- NOTCH SENSITIVITY
- It is observed that the actual reduction in the endurance limit of a material due to stress concentration is less than the amount indicated by the theoretical stress concentration factor Kt. Therefore, two separate notations, Kt and Kf, are used for stress concentration factors. Kt is the theoretical stress concentration factor, as defi ned in previous sections, which is applicable to ideal materials that are homogeneous, isotropic and elastic. Kf is the fatigue stress concentration factor, which is defi ned as follows:

$$K_f = \frac{\text{Endurance limit of the notch free specimen}}{\text{Endurance limit of the notched specimen}}$$

- This factor Kf is applicable to actual materials and depends upon the grain size of the material. It is observed that there is a greater reduction in the endurance limit of fi ne-grained materials as compared to coarse-grained materials, due to stress concentration. Notch sensitivity is defi ned as the susceptibility of a material to succumb to the damaging effects of stress raising notches in fatigue loading. The notch sensitivity factor q is defi ned as

$$q = \frac{\text{Increase of actual stress over nominal stress}}{\text{Increase of theoretical stress over nominal stress}}$$

- Since σo = nominal stress as obtained by elementary
- equations

$$\therefore \quad \text{actual stress} = K_f \sigma_o$$
$$\text{theoretical stress} = K_t \sigma_o$$

increase of actual stress over nominal stress $= (K_f \sigma_o - \sigma_o)$

increase of theoretical stress over nominal stress = $(K_t \sigma_o - \sigma_o)$

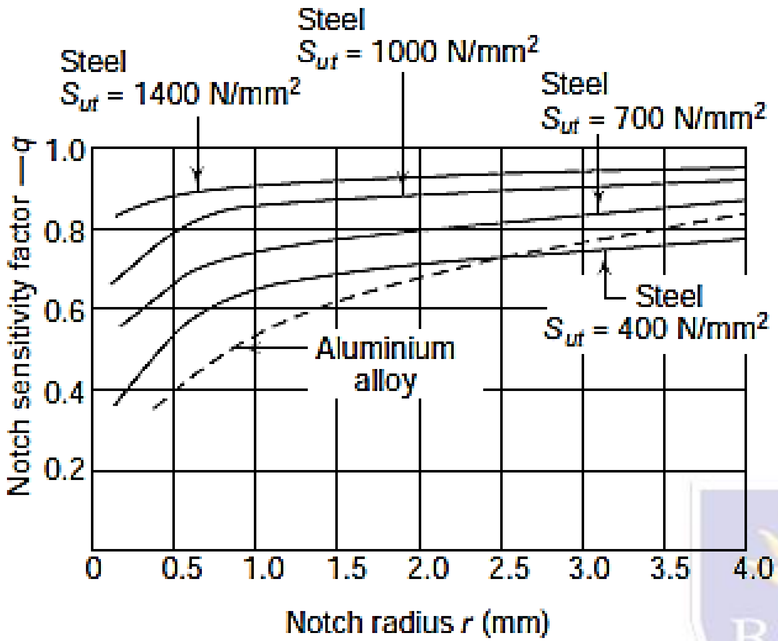

Fig. 5.22 *Notch Sensitivity Charts (for Reversed Bending and Reversed Axial Stresses)*

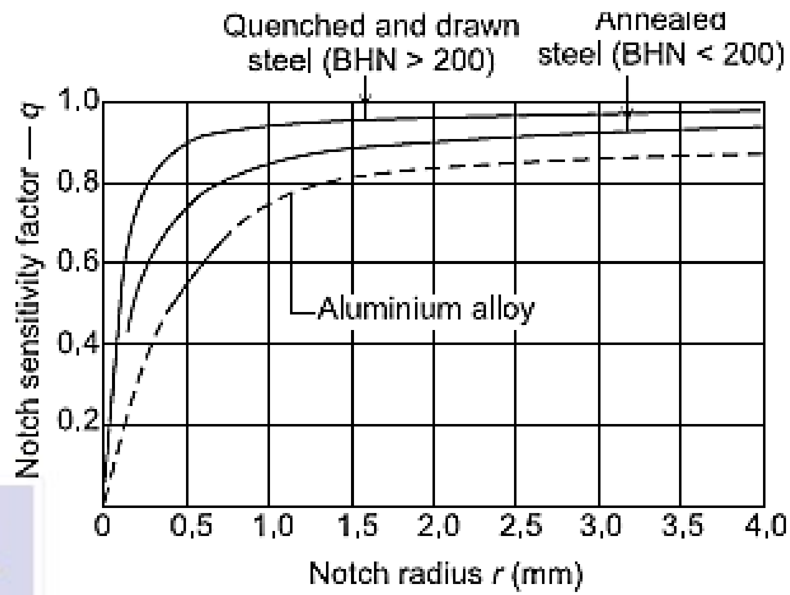

Fig. 5.23 *Notch Sensitivity Charts (for Reversed Torsional Shear Stresses)*

$$q = \frac{(K_f\sigma_o - \sigma_o)}{(K_t\sigma_o - \sigma_o)}$$

or
$$q = \frac{(K_f - 1)}{(K_t - 1)} \qquad (5.11)$$

The above equation can be rearranged in the following form:

$$K_f = 1 + q(K_t - 1) \qquad (5.12)$$

The following conclusions are drawn with the help of Eq. (5.12).

(i) When the material has no sensitivity to notches,

$q = 0$ and $K_f = 1$

(ii) When the material is fully sensitive to notches,

$q = 1$ and $K_f = K_t$

Lecture Machine Design

- REVERSED STRESSES—DESIGN FOR FINITE AND INFINITE LIFE
- There are two types of problems in fatigue design—
- (i) components subjected to completely reversed stresses, and (ii) components subjected to fl uctuating stresses.
- The design problems for completely reversed stresses are further divided into two groups—
- (i)design for infi nite life, and
- (ii) design for fi nite life.
- Case I: When the component is to be designed for infi nite life, the endurance limit becomes the criterion of failure. The amplitude stress induced in such components should be lower than the endurance limit in order to withstand the infi nite number of cycles. Such components are designed with the help of the following equations:

$$\sigma_a = \frac{S_e}{(fs)} \qquad (5.31)$$

$$\tau_a = \frac{S_{se}}{(fs)} \qquad (5.32)$$

where (σ_a) and (τ_a) are stress amplitudes in the component and S_e and S_{se} are corrected endurance limits in reversed bending and torsion respectively.

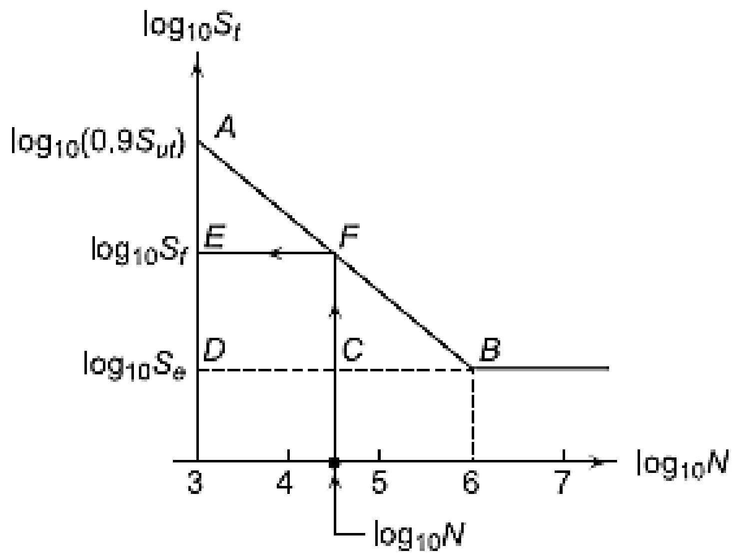

Fig. 5.27 *S-N Curve*

- Case II: When the component is to be designed for fi nite life, the S–N curve as shown in Fig. 5.27 can be used. The curve is valid for steels. It consists of a straight line AB drawn from (0.9 Sut) at 103 cycles to (Se) at 106 cycles on a log-log paper.

- The design procedure for such problems is as follows:
- (i) Locate the point A with coordinates [3, log10 (0.9Sut)] since log10(103) = 3
- (ii) Locate the point B with coordinates [6, log10 (Se)] since log10(106) = 6
- (iii) Join AB, which is used as a criterion of failure for fi nite-life problems
- (iv) Depending upon the life N of the component, draw a vertical line passing through log10 (N) on the abscissa. This line intersects
- AB at point F.
- (v) Draw a line FE parallel to the abscissa. The ordinate at the point E, i.e. log10 (Sf), gives the fatigue strength corresponding to N
- cycles. The value of the fatigue strength (Sf) obtained by the above procedure is used for the designcalculations.

Example 5.3 *A plate made of steel 20C8 (S_{ut} = 440 N/mm²) in hot rolled and normalised condition is shown in Fig. 5.28. It is subjected to a completely reversed axial load of 30 kN. The notch sensitivity factor q can be taken as 0.8 and the expected reliability is 90%. The size factor is 0.85. The factor of safety is 2. Determine the plate thickness for infinite life.*

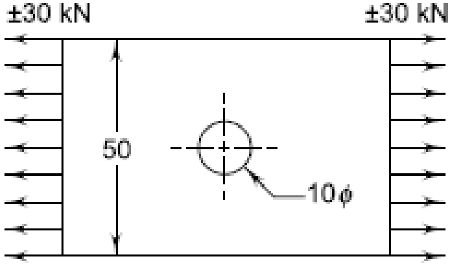

Fig. 5.28

Solution

Given $P = \pm 30$ kN $S_{ut} = 440$ N/mm² $(fs) = 2$
$R = 90\%$ $q = 0.8$ $K_b = 0.85$

Step I *Endurance limit stress for plate*

$S'_e = 0.5\, S_{ut} = 0.5(440) = 220$ N/mm²

From Fig. 5.24 (hot rolled steel and S_{ut} = 440 N/mm²),

$K_a = 0.67$
$K_b = 0.85$

For 90% reliability,

$K_c = 0.897$

$$\frac{d}{w} = \frac{10}{50} = 0.2$$

From Fig. 5.2, $K_t = 2.51$

From Eq. (5.12),

$K_f = 1 + q\,(K_t - 1) = 1 + 0.8\,(2.51 - 1) = 2.208$

$$K_d = \frac{1}{K_f} = \frac{1}{2.208} = 0.4529$$

$$S_e = K_a K_b K_c K_d S'_e$$
$$= 0.67(0.85)(0.897)(0.4529)(220)$$
$$= 50.9 \text{ N/mm}^2$$

For axial load, (Eq. 5.30)

$$(S_e)_a = 0.8\, S_e = 0.8(50.9) = 40.72 \text{ N/mm}^2$$

Step II *Permissible stress amplitude*

$$\sigma_a = \frac{(S_e)_a}{(fs)} = \frac{40.72}{2} = 20.36 \text{ N/mm}^2 \qquad \text{(a)}$$

Step III *Plate thickness*

$$\sigma_a = \frac{P}{(w-d)t} = \frac{(30)(10^3)}{(50-10)t} \text{ N/mm}^2 \qquad \text{(b)}$$

From (a) and (b),

$$20.36 = \frac{(30)(10^3)}{(50-10)t}$$

$$\therefore \qquad t = 36.84 \text{ mm}$$