HEATING BROILER HOUSES WITH THERMIC ENERGY FROM BIOMASS

E. Murad[1], N. Lungu[2], Georgeta Haraga[1], C. Sima[3]

[1]POLYTECHNICS University of Bucharest
[2]S.C. Crevedia S.A.; Crevedia, Ilfov county
[3]S.C. Marvior Expert SRL, Bucharest
e-mail: erolmurad@yahoo.com

Abstract

The paper analyzes an alternative to the heating of broiler houses with thermic energy produced thru thermo-chemical gasification of biomass available locally in cross-flow gasifier. Different types of heating installations will be studied using biomass from functional, energetic, automatic control as well as from economical and environmental point of view.

For the performance evaluation we have used a simulation program of the microclimate from the broiler houses on permanent layer CLIMPUI05, in which simulation modules of the thermal instalations with biomass were introduced. The comparation of the performances is made in a broiler house usually heated with hot air generators fed with diesel fuel.

The local biomass used in the process, having relatively low price, compete to the CO_2 emission reducing, and to the development of productive activities that increase the employment of rural population, being integrated into the concept of sustainable development of agriculture.

Key words: broiler house, heating, biomass, gasification

INTRODUCTION

Considering the desire of CO_2 emission reducing in the terrestrial atmosphere, the heating only with thermal energy produced from local minced or pellets biomass in the cold periods of the year was studied.

The current structure of the ventilation and heating systems of the broiler houses is well organized and relies on combustion of LPG or diesel in air heaters placed inside the broiler house. We studied a modern system of ventilation and heating/cooling in which the air is distributed via two flexible tubes of high density polyethylene with cutouts to create jets [15], thus constructive solution to obtain a better distribution uniformity of heated air in the broiler house and cold drafts are avoided. The introduced air is heated by a flue gas heat exchanger air-powered heat produced by burning fuel gas obtained thru thermo-chemical gasification of biomass in cross-flow gasifiers.

The air exhausting of the broiler house is made by two side channels with holes above the area of chicken residence. We can optionally put on the exhausting circuit a heat recovery exchanger that can cover up to 40% of thermal power necessary to preheat the outside air.

For the evaluation of microclimate parameters and the energy balance, actual consumption of fuel used a simulation program of conditioning processes in a broiler house with constructive solutions mentioned above. The program was developed in CLIMPAS simulation environment developed in the Free PASCAL V.2.1.2 language at Biotechnical Systems Department of POLYTCEHNICS University of Bucharest.

MATERIAL AND METHODS

Acclimatization of the broiler houses

For analysis purpose a broiler house intensive meat chicken with a simple construction have been used, with dimensions of 10mx75m, well organized constructively, proposed by [12.16], in which a distribution of caloric system was introduced for ventilation, heating and cooling, consisting of two flexible perforated ducts with slotted side for the creation of jets, while air evacuation from the broiler house is made through holes opened in two sided channels as the air comes out vertically to reduce the concentration of pollutants discharged (as seen in Figure 1a and 1b) [15]. The study revealed that a broiler house is feasible with less length, 10m x 40m, the variant for which the simulation experiments were conducted. To reduce heat transfer through the walls and roof they were isolated at the level of thermal resistance R9.

We have analyzed three different variants heating fresh air introduced in the broiler house:

- First, the air from broiler house with cross ventilation is heated with four air heaters that burn diesel fuel;
- Second, fresh outside air introduced into the broiler house is heated by a heat exchanger supplied with thermal energy from a gasifier with biomass;
- Third, exhaust air of the broiler house goes through a recovery heat exchanger and transfers a part of the outside air enthalpy to be placed in the broiler house (as shown in Figure 1a and 1b);

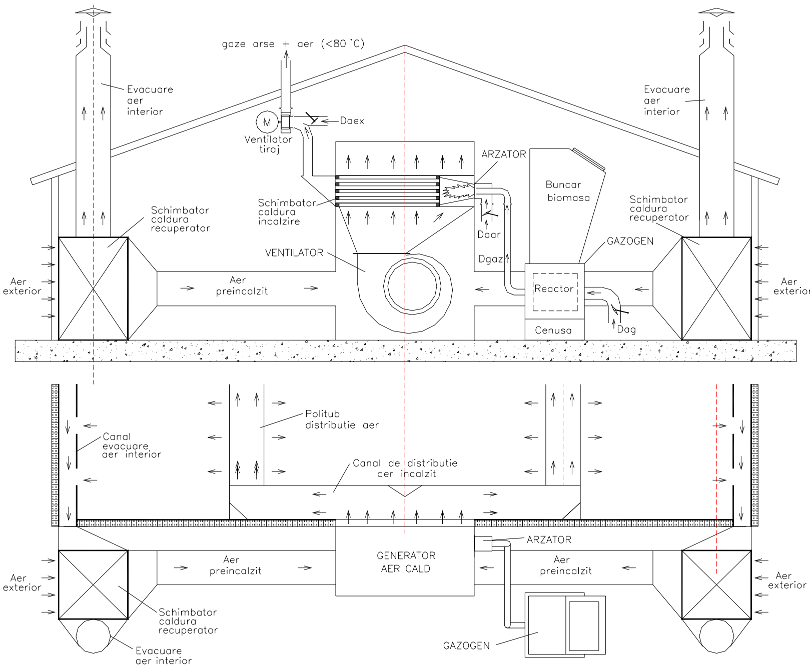

Fig. 1 Scheme of the installation of ventilation and heating with biomass

Thermal energy required is obtained from biomass that is gasified thermo-chemical to obtain a combustible gas, called gazgen, which contains about 20% H_2, 20% CO, 2...4% CH_4 and N_2 for the remaining content. Lower calorific value of gas is 4...5 MJ/Nm^3 depending on the chemical composition and moisture content of biomass gasified. Currently the pellets are the most used for thermal energy production as pellets represent a biomass highly compacted. Due to the mechanical processes necessary for the crushing and compacting a relatively more energy is consumed which brings the average price of pellets to the EU market at about 100...120 €/t. Considering that the study refers to an increase in pup hall with an area of 400 m^2 only, local harvestable biomass use was taken into account, with minimal transport operations and mechanical processing, to increase the level by energetic independence to agriculture farms, important factor in sustainable development of agriculture. This biomass comes from secondary products of field crops, greenhouses, and vineyards; biomass, initially chopped into pieces of size less than 50 mm, is stored in containers with wired-mesh walls which is naturally dry to 10% RH. The average cost of a ton of this biomass type averaging 20% humidity reaches its maximum of 70 €/t, at least 36% cheaper than pellets.

To efficiently gasify a variety of biomass, with different chemical composition, moisture content and size was adopted the gasification process of cross-flow with diffuse jets, which has a high temperature in the reactor, 950...1000ºC, providing full utilization of water in the gasification process and a good incandescent carbon reduction [3,6,8,9,10,14].

As model, a cross-flow gasifier manufactured by Herbst (UK) have been adopted; the family's main features are presented in Table 1.

Table 1 Characteristics of the Herbst gasifiers

Parameter	**UM**	**Type gazogen**			
		G-30	**G-60**	**G-100**	**G-200**
Thermal power	kW	30	60	100	200
Energy efficiency	%	90	90	90	90
Hourly pellets consumption	kg/h	9	18	30	57
Hourly chopping consumption	kg/h	10,5	21	34	65
Hopper volume	m^3	0,37	0,5	0,75	1,35
Length	mm	1300	1400	1500	1500
Width	mm	700	800	800	1300
Height (with hopper)	mm	2350	2500	2600	2700
Weight	kg	290	380	400	700

Simulation Program

The program is initialized with data referring to external weather conditions, the characteristics of the broiler house, the installation of acclimatization and for bird populations [7]. For modeling the microclimate was used a system of differential equations obtained by applying the principle of mass and energy balances for air, absolute humidity and heat [5,7,11,13].

In the process of growth of the birds was used a polynomial model of the form:

$$m_{pui} = A_0 + A_1 t + A_2 t^2 + A_3 t^3 \qquad (1)$$

for which values of the coefficients were calculated through polynomial regression from breed-specific increase tables that populates broiler house.

For the total heat flow dQ_{pui}/dt, plus latent sensitive and moisture dm_{ap}/dt given by birds equations (2) and (3) with two variables, indoor temperature Ti and m_{pui} body mass and periodic diurnal variation are used [1, 4, 7, 11].

$$(2)\quad \frac{dQ_{pui}}{dt} = N_p m_{pui}\left(C_0 + C_1 T_i + C_2 T_i^2 + C_3 T_i^3\right)\left[1 + K_{cp}\left(\frac{\pi}{12}(t - t_0)\right)\right]$$

$$(3)\quad \frac{d\,m_{ap}}{dt} = N_p\, m_{pui}\left(B_0 + B_1 T_i + B_2 T_i^2 + B_3 T_i^3\right)\left[1 + K_{up}\left(\frac{\pi}{12}(t - t_0)\right)\right]$$

In the heating system model, to calculate the heat exchanger efficiency, the NTC calculation method used the following relationship:

$$\varepsilon = 1 - \exp\left[\frac{\exp(-N \cdot C^{*} \cdot n) - 1}{C^{*} \cdot n}\right] \qquad (4)$$

where: N = NTC_{max} that is the maximum number of heat transfer units;

$C^{*} = C_{min}/C_{max}$, the ratio of thermal capacity of fluids between which heat is transferred;

$n = N^{-0.22}$, calculation coefficient.

Maximum output of tubular type exchangers were elected to the value 0.85, specific to these types of heat exchangers [2].

The simulated experiments performed are as follows:

- V1M - broiler house heated by hot air generators, diesel fueled, mounted inside the broiler house;
- V2B, and V3B - broiler house, according to the analyzed solution, heated with a heat exchanger where the burned gas is produced by burning gasifier where biomass is gasified;
- V4B - broiler house, according to the analyzed solution heated by a heat exchanger where enter outside air preheated by indoor air discharged through recuperative heat exchangers.

RESULTS

In figures 2 and 3 graphs resulted from running experiments V1M and V4B are presented, while table 2 summarizes the main data from experiments. Populating the broiler houses was made with an average of 14 birds per m^2.

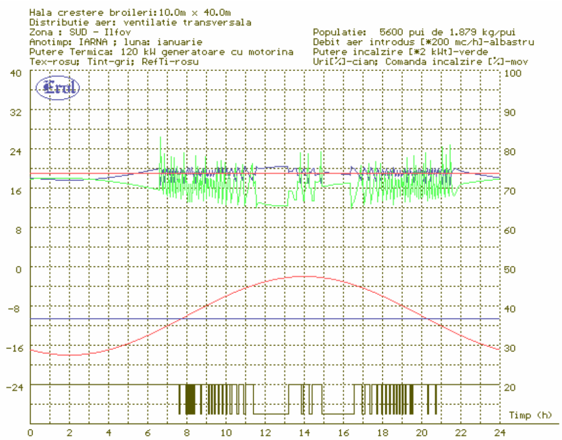

Fig. 2 V1M experiment chart

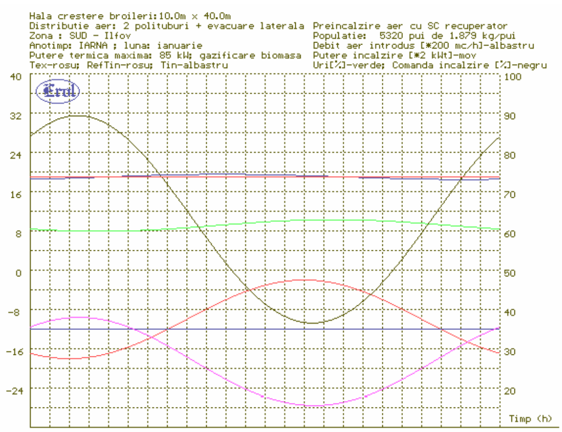

Fig. 3 V4B experiment chart

Table 2 Experiments result

Size	UM	Experimental variants			
		V1M	V2B	V3B	V4B
Size broiler houses-BxLxH	m	10 x 40 x 4.2	10 x 40 x 4.2	10 x 40 x 4.2	10 x 40 x 4.2
Heat Recovery	-	NU	NU	NU	DA
Fuel type	-	diesel	biomass	biomass	biomass
Fuel Price	€/t	1500	70	70	70
$T_{ex\cdot min}/T_{ex\cdot max}$	°C	-18 / -2	-18 / -2	-18 / -2	-18 / -2
Broilers population	pc	5600	5320	5320	5320
Reference temperature	°C	19	19	19	19
Indoor temperature	°C	16.7...20.5	18.7...19.3	18.4...19.6	18.5...19.5
Indoor humidity	%	64...82	60...63	59...63	60...63
Heating power mim/max	kW	120/120	42/88	43/85	31/76
Fuel consumption	kg/zi	300	600	600	500
Fuel Costs	€/zi	450	42	42	42
Specific fuel cost	€/chicken.day	0.0804	0.0080	0.0080	0.0066
CO_2 emission	kg/day	838	0	0	0

Differences of population arise from to reduced useful space due to installation the side channels used for air evacuation of the broiler house. A population aged 40 days and an average weight of 1.88 kg alive was chosen for the experiments.

It appears that in all experiments specific microclimate sizes match to the acceptable limits of a comfortable climate that is not stressful. In the experiment V1M the largest absolute deviations ± 1,5ºC indoor temperature have been found, deviations which because of the use of automatic control of a bi-positional type algorithm chosen as mode of operation for the heaters where the diesel gas is burned.

In experiments V2B, V3B and V4B, where the thermal power produced by cross-flow gasifier can continuously be adjusted by changing the air flow D_{ag} for gasification, we used the PID-numerical algorithm for automatic control which compensates in optimal mode the main effect of the time constants of the gasification process and heat exchanger.

As a result, the absolute deviations of the internal temperature are much lower than ± 0.5ºC; this aspect may contribute to thermal comfort and indirectly to a more efficient use of feed.

In a cold winter day for ventilation air a minimum of 0.7 Nm^3/kg chicken was used, value that assures the O_2 concentration and maintain concentrations below the permissible contaminant.

Indoor humidity is kept within optimum limits, the higher oscillations being found in the experiment V1M due to higher indoor temperature variations. Under similar microclimate conditions, the heating cost per day when biomass is used represents up to 10% that of diesel fuel, that may reach 450 €/day. Thus, under the experiential conditions 400 €/day may be saved, an amount which can contribute to faster depreciation of additional investment for a biomass heating system.

Reducing fuel costs also contribute to a faster return on additional investment, that makes more attractive the solution proposed in this paper.

In the end we must emphasize the environmental effect that biomass use instead of fossil fuels for heating pup halls may bring - reducing CO_2 emissions by about 800 kg/day, hence the use of biomass leads to a zero balance.

CONCLUSIONS

The study of broiler house heating opportunities for intensive broiler breeding with biomass instead of fossil fuels leads to the conclusion that is technically economically as well as ecologically feasible.

The technical solution adopted for heating a 10mx40m broiler house with biomass by air distribution through flexible perforated duct and evacuation through side holes helps to reduce the cold air drafts to control the evacuation and to recover the exhausting air enthalpy. The cross-flow gasifier with diffused jets can effectively gasify the local biomass with a wide dimensional and humidity variety obtained at extremely low cost leading to the development of productive activities that increase the employment, being also integrated into the concepts of sustainable development in agriculture.

To have the same microclimate conditions, the cost of biomass for heating is less than 10% compared to that using diesel fuel, reducing the specific cost of heating according to the simulated experiments from 8 Eurocents/chicken-day to 0,8 Eurocents/chicken-day.

Using biomass for heating the broiler house increases direct and effective the contribution to CO_2 emissions reducing in the atmosphere by about 800 kg/day for the case study.

We developed a simulation program to study the microclimate in the broiler houses heated with biomass thermo-chemical gasified in gasifiers of cross-flow type that can be developed for further studies of growth opportunities for energy independence and productions costs reducing both technically and economically.

BIBLIOGRAFY

[1] Aykuz A., Boyaci S., Determination of Heat and Moisture Balace for Broiler House, Journal of Animal and Veterinary Advances 9 (14); 1899-1901, 2010

[2] Badea A., ş.a.: Echipamente şi instalaţii termice, Editura Tehnică, Bucureşti, 2003

[3] Belonio Alexis, Rice husk gas stove handbook, College of Agriculture, Central Philippine University, 2005

[4] Little E., May J., Simmons J., Lott B.,: Financial Analysis of Selected Setpoints for Broiler Houses, Journal of the ASFMRA, 2001

[5] McKibbin_R., Wilkins A., Modelling of a poultry shed, Massey University at Albany, Auckland, NZ., 2003

[6] Murad E., Producerea de energie prin gazeificarea resurselor regenerabile de biomasă agricolă, INMATEH- 2002, România, Bucureşti, mai 2002

[7] Murad.E., Simularea microclimatului în halele de creştere a păsărilor, INMATEH 2002, Bucureşti, sep. 2002

[8] Murad E., Optimisation of biomass gasification load regime, Conferinţa Internaţională ENERGIE - MEDIU CIEM 2005, UPB, Bucureşti oct. 2005

[9] Murad E., Safta V., Haraga G., Biomass regenerating source of thermal energy for drying installations, Conferinţa ISIRR, Hunedoara, aprilie 2009

[10] Reed T.B., Das A., Handbook of Biomass Downdraft Gasifier Engine Systems, U.S Department of Energy, Colorado, 1988

[11] Silva1 M., ş.a., Evaluation of a simplified model for estimating energy balance in broilers production housing, Revista Brasileira de Engenharia Agrícola e Ambiental, v.11, n.5, p.532–536, 2007

[12] Wimberly J.,: A Review of Biomass Furnaces for Heating Poultry Houses in the Northwest Arkansas Region, BioEnergy Systems LLC, Fayetteville, AR, May 2008

[13] Zhang Y, Barber E. M., Sokhansanj S.- A Model of the Dinamic Thermal Environement in Livestock Buildings, Journal of Agricultural Engineering Research, 1992, Vol. 53, nr.2 , pag. 103-122

[14] Xin H., Berry I.L.,Tabler T.A., Costello T.A., Heat and Moisture and Production of Poultry and their Housing Systems Broilers, Transaction of ASAE, 2001, Vol.44(6), pag. 1851-1857

[15] * * *, Hot-Air Alternative Heating System Study - Hot Air Distribution, Poultry Housing Tips, Volume 21 Number 2, February 2009 College of Agricultural and Environmental Sciences, The University of Georgia

[16] * * *, Broiler House, Mechanical or Natural Ventilation, Plan No.832, Biological and Agricultural Engineering Department North Carolina State University