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CONTROLLED COMBUSTION OF HYDROGEN-OXYGEN FLAME AT HIGH PRESSURES

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In this article the results of experiments of technology of controlled combustion of hydrogen-oxygen flame are presented during the special conditions in high-pressure chamber. The measurement of achieved pressures and temperatures at the controlled process of combustion of hydrogen and oxygen flame was realised as temperature measurement in calibration zone, temperature measurement at the front face of the head, temperature measurement in the pressure chamber and pressure measurement in the pressure chamber.

Key words: *controlled combustion, high-pressure chamber, temperature measurement, pressure measurement*

Kontrolirano izgaranje vodika i kisika u plamenu pri visokom tlaku. U ovom članku prikazani su rezultati eksperimenata tehnološki kontroliranog izgaranja mješavine vodika i kisika u plamenu tijekom posebnih uvjeta u visokotlačnoj komori. Mjerenja ostvarenih tlakova i temperatura pri kontroliranom procesu izgaranja vodika i kisika u plamenu realizirana su kao mjerenje temperature u zoni kalibracije, mjerenje temperature na prednjoj strani glave, mjerenje temperature u tlačnoj komori i mjerenje tlaka u tlačnoj komori.

Ključne riječi: *kontrolirano izgaranje, visokotlačna komora, mjerenje temperature, mjerenje tlaka*

INTRODUCTION

For the development of technology of controlled combustion of hydrogen-oxygen flame in the environment being characterised by high pressure values - up to 6 MPa, special devices and measurement and control members have been created.

First of all it is the device called the flame injector being the performance member of the whole system. The construction of the flame injector enables mixing gaseous media in required proportions and regulatory quantity whereby the output of the device is being regulated. A part of the device is the system of ignition and cooling. With regard to generated temperatures - above 2700 °C the surface of the flame injector had to be protected against high temperatures by a protection layer.

Another device is a high-pressure chamber, made in a special way, so that there could be "pressure-tightly" placed the performance member of the system - the flame injector.

The pressure chamber was constructed and tested for the pressure of 16.7 MPa at the chamber's mantle, temperature not exceeding 200 °C.

The pressure chamber is equipped with the remote controlled safety venting valve. The whole system is controlled in real time through hardware and software

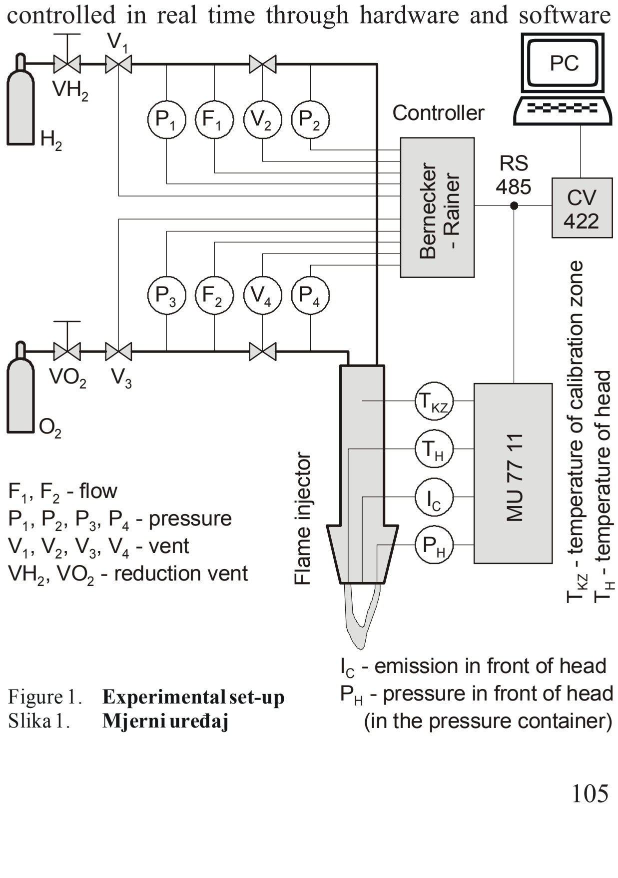

Figure 1. **Experimental set-up**
Slika 1. **Mjerni uređaj**

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elements, more particular in all the phases - from the gaseous media's flow control, through igniting the ignition head, media's flows and pressures control, as well as the venting. The safety system is doubled and besides the possibilities that offer the check and control system in real time, there is also the safety circuit, which "hardly" blocks the whole system by closing the valves enabling the hydrogen and oxygen flow.

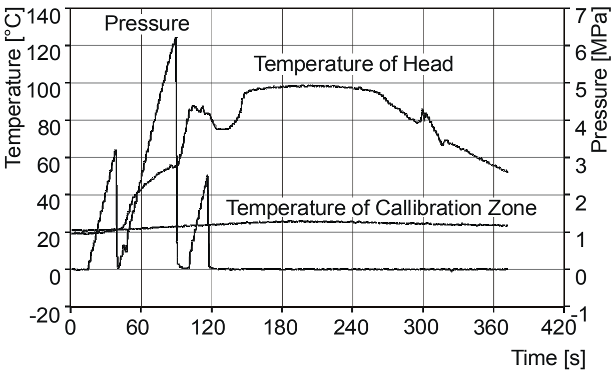

Figure 2. **Time reliance of pressure in flame zone and temperature in calibration zone and after the head**
Slika 2. **Vremenska promjena tlaka u zoni plamena i temperature u kalibracijskoj zoni iza glave**

CASE STUDY

The measurement of achieved pressures and temperatures at the controlled process of combustion of hydrogen and oxygen flame was realised as follows (Figure 1.):

- temperature measurement in calibration zone;
- temperature measurement at the front face of the head;
- temperature measurement in the pressure chamber;
- pressure measurement in the pressure chamber.

For the process control in real time it is also necessary to measure and regulate:

pressures and flows in front and behind the regulation valves between the source (coil of pressure H_2 and O_2 cylinders) and the pressure vessel [2].

In June 1999, a series of experiments was carried out with help of the described system with the purpose of:

- verifying the reliability of igniting the flame at high pressures;
- testing the H-O flame burning at high pressures (closed pressure chamber's "venting valve);
- testing the continuity of the H-O flame burning at rapid pressure decrease in the chamber (short-period venting valve opening).

Results of the experiment No. 8 are given in a written and graphical form (Figures 2. - 4.).

The aim of this experiment was in igniting the flame at closed vessel and pressure increasing in the vessel up to 6 MPa.

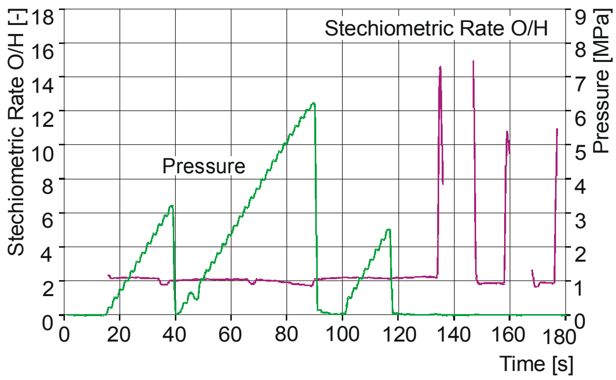

Figure 3. **Time reliance of stechiometric rate and pressure in flame zone**
Slika 3. **Vremenska promjena stehiometrijskog odnosa i tlaka u zoni plamena**

The flame was successfully ignited at the closed vessel, which was registered by the signal from optical radiation detector. After a short time period the signal vanished, while the pressure increased to 3.2 MPa, when the V5 valve was opened for a short time. At the pressure decrease in the vessel the optical detector's signal temporarily increased to maximum values of 2200 mV and after the pressure increase in vessel above 1.6 MPa the signal vanished [1]. This was repeated also at further letting the pressure out of the vessel, while the optical detector's signal after finishing the experi-

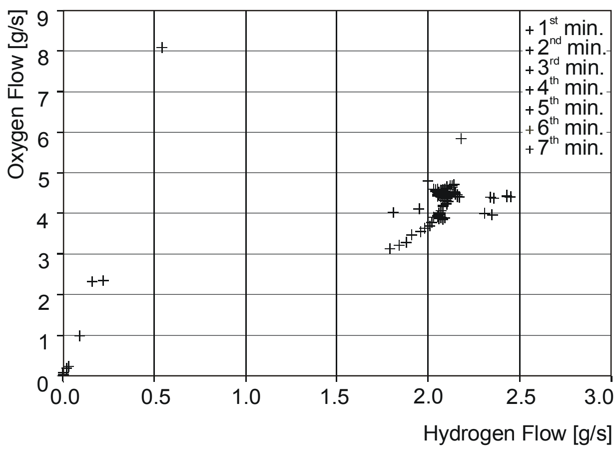

Figure 4. **Time depend graphical reliance of hydrogen and oxygen flow (stechiometric ration)**
Slika 4. **Vremenska promjena vodikovog i kisikovog masenog protoka (stehiometrijski odnos)**

ment did not decreased to zero - the back-ground radiation (heating up the vessel's walls) was registered. Another interesting parameter is the temperature of head. According to the analysis of the head's front face heating up mechanisms, the prevailing mechanism of the temperature increase is the heating up from gases (water vapours) in the vessel and the prevailing mechanism of the head's front face temperature decrease is the temperature removal by the cooling liquid [3]. In case of closing the vessel with burning flame, the average gas temperature in the vessel should increase and in case of dynamic unbalance between the heat absorbed by head from the gas and the heat removed from the head by cooling liquid the heads temperature must increase.

By the analysis of dependence of increasing the front face head's temperature in this experiment we will come to the conclusion that the rapid temperature increase always follows with a certain delay (5 - 10 s) after letting the pressure out of the vessel caused by the inertia of the gradual heating up of the whole head as far as the sensor [4].

CONCLUSION

In the paper there is documented a case history with the aim to prove the ability of the developed system to ignite and control burning of the H-O flame in conditions of dynamically changing pressure. The described achieved results given in this contribution are arranged in a law because partial results were the same also in other experiments having defined different aims.

The mastered technology has its applications in geotechnics, pyrometallurgy, materials engineering, as well as acquiring new knowledge within the investigation in geology and possibilities in acquiring raw materials.

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