Exploration and experimental study on test method of AEPS

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Abstract. In this paper, based on the analysis of the existing limitations in the application of the existing fire performance test methods of AEPS, an improved scheme is proposed. The cone calorimeter is introduced to obtain the differential fire characteristics of AEPS with different density conditions under different radiation intensity conditions. Through the optimization of the combustion heat test sampling and calculation method, the repeatability and representativeness of the test results are significantly improved and verified by experiments.

1. Introduction

The traditional EPS board is made of heated EPS particles after heating and pre foaming, then molded in the mold. The EPS board with closed hole structure is generally used below 75 degrees. The products with different density, different thickness and different shapes can be realized by controlling the technological parameters and the mold. The modified EPS board is a new product formed on the basis of the traditional process improvement. AEPS is made from low combustion heat components by vacuum infiltration on EPS foam substrate, or mixed with EPS particles and flame retardant slurry after being mixed and molded. AEPS has advantages of mature manufacturing process, simple process control and low cost compared with other modified EPS. The results show that the AEPS with excellent heat insulation performance and fire performance class can be prepared by adjusting the ratio of inorganic additive to EPS particles.

In the practice of fire performance evaluating of a large number of AEPS, the author found that due to the special composition and structure, there are some limitations in the existing evaluation methods for such samples. Such as small-scale tests, are greatly affected by the sampling location or method, and the results are not satisfactory in large scale fire because the low heat release characteristics of the board can not be shown, and the classification conclusion can not effectively reflect the differential characteristics formed by different formulations and processes.

For this reason, fire performance tests of combustion characteristics on some typical formula with different density of EPS board products are carried out. The test methods involved covered different scale and application forms of fire scenarios and investigation mode, trying to explore the existing test methods and operation procedures on AEPS, to establish a more suitable test method for AEPS, providing more reliable test technical support for objectively and accurately performance and fire classification of AEPS.
2. Limitations and optimization of existing classification test methods

(1) Limitations of single burning item (SBI)

According to the current national standard GB8624-2012, the fire performance of AEPS is evaluated as Grade A. The main test methods commonly used include SBI and combustion calorific value test. The combustion characteristic parameters of two vertical plate specimens under the condition of external heat source with specific power are reflected by SBI. The test results of SBI and combustion calorific value test under five different formulations and densities are shown in Table 1.

Table 1. SBI results on fire performance of AEPS

| Item                  | Sample1   | Sample2   | Sample3   | Sample4   | Sample5   |
|-----------------------|-----------|-----------|-----------|-----------|-----------|
| Sample density, Kg/m³ | 119.68    | 139.84    | 165.20    | 159.7    | 170.0    |
| FIGRA₀.2, W/s         | 8.5       | 0.0       | 0.0       | 0.0       | 0.0       |
| THR₆₀₀, MJ            | 0.2       | 0.3       | 0.2       | 0.2       | 0.1       |

It can be found from the results that there is little difference in the results of SBI for AEPS with five density levels, and the main grading parameters such as FIGRA₀.2 and THR₆₀₀ can hardly reflect the difference. Based on a large number of test data in the past, when the density of AEPS is less than 140kg / m³, FIGRA is maintained at a very low level close to 0, and THR level is basically maintained at about 0.2MJ.

(2) Cone calorimeter

Cone calorimeter belongs to the small-scale combustion characteristic test, which evaluates the fire response properties of the sample by obtaining the heat release characteristic quantity of the sample under the specific external radiation intensity. The test control mode is more flexible, the combustion mode is more diverse, and the test results are more comprehensive.

The samples with the same composition and density were selected and tested under the external radiation intensity of 30kW and 50kW respectively. Ignition time, peak heat release rate, average heat release rate, total heat release and weight loss were obtained, which are listed in Table 2 and Table 3.

Table 2. Cone test results of AEPS under different external radiation conditions

| Item     | 30kW      | 50kW      |
|----------|-----------|-----------|
| HRRₚₑᵃᵏ, kW/m² | Test1 | Test2 | Test3 | Avg | Test1 | Test2 | Test3 | Avg |
| HRRₚₑᵃᵍ, kW/m² | 97.82 | 94.38 | 97.41 | 96.5 | 156.58 | 125.07 | 140.47 | 140.7 |
| THR, MJ  | 17.41 | 15.04 | 15.95 | 16.1 | 16.85 | 16.26 | 18.01 | 17.0 |
| Mass lose, g | 0.83 | 0.84 | 0.81 | 0.83 | 1.41 | 1.63 | 1.34 | 1.5 |
| Ignition time, s | 44 | 39 | 35 | 39 | 17 | 17 | 18 | 17 |

Figures 1 and 2 show the after state of two kinds of radiation intensities. The state of the low calorific value inorganic material is significantly different under two radiation modes. The edge of the inorganic surrounding EPS particles under the 30kW radiation condition is clear, and the arrangement is more regular. However, under the condition of 50KW, due to the relatively more violent combustion, the inorganic material is strongly impacted by high temperature, and the edge pulverization is obvious.

Figure 1. After state of 30kW radiation condition

Figure 2. After state of 50kW radiation condition
As shown in Fig. 3 and Fig. 4, by studying the heat release rate curve of the samples, we can find that the first peak appears when the three samples burn to about 70s under the condition of 30kW external radiation, and then the heat release rate decreases rapidly until it increases again about 150s, but the speed is relatively slow. When the test time reaches about 300s, the second peak of heat release rate comes. Similarly, the curve of heat release rate at 50KW also has two peaks at 50s and 150s, and the second slow growth period of heat release rate between the two peaks is shorter than that at 30kW. Comparing the heat release rate curves of the two modes, it can be seen that higher radiation intensity has stronger heating ability for the molten EPS particles, less time is needed for the secondary combustion of the molten material, and the interval between the two peaks is shorter.

3. Limitation of heat combustion test
The forming process of AEPS is very special. Generally, low calorific value components are added to the EPS foam substrate through vacuum infiltration. However, the products prepared in this way are relatively evenly dispersed in the gap between EPS particles from macroscopic view, but there is some difference in some sampling points. When sampling at the same location for calorific value test, the proportion of EPS particles and low calorific value components are not the same, which makes the sampling location have a significant impact on the test results.

4. Advantages of scattered sampling method
In order to reduce the problem of poor reproducibility of test results caused by different sampling locations, a more scientific and accurate sampling method is designed. Before the test, the EPS particles and inorganic materials are completely separated, and the calorific values of the two components are accurately determined separately, and then the total calorific value of the sample is calculated by the
way of content weighting Calorific value. In this way, by increasing the number of samples, the representativeness of the proportion of the two components in the tested sample is significantly improved, and the combustion calorific value of the individual components is more accurate, so the repeatability of the overall calorific value results is significantly improved.

**Table 3.** Test results of heat combustion of traditional sampling

| Item                        | Sample A       | Sample B       |
|-----------------------------|---------------|---------------|
| Sample mass, g              | 0.3002        | 0.3195        |
| Heat combustion, MJ         | 0.32 0.68     | 0.50 0.41     |
| Avg. MJ standard deviation  | 0.15          | 0.34          |
| Test1 Test2 Test3 Test4 Test5 |               |               |

**Table 4.** Sample A test results of heat combustion of dispersed sampling

| Item                        | Test1 Test2 Test3 Test4 Test5 |
|-----------------------------|-------------------------------|
| Sample tole mass, g         | 5.4219 6.3950 5.5084 5.5396 6.4543 |
| EPS partical mass, g        | 0.021 0.024 0.021 0.022 0.024  |
| Heat combustion of EPS partical, MJ/kg | 38.75 37.98 38.33 38.29 38.30  |
| inorganic powder, g         | 5.4009 6.3710 5.4874 5.5176 6.4303 |
| Heat combustion of inorganic powder, MJ/kg | 0.38 0.37 0.40 0.38 0.37  |
| Total heat, MJ/kg           | 0.52 0.51 0.54 0.53 0.51       |
| Avg. MJ/kg standard deviation | 0.15          | 0.34          |

**Table 5.** Sample B test results of heat combustion of dispersed sampling

| Item                        | Test1 Test2 Test3 Test4 Test5 |
|-----------------------------|-------------------------------|
| Sample tole mass, g         | 12.3215 11.3753 13.2534 10.5396 14.4235 |
| EPS partical mass, g        | 0.186 0.159 0.197 0.160 0.208 |
| Heat combustion of EPS partical, MJ/kg | 39.12 38.98 38.48 38.59 38.30 |
| inorganic powder, g         | 12.1355 11.2163 13.0564 10.3796 14.2155 |
| Heat combustion of inorganic powder, MJ/kg | 0.38 0.37 0.41 0.40 0.37  |
| Total heat, MJ/kg           | 0.96 0.91 0.97 0.98 0.92       |
| Avg. MJ/kg standard deviation | 0.9            | 0.03          |

The scattered sampling calorific value test method introduced here significantly increases the quality of sample collection. EPS particles and inorganic powder are completely separated by hand, and their mass ratio is accurately calculated by weighing and recording. Then the calorific value of separated EPS particles and inorganic powder is independently tested for many times, and weighted calculation is carried out based on the two mass ratios, so as to obtain the overall calorific value of the material.

It can be clearly found that, as shown in Table 3, test results of heat combustion of traditional sampling are not satisfactory, standard deviation of Sample A and B are 0.15 and 0.34, the repeatability of multiple independent calorific value test results of each component in table 4 and table 5 are very good, and the stability of overall calorific value results obtained by weight weighted calculation is also relatively ideal. The maximum and minimum deviations of overall calorific value of sample is only 0.03, and the standard deviations is 0.01, The results are far lower than the overall sampling test results. This shows that the dispersed sampling test can obviously offset the difference of component content at different positions by increasing the sampling quality. The calorific value test accuracy of the main
combustion components in the samples can be effectively improved by repeatedly and independently testing the calorific value of the components.

5. Conclusion
In this paper, the cone calorimeter is introduced into the fire performance test of AEPS, which makes full use of the advantages of the cone calorimeter, such as flexible test scheme setting, rich and comprehensive test results, so that the differences of fire performance parameters which can not be distinguished in detail in SBI test can be fully reflected; a dispersed sampling heat combustion test method is designed, the accuracy and representativeness of heat combustion test are improved, and the test verification is carried out. The optimization scheme of fire performance test of AEPS explored in this paper is of great significance to improve the objectivity and scientificity of fire safety evaluation results of such products.

References
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