- Cost-effective measurement system

Temperature values rising in gasifiers can be found in the specialized literature. For this reason a device with automatic control with widely variable discreet range was needed

Another aspect of the planning process was to create inert atmosphere in the reactor space, so the reaction can take place in Nitrogen atmosphere. For this reason Nitrogen input had to be fashioned. In order to promote even gas distribution and reliability double gas input had to be established, in this way the appropriate amount of nitrogen can be ensured both around the Nitrogen input and the reaction space. Meanwhile the reactor space's appropriate sealing had to be established in order to keep ambient air out of the reactor.

An essential parameter measured is the fuel consumption, so a scale had to be designed which is able to register data even during thermal load.

Last but not least to promote reliable measurements the fuel's fast and sudden filling must be ensured.

With the help of the measurement system we managed to realize the goals drafted above:

- The furnace is supplied with calibrated digital temperature regulator.
- The scale is also calibrated and placed outside the furnace, to prevent thermal load, while it is not suspended, which promotes more stable operation.
- Optimal volume of the furnace (9l) promotes homogenous temperature and nitrogen distribution and small scale measurements.
- With the modification of the furnace door the removal of the samples can be done continuously, safely, and in an airtight way, and with the help of the cooler the gasification of the samples before measurements can be prevented.

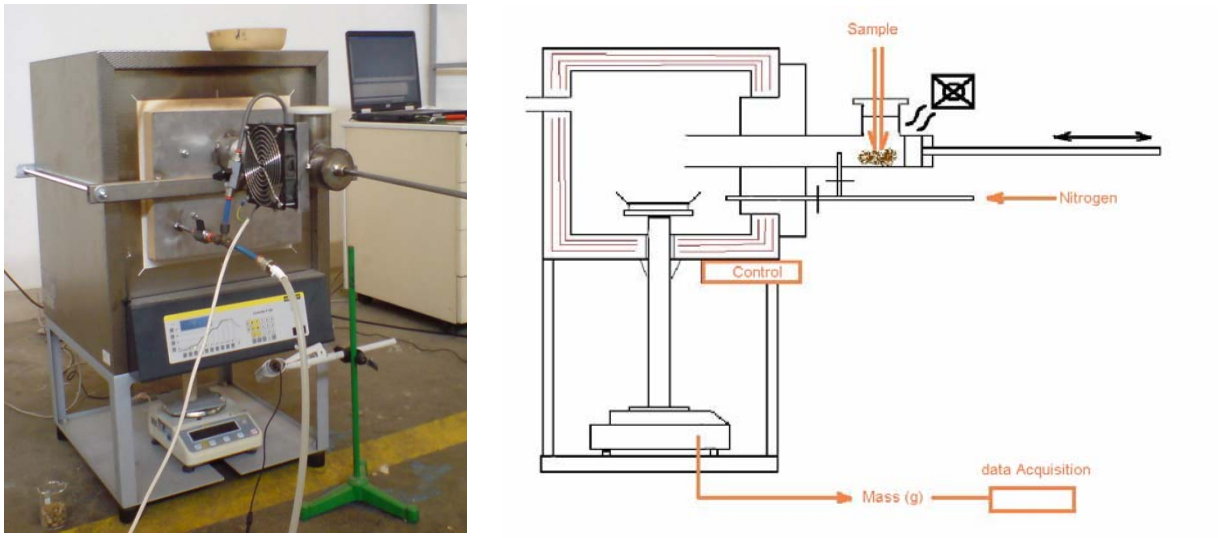

Fig. 1.: Measurement system design

Measurement steps:

1. The heat resistant porcelain must be placed on the scale tray. Discharge of the scale rods must be checked, and the door must be installed. Load on the scale rods must be relieved,
2. The furnace must be heated until the given temperature, the fuel feeding system must be cooled,
3. After reaching the set temperature the Nitrogen feeding must be set,
4. The scale must be reset to zero,
5. The data collector must be started,
6. Insert sample,
7. Recording data until reaching constant mass,
8. The scale must be tared. This step must be repeated,
9. Furnace cooling,
10. Sampling, placing it into the desiccators,

The measurement system was developed for two reasons:
1. To identify the chosen fuels' behavior and their ability to be gasified.
2. To identify the pyrolysis time needed by the examined fuels, to promote sizing of the technology.

During listing the examined fuels the domestic potentials was kept in view, while we choose both woody and herbaceous materials as well. According to these the following fuels were examined:

Mixed woodchips
Pine woodchips
Corn pellet
Straw pellet
Agripellet

RESULTS

The measurements were done on three temperatures (400, 600 and 900°C) and at least two occasions each. We choose these temperature values because according to the specialized literature and technical parameters these temperatures are optimal. 400°C is the average value of the first temperature range, where the drying process takes place and most of the volatile compounds leave the material. 600°C is optimal due to energetic reasons, since volatile compounds keep vaporizing on this temperature while it is high enough to ensure the absolute completion of the thermo chemical processes. In this way the heat requirement of the whole gasification system can be decreased, which increases the economic efficiency of the whole system. The temperature of 900°C was analyzed because according to the specialized literature the thermo chemical reactions and the composition of the gas created brought around the best results around this value.

An additional goal of the measurement series is to determine whether the single-staged or the multi-staged systems are able to gasify herbaceous fuels.

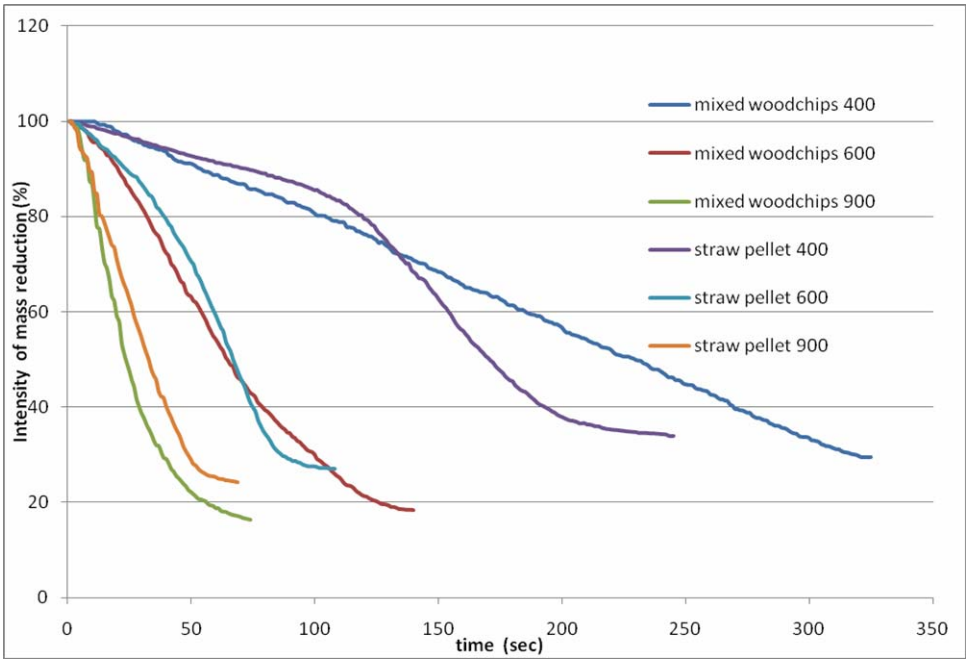

Fig. 2.: Change of pyrolysis time according to temperature

As we can see in figure 2 the time needed by the pyrolysis process to complete decreases independently of the fuel type on increasing temperatures. We experimented with all examined fuel materials, but we only depict the results of the measurements on woodchips and straw pellet to make the figure understandable.

On 400°C mass constancy is established after 220-320 seconds. On 600°C the required decreased to around half of the previous value, while on 900°C pyrolysis time reached 1 minute minimum.

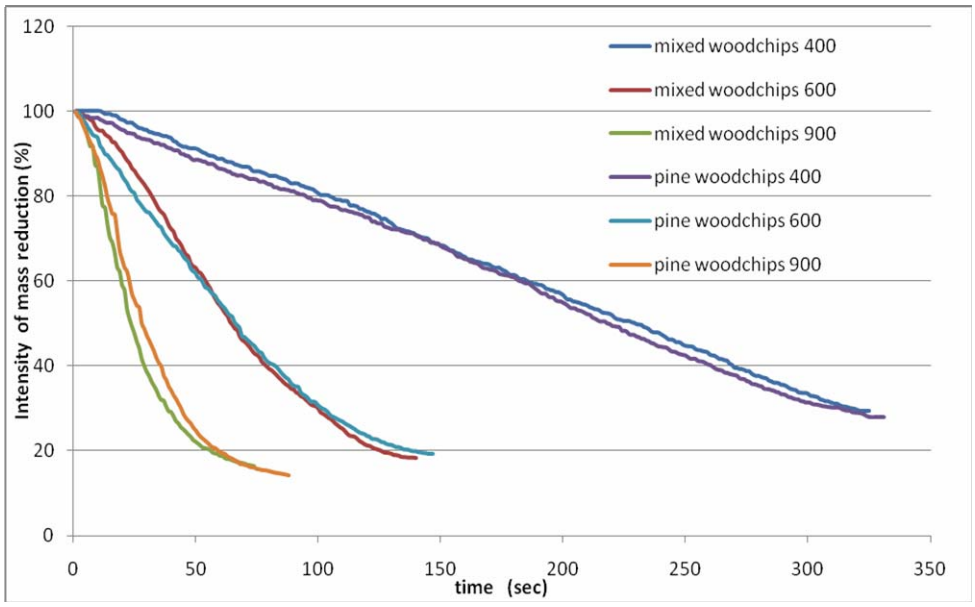

Fig. 3.: Comparing wood chips pyrolysis time

Based on the measurements no difference can be detected between the gasification intensity of the different type of wood materials, this means that the different woodchip types have almost the same pyrolysis intensity and time. The data collected indicates almost no difference between the analyzed wood types, see figure 3.

We analyzed how the pellet fuels' pyrolysis time relate to the wood chips' on the temperature value (400°C) resulting the biggest difference. For this reason we compared the four pellet fuels to the two wood chip fuels.

As we can see on figure 4 the pellets have similar behavior, which is independent from material type and the intensity of their pyrolysis is almost identical. The only significant difference is in case of the pyrolysis time of the pine pellet, since in this case the pyrolysis time is longer and the amount of residuals is less. The reason behind this might be the lower ash content of the pine pellet, since its ash content is only 1%, while in case of the other pellet this value is around 6-7%.

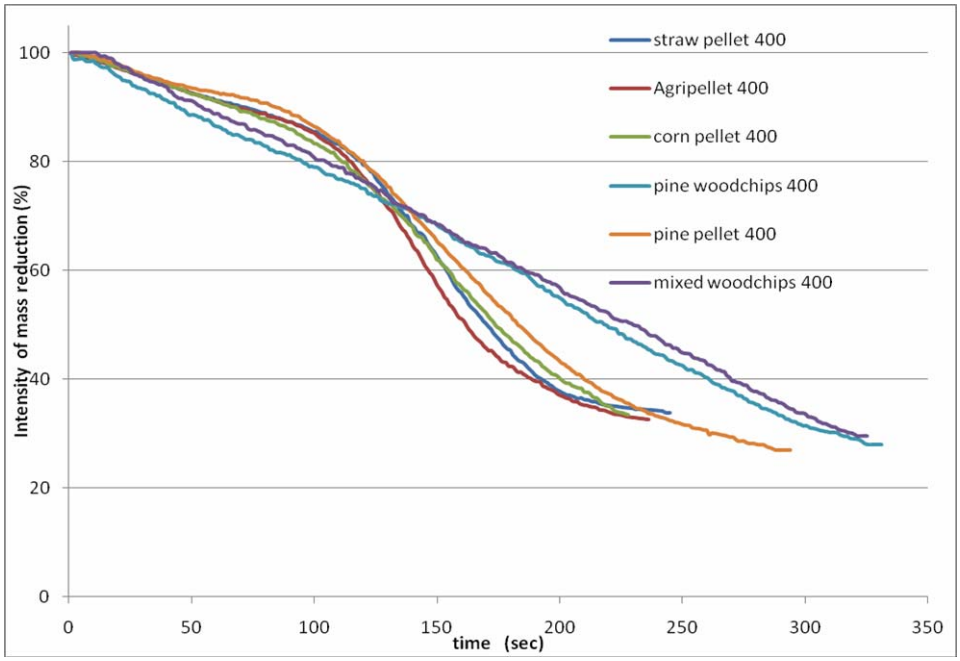

Fig. 4.: Comparison of the pyrolysis time of the pellets and chips on 400°C

So it can be stated that the gasification intensity of pellet fuels differ from chip fuels on 400°C, while the difference is independent of their base material.

Against this, as we can see on figure 5, the reactions taking place on 600°C and 900°C does not differ. Consequently the differences deriving from fuel improvement vanish around 700-800°C.

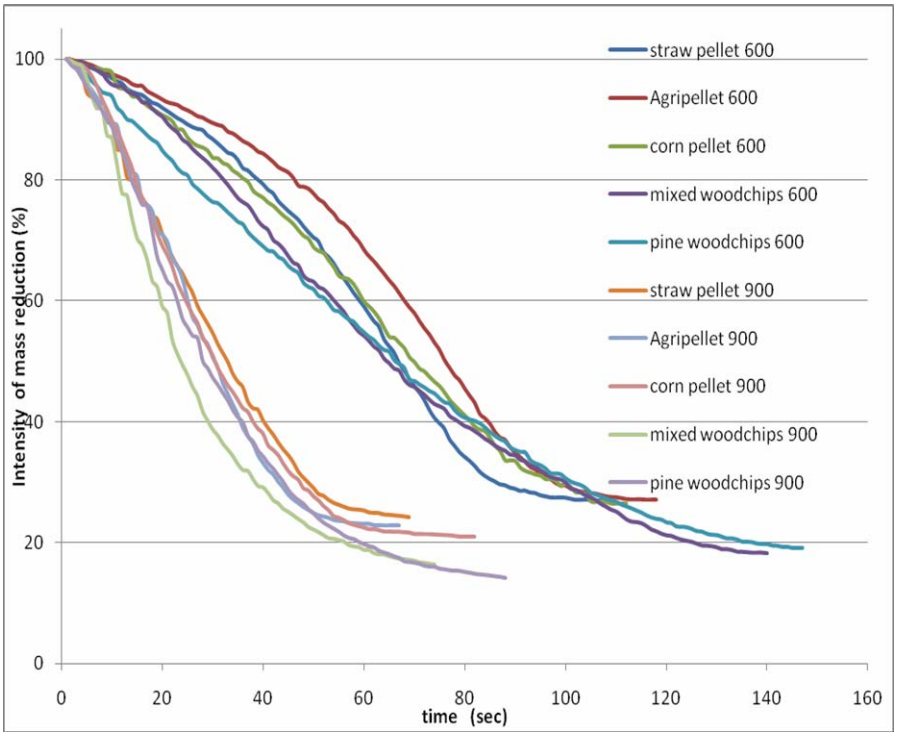

Fig. 5.: Comparison of chips and pellet fuel pyrolysis time on 600°C and 900°C

CONCLUSIONS

With increasing pyrolysis temperatures the amount of residuals decrease, that means the samples burn out more properly. On the lower temperature we experienced the highest residual content while analyzing the mixed wood chips. The reason behind this might be the significant amount of impurities present in this material due to the high bark content of the chips, which do not burn on 400°C.

Another explanation could be the temperature ranges of thermal decomposition of lignocelluloses, namely the lignin degrades intensively between 400°C and 500°C. These ranges can be found in the revision of the specialized literature.

In case of the experiments done on the highest temperature (900°C) the fuel with the highest ash content, namely the stray pellet, leaves the most residual behind.

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