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Standard Practice for Calculating Areas, Volume, and Linear Change of Refractory Shapes[1]

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1. Scope

1.1 This practice presents the methods of calculating areas, volumes and linear changes of irregularly shaped refractory specimens.

1.2 Areas of irregular (both conventional and shaped) specimens are required for determining the creep of certain refractory products.

1.3 Linear and volume changes or irregularly shaped refractories are required for determining reheat change.

1.4 The values stated in Si units are to be regarded as the standard.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water[2]

C 113 Test Method for Reheat Change of Refractory Brick[2]

C 830 Test Method of Apparent Porosity, Liquid Absorption, Apparent Specific Gravity, and Bulk Density by Vacuum Pressure[2]

C 832 Test Method of Measuring the Thermal Expansion and Creep of Refractories Under Load[2]

E 691 Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method[3]

3. Significance and Use

3.1 Fireclay steel-teeming nozzles and sleeves are classified by volume reheat change. Bloating of some refractories results in irregular reheat dimensions, which are difficult to measure. This practice determines the volume without depending upon physical linear measurements.

3.2 Blast furnace checkers that have irregular cross-sections are classified by "creep properties." This practice determines the average cross-sectional area without requiring area measurements.

4. Procedure

4.1 The test specimens shall have their volume (V_A) predetermined using the standard procedure described in Test Methods C 20 or C 830.

4.2 Dry the specimens to constant weight.

4.3 Weigh the specimens to the nearest 0.1 g and record as *W*.

4.4 If the specimens have parallel faces (such as ground surfaces for applying load for creep data) measure the length to the nearest 0.005 in. (0.13 mm) and record as *L*.

5. Calculation

5.1 *Area of Creep Specimens (Irregular Cross-Sections)*:

5.1.1

$$\text{area } (A) = \frac{\text{volume}(V)\ (\text{C 20 or C 830})\ \text{cm}^3}{\text{length}(L)\ (\text{cm})} = \text{cm}^2\ (10^{-4}\ \text{m}^2) \quad (1)$$

5.1.2

$$\text{volume(V)} = \frac{\text{weight}(W)\ (\text{g})}{\text{bulk density}\ (\text{g/cm}^3)} = \text{cm}^3\ (10^{-6}\ \text{m}^3) \quad (2)$$

5.1.3 *Illustration*:

Weight (W) = 375.2 g
Bulk Density = 2.56 g/cm^3(Mg/m^3)
Length (L) = 10.795 cm (10^{-2} m)

$$V = \frac{375.2}{2.56} = 146.56\ \text{cm}^3\ (10^{-6}\ \text{m}^3) \quad (3)$$

$$A = \frac{\text{Volume}}{\text{Length}} = \frac{146.56}{10.795\ (10^{-2}\ \text{m})} = 13.58\ \text{cm}^2\ (10^{-4}\ \text{m}^2) \quad (4)$$

5.2 *Volume Change of Reheat Specimens*:

$$\%\ \text{volume change}\ (\Delta V) = \frac{V_B - V_A}{V_A} \times 100 \quad (5)$$

where:

V_A = original volume, cm^3(10^{-6} m^3)
V_B = final reheat volume, cm^3(10^{-6} m^3), and
ΔV = (V_B - V_A) change in volume from State A to State B (volume obtained from either Test Method C 20 or Test Method C 830).

5.3 *Converting % Volume Change ΔV to % Linear Change ΔL of Reheat Specimens*:

5.3.1 If volume change is negative (shrinkage) then:

[1] This practice is under the jurisdiction of ASTM Committee C-8 on Refractories and is the direct responsibility of Subcommittee C08.03 on Physical Tests.
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[2] *Annual Book of ASTM Standards*, Vol 15.01.
[3] *Annual Book of ASTM Standards*, Vol 14.02.

$$\% \text{ linear change } (\Delta L) = -[1-(1+\Delta V/100)^{1/3}] \times 100 \quad (6)$$

5.3.1.1 Illustrate for an –8 % volume change (shrinkage) as:

$$\% \text{ linear change } (\Delta L) = -[1-(1-0.08)^{1/3}] \times 100 \quad (7)$$

$$= -[\,1-(0.92)^{1/3}\,] \times 100$$

$$= -[1-(0.973\,\} \times 100$$

$$= -\,0.027 \times 100 = -\,2.7\,\%$$

5.3.2 If the volume change is positive (expansion) then:

$$\% \text{ linear change } (\Delta L) = [(1+\%\,\Delta V/100)^{1/3} - 1] \times 100 \quad (8)$$

5.3.2.1 Illustrate for a + 8 % volume change (expansion) as:

$$\% \text{ linear change } (\Delta L) = [(1+0.08)^{1/3} - 1] \times 100 \quad (9)$$

$$= (1.026 - 1) \times 100$$

$$= 0.026 \times 100 = 2.6\,\%$$

NOTE 1—The linear reheat change calculated from the volume change is only an approximation and may be different from a measured value.

6. Keywords

6.1 area; checkers; creep; Fireclay nozzle; Fireclay sleeves; irregular shapes; linear change; refractories; reheat change; volume; volume change

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