FRI-9.3-1-THPE-10

RESEARCH REGARDING THE PYROLYSIS OF poultry WASTE AS AN ALTERNATIVE FOR ITS USE IN ENERGY PRODUCTION

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Abstract: *In the actual ecological conception, the poultry waste can be stored at carefully chosen distances so that the bad odors do not disturb human communities or commercial societies. From these storing facilities, the farmers can use the manure as fertilizer, especially for vegetables.*

Through surface water, but also by phreatic water from the soil, the pollution can be significant. In the paper the qualities of the chicken manure, in the form of elemental analysis and energy characteristics are presented. On the basis of these data, the possibility of its energy use emerges, either by pyrolysis or by direct burning.

From the point of view of combustion, the main impediments are the very high moisture and the low heat value. The data resulted from the research have application in taking the decision regarding the ecological possibility of combustion of the poultry wastedeposits, including a positive energy effect.

Keywords: *Chicken waste, Two stage pyrolysis, Energy balance.*

JEL Codes: *Q2, Q4, Q5*

INTRODUCTION

The avian farms generate very large quatities of waste, temporarely stored inside the farm and permanently stored in ecologicaly controlled storage facilities, partily by chosing of locations where the odours do not disturb and the waters to be as least possible affected.

A part of he stored waste is used as agricultural fertilizer, especially for vegetables culture. The unused part, which will grow in time, could reach incineration in function of the ecological requests.

The main incineration technologies are:

- direct burning with thermal support fuel;
- gaseification;
- pyrolysis.

The incineration, regardless of the used method, will lead to obtaining energy, the chosen technology being imposed by the multitude of its component elements, which are accessible in function of the quality of the waste.

From the presented techonologies, the research in this paper includes only the pyrolysis, which is considered to be the most accessible from the point of view of the feeding of the installation with the waste and with the final products that are ecological and easy to incinerate for energy production.

EXPOSITION

Particulars of poultry waste with respect to storage and to incineration

The avian waste is characterized by very high moisture and a reduced heat value. However, the high volatiles content permits aeasy ignition in a high temperature range, over 900°C - 950°C. The experimental research made have shown that there are sensible differences in the energy characteristics of the pure avian waste and the one deposited on a bed of solid combustible biomass of agricol essence, such as cereal straw, or of wooden origin such as shavings and sawdust. It is worth to be mentioned that the solid combustible biomass bed is in a range of 10%-15% mass content percentage.

The elemental analysis of the pure poultry waste, determined by tests made in our Department laboratory was characterized by the following limit values:

C^i = 8 - 16.4 %;
H^i = 4.2 - 5.2 %;
S_C^i = 1.4 - 1.7%;
O^i = 30.1 - 32.2 %;
N^i = 0.88 - 1.78 %;
A^i = 8 - 13.2 %;
W_t^i = 42.3 - 48 %;

The technical analysis comprised the following values range:

Fixed carbon - C_f^i = 4.6 - 12 %;
Volatiles - V^i = 28 - 32 %;
Ash - A^i = 8 - 13.2 %;
Total moisture - W_t^i = 42.3 - 48 %;

The "i" symbol indicates the reference to the initial state of the waste considered as fuel.

The lower heat value (LHV) is in the range:

H_i^i = 5000 - 6200 kJ/kg.

The Pyrolysis - An Applicable Technology For An Incineration Chain

The pyrolysis is obtained by the heating of the waste in the absence of air. The high temperature from the reactor space leads to the successive elimination of water, then of the volatile matter and then to the distraction of the organic links, finally resulting:

- combustible gas;
- coke or semi-coke;
- combustible oil.

All these components can be later used for energy production. In the figure 1 is presented the physical-chemical concept of the pyrolysis.

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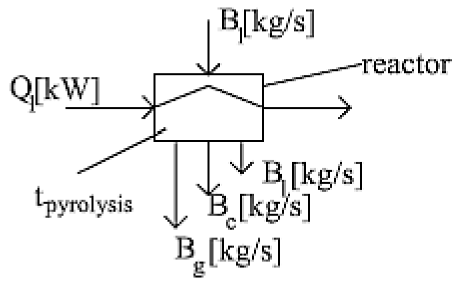

Fig. 1. The schema of the pyrolysis process

The quantity B_1 in kg/s of the material subjected to pyrolysis is heated from an external source with the value Q_1 in kW. A quantity of coke B_c, a quantity of combustible gas B_g and a quantity of liquid tar B_l result.

If the temperature in the reactor is 450-580°C, the pyrolysis leads the formation of semi-coke. For the temperature of 900-1050°C the solid product will be represented by coke. The difference between coke and semi-coke consists in the degree of volatilization, partial in the case of semi-coke formation and total at the coke formation.

In the semi-coke formation the light hydrocarbons and carbon oxide are released, the hydrogen elimination being made only by reaching the coking temperature.

The pyrolysis was chosen as a technically applicable solution, for this type of very moist and very sticky waste, with the final obtain of three components that are easy usable for energy.

The Q_1 heat is determined with relation:

$$Q_1 = B_1 \cdot (c \cdot \Delta t + Q_{vap})[\text{kW}], \qquad (1)$$

where c is the specific heat and Δt is the temperature increase from the initial value to that of the pyrolysis and Q_{vap} is the vaporization heat.

The quantity of coke can be determined theoretically with the relation:

$$B_c = B_1 \cdot (100 - W_t^i - V^i) \quad [\text{kg/s}], \qquad (2)$$

specifying that the coke has in its components the mineral mass also (the ash).

The quantity of gas can be approximated, for the final phase of the pyrolysis, by the relation:

$$B_g = B_1 \cdot \frac{V^i + W_t^i}{100} \quad [\text{kW}] \qquad (3)$$

The lower heat value of the coke can be determined, with an acceptable approximation, by the relation:

$$H_c = 30000 \cdot \frac{\left(100 - A^i\right)}{100} \quad [\text{kJ/kg}] \qquad (4)$$

considering that the combustible base of the coke is represented by the carbon.

The lower heat value of the produced combustible gas requires an analysis of its composition.

Due to its partial de-volatilization, the lower heat value of the semi-coke requires the determination in a laboratory.

Because the gas exhausted in the pyrolysis process is very moist (it contains also the moisture, making it thus unusable), the placement of a dryer before the pyrolysis reactor is recommended, the temperature in drying process not exceeding the 250ºC value. In this case, the temperature in the reactor is maintained in the same range 450-580 ºC.

In the figure 2 is presented the schema of the low temperature pyrolysis process with the dryer.

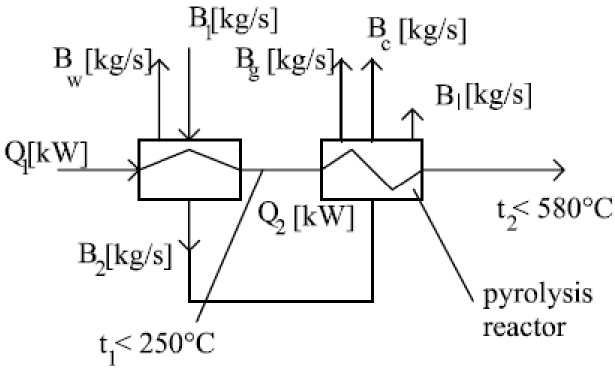

Fig. 2. The pyrolysis process with preceding drying

The heat for the drying process will be determined by the relation:

$$Q_1 = B_1 \cdot \left(c_1 \cdot \Delta t_1 + 2510 \cdot \frac{W_t^i}{100} \right) \quad [\text{kW}] \tag{5}$$

where: $\Delta t_1 = t_1 - t_i$; t_i is the initial temperature.

$$B_2 = B_1 \cdot (100 - W_t^i) \quad [\text{kg/s}] \tag{6}$$

$$B_W = B_1 \cdot W_t^i / 100 \quad [\text{kg/s}] \tag{7}$$

The resulting coke quantity respects the relation (2).

The quantity of fuel gas will be:

$$Bg = B1 \cdot Vi / 100 \quad [kg/s] \tag{8}$$

It is stated that the volatiles contained in the initial matter were not released during the drying phase.

The heat consumed for the pyrolysis:

$$Q2 = Bc \cdot c2 \cdot \Delta t2 \tag{9}$$

with

$$\Delta t_2 = t_2 - t_1 \tag{10}$$

A calculation regarding the energy efficiency for processing of mass unit of fuel indicates:

The specific heat consumed in the drying process was assimilated with that of the peat, a fuel that is similar to the avian waste:

$$c_1 = 0.01 \cdot W_t^i \cdot c_w + (1 - 0.01 \cdot W_t^i) \cdot c_c \ [\text{kJ/(kg·K)}], \tag{11}$$

where $c_c = 1.2$ for temperatures above 250 °C.

For an avian waste with $W_t^i = 40\ \%$ and $V^i = 27\ \%$, the result is:

$c_1 = 0.01 \cdot 40 \cdot 4.18 + (1 - 0.01 \cdot 40) \cdot 1.2 = 2.4$ [kJ/(kg·K)].

For $\Delta t_1 = 250 - 20 = 230$ °C, the result for the heat consumption for the dryer, with the considered mass flow rate $B_1 = 1$ kg/s, was the following:

$Q_1 = 2.4 \cdot 230 + 2510 \cdot 40/100 = 1550$ [kW].

The mass flow rate of waste entering the pyrolysis reactor will become:

$B_2 = 1 \cdot (100-40) = 0.6$ [kg/s].

The mass flow rate of combustible gas exhausted from the pyrolysis reactor:

$B_g = 0.6 \cdot 27/100 = 0.162$ [kg/s].

The solid mass flow rate of pyrolysed waste (the coke rate) will be:

$B_c = 1/100 \cdot (100 - 40 - 27) = 0.33$ [kg/s].

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The heat consumed for the pyrolysis based on the data:

$\Delta t_2 = t_2 - t_1 = 540 - 250 = 290$ °C.

$c_2 = 1.4$ [kJ/(kg·K)],

obtained from the case of the anhydrous peat at $t_m = 400$ °C:

$Q_2 = 0.33 \cdot 1.4 \cdot 290 = 134$ [kW].

For the entire pyrolysis process, the consumed heat will be:

$Q = Q_1 + Q_2 = 1550 + 134 = 1634$ [kW].

The heat produced by burning of the coke containing ash in the percentage $A^i = 7$ %, will be:

$Q_{coke} = B_c \cdot H_c = 0.33 \cdot 30000 \cdot (100 - 7)/100 = 9200$ [kW].

Even if the energy value of the resulting combustible gas is not considered, it is to be remarked that the value of the heat produced by the burning of the coke (semi-coke) is net superior to that consumed for the heating. It results that is technically and economically feasible to use the pyrolysis technology of the avian waste.

CONCLUSION

The paper continues a series of experiments and analyses regarding the application possibility of the pyrolysis as a technology of energy use of the avian waste.

The anterior experimental data were the foundation for the numerical application regarding the energy efficiency of the pyrolysis process.

The numerical application has evidently demonstrated the existence of an active thermal energy with respect to the consumptions imposed by the pyrolysis process.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Ministery of Research and Innovation, CCCDI-UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0404 /31PCCDI/2018 and 37BM PNIII-P3-199/2016-I05.16.01, within PNCDI III.

This work was supported by the project UPB: T-ME 16-17-01, financed by Elsaco Electronic.

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