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Carbon-fibre-reinforced plastics — Determination of the size and aspect ratio of crushed objects

Plastiques renforcés de fibres de carbone — Détermination des dimensions et du rapport de côtés des objets écrasés

ICS 59.100.20

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Foreword

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ISO 30012 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

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Carbon-fibre-reinforced plastics — Determination of the size and aspect ratio of crushed objects

1 Scope

This standard specifies the test method for measurement of the size and aspect ratio of crushed carbon-fibre-reinforced plastic (CFRP), especially for recycling purpose. In this standard the shape of crushed CFRP, the fragment, is treated as a rectangular shape, and the measurement of the long and short side of the shape is described. Preferable average dimensions of the fragments are;

Length of the long side: 5 mm - 50 mm

Width of the short side: 1 mm - 10 mm

This standard provides three measuring methods, two methods are manual methods using microscope and scale and the third is an automatic method using a measuring apparatus.

Crushed CFRP's obtained from thermosetting or thermoplastic resin matrices are covered by this standard.

NOTE If the crushed CFRP contain a lot of small fragments and fine particle, it is recommended to screen out by a sieve of 1 mm size before the measurement.

2 Normative references

The following referenced documents are indispensable for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO291, *Plastics — Standards atmospheres for conditioning and testing*

3 Symbols and abbreviated terms

CFRP is an abbreviated term of carbon-fibre-reinforced plastic.

The symbols used in this international standard are as follows:

W the width of CFRP fragment represented by the short side of a rectangular shape

L the length of CFRP fragment represented by the long side of a rectangular shape

\overline{W} the average width of CFRP fragments

\overline{L} the average length of CFRP fragments

AR the aspect ratio of CFRP fragments which is calculated as the ratio of the length to the width of CFRP fragment

\overline{AR} the average aspect ratio of CFRP fragments

$\sigma(L)$ the standard deviation of length of CFRP fragments

$\sigma(W)$ the standard deviation of width of CFRP fragments

4 Principle

The fragments obtained from crushing CFRP laminate are impartially and measured.

Most fragments of CFRP have a shape that can be approximate to a rectangular. Each fragment is observed with an optical microscope or equivalent equipment and the width and length of the rectangular measured.

At least one hundred fragments are measured. The size and aspect ratio of crushed CFRP fragments are reported as average and standard deviations of W , L , and average of aspect ratio AR .

5 Apparatus

5.1 Stereomicroscope, comprised of a light source, scales and a stage which supports a glass plate carrying the fragment of CFRP. Magnification should be variable up to 10 times. Scales shall be readable to 0,1 mm. (Method A)

5.2 Projection microscope, comprised of a projector, light source, scales and a stage that supports a slide carrying the fragment of CFRP. Magnification should be variable up to 10 times. Scales shall be readable to 0,1 mm. (Method B)

NOTE A personal computer, connected to the projection microscope and with software of measuring the length and width of the fragments enables faster and easier measurements to be made (Method B)

5.3 Automatic size and shape measurement apparatus, an apparatus such as an image analyzer with magnification for carrying out semi-automatic measurement of the length and width of the CFRP fragments. (Method C)

5.4 Calibrated rule or scale, used to calibrate measurement scales on microscope and projection equipment

6 Sampling

Unless otherwise specified, the following sampling procedure shall be respected.

6.1 Crushed CFRP is sampled from a pile into a bag of 20 - 50 litre volume.

NOTE Use caution when handling CFRP fragments. Handling them with unprotected hands can easily result in minor irritation/injury due to CFRP slivers. Protective gloves made of impervious material should be used.

6.2 Take 3 samples from one bag. Avoid samples of outer locations of around 20 % of the total volume. Take 3 samples from inner locations impartially, e.g. upper, centre and lower locations.

NOTE Distribution of size or shape of the CFRP fragments may not be identical among locations in the bag, due to sampling or transportation causes.

6.3 Mix the 3 samples impartially for the measurement. The amount of the total sample shall contain at least 100 fragments to be measured.

7 Measurement

7.1 General

The shape of each fragment is approximated to a rectangle circumscribing the fragment as represented by white line in the Figure 1. L and W of the rectangle in Figure 1 stand for length and width of the fragment respectively. The shape of the rectangle is decided so as to minimize the value of W . Short fragments of the length of 2 mm or shorter may be omitted from the following measurements.

7.2 Method A: Manual method (Stereomicroscope)

7.2.1 Each fragment is arranged on the glass plate on the stereomicroscope. The magnification of the microscope is adjusted appropriately to the average size of the fragments.

7.2.2 Calibrate the measurement scale with a calibrated ruler or scale

7.2.3 The fragment is aligned with the long side parallel to one of the scales.

7.2.4 The length of the long side of the fragment is measured as length L and the short side as width W . Measure the length and width to 0,1 mm.

7.2.5 Repeat the measurement for at least 100 fragments.

7.3 Method B: Projection microscope

7.3.1 Arrange an adequate number of fragments on the glass plate. Distribute fragments avoiding them contacting and overlapping .

7.3.2 Set the glass plate on the stage of the microscope connected to the personal computer.

7.3.3 Calibrate the personal computer measurements using a calibrated ruler.

7.3.4 The magnification of the microscope is adjusted appropriately to the average size of the fragments.

7.3.5 The observed fragments are projected on the monitor. The length L and the width W of the fragment is measured to 0,1 mm.

7.3.6 Repeat the measurement for at least 100 fragments.

7.4 Method C: Automatic shape and size measurement apparatus

7.4.1 Arrange an adequate number of the sample fragments on the stage of the apparatus. Distribute fragments avoiding them contacting and overlapping .

7.4.2 The observed fragments are projected on the monitor

7.4.3 The length L and width W of each fragment is measured to 0,1 mm, and recorded automatically

7.4.4 Repeat the measurement for at least 100 fragments.

Figure 2 is for an example of UD CFRP for measurement method C. All CFRP fragments are approximated to rectangular shape by the construction lines shown in white in Figure 2.

Figure 3 is for an example of crushed cloth CFRP. Figure 4 is for an example the mixture of crushed UD and cloth CFRP.

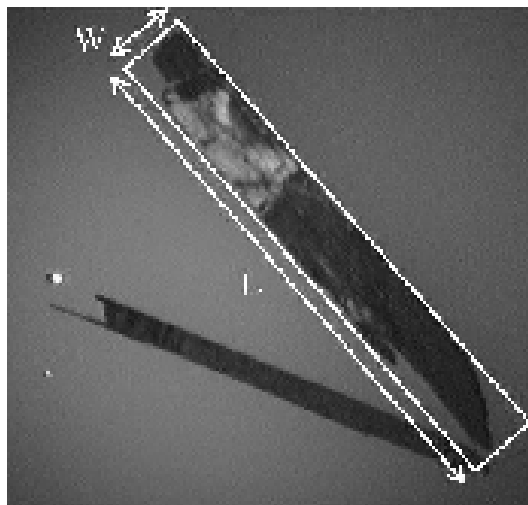


Figure 1 — Length (L) and width (W) of the fragment of CFRP respectively



Figure 2 — Example of crushed UD CFRP fragments, which are approximated to rectangular shape shown by the line for the method C.



Figure 3 — Example of crushed cloth CFRP

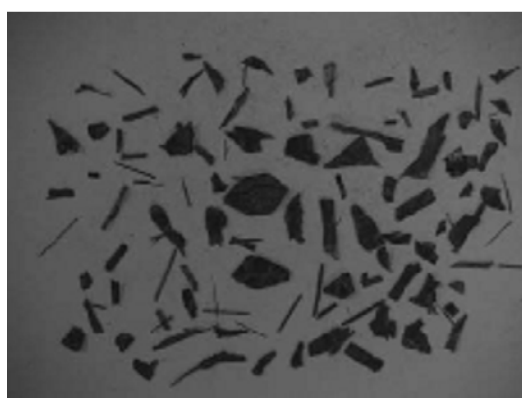


Figure 4 — Example of UD/cloth mixture

8 Calculation and expression of results

8.1 The average of length L and width W of fragments is calculated by the following formula;

$$\bar{L} = \frac{\sum L_n}{N} \quad (n=1 \text{ to } N)$$

$$\bar{W} = \frac{\sum W_n}{N} \quad (n=1 \text{ to } N)$$

Where,

\bar{L} is the mean length of fragments ,

\bar{W} is the mean width of fragments ,

n is the number of fragments ,

N is the measurement number ,

L_n is the measurement length of n -th fragment ,

W_n is the measurement width of n -th fragment.

NOTE Log or Log natural of \bar{L} or \bar{W} may be used instead of the measured data.

8.2 The standard deviation $\sigma(L)$ and $\sigma(W)$ of length L and width W of fragments are calculated by the following formulas:

$$\sigma(L) = \left[\left(\frac{\sum L_n^2}{N} \right) - \bar{L}^2 \right]^{1/2} \quad (n=1 \text{ to } N)$$

$$\sigma(W) = \left[\left(\frac{\sum W_n^2}{N} \right) - \bar{W}^2 \right]^{1/2} \quad (n=1 \text{ to } N)$$

Where,

$\sigma(L)$ is the standard deviation of length L ,

$\sigma(W)$ is the standard deviation of width W .

NOTE Log or Log natural of \bar{L} or \bar{W} may be used instead of the measured data.

8.3 The aspect ratio AR of each fragment and the average of the AR_n are calculated by the following formulas;

$$AR_n = \frac{L_n}{W_n}$$