

Research on Combustion Heat Release Rate Testing Technology Based on TDLAS

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Abstract

This paper researched heat release rate testing technology based on TDLAS oxygen analyzer and paramagnetic oxygen analyzer, and researched the test data of the two systems when testing the oxygen concentration of air and the combustion exhaust gas. Experiments showed that, the TDLAS testing system could realize the measurement of the combustion heat release rate. Compared with the paramagnetic testing system, the TDLAS testing system has a shorter response time to the change of heat release rate which was about 3s, but the data fluctuation range is bigger and the biggest data fluctuation was bigger than 10kW under test condition.

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Nomenclature

\dot{q}	Heat released rate, kW
k	Constant;
ΔP	The orifice meter pressure differential, Pa
T	The absolute temperature of gas at the orifice meter, K
C	The oxygen analyser reading, mole fraction of oxygen, %

1. Introduction

The cone calorimeter based on the principle of oxygen consumption has been widely used in the world. It was widely used not only in fire engineering research field, but also in the research of polymer materials [1-2].

General cone calorimeter use paramagnetic oxygen analyzer to analyse oxygen concentration of the combustion exhaust gas. Because paramagnetic oxygen analyzer is particularly sensitive to water, so the exhaust gas must be cooled and filtered before entering the oxygen analyzer. Due to the complexity of the sample gas handling system, the response time to the change of the exhaust gas was longer, and also causes linear drift of data in long duration tests because of the gradual

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increase of water content in the sample gas. At the same time, the maintenance of the sample gas handling system was not easy, and which cause the high cost of the testing.

A new type of high precision oxygen analyzer based on laser has been emerged in recent years. Tunable diode laser absorption spectroscopy(TDLAS), is established on the basis of infrared absorption, which is based on Beer-Lambert's law. The gas concentration is obtained by analyzing the signal changes of the laser beam after the selected absorbing [2-7].

TDLAS technology is becoming the best choice for gas analysis in the chemical and petrochemical industries. TDLAS oxygen analyzer has many advantages, such as high accuracy, simple and easy to use, shorter response time and so on. Therefore, TDLAS technology must be used in the combustion heat release rate testing technology in the future.

This paper researched heat release rate testing system based on TDLAS, compared and analyzed the testing data from two testing system.

2. Formula for calculating heat release rate of combustion [1]

The net heat of combustion is proportional to the amount of oxygen required for combustion, the relationship is that approximately 13100kJ of heat are released per kilogram of oxygen consumed. The combustion heat release rate testing technology based on this theory. The simplified formula for calculating heat release rate of combustion sees Equation (1).

$$\dot{q} = k \times \left(\frac{0.2095 - C}{1.105 - 1.5C} \right) \times \sqrt{\frac{\Delta P}{T}} \quad (1)$$

Where, \dot{q} is the heat released rate, kW;

k is the constant;

ΔP is the orifice meter pressure differential, Pa;

T is the absolute temperature of gas at the orifice meter, K;

C is the oxygen analyzer reading, mole fraction of oxygen, %.

3. Combustion heat release rate testing system

The Schematic of combustion heat release rate testing system based on TDLAS see Fig.1.

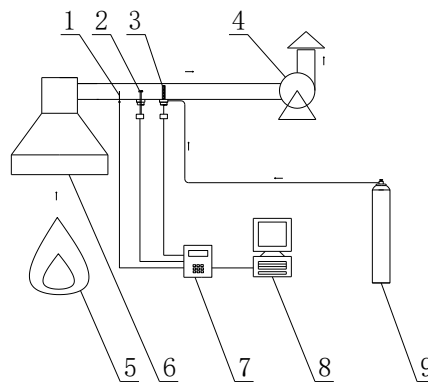


Fig. 1. Schematic of combustion heat release rate testing system based on TDLAS

1. Thermocouple; 2. Pressure sensor; 3. TDLAS oxygen sensor; 4. Exhaust fan; 5. Fire; 6. Exhaust hood; 7. Data acquisition unit; 8. Computer; 9. Nitrogen gas cylinder

During the test, the thermocouple was used to test the temperature of the combustion exhaust gas, the pressure sensor was used to test the orifice meter pressure differential, and nitrogen gas was used to protect the TDLAS oxygen sensor. All data was transmitted to the computer, special computer software calculated the heat release rate nearly in real time.

The TDLAS oxygen analyzer was made by METTLER TOLEDO, the type is GPro 500, see Fig.2 and Fig.3. The paramagnetic oxygen testing system was made by FTT, the type is furniture calorimeter, see Fig.4.

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