Researches on the Renewable Fuels Gas Production and their Economical and Ecological Utilization

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The paper aims at researching the possibilities to introduce certain renewable gas fuels, obtained through synthesis procedures, gasification and fermentation in the country's balance of primary energy.

Keywords: renewable fuel, synthetic gases, biomass, combustion, pollutant emissions

The production of renewable fuel gas is an older concern of the technique, but its importance increased over the last years along with the massive rise of the prices of fossil fuels and with the restriction of the emission of CO_2. The Kyoto Treaty meets the trends of restricting the use of fossil fuels, showing the use of biomass, of biogas and of other synthetic gases as one of the ways. The paper aims at researching the possibilities to introduce certain renewable gas fuels, obtained through synthesis procedures, gasification and fermentation in the country's balance of primary energy. The first objective of the authors comprises the development of the technologies for the production of the dimethyl ether (DME), of the gas-producing gas through the bio-mass gasification, of the fermentation biogas as well as testing them on pilot equipment. Further, the optimal technology for burning these renewable fuels was treated, along with the technology for burning of mixtures between these fuels.

Within the technologies for the energy revaluation, the issues related to the chemical thermo physics were researched, to determine the criteria for burning and for stability of burning, and also for production of polluant emissions. The burners developped within the researches should meet the requests for economic and ecologic functionning.

The second objective is to combine the benefits of using DME as fuel very low pollution of the environment, since during the combustion it does not generate oxides or particles of sulphite with the low price of the bio-mass gasification and the fermentation biogas.

Numeric modelling

Modelling the functioning of 1 MWt furnace with gas fuel implies its discretisation in a number of volumes of calculation, targeting a dimension of the calculation cells as small as possible in the areas where we expect high values of speed and temperature gradients [1]. For solving the equations system governing the thermal-gas-dynamic and chemical complex processes in the furnace, the starting point is to precise the limit terms due to the particularities of each sub-model apart (the submodel for calculation of flowing, the sub-model for calculation the heat transfer and the sub-model for calculation the burning reactions). The limit terms should be specified for each border cell apart. Thus, the calculation cells representing the walls of the interior should have specified the temperature (either direct, or by defining a certain way of heat transfer to the outside – Dirichlet, Newman or Cauchy conditions) and the emission factor of the wall. The rest of the parameters, such as speeds, pressures, concentrations do not appear because for the wall-type cells, the connections between the respective differential equation are cut. The calculation cells modeling the sections „entrance" type in the field of analysis of the fuels and of the oxidizer need to have defined the three space components of the speed vector, the temperature, the intensity of the turbulence and the concentration of the chemical substances taking part in the reaction (fuel or oxidizer). The exit from the room of burning the mass flow is considered to be achieved through special cells, of „exit" type. No simplification is used in elaborating the mathematical model of the furnace, as far as the geometric symmetry compared with the medium vertical plan of the burner is concerned, because the field of speeds, of temperatures and of concentrations will have an asymmetrical feature compared with this plan due to the swirling of the burning air jet. At the same time, the mathematic model includes the effect of gravitation, allowing to emphasize its effects over the shape of the flame.

Calculation data related to the thermic regime

As data of entrance regarding the thermal regime there are stated the temperatures of the walls screening the burning interior as well as the temperatures of the jets of fluid getting into the interior under the shape of burning air or fuel. In case a constant thermal flow on one of the interior's walls is imposed, this can be defined as entrance datum. For the study of the heat transfer through radiation it is necessary to provide the emission values of each area taken into consideration. The entrance and exit sections of the fluid from the interior are considered to adsorb the radiation. Meanwhile, for the heat transfer through radiation, the discreet transfer model (**DTRM**) has been adopted, for which the following definition are given: adsorption coefficient: 0.2; number of prismatic elements: 124971; number of surface elements: 8105.

The geometrical model of the gas furnace is shown in figure 1.

Calculation data related to gas-dynamic regime

From the point of view of gas-dynamic regime of functioning, the entrance data must refer to the speed of entrance of air through the burner's vents. With this purpose, the component of the speed on the three axes of coordinates, namely *u*, *v* and *w* for each type of entrance cell aside should be defined. The values of these speeds are determined from the condition of the flow of air needed

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Table 1

No.	Characteristic	Biogas	DME	Gasification gas
1.	Formula	CH_4 = 50%; CO_2 = 50%	C_2H_6O =100%	CO=32,4%; CO_2 = 8,5%; CH_4=1,1%; H_2 = 12,9%; N_2 = 44,9%
2.	Lower heating value, kJ/m^3_N	18.000	28.000	5.850
3	Density	1,346 kg/m^3	2,109 g/l(gas)	1,154 kg/m^3
4	R, (J/kg.K)	276,75	180,44	763,7
5	Molecular mass	30	46	25,86

Table 2

Variant number	The flow of gas fuel, [kg/s]	The flow air [kg/s]
I: 30% DME + 35% gasification gas + 35% biogas;	0.0322	0.11832
II : 30% DME + 70% gasification gas;	0.0268	0.08118
III : 30% DME + 70% biogas.	0.027	0.1417

for the burning of the flow of gas fuel introduced into the furnace. The level of swirling of the radial blades in the burner's box has been regulated for the value *n* = 1, for all loads of functioning. The model of turbulence adopted in the calculations has been **k-ε RNG** and the standard equilibrium functions have been used as wall functions.

Data related to the chemical reactions

The chemical reactions have been shaped based on the fraction of the mixture/the function of the probability density, being monitored the variation of the concentration for chemical compounds: DME, H_2, CH_4.It is worth remarking that in shaping the burning reactions the model of non-equilibrium has been used, and for the function of the probability density the shape β-PFD has been chosen.

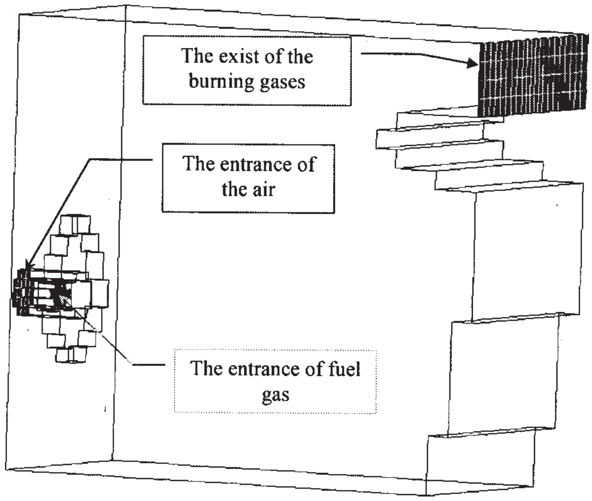

Fig.1. The geometrical model of the furnace

Results and discussions

The main characteristics of the renewable gas fuels used in numerical modelling are presented in table 1.

Three mixtures of renewable gas fuelshave been simulated. The mixture proportion and the flows of the compounds burning is given in table 2.

The numerical modeling was performed with FLUENT program and the results are presented in diagrams form. The distribution of the temperature depending on the average value and on the variants of the mixture fraction is presented in figures 2, 4 and 6. Figures 3, 5 and 7 show the distribution and the concentration of monoxide nitrogen [2].

The first variant

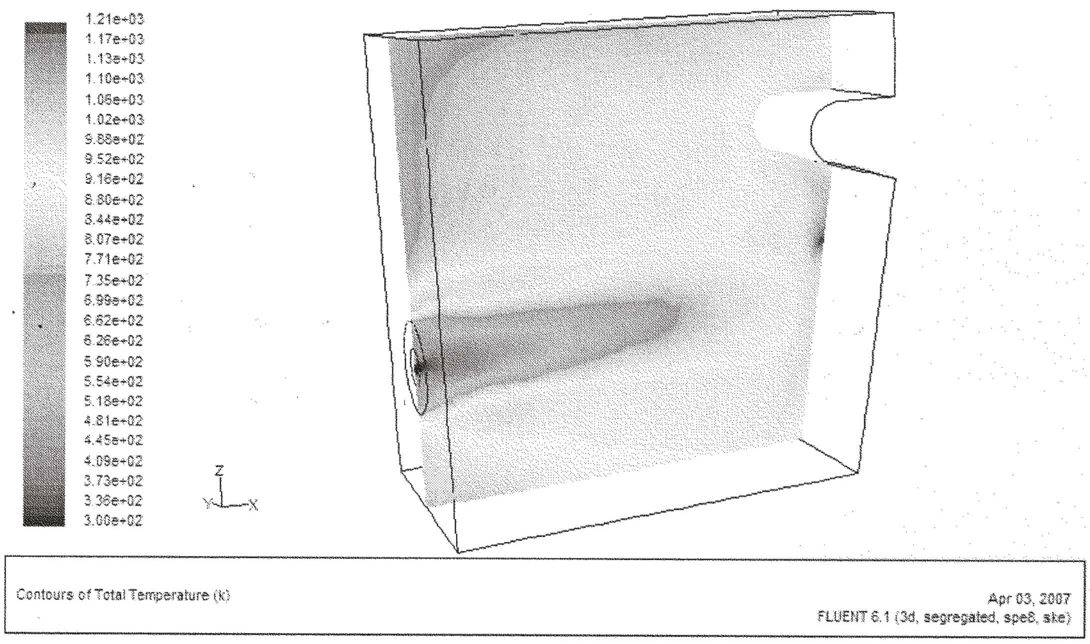

Fig.2. The temperature distribution

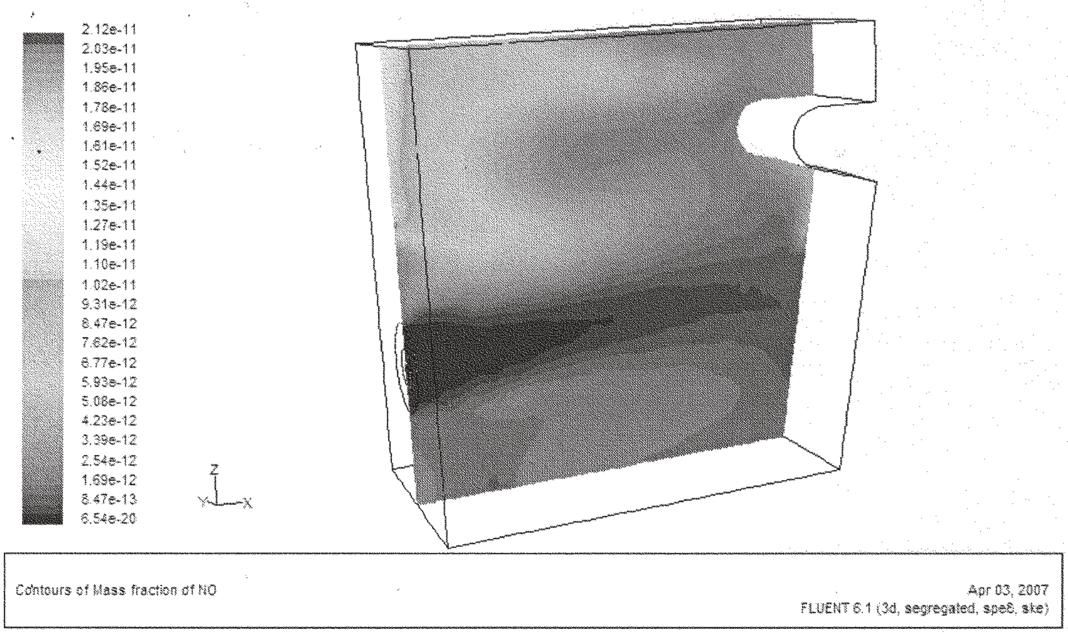

Fig.3 The NOx distribution

The second variant

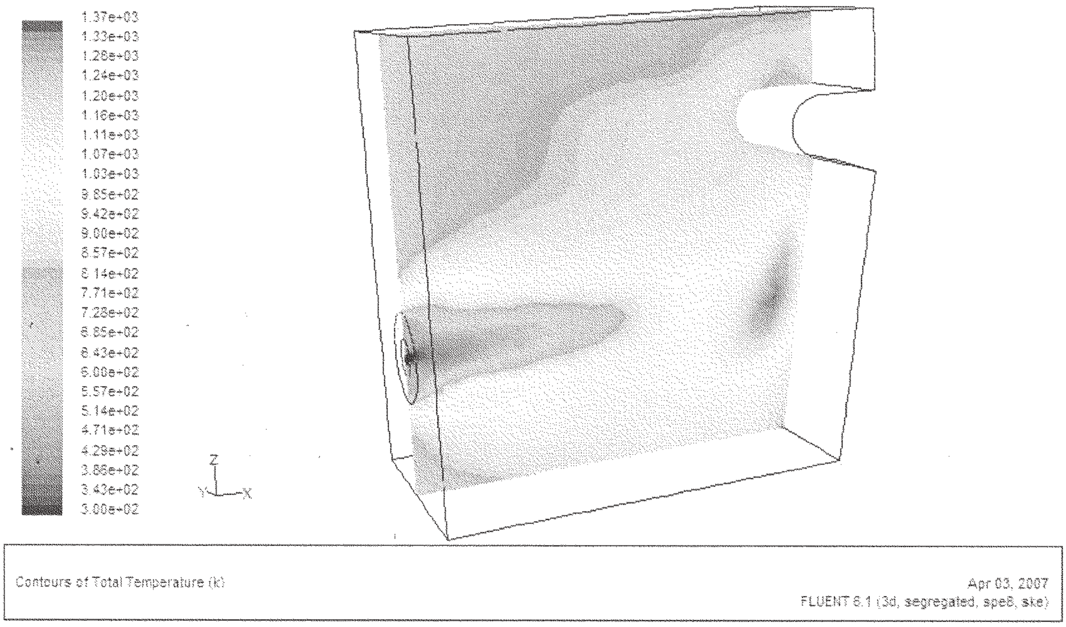

Fig.4. The temperature distribution

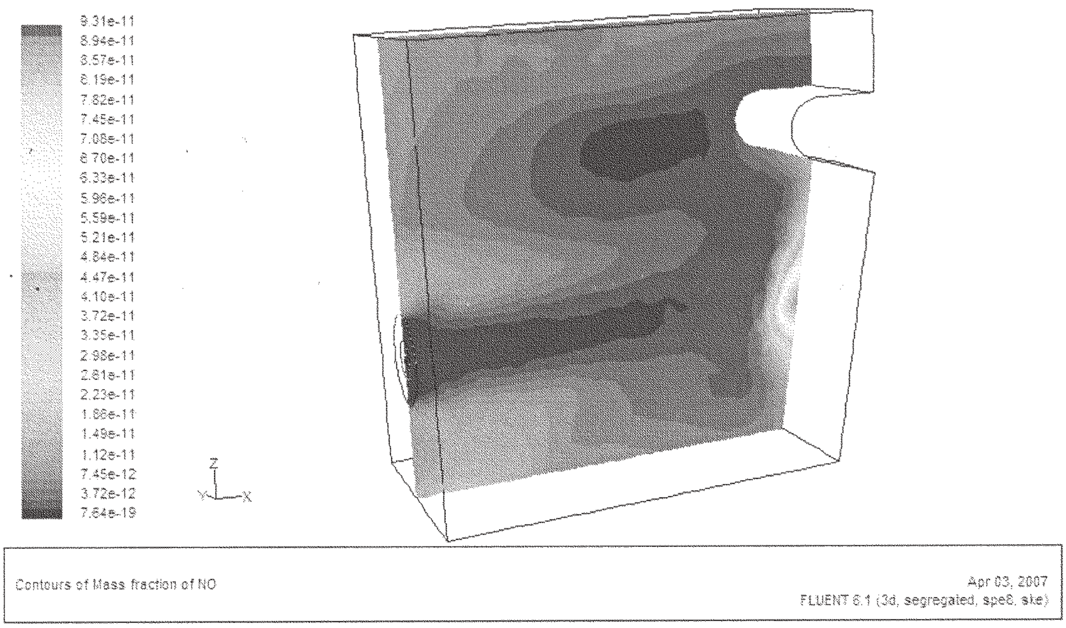

Fig.5 The NOx distribution

The third variant

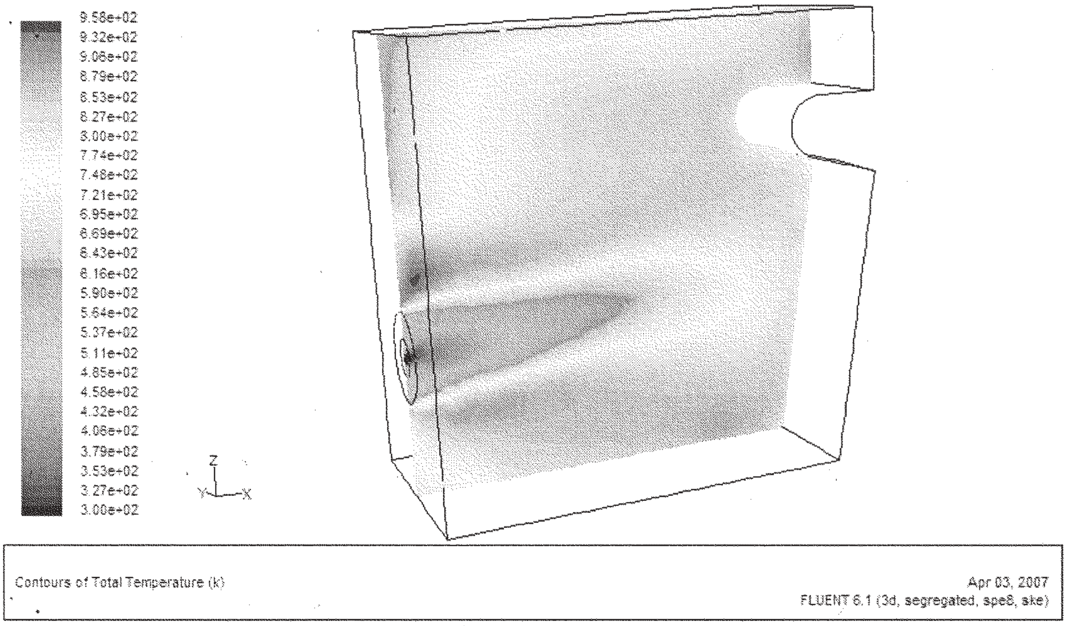

Fig.6. The temperature distribution

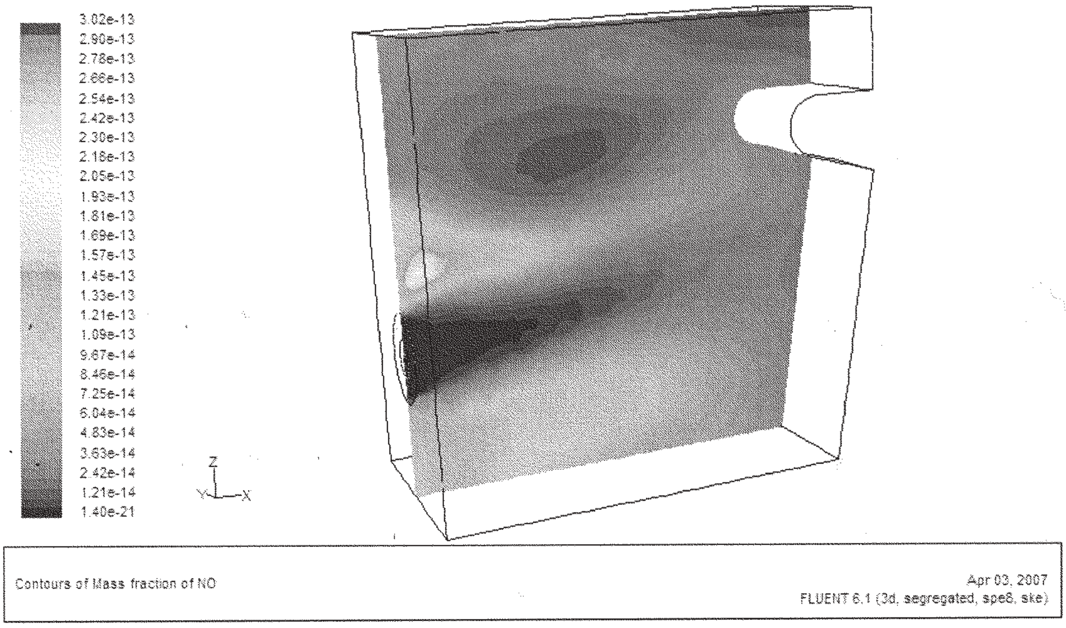

Fig.7. The NOx distribution

Conclusions

The simulation results were compared with the natural gas combustion. There are some interesting conclusions as follows:

-the length of the flames is bigger to the renewable fuels comparing with natural gas, because DME contains a higher oxygen quantity and the kinetically character of the flame increases;

-the temperatures level is smaller because the renewable fuel gas a heating values under the natural gas heating value;

-the flame stability is assured by presence of DME in mixtures;

-the maximum efficiently of the mixture renewable fuels combustion is when the excess air ratio is situated near by the stoichiometrical value;

-the quantities of CO and NO are, substantially, smaller comparing with the natural gas combustion; the level of pollutant decreases;

-obviously, it is necessary for each renewable fuel gas mixture to realize a numerical simulation; after that is possible to design the combustion installations (the burners and the furnace);

-economical speaking, the solutions with renewable fuel gases in mixtures are more advantageous, by an average, with 10-20 %;

-the utilization of these solutions are advantageous, specially, for units with slow and medium thermal power.

References

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