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Weibull statistics for strength data of fine ceramics

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Table of Contents

1 Scope

This standard specifies the parameter estimation method of the probability distribution of the uniaxial strength data of fine ceramics characterized by brittle failure.

Note. The failure strength of fine ceramics is treated as a continuous random variable. Under normal circumstances, samples with fixed geometric dimensions fail under loading.

The load at the time of failure is recorded, and the resulting failure stress is used to estimate the parameters related to the overall distribution.

This standard applies to the two-parameter Weibull distribution based on failure strength. In addition, this standard limits test samples (tensile, bending, plus The load ring, etc.) is subject to uniaxial stress. 6.4 and 6.5 outline the method of correcting Weibull parameter estimation deviation, and from all fractures originating from a single defect The overall (ie, single failure mode) data set calculates the confidence interval for these estimates. For samples where the fracture originates from multiple independent defect populations (For example, competitive failure mode), the methods of bias correction and confidence interval calculation in 6.4 and 6.5 are not applicable.

2 Normative references

The following documents are indispensable for the application of this document. For dated reference documents, only the dated version applies to this article Pieces. For undated reference documents, the latest version (including all amendments) is applicable to this document.

GB/T 3358.1 Statistical vocabulary and symbols Part 1.General statistical terms and terms used in probability (GB/T 3358.1-2009, ISO 3534-1.2006, IDT)

3 Terms and definitions

The following terms and definitions defined in GB/T 3358.1 apply to this document.

3.1 Defects overall

3.1.1 Flaw Areas with inhomogeneous or discontinuous features in the material are likely to cause stress concentration and fracture under external load.

Note. When the defect becomes the source of material failure, the defect is the key factor of material failure.

3.1.2 Censoreddata Intensity data (ie a sample) includes delayed observations caused by multiple competing or coexisting defects.

Note. Fracture analysis clearly shows that there are three types of concurrent defect distributions in a sample (the sample can also contain any number of concurrent defect distributions), respectively Denoted as distribution A type, distribution B type and distribution C type. According to the fracture analysis, the strength of each sample corresponds to a defect distribution leading to failure. in When estimating the characteristic parameters of the intensity distribution related to the defect distribution type A, all samples should be included in the analysis (not just due to the distribution of type A defects).

Failed samples) to ensure the efficiency and accuracy of the obtained parameter estimates. The strength of the failed sample due to the distribution B type (or distribution C type) defect can be It is regarded as a right censored observation relative to the distribution type A defect, and the distribution type A defect is delayed due to the failure of the distribution type B (or distribution type C) defect The resulting failure, limiting or censoring the distribution of type A defect information in the sample [2]. Samples damaged by defects in distribution type B (or distribution type C)

Among them, the most severe distribution type A defect dominates with a higher intensity (and therefore on the right) the observed failure intensity. However, there is currently no information about this intensity difference Information of different levels. This standard's method of analyzing censored data can use incomplete information to provide effective and relatively unbiased estimates of distribution parameters.

3.1.3 Competing failure modes Different types of fracture source phenomena caused by coexistent (competitive) defect distribution.

t The normalized value of the confidence interval for calculating the Weibull feature intensity defined by formula (17)

UF unbiased factor V The volume of the sample subjected to tensile stress V0 unit volume Veff effective volume beta Weibull scale parameter sigma uniaxial tensile stress sigma^ Estimated average intensity sigmaj Maximum stress when the jth sample fails sigma0 Weibull material scale parameter defined by formula (7) (strength corresponds to unit volume or area) sigma^0 Estimated value of Weibull material scale parameter sigmatheta Weibull characteristic intensity defined by formula (5) (related to the test sample)

sigma^theta Estimated value of Weibull characteristic intensity

5 Significance and use 5.1 This standard can be used by experimenters to estimate Weibull distribution parameters of strength data. These parameters describe the fracture of fine ceramics for different purposes.

The statistical distribution of strength can be used for reliability evaluation during mechanical design. The intensity value depends on the sample size and geometry. Parameter Estimation The value can be calculated by (m^,sigma^theta) of a given geometric shape sample, but it is recommended that the report be converted into an estimate of material-specific parameters (m^,sigma^0)

value. In addition, different defect distributions (for example, failure due to inclusions or processing damage) have their own unique strength distribution parameters. For typical Please refer to Appendix C for details on the conversion of estimated values of sample parameters of any shape and defect distribution.

5.2 This standard provides two data processing methods, A and B, for different purposes.

Method A is suitable for simple analysis of samples whose dominant strength defects are known or assumed to come from a single population. So there is no need for fracture points Analysis to identify defect types and classify different samples. This method is suitable for simple material screening.

Method B is suitable for the design and analysis of final parts, that is, there is a general situation of competitive defects. This method requires fracture analysis Defect origin of dominant strength, determine the overall type of defect.

5.3 Method A analyzes the intensity data set and obtains the estimated value of Weibull modulus m^ and the estimated value of characteristic intensity sigma^theta and its confidence interval if any If necessary, the average intensity can also be calculated. Finally, the failure data is shown graphically in the test report. When the confidence interval is large, the result of the analysis should not be It is used to analyze situations that are extrapolated beyond the existing confidence interval. Effective extrapolation analysis (about effective volume Veff and/or small failure probability)

The premise is that the defects of all samples are of the same type.

5.4 Method B is to characterize the origin of fracture by fracture analysis of each failed sample. Filter out the outliers of each defect distribution. If all Defects originate from a single defect distribution, and the unbiased estimate of Weibull modulus, the confidence zone of Weibull modulus and Weibull characteristic intensity estimate can be calculated between. If the fracture originated from one or more defect types, separate relevant data sets for each defect type, and compare these data sets separately Perform censoring analysis. The failure data is shown graphically in the final test report. When using the analysis results for design purposes, it should be noted that the assumptions are The part and the sample have the same defect type.

6 Method A. Maximum likelihood method parameter estimation of a single defect population

6.1 Summary This standard is based on the maximum likelihood method for parameter estimation (see References [13], [14], [20] and [21]). Use maximum likelihood The parameter estimate obtained is unique (two-parameter Weibull distribution), and as the number of samples increases, the statistical estimate The calculation method more effectively approximates the real population.

Appendix E (Informative appendix) Analysis of samples with uncertain sources of fracture

E.1 Four options E.1.1 Overview 7.2.2 describes the four options a) ~ d) when the experimenter encounters an uncertain fracture source during fracture analysis. E.1.2~E.1.5 further These four options are defined, and the applicable and non-applicable situations are listed.

E.1.2 Option a)

Option a) involves using all available fracture analysis information to subjectively classify samples of unknown fracture sources as previously identified fracture sources classification. Many samples with unknown fracture sources have partial fracture information but are considered insufficient for correct identification and classification. (It should be pointed out that The degree of certainty required for "correct identification" of fracture source defects varies among different fracture analysts). under these circumstances, Option a) allows the experimenter to use incomplete fracture analysis information to assign unidentified fracture sources to the previously determined defect classification. Such as If partial fracture analysis information is available, this option is preferred. For example, the fracture analysis of a tensile sample shows that the fracture originated from the surface of the sample Or it is very close to the surface of the sample, but the fracture initiation defect cannot be "correctly identified". Other samples from the same sample were determined to be due to lack of processing Sink and fail. Usually processing damage is often difficult to identify. Therefore, in this case, use option a) and infer that the origin of the sample fracture is The work injury is reasonable. The test report should clearly record each sample of unknown fracture source classified by this (or any other) option. however, The conclusion about the processing damage in this example may be wrong; for example, the fracture initiation defect may be a "typical microscopy" located near the surface of the specimen.

Structural features" (mainstreammicrostructuralfeature)[3][12] (usually difficult to distinguish