Influence of Air flow in the OSU Calorimeter on Test Results

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The report provides and discusses the results of research into the influence of the rate of air flowed through the OSU calorimeter on the calibration factor of the device and the heat release parameters for materials tested: the total amount of the heat released during the first two minutes of the test, maximum heat release rate and the time it takes to achieve it.

Changing to greater or lesser degree the amount of air flowed to the plant may influence data reproducibility to either good or bad effect, since there can be a change in the combustion conditions for samples and in the impact of the equipment operation characteristics.

While testing aircraft materials which emit comparatively little heat during combustion and, therefore, consume a little quantity of oxygen there is not much point in flowing a large amount of air to the device. The present paper deals with the influence of reduced (ranges from nominal value to 1/5 from the nominal) air flow on the calibration factor and heat release registered, as well as tries to find out in how far the testing with reduced air flow is justified.

In the process of burning of materials, **12.72 kJ** of heat is emitted when **1g of oxygen** is consumed.

Therefore, during burning specimen of a standard size (150x150mm), with heat release rate of up to **65 kW/m^2**, no more than **0.115 g of oxygen** per second will be consumed.

With standard air flow through the device at 40 l/s, 10 l/s of air passes through the environmental chamber, which works **3 g of oxygen** per second.

During testing with the standard air flow, no more than 4 % of oxygen of air from the environmental chamber is used for the material burning and 1.6 % of oxygen is consumed for methane burning in the upper and lower ignition burners.

It means that the oxygen concentration in air which flowed through the environmental chamber decreases from 21 down to 19.5 %.

While the calibration the maximum methane consumption amounts to 8 l/min, and the rate of oxygen consumption is 16 l/min, which accounts for 12.5 % of the whole oxygen content in the air flowed into the environmental chamber.

It means to say that the oxygen concentration in the air flowed through environmental chamber decreases from 21 down to approximately 18 %.

Calibration with the methane consumption of **7** l/min corresponds to heat release rate of about **180 kW/m²**, which exceeds the maximum acceptable peak by more than **2.5 times**.

Calibration should be performed with the methane consumption from 1 l/min (basic flow equal to methane consumption by the upper and lower pilot burners) to 4 l/min (since **3 l/min** for methane corresponds to heat emission of about **75 kW/m²**).

Calculations have shown that at the heat release rate of **65 kW/m²** and air flow through the device of **40 l/s** the absolute weight growth for the air that passes through the environmental chamber due to the formation of carbon dioxide and water instead of the oxygen consumed during burning is less than **1.5 %**, whereas the change in the heat capacity for the flowed air due to the chemical composition alteration is only about **0.2 %**.

With the increase in the air flowed into the device, calibration factor value is going to grow proportionally, since the calorimetric gauge signal value falls down. With the increase air flow into the device the valid signal value decreases while the parasite signal (‘noise’) remains the same, i.e. greater error while determining the heat release rate value.

Table 1

Samples characteristics

Sample supplier	Sample description	Thickness, mm
TC FAA USA	Standard sample for checking equipment operation (Standard core panel)	3.5
VIAM Russia	Panel: 2 layers of fiberglass + binder of a phenol type. Decorative coating – epoxyfluorine enamel	0.45

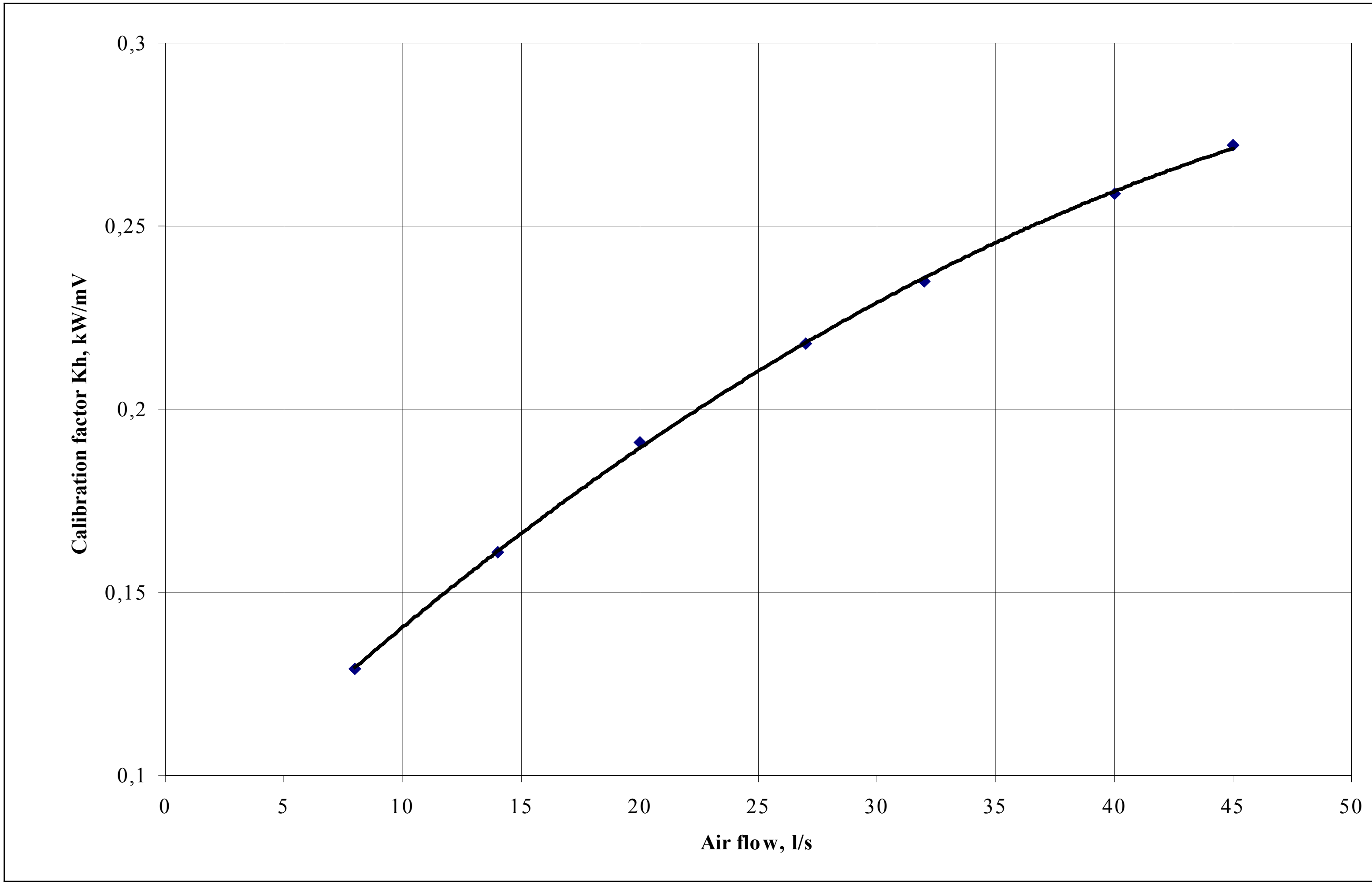

Fig. 1 The calibration factor value of the HRR-3 calorimeter versus air flow through the device

Table 2

Calibration factor value for the HRR-3 calorimeter at different levels of air flow through the device

Air flow through the device, l/s	Calibration factor average value, Kh, kW/mV	Average value for calibration factor standard deviation, %	Number of calibration tests
8	0,129	3,8	2
14	0,161	6,7	2
20	0,191	4,7	1
27	0,218	4,1	More then 10
32	0,235	3,4	1
40	0,259	3,0	More then 10
45	0,272	2,7	1

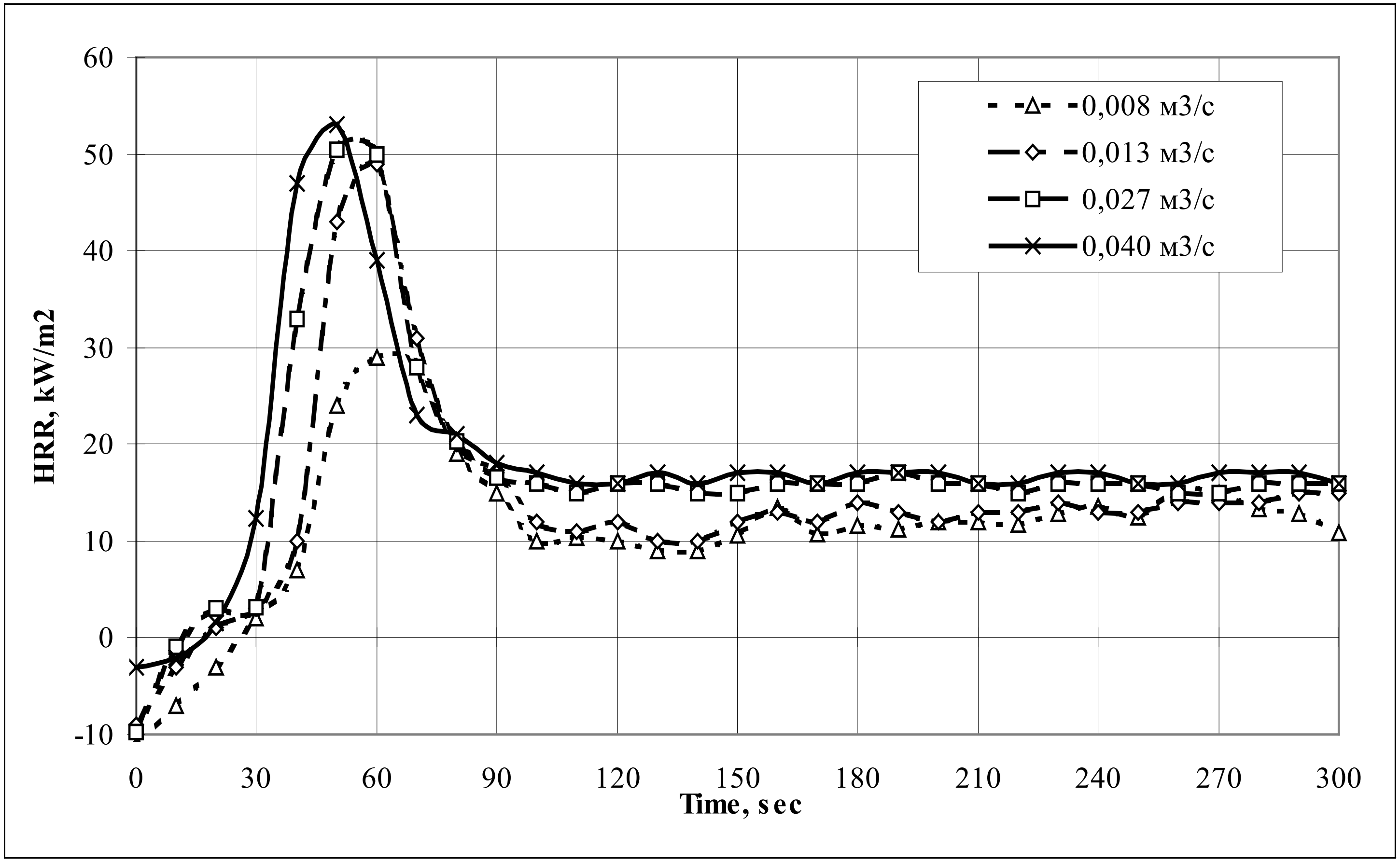

Fig.2 Heat release chart for a standard core panel at different air flow through the device

Table 3

Heat release rates for a standard core panel at different air flow

Air flow, m^3/s	HRR initial time, s	Peak time, s	Peak, kW/m^2	Total heat release, $kW \cdot min/m^2$
0,008	29	62	29	22
0,013	21	55	49	33
0,027	19	52	51,7	35,5
0,04	19	50	53	37

Table 4

Basic line deviation value from the average value at different air flow levels through the device

Air flow, l/s	Deviation value, kW/m^2
20	± 4
27	± 3
32	± 3
40	± 4
50	$\pm 4,5$

Table 5

Results reproducibility at different air flow levels

Air flow, l/s	Standard deviation for peak, %	Standard deviation for total heat release, %
27	2,6	2,8
40	6,2	3, 4

Conclusions:

1. In case of continuous air flow through the device throughout the experiment (from calibration up to the end of the testing) changing air flow, as compared with the nominal level 40 l/s, to 27÷20 l/s does not worsen the equipment operation; the average standard deviation value for the calibration factor remains unchanged;

Conclusions :

2. Decrease in air flow causes the time of span from beginning experiments to the peak to increase; changing air flow from the nominal to ½ of the standard level makes practically no impact on the registered maximum heat release rate and the total heat emitted; further reduction in the air flowed leads to the lowering of the heat release values (those of the peak and the total heat), the peak shape alternates – it becomes more sloping;

Conclusions:

3. Decrease in the air flow in range from nominal level to 2/3 of its does not affect the test data reproducibility.

Thus, decrease in the amount of the air delivered to the calorimeter to 2/3 ÷ 1/2 of the nominal has no negative effect on the of the measuring equipment operation and on the value of the normalized heat emission characteristics.