Designation: C1495 − 16 (Reapproved 2023)

Standard Test Method for Effect of Surface Grinding on Flexure Strength of Advanced Ceramics[1]

This standard is issued under the fixed designation C1495; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the effect of surface grinding on the flexure strength of advanced ceramics. Surface grinding of an advanced ceramic material can introduce microcracks and other changes in the near surface layer, generally referred to as damage (see Fig. 1 and Ref. (**1**)).[2] Such damage can result in a change—most often a decrease—in flexure strength of the material. The degree of change in flexure strength is determined by both the grinding process and the response characteristics of the specific ceramic material. This method compares the flexure strength of an advanced ceramic material after application of a user-specified surface grinding process with the baseline flexure strength of the same material. The baseline flexure strength is obtained after application of a surface grinding process specified in this standard. The baseline flexure strength is expected to approximate closely the inherent strength of the material. The flexure strength is measured by means of ASTM flexure test methods.

1.2 Flexure test methods used to determine the effect of surface grinding are C1161 Test Method for Flexure Strength of Advanced Ceramics at Ambient Temperatures and C1211 Test Method for Flexure Strength of Advanced Ceramics at Elevated Temperatures.

1.3 Materials covered in this standard are those advanced ceramics that meet criteria specified in flexure testing standards C1161 and C1211.

1.4 The flexure test methods supporting this standard (C1161 and C1211) require test specimens that have a rectangular cross section, flat surfaces, and that are fabricated with specific dimensions and tolerances. Only grinding processes that are capable of generating the specified flat surfaces, that is, planar grinding modes, are suitable for evaluation by this method. Among the applicable machine types are horizontal and vertical spindle reciprocating surface grinders, horizontal and vertical spindle rotary surface grinders, double disk grinders, and tool-and-cutter grinders. Incremental cross-feed, plunge, and creep-feed grinding methods may be used.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C1145 Terminology of Advanced Ceramics
C1161 Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature
C1211 Test Method for Flexural Strength of Advanced Ceramics at Elevated Temperatures
C1239 Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics
C1322 Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics
C1341 Test Method for Flexural Properties of Continuous Fiber-Reinforced Advanced Ceramic Composites

3. Terminology

3.1 *Materials Related:*

[1] This test method is under the jurisdiction of ASTM Committee C28 on Advanced Ceramics and is the direct responsibility of Subcommittee C28.01 on Mechanical Properties and Performance.

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[2] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

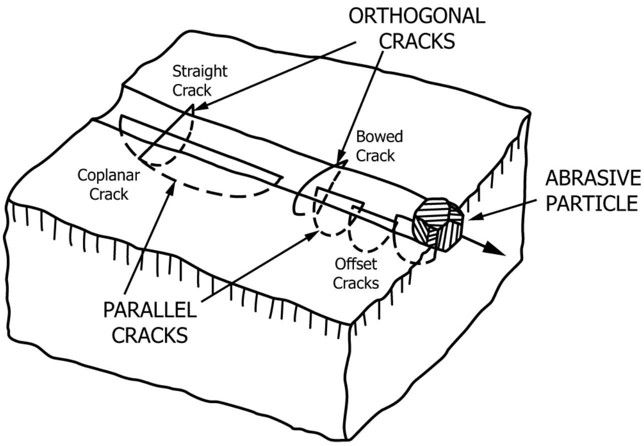


FIG. 1 Microcracks Associated with Grinding (Ref. (1))[2]

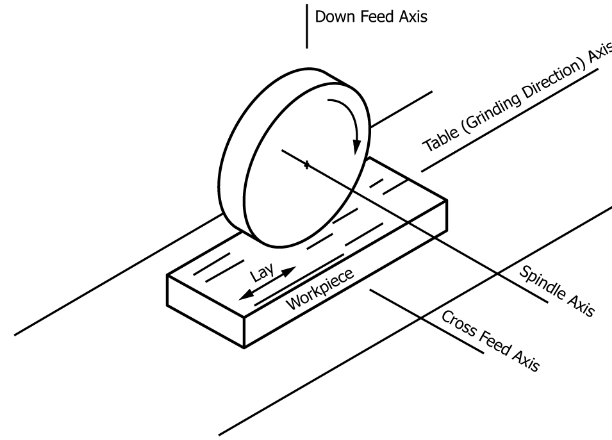


FIG. 2 Machine Axes for Horizontal Spindle Reciprocating Surface Grinder

3.1.1 *advanced ceramic, n*—a highly engineered, high-performance, predominately nonmetallic, inorganic, ceramic material having specific functional attributes. **C1145**

3.1.2 *baseline flexure strength, n*—in the context of this standard, refers to the flexure strength value obtained after application of a grinding procedure specified in this standard.

3.1.2.1 *Discussion*—For the advanced ceramics to which this standard is applicable, the baseline flexure strength is expected to be a close approximation to the inherent flexure strength.

3.1.3 *ceramic matrix composite, n*—a material consisting of two or more materials (insoluble in one another) in which the major, continuous component (matrix component) is a ceramic, while the secondary component(s) (reinforcing component) may be ceramic, glass-ceramic, glass, metal, or organic in nature. These components are combined on a macroscale to form a useful engineering material possessing certain properties or behavior not possessed by the individual constituents. **C1341**

3.1.4 *grinding damage, n*—any change in a material that is a result of the application of a surface grinding process. Among the types of damage are microcracks (Fig. 1), dislocations, twins, stacking faults, voids, and transformed phases.

3.1.4.1 *Discussion*—Although they do not represent internal changes in microstructure, chips and surface pits, which are a manifestation of microfracture, and abnormally large grinding striations are often referred to as grinding damage. Residual stresses that result from microstructural changes may also be referred to as grinding damage.

3.1.5 *inherent flexure strength, n*—the flexure strength of a material in the absence of any effects of surface grinding or other surface finishing process, or of extraneous damage that may be present. The measured inherent flexure strength may depend on the flexure test method, test conditions, and test specimen size.

3.1.5.1 *Discussion*—Flaws due to surface finishing or extraneous damage may be present but their effect on flexure strength is negligible compared to that of "inherent" flaws in the material.

3.1.6 *materials lot or batch, n*—a single billet or several billets prepared from defined homogeneous quantities of raw materials passing simultaneously through each processing step to the end product is often referred to as belonging to a single lot or batch.

3.1.6.1 *Discussion*—There is no assurance that a single billet is internally homogenous or that billets belonging to the same lot or batch are identical.

3.2 *Grinding Process Related*—Definitions in this section apply to grinding machines and modes that generate planar surfaces. Applicable grinding machines types are identified in (1.4). Some definitions may not be applicable when used in connection with non-planar grinding modes such as centerless and cylindrical modes which are outside of the scope of this standard.

3.2.1 *blanchard grinding, n*—a type of rotary grinding in which the workpiece is held on a rotating table with an axis of rotation that is parallel to the (vertical) spindle axis.

3.2.2 *coolant, n*—usually a liquid that is applied to the workpiece or wheel, or both, during grinding for cooling, removal of grinding swarf, and for lubrication.

3.2.3 *coolant flow rate, n*—volume of coolant per unit time delivered to the wheel and workpiece during grinding.

3.2.4 *creep-feed grinding, n*—a mode of grinding characterized by a relatively large wheel depth-of-cut and correspondingly low rate of feed.

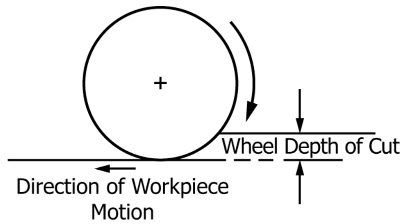
3.2.5 *cross-feed, n*—increment of displacement or feed in the cross-feed direction.

3.2.6 *cross-feed direction, n*—direction in the plane of grinding which is perpendicular to the principal direction of grinding. (Fig. 2)

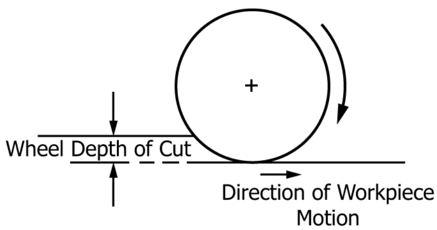
3.2.7 *down-feed, n*—increment of displacement or feed in the down feed direction. (Fig. 2)

3.2.8 *down-feed direction, n*—direction perpendicular to the plane of grinding for a machine configuration in which the grinding wheel is located above the workpiece. (Fig. 2)

3.2.9 *down-grinding, n*—A condition of down-grinding is said to hold when the velocity vector tangent to the surface of

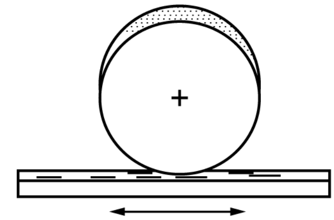


(a) Down Grinding

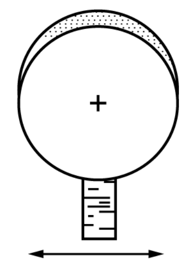


(b) Up Grinding

FIG. 3 Relative Wheel and Workpiece Directions of Motion for Down Grinding and Up Grinding



(a) Longitudinal Direction



(b) Transverse Direction

FIG. 4 Grinding Directions with Respect to Flexure Bar Orientation

the wheel at points of first entry into the grinding zone has a component normal to and directed into the ground surface of the workpiece. (Fig. 3a)

3.2.10 *dressing, n*—a conditioning process applied to the abrasive surface of a grinding wheel to improve the efficiency of grinding.

3.2.10.1 *Discussion*—Dressing may accomplish one or more of the following: (*1*) removal of bond material from around the grit on the surface of the grinding wheel causing the grit to protrude a greater distance from the surrounding bond, (*2*) removal of adhered workpiece material which interferes with the grinding process, removal of worn grit, (*3*) removal of bond material thereby exposing underlying unworn grit, and (*4*) fracture of worn grit thereby generating sharp edges.

3.2.11 *grinding axis, n*—any reference line along which the workpiece is translated or about which it is rotated to effect the removal of material during grinding.

3.2.12 *grinding direction, n*—when used in reference to flexure test bars, refers to the angle between the long (tensile) axis of the flexure bar and the path followed by grit in the grinding wheel as they move across the ground surface. See longitudinal grinding direction and transverse grinding direction. (Fig. 4)

3.2.13 *grit depth-of-cut, n*—nominal maximum depth that individual grit on the grinding wheel penetrate the workpiece surface during grinding. Synonymous with undeformed chip thickness.

3.2.14 *in-feed, n*—synonymous with wheel depth-of-cut and down feed.

3.2.15 *longitudinal grinding direction, n*—grinding direction parallel to the long axis of the flexure bar. (Fig. 4a)

3.2.16 *machine axes, n*—reference line along which translation or about which rotation of a grinding machine component (table, stage, spindle...) takes place. (Fig. 2)

3.2.17 *planar grinding, n*—a grinding process which generates a nominally flat (plane) surface.

3.2.18 *reciprocating grinding, n*—mode of grinding in which the grinding path consists of a series of linear bi-directional traverses across the workpiece surface.

3.2.19 *rotary grinding, n*—modes of planar grinding in which the grinding path in the plane of grinding is an arc, effected either by rotary motion of the workpiece or of the grinding wheel.

3.2.19.1 *Discussion*—Grinding striations left on the workpiece surfaces are arcs.

3.2.20 *surface grinding, n*—a grinding process used to generate a flat surface by means of an abrasive tool (grinding wheel) having circular symmetry with respect to an axes about which it is caused to rotate. (Fig. 2)

3.2.21 *table speed, n*—speed of the grinding machine table carrying the workpiece usually measured with respect to the machine frame.

3.2.22 *transverse grinding direction, n*—grinding direction perpendicular to the long axis of the flexure bar. (Fig. 4b)

3.2.23 *truing, n*—process by which the abrasive surface of a grinding wheel is brought to the desired shape and is made concentric with the machine spindle axis of rotation.

3.2.24 *undeformed chip thickness, n*—maximum thickness of a chip removed during grinding, assuming that the chip is displaced from the surface without deformation or change in shape.

3.2.24.1 *Discussion*—Equivalent in size to grit depth-of-cut.

3.2.25 *up-grinding, n*—a condition of up-grinding is said to hold when the velocity vector tangent to the surface of the wheel at points of first entry into the grinding zone has a