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APPENDICES

APPENDIX- 1

Barba’s Law

Barba’s law is used to develop a geometrically similar tensile specimen with similar necked regions.

In tensile testing the extension of specimen at fracture can be expressed as

$$l_f = e_u l_i + \alpha \tag{1}$$

Where , l_f is extension at fracture

α is local necking extension

$e_u l_i$ is uniform extension.

Hence, the engineering strain will be given as

$$e = \frac{l_f - l_i}{l_i} = \frac{\alpha}{l_i} + e_u \tag{2}$$

According to Barba’s law, for geometrically similar necked region:

$$\alpha = \beta\sqrt{A_0} \tag{3}$$

Where A_0 represents initial area.

Then,

$$e = \frac{\beta\sqrt{A_0}}{l_i} + e_u \tag{4}$$

In general, a geometrically similar specimens can be compared for measurement of elongation of different sized specimens.

Equation (4) shows an important geometrical factor $\frac{l_i}{\sqrt{A_0}}$ for sheet specimen and $\frac{l_i}{D_o}$ for round bars.

So for a constant value of elongation , for two different specimens of same metal spec, the geometrical requirement would follow:

$$\frac{\sqrt{A_1}}{l_1} = \frac{\sqrt{A_2}}{l_2} \tag{5}$$

Standard values of $\frac{l_i}{\sqrt{A_0}}$ and $\frac{l_i}{D_o}$ are used in different countries , which are given in Table 7.1

Table 7.1: Dimensional relationships of tensile specimens used in different countries (Dieter)

Specimen type	US (ASTM)	Great Britain	Germany
Sheet $\left(\frac{l_i}{\sqrt{A_0}}\right)$	4.5	5.65	11.3
Round $\left(\frac{l_i}{D_o}\right)$	4.0	5.0	10.0

APPENDIX- 2

Calculation of Crystallite size and residual lattice microstrain

Crystallite size (*D_{hkl}*) and residual lattice microstrain (*e_{hkl}*) are determined on the major XRD peaks individually of α-Al, (111), (220), (311) planes from the corrected Lorentzian and the Gaussian components of integral breadth widths. The corrected Lorentzian (L) component of the integral breadth β'_L for each plane is separated from instrumental breadth using (1))

$$\beta'_L = \beta_L - \beta_{L0} \tag{1}$$

Where instrumental breadth β_{L0} for the respective 2θ of α-Al reflecting plane is obtained by putting the 2θ value in polynomial equation obtained from polynomial fitting of second-order using 2θ vs β_L for all major reflecting planes of standard Si crystal. β_L is a Laurentzian component of the integral breadth of the respective 2θ of the α-Al reflecting plane. The corrected (for instrumental broadening) Gaussian component (β'_G) of the integral breadth is extracted from the Gaussian component (β_G) using Equation (7).

$$\beta'^2_G = \beta^2_G - \beta^2_{G0} \tag{2}$$

Where instrumental breadth β_{G0} for the respective 2θ of α-Al reflecting plane is obtained by putting the 2θ value in polynomial equation obtained from polynomial fitting of second-order using 2θ vs β_G for all major reflecting planes of standard Si crystal. The crystallite size (D_{hkl}) on all planes, (111), (220), and (311), and lattice microstrain (e_{hkl}) are calculated from equation (3) and (4)

$$D_{hkl} = \frac{0.91\lambda}{\beta'_L Cos(\theta)} \quad (3)$$

$$e_{hkl} = \frac{\beta'_G}{4tan\theta} \quad (4)$$

Where θ is the Bragg angle, D is crystalline size, λ is the wavelength of the X-ray radiation.

The dislocation density at (*hkl*) is calculated for the crystallite size and microstrain using the equation (5) from the diffraction measurement.

$$\rho_{hkl} = \frac{2\sqrt{3}\langle e_{hkl}^2\rangle^{1/2}}{D_{hkl}b} \quad (5)$$

Where b is the Burger vector taken for α-Al as 2.85 $\dot{A}$.