

Mechanism of influence water vapor on combustion characteristics of propane-air mixture

V M Larionov¹, G A Mitrofanov¹, A V Sachovskii¹ and N K Kozar²

¹Kazan Federal University, 18 Kremlyovskaya str., Kazan 420008, Russian Federation

²Kazan cooperative Institute Russian University of cooperation, 58 Nikolaya Ershova, Kazan 420081, Russian Federation

E-mail: techphyskfu@gmail.com

Abstract. The article discusses the results of an experimental study of the effect of water vapor at the flame temperature. Propane-butane mixture with air is burning on a modified Bunsen burner. Steam temperature was varied from 180 to 260 degrees. Combustion parameters changed by steam temperature and its proportion in the mixture with the fuel. The fuel-air mixture is burned in the excess air ratio of 0.1. It has been established that the injection of steam changes the characteristics of combustion fuel-air mixture and increase the combustion temperature. The concentration of CO in the combustion products is substantially reduced. Raising the temperature in the combustion zone is associated with increased enthalpy of the fuel by the added steam enthalpy. Reducing the concentration of CO is caused by decrease in the average temperature in the combustion zone by applying steam. Concentration of active hydrogen radicals and oxygen increases in the combustion zone. That has a positive effect on the process of combustion.

1. Introduction

The combustion efficiency can be improved in various ways. These methods are known as methods for combustion control [1].

The great interest in the practice of creating have methods based on the use of various types of fuel additives. In recent years, researchers are paying attention to water-steam additives. Experiments indicate that the presence of water vapor in the gaseous fuel increases the environmental safety of power plants. Furthermore, water vapor have a catalytic effect on the combustion process. This may involve the afterburning of carbon monoxide.

Partial reduction of the temperature in the combustion zone has an effect on nitric oxide. Thus there is a reduction in the concentration of harmful substances [2]. Furthermore, the supply of steam into the combustion zone substantially changes characteristics of the pulsation of the combustion zone [3]. In gas turbine engines marked effect of water injection into the combustion zone for combustion efficiency and emissions of NO_x, CO, and others [4].

2. The method of investigation

Combustion of propane-butane mixture with air was carried out on a modified Bunsen burner [2]. Burner of the experimental setup is shown in Figure 1. Propane butane mixture fed into the receiver through the pipeline. Air fed by the air pump. Consumption of air and fuel gas measured by flow



meters Bronkhorst. Water from the tank was fed to the electric heater. It produces a sequence of evaporation of water and heating the resulting steam to a predetermined temperature. The heated steam is fed into the receiver, where it is mixed with the gas-air mixture, and then the resulting mixture was fed to a modified Bunsen burner.

Before the experiments were carried out with the burning of the study process of producing superheated steam. Electric heater had three stages. This provided an opportunity to produce steam temperatures up to 700°C. The steam consumption was calculated on the average volumetric flow rate of water. In addition, the investigated regimes of stable combustion of the fuel mixture (Figure 1), assessed the possibility of visualizing the flame on the burner with a thermal imager Dali LT7 (Figure 2).



Figure 1. Combustion of the fuel mixture.

In addition, for measuring the average temperature in the combustion zone mica used. The temperature of the heating plate mica flame recorded imager.

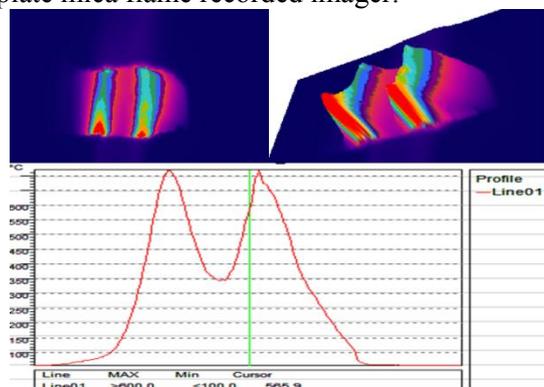


Figure 2. Visualization of the flame on the burner with a thermal imager Dali LT7.

3. The results of the study and discussion

Admission heated or superheated steam into the combustion zone substantially modifies the combustion process. Combustion goes from laminar to turbulent. The sound field produced by an open flame is changed. There are changes of luminosity and colour of the flame. The colour of the flame turns blue (Figure 1). The lack of yellow colour indicates that the concentration of free carbon in the flame during the steam supply drops sharply. The luminosity of the flame changes due to temperature reduction during the combustion zone feed steam.

Increasing the temperature raises the temperature of the steam in the combustion zone. Changes in the relative amount of water vapor in the composition of gaseous fuel also leads to a corresponding change in the wall temperature.

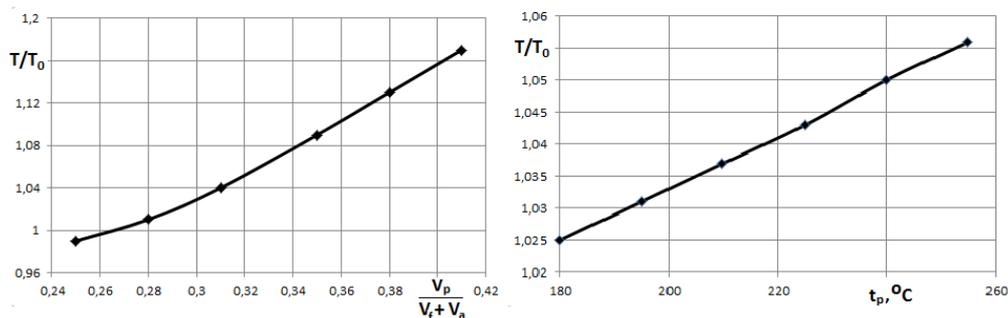


Figure 3. Graphs of the relative temperature of the wall of the quartz tube.

Figure 3 shows graphs of the relative temperature of the wall of the quartz tube T/T_0 , depending on the relative amount of water vapor in the composition of gaseous fuel $V_p/(V_a+V_f)$ and depending on the temperature of the steam t_p . T and T_0 , - measuring (steam) and initial (no steam) tube wall temperature, V_p , V_f , V_a , - the volume of water vapor, the gaseous fuel and air. Figure 4 is a graph of change in enthalpy of water vapor depending on the temperature [5]. Graphs of the enthalpy of steam and temperature changes similar wall. This suggests that the increase in enthalpy of the fuel leads to a proportional change in the temperature in the combustion zone.

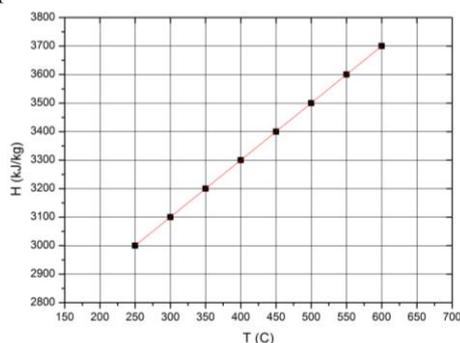


Figure 4. Graph of change in enthalpy of water vapor.

Increasing the temperature of the combustion zone increases the rate of chemical reactions. Reducing the concentration of CO is caused by decrease in the average temperature in the combustion zone by feeding water vapor. Furthermore, when the steam in the combustion zone increases the concentration of active hydrogen radicals and oxygen, which has a positive effect on the process of combustion.

4. Conclusion

Thus, the use of superheated steam in the composition of the gaseous fuel increases the thermal and environmental efficiency of combustion. Changing the combustion gas-air mixture is caused by an increase in temperature of the combustion zone, which is due to the summation of the enthalpy of superheated steam enthalpy of fuel.

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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