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EXPERIMENTAL TESTS IN OVEN EQUIPPED WITH BURNER SONIC GENERATOR GAZODYNAMIC

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ABSTRACT

Burning is the oldest technology of humanity, and it has been used for more than a million years.Combustion plants must be as efficient, to achieve a more complete combustion, to have a higher efficiency and an emission as reduced pollutants.
A main factor, which determines the effectiveness of the operation of a combustion plant is getting the fuel mixture and perfect combustion of fuels. A primary factor that determines the effective functioning, of a combustion plant is obtaining mixture fuel and the perfect combustion of fuels.

1. Introduction

Currently, about 90% of the energy produced worldwide is produced by burning (generating electricity, house warming, heating in industrial processes, transportation, etc.) [2]. It is for this reason that burning has captured the interest of specialists.
A new technology for burning liquid and gas fuels appeared in the 1980s, which besides increasing combustion efficiency, conduct and decrease the emission of nitrogen oxides, that occurs due to increased heat transfer and mass flame by using generators sonic gasodynamic and hydrodynamic.
This paper, is intended to make a small contribution to the concerns of the national target of energy saving [1].
Industrial production and global consumption, have exceeded its capacity for renewal of natural resources and the capacity of governments to manage pollution and waste.
Industrial growth, has helped to raise the tens of millions of people, in poverty in many countries in recent decades, in particular in urban growth. It is clear that economic growth and urbanization have not come without a price.
These deficiencies inhibit economic growth, constitute a factor of additional stress on natural systems and adversely affect public health and investment climate.
International interest about climate, change at the global level is on the rise.
The impact of climate, change can be very serious for all countries, and in particular for the countries which are poorly equipped to handle effects on agricultural production, labor productivity, and health. Intensified competition for scarce resources, including water and energy, may amplify conflicts within the industrial context.
Environmental degradation and climate, change may also intensify the already worrying trends such as desertification, rising sea levels, events, severe weather frequently and shortages of freshwater, leading in the worst case scenarios of civil conflict and transboundary and uncontrollable migration. Efficient use of resources and economic development with reduced carbon footprint, can reduce the pressures and may help to avoid major cases of deep social conflict.
The Energy Information Administration (US Energy Information Administration - EIA) International Energy Outlook by the ratio 2013 (IEO2013) expects world energy consumption increased by 56% between 2010_and_2040_[1].
Total world energy consumption amounts to 553'109 GJ in 2010, 109 in 2020 and 664 · 865 · 109 GJ in 2040.
Energy from renewable sources and nuclear energy are the fastest growing in the world, each with an increase of 2.5% per year. However, fossil fuels still provide almost 80% of energy consumption in the world by 2040.
Natural gas is the fossil fuel with the fastest growing in perspective. Natural gas consumption worldwide increased by 1.7% per year. Combustion is the oldest technology of humanity, as it has been used for more than one million years. Therefore, burning has been used both in the most primitive societies as well as in the most sophisticated, practically it has been and will be used for ever.

At present, about 90% of the electricity produced in the world is produced by combustion (electricity generation, domestic heating, heating in industrial processes, transport, etc.) [2]. This is why burning captured the interest of specialists. Despite the long experience in applying combustion, practical knowledge of the field has exploded in the last 30 years. Meanwhile, several new technologies have been developed and implemented commercially.

2. The construction of the furnace

Since experimental research could not be carried out on the furnace which has achieved thermoeconomic analysis, technological reasons (continuous operation not allowed off for modifying the burners and conducting experiments), it proceeded to build a furnace small for heating blanks in order forging SC Cunax Ferostil SRL Braila (Figure 1).

The burner is mounted in the upper part of the furnace (which there is a box of insulating material) having a flame directed downward. After making the oven, it was tested first with three smaller gas burners to see the behavior of the oven (Figure 2).

Figure 3 presents a view of the oven ceiling where you can see experimental sonic generator and in figure 4 the compressed air supply system of the burner and generator and sonic elements that control air pressure.

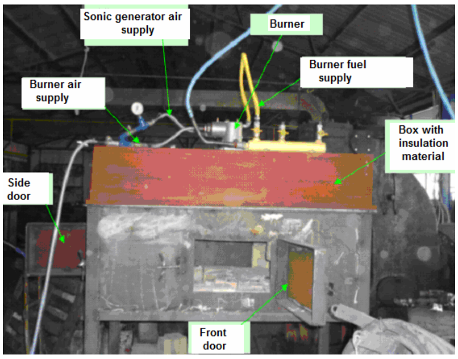

Figure 1. The experimental testing oven burner equipped with gazodynamic radial sonic generator

Figure 2. Testing the furnace with 3 smaller gas burners.

Figure 3. The inside of the oven (the sonic generator is located in the ceiling of the oven).

3. Apparatus and methods for measuring parameters of termogazodynamic

Gas flow was measured using the portable ultrasonic flowmeter FLUXUS G601 (figure 5.8) whose characteristics are given in table 5.2.

Combustion gas analysis was performed with an analyzer model Minilyzer 02 of the German company Afriso-Euro-Index (figure 4).

Minilyzer 02 is a portable digital device, with a small microprocessor [3].

The device has additional pump sensor cleaning with automatic operation, depending on the quality of combustion.

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The device has an additional pump, for cleaning the sensors, with automated operation depending on the quality of combustion.

Table 5.2. The characteristics of ultrasonic flowmeter FLUXUS G601 [82].

Feature Size	The value
Measuring principle	The principle correlation of transit times
Working temperature	(-40…+170)°C
Pipe diameter	DN 30… 1600
The flow rate	(0,01…35) m/s
Accuracy	± 0,5 %
Repeatability	0,15 %
Power	< 6 W

Figure 4. Combustion gas analyzer MINILYZER 02.

Figura 5. Flue gas analysis in experimental furnace.

4. Combustion efficiency in the furnace

To determine the efficiency of the combustion of natural gas in the experimental furnace it is necessary to know the amount of air necessary for combustion, volumes of flue gases and the content of the flue gas heat (enthalpy).[4]

The determination of the volumes of air necessary for combustion and flue gas of a gaseous fuel is made using the stoichiometric reaction of burning gas with the general chemical formula C_mH_n :

$$C_mH_n + \left(m + \frac{n}{4}\right)O_2 \rightarrow mCO_2 + \frac{n}{2}H_2O \qquad (5.8)$$

The combustion efficiency will be determined with the help of combustion gas analyzer with the possibility to calculate and display this size.

Through burning, the fuel is converted into exergy combustion products, the transformation of exergy fuels meeting the ideal case, in which case the combustion process is reversible [2].

5. Emissions of CO and NOx produced by burning natural gas in oven.

Intervention in reducing carbon monoxide emissions and nitrogen oxide emissions by burning organic fuels results requires knowledge of the mechanisms of their formation. Genesis of pollutants in combustion processes, is closely linked to individual chemical reactions that sustain combustion.

With the increase of air/fuel ratio, the adiabatic conditions, the concentration of CO in flue gases decreases, and the Nox increases until it reaches a maximum and then declines.

Combustion plants operate with air excess (oxygen) to ensure a low emission of CO and high combustion efficiency [5].

Excess of oxygen mixing reagents, compensates imperfections daily and seasonal variations, in temperature and humidity, fuel composition.

Increasing the firing temperature leads to a decrease in the CO concentration and NOx concentration increases.

The burning temperature increase leads to decreased concentration of CO and increased concentration of Nox .

The emission of CO is especially important, in small furnaces, that are not fitted with flue gas collection and CO into the atmosphere around the oven .

Before the excess oxygen, flame to a small extent influences the concentration of CO. The concentration of CO, decreases with increasing oxygen concentration in the flame, due to the fact that oxygen in excess compensate for imperfections in mixing of the reactants and as a result of dilution of the gas mixture. The process of burning organic fuels leads to the formation of nitrogen oxides. About 95% of nitrogen oxides in flue gases are in the form of nitrogen monoxide and only 5% as nitrogen dioxide [3].

6. Experimental results

Several attempts were made on experimental furnace, first trying it without sonic generator burner and with different values of excess air. They were pursued CO and NOx combustion efficiency (thermal efficiency and exergetic) adiabatic temperature and flue gas temperature for different air power pressures gasodynamic sonic generator [9]. The results of the experiments carried out on the furnace are given in figures 6 and 7.

During the tests were kept an unchanged gas flow of 2 m^3 / h and other conditions of combustion, as less air flow to the burner supply air pressure, sonic generator and sonic generator slit nozzle

The best results, i.e. maximum combustion efficiency, the maximum temperature of the flame and minimal CO emissions were obtained for the supply of air pressure of 0.2 MPa sonic generator and sonic generator slot of 0.25 mm.

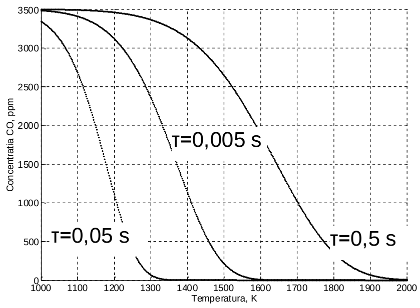


Figura 6. Variation of the concentration of CO in the flame according to the temperature of the flame, 3 times for residence.

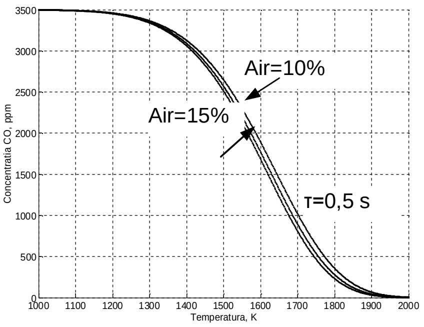


Figura 7. Variation of the concentration of CO in the flame according to the temperature of the flame, for three values of air excess into the flame.

Almost as good results were obtained, for the supply air pressure of 0.15 MPa sonic generator and sonic generator slot of 0.5 mm. For both sizes, of slot sonic generator to supply high pressure, air generator sonic flame shortens much so that it no longer reaches, the parts of the oven [7]. As the use of air power generator sonic excess air leads to increased flame, attempted to obtain the same coefficient of excess air, supply air flow by adjusting the burner for two different air pressures, feed sonic generator.
Figure 8 shows the gas burner flame Garit-T not have gasodynamic sonic generator mounted thereon. The flame is blue with little orange areas with good nucleus located at the parts to be heated in the oven.
Results almost as good was obtained for the supply air pressure of 0,15 MPa sonic and sonic generator of 0.5 mm.
In Figure 9 shows the flame produced by the burner with the sonic generator with fanta δ = 0.5 mm and is supplied with air at a pressure of 0, 05MPa.
In figure 9 is shown the flame produced by the burner equipped with the sonic generator with the slot δ = 0.5 mm and is supplied with air at a pressure of 0,05MPa.
It can be seen that the flame is long, with large areas of orange, which indicates incomplete combustion due sonic generator malfunction [10].

Figure 11 shows the burner flame obtained maximum pressure of 0.3 MPa to supply air sonic generator and sonic generator slot of 0.5 mm.
The flame is short, dispersed at the burner head, ie at ceiling level, without reaching parts of the oven. Although the flame is invisible to the areas of blue, indicating an almost complete combustion, due to the shape it is inappropriate parts of the oven heating [12].
Almost invisible blue flame of Figure 11 has an appropriate manner, at its core is located at the parts to be heated. The color indicates good combustion, the less fuel burned incompletely.

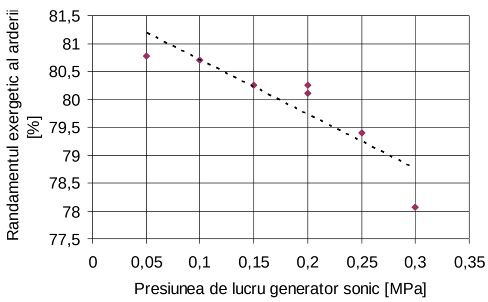
Figura 8. The operation of the burner without the sonic generator.

Figure 9. The operation of the burner with the sonic. generator to supply air pressure of 0,15 MPa, the slot generator of 0,25 mm.

Figure 10. The operation of the burner with the sonic generator to power a maximum air pressure of 0.3 MPa and slot generator of 0,25 mm.

Figure 11. The operation of the burner with sonic generator

Variation in NOX emission intensity levels for the notch acoustic sonic generator 0,5 mm and 0.25 mm, has a growing trend, while in the second case, it increases slightly, and then begins to decline.



b)

Figura 12. Exergetic efficiency of combustion variation with acoustic intensity levels for the notch on sonic generator δ = 0.5 mm (a), and δ = 0,25 mm (b).

Acoustic intensity growth has different effects on the temperature variation of the combustion gases.

For 0,5 mm slot, gas temperature increases, and 0,25 mm slot, it varies very little. For both dimensions of the gap of 0.5 mm and 0.25 mm, yield burning has about that variation with increasing acoustic intensity, increases up to a certain value, then decreases [11].

Unlike the exergetic efficiency, combustion efficiency decreases with increasing intensity level continuous acoustic for both sonic generator gap sizes (Figure 12)

7. Conclusions

Combustion is an area for interdisciplinary, they interact as thermodynamics, chemistry, mechanical fluids and heat transfer and therefore it is difficult to describe in simple terms and in a balanced manner between different Basic sciences.

Fuel and oxidant are the two essential components of a burning process [2].

Fuels can be regarded as substances which releases heat when chemically react with an oxidant. Practical use of a fuel requires that this should be available in sufficient quantities and cheap, and using it to comply with environmental regulations.

Fuels for transport and the generation of electricity can be present in all the statuses of aggregation: solid, liquid or gas.

Natural forms of solid fuels include wood and other forms of biomass, peat, lignite and coal. Liquid fuels are derived primarily from crude oil.

The refining processes be exacted distilled, cracker, reform and removal of the impurities are used to produce more products, including gasoline, diesel, motor fuels for aircraft and heating fuel.

The most used gaseous fuels for the production of electricity and heating are natural gas and liquefied petroleum gas [2].

Science thermodynamics lays down the rules physico-chemical governing how much of the energy of a fuel can be transformed into mechanical energy.

Thermal machines available on the market can transform only between 25% and 50% of fuel energy into mechanical work.

They are able to be improved through research and development, but of the massive fuel efficiency of utilisation are not possible to attain without a penalty costs considerably [2].

Fuel and oxidant are components in primary combustion. For most of the combustion processes, using the oxygen in the air as oxidising, because the air is available almost everywhere on earth [5].

Fuel choice is dependent on the purpose of the combustion process and shall have regard to local safety and emissions.

Fuel choice depends on several factors, such as: safety, the content of energy per unit of volume or weight, the characteristics of combustion and fuel, and the cost [5].

Combustion processes varies according to the status of aggregation of fuel, making it a logical basis for the purpose of classification [5]: - solid fuels (wood, coal, biomass) - with a > b produce more CO2 when burned; - liquid fuels (petrol, diesel) - with a < b; - gaseous fuels (natural gas, hydrogen, gas summary) - with a << b have the lowest of the ratios C/H, thereby causing the smallest quantity of greenhouse gases (CO2) reported in the unit of energy.

Depending on the condition of aggregation of REAGENTS (fuel and oxidant), combustion processes may be: homogeneous, when reactantii shall have the same status of aggregation-giant (specific flaring gaseous fuels), and heterogeneous, when the state of aggregation of REAGENTS is different (specific combustion solid fuel and liquid) [8].

To see the effects of using gazodinamic on the sonic generator combustion of natural gastests were carried out on the experimental furnace equipped with natural gas burner GARIT-T.

During the tests was kept unchanged gas flow (2 m3/h), the combustion air temperature and other conditions of firing, the less air pressure supply of sonic and sonic generator nozzle slit.

The best results, i.e. maximum combustion efficiency, maximum temperature of flame and minimum emission of CO were obtained for supply air pressure of 0,15 MPa sonic and the sonic generator to .25 slot mm.

Air power because of the sonic generator results in increased slightly overweight air flame in an attempt was made to obtain the same coefficient of excess air by adjusting the air flow to the burner power for two different air pressure supply of sonic generator.

Analysis of the results obtained has highlighted the following:

- CO emissions lowers the acoustic intensity with increased for the two gap sizes of 0,25 mm and 0,5 mm. In the second case the decrease is more accentuated;
- the emission of NOx has a tendency of increasing with increasing intensity acoustic generator 0.5 mm slot, while for 0,25 mm slot, it increases slightly, and then begin to decline;
- increase intensity acoustic has different effects on the temperature variation of the combustion gases. For 0,5 mm slot, gas temperature increases, and 0,25 mm slot, it varies very little;
- for both gap sizes of 0.5 mm and 0.25 mm, yield burning has about that variation with increasing acoustic intensity, increases up to a certain value, which decreases;
- unlike the combustion plant yield, yield of exergetic combustion plant continuously decreases with increasing level of acoustic intensity for both the sonic generator gap sizes.

CO emissions decreased from 352 mg/m3N at 103 mg/m3N which means a reduction of 70%.

Emission of NOx decreased slightly, from 175 mg/m3N to 156,8 mg/m3N which means a reduction of only 10%. This reduction takes place at the expense of reducing the excess air from the flame.

Flue gas temperature increased from 678 to 752 ° f ° C, and the efficiency of the combustion plant at 92,8% 96.7%, i.e. an increase of 4%. Excess air coefficient dropped from 1.25 in 1,05.

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