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Textiles - Determination of thermal effusivity of fabrics - Modified transient plane source method

纺织品 织物蓄热系数的测定 改型平面瞬态热源法

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1 Scope

This document describes a method for testing the thermal effusivity of fabrics using a modified transient plane source.

This document applies to woven fabrics, knitted fabrics and nonwovens; fabrics containing a filling are tested by reference to it.

2 Normative references

The contents of the following documents constitute indispensable provisions of this document through normative reference in the text. For dated references, only the edition corresponding to that date applies to this document; for undated references, the latest edition, including all amendments, applies to this document.

GB/T 3820 Determination of thickness of textiles and textile products. GB/T 6529 Textiles - Standard atmospheres for conditioning and testing. GB/T 8170 Rules of rounding off for numerical values and expression and judgement of limiting values.

3 Terms and definitions

Modified transient plane source (MTPS): a device having a single-sided plane heat source and a heating guard ring mounted perpendicular to the plane heat source, which sends an instantaneous heat pulse into the specimen through contact with one face of it.

Thermal effusivity: a characterization of the ability of one material to exchange heat when it is in contact with another material. Note: the defining expression for thermal effusivity is given as formula (1). In the formula: e is the thermal effusivity of the material, expressed in watts times the square root of a second per square metre kelvin; lambda is the thermal conductivity of the material, expressed in watts per metre kelvin; c sub p is the specific heat capacity of the material, expressed in joules per kilogram kelvin; rho is the density of the material, expressed in kilograms per cubic metre.

4 Principle

A constant current is applied to the heating element of the sensor, which supplies a small quantity of heat and transfers it in one direction into the specimen. The rise in temperature at the contact face between specimen and sensor causes a change in the sensor voltage. The rate of temperature rise is determined from the curve relating the change in sensor voltage to the test time, and from it the thermal effusivity of the specimen is calculated.

5 Test apparatus

Thermal effusivity tester. A schematic diagram is given in Figure 1. The instrument comprises: a) a sensor, of diameter (18.0 +/-0.01) mm, able to display the surface temperature of the specimen tested to 0.01 degrees Celsius, with accuracy within +/-1 percent and precision within +/-5 percent; b) a heater, able to supply an instantaneous heat pulse to one face of the specimen; c) a controller, which supplies the power pulse to the heater; d) a heating guard ring, able to ensure that heat is transferred to the specimen in one direction and perpendicularly; e) a data processing system, comprising a data acquisition device and data analysis software, the data acquisition device being able to acquire, store and display signals, including measured and calculated signals, at an acquisition rate of not less than 20 data points per second, and the data analysis software being able to run the necessary calculations and to calculate and record the thermal effusivity from the change in temperature and time; f) a loading device, able to apply a pressure of 10 kPa to 50 kPa to the specimen. Note: a standard weight of nominal value 500 g with a maximum permissible error of 0.025 g is generally used.

In Figure 1 the key is: 1, fabric specimen; 2, sensor; 3, heater; 4, controller; 5, data processing system; 6, loading device; 7, heating guard ring.

Thickness gauge. It shall meet the requirements of GB/T 3820.

6 Preparation of specimens

Where the thickness of a single layer of the specimen reaches or exceeds 1.0 mm, take 5 specimens from the sample to be tested. Where the thickness of a single layer of the specimen is less than 1.0 mm, take 5 sets of combined specimens from the sample to be tested, the thickness of each set of combined specimens reaching or exceeding 1.0 mm. Take a further number of supplementary specimens from the sample to be tested. When sampling, make sure that no two specimens contain the same yarns; the size of the specimen shall be such that it completely covers the sensor area.

Note: a thickness of 1.0 mm and above ensures that the heat flow does not penetrate through its maximum test penetration thickness during the test, and ensures that even where the thermal effusivity of the fabric is very high the penetration depth of the heat flow during the test still remains within the fabric.

7 Standard atmosphere for conditioning and testing

The standard atmosphere for conditioning and testing is applied in accordance with GB/T 6529, and the specimens shall be conditioned to equilibrium before the test. During the measurement, air movement shall be kept to a minimum so as to reduce temperature fluctuation.

8 Test procedure

Place one specimen or one set of combined specimens face up over the sensor of the modified transient plane source so that the sensor is completely covered. For a combined specimen, place the adjacent layers stacked at 30 degrees to one another, so that the layers of the specimen do not line up with the adjacent layers.

Place a 500 g standard weight, giving a pressure of 20 kPa, on top of the specimen, so as to ensure close contact between specimen and sensor. Where close contact between specimen and sensor cannot be obtained at that pressure, or where the parties concerned so agree, another pressure may be chosen, applied by means of the loading device, and stated in the report.

Begin the test. Supply a constant instantaneous power pulse to the heater and to the heating guard ring, such that the surface of the specimen shows a temperature rise of 1 degree Celsius to 3 degrees Celsius within 1 s to 3 s.

Record the thermal effusivity of the specimen.

Allow the specimen and the instrument to cool to ambient temperature. Note: the cooling time is generally not more than 1 min.

Add supplementary specimens layer by layer on top of the specimen or set of combined specimens used in 8.1 and test again, calculating the deviation of the thermal effusivity at each number of layers from that at the previous number of layers. Where the rate of change of the thermal effusivity does not exceed +/-5 percent, the previous number of layers shall be taken as sufficient, and the thermal effusivity at that sufficient number of specimen layers shall be taken as the thermal effusivity of that specimen or set of specimens.

Using the sufficient number of specimen layers determined in 8.6, repeat the test steps of 8.1 to 8.5 on the other 4 specimens or 4 sets of specimens.

9 Calculation of results

The thermal effusivity of the sample is expressed as the arithmetic mean of the test results of the 5 specimens or 5 sets of specimens, and the result is rounded to one decimal place in accordance with GB/T 8170.

10 Test report

The test report shall include the following: a) the number of this document; b) a description of the sample; c) the number of specimen layers; d) the pressure used; e) the face in contact with the sensor; f) the thermal effusivity of the specimen; g) the temperature and relative humidity of the test environment; h) details of any deviation from this document; i) the date of the test.