

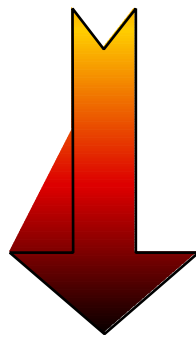
IL COLLASSO MECCANICO

COLLASSO MECCANICO: ogni alterazione di dimensione, forma o proprietà di una struttura, macchina o parte di queste che la renda incapace di svolgere in maniera soddisfacente le sue funzioni

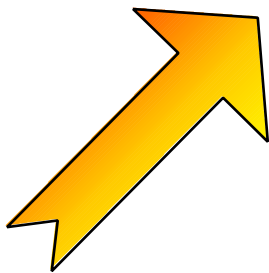
- Manifestazioni del collasso
 - deformazione elastica
 - deformazione plastica
 - alterazione del materiale
 - metallurgica
 - chimica
 - nucleare
- Agenti del collasso
 - forza
 - tempo
 - temperatura
 - ambiente
- Localizzazione del collasso
 - superficiale
 - volumetrica

DESCRIZIONE DEL MODO DI COLLASSO

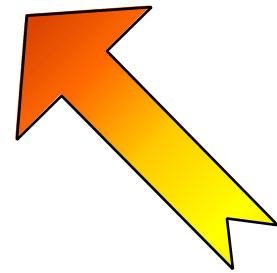
FORZA COSTANTE
TEMPERATURA AMBIENTE



SNERVAMENTO



DEFORMAZIONE
PLASTICA



LOCALIZZAZIONE
VOLUMETRICA

I MODI DI COLLASSO

- Eccesso di deformazione
- Snervamento
- Indentazione
- Rottura duttile
- Rottura fragile
- Fatica
- Corrosione
- Usura
- Sfregamento
- Creep

COLLASSO E BIOCOMPATIBILITA'

- **Tensioni residue**
 - Snervamento, Indentazione
 - Rottura duttile
 - le tensioni residue possono alterare la biochimica del materiale specie nei materiali cristallini
- **Alterazione superficiale**
 - Rottura fragile, Fatica
 - la superficie fratturata può presentare caratteristiche di adesività alterate
- **Alterazione chimica**
 - Corrosione
 - la biocompatibilità di un materiale non garantisce che i suoi prodotti di corrosione lo siano
- **Produzione di detriti**
 - Usura, Sfregamento
 - i detriti di un materiale biocompatibile possono non essere biocompatibili

ROTTURA STATICA

- Modalità di rottura statica

- duttile

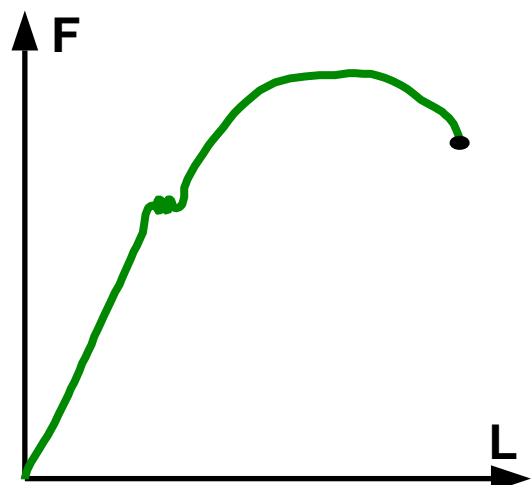
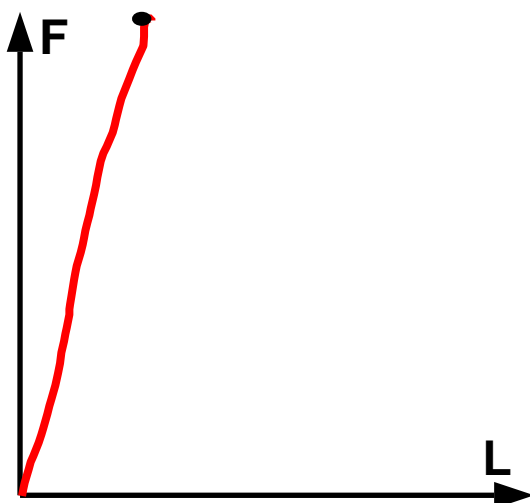
- indentazione
 - deformazione plastica
 - snervamento
 - rottura duttile

- fragile

- rottura fragile

- Fattori influenzanti

- composizione chimica del materiale
 - stato di fornitura
 - lavorazioni
 - trattamenti termici
 - finitura superficiale
 - Concentratori di tensione



TRATTAMENTI TERMICI

- RICOTTURA

- coalescenza del grano
 - cambia la struttura
- rinvenimento
 - elimina le tensioni residue
- distensione
 - corregge deformazioni

- TEMPRA

- aumento durezza

- BONIFICA

- aumento resistenza

- CEMENTAZIONE

- aumenta durezza di pelle

CONCENTRAZIONE DELLE TENSIONI

INTRODUCTION

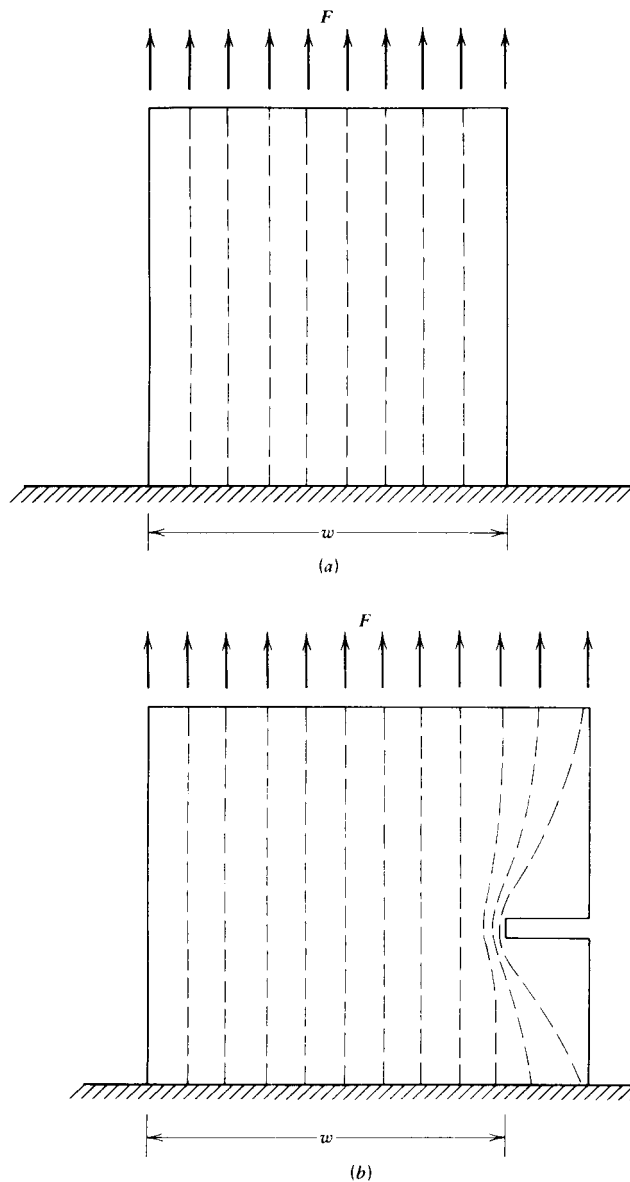


FIGURE 12.1. Intuitive concept of stress concentration. (a) Without stress concentration. (b) With stress concentration.

ZONE CRITICHE

STRESS CONCENTRATION

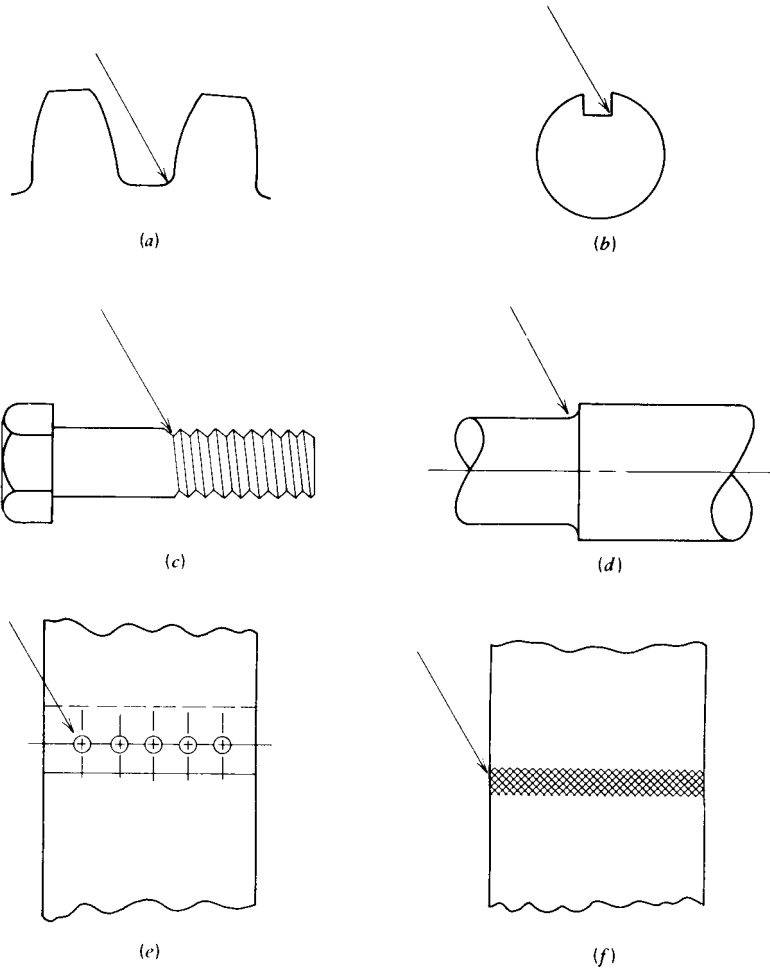


FIGURE 12.2. Some common examples of stress concentration. (a) Gear teeth. (b) Shaft keyway. (c) Bolt threads. (d) Shaft shoulder. (e) Riveted or bolted joint. (f) Welded joint.

FATTORE DI FORMA

Il fattore di forma (stress intensity factor, K_t) dipende solo dalla geometria e dal carico

STRESS CONCENTRATION FACTORS FOR THE ELASTIC RANGE

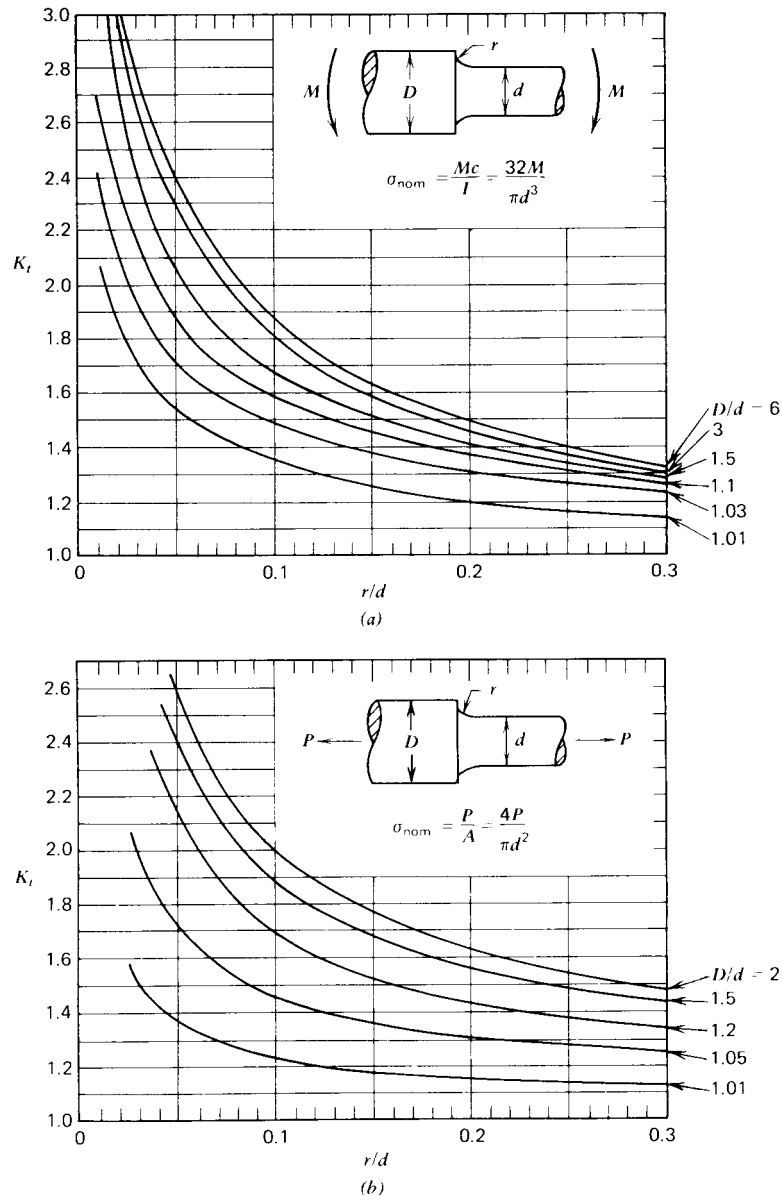


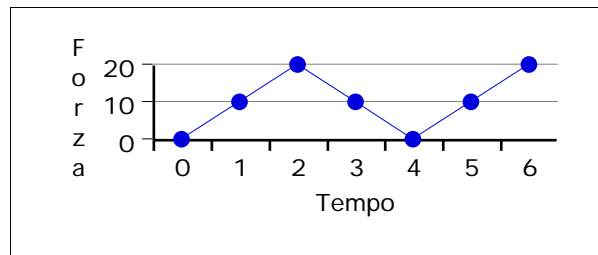
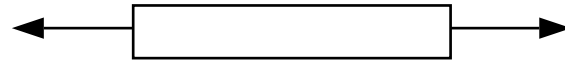
FIGURE 12.3. Stress concentration factors for a shaft with a fillet subjected to (a) bending, (b) axial load, or (c) torsion. (From ref. 4; adapted with permission from John Wiley & Sons, Inc.)

Il fattore di effetto di intaglio tiene conto del materiale
per materiali duttili con $A > 5\%$ = 1
per materiali fragili =

ALTRI MODI DI COLLASSO

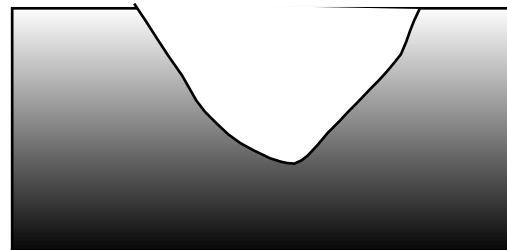
- **Fatica**

- high-cycle
- low-cycle
- termica



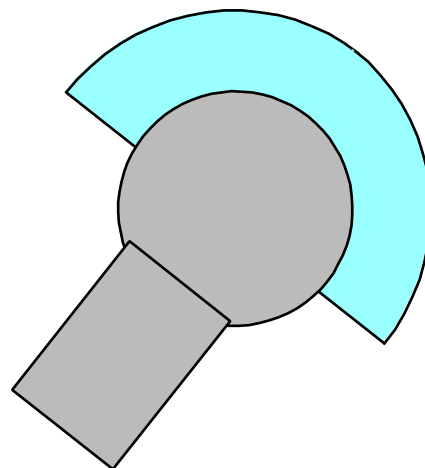
- **Corrosione**

- galvanica
- interstiziale
- pitting
- da sfregamento



- **Usura**

- adesiva
- abrasiva
- da impatto



LA RESISTENZA A FATICA

DIAGRAMMA DI WOHLER

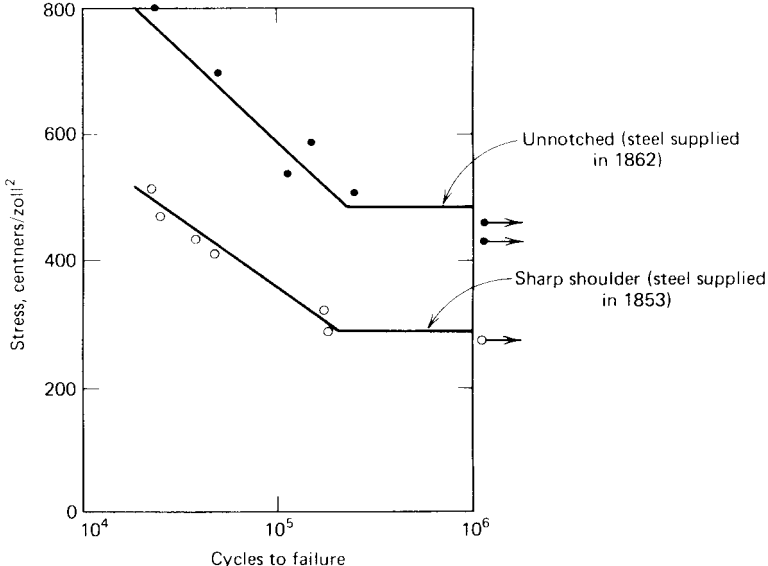


FIGURE 7.1. Fatigue data reported by Wöhler in an early investigation on fatigue of railway axle steel. Note: 1 centner = 50 kg, 1 zoll = 1 inch, 1 centner/zoll² ≅ 110 psi.

ROTTURA A FATICA

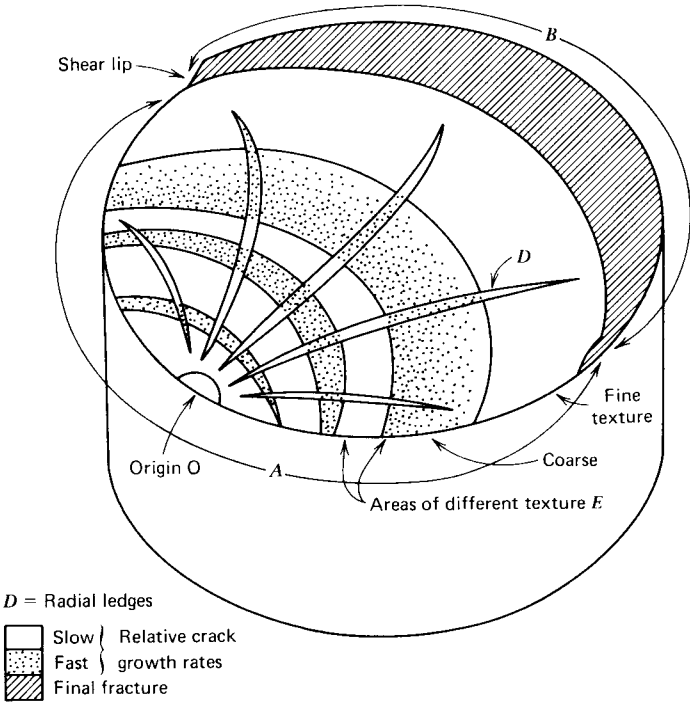


FIGURE 7.3. Features of the failure surface of a typical ductile metal subjected to alternating cyclic loads. (From ref. 19; Reproduced by kind permission of Blackie and Son, Limited, Glasgow.)

DETERMINAZIONE SPERIMENTALE

LABORATORY FATIGUE TESTING

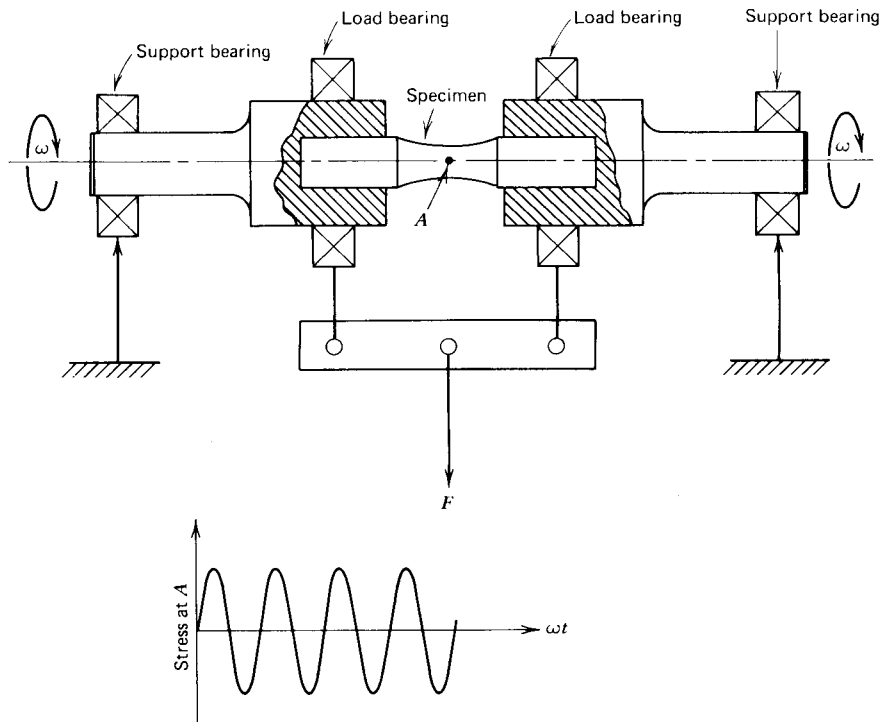


FIGURE 7.7. Rotating-bending fatigue testing machine of the constant bending moment type.

HIGH-CYCLE FATIGUE

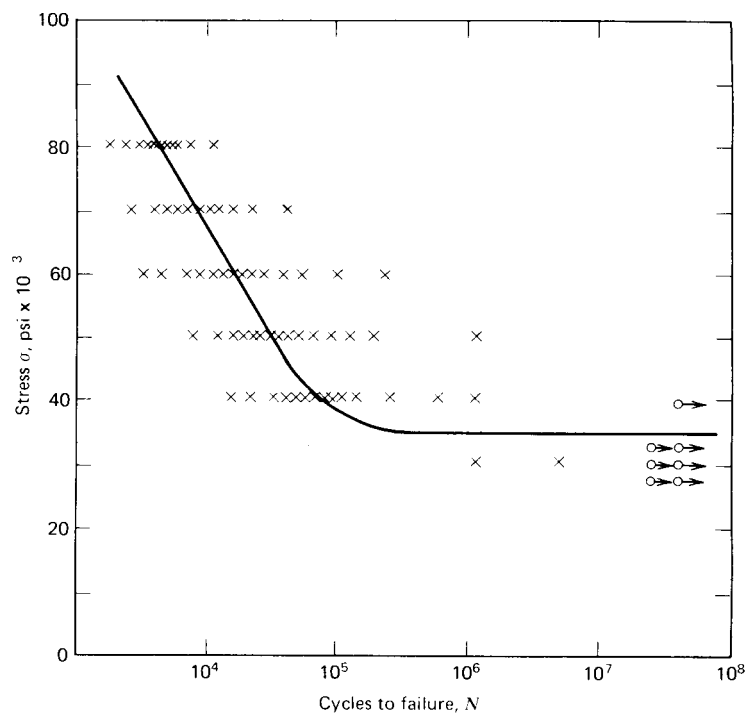
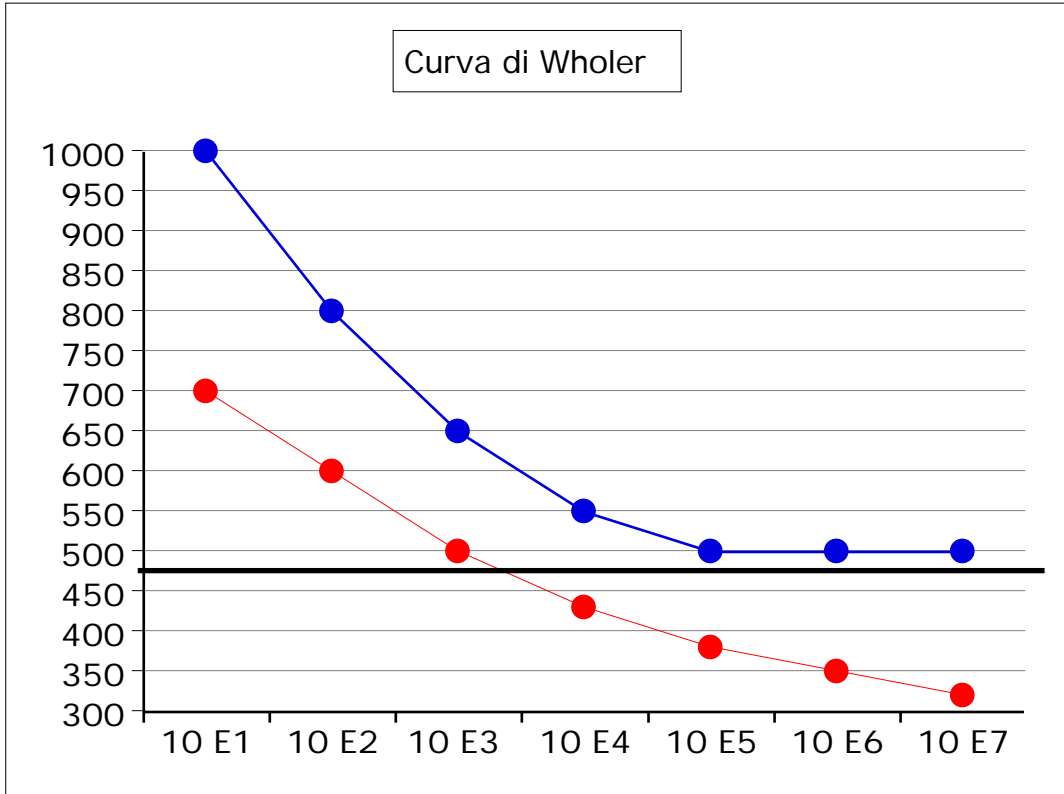


FIGURE 7.13. Plot of stress-cycle ($S-N$) data as it might be collected by laboratory fatigue testing of a new alloy.

LIMITE DI FATICA



HIGH-CYCLE FATIGUE

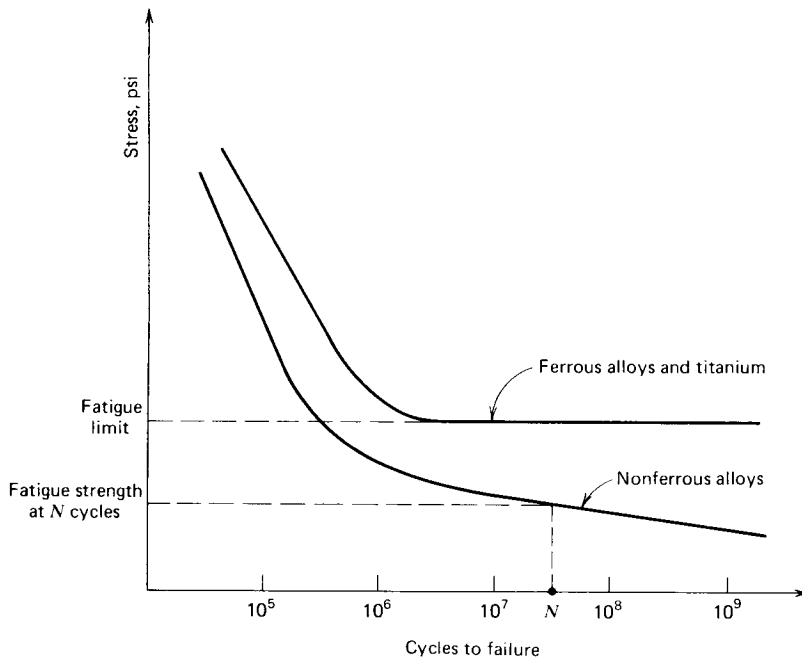


FIGURE 7.16. Two types of material response to cyclic loading.

FATTORI CHE INFLUENZANO LA RESISTENZA A FATICA

- Tipo di sollecitazione
- Composizione chimica
- Struttura cristallina
- Trattamenti termici
- Lavorazioni meccaniche
- Concentratori di tensione
- Finitura superficiale
- Size effect
- Tensioni residue
- Temperatura di esercizio
- Corrosione
- Fretting
- Velocità di funzionamento
- Storia di carico e memoria

MICRO STRUTTURA

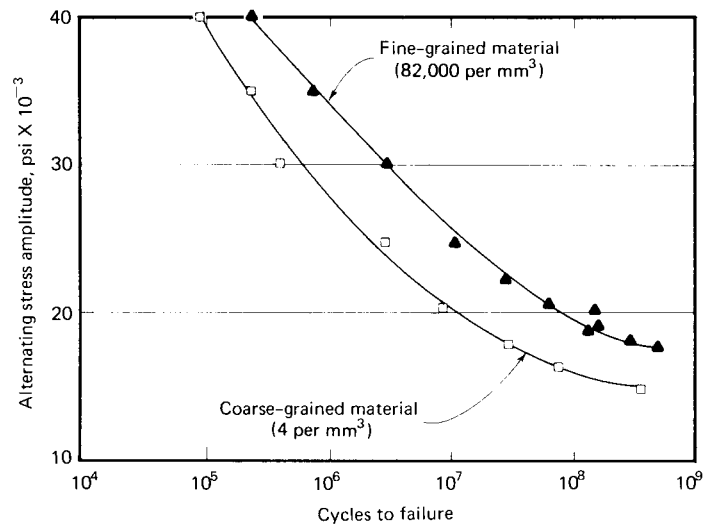


FIGURE 7.18. Effect of grain size on the $S-N$ curve for 18S aluminum alloy. Average diameter ratio of coarse to fine grains is approximately 27 to 1. Nominal composition: 4.0 percent copper, 2.0 percent nickel, 0.6 percent magnesium. Note that at a life of 10^8 cycles the mean fatigue strength of the coarse-grained material is about 3000 psi lower than for fine-grained material. (Data from ref. 3; adapted from *Fatigue and Fracture of Metals*, by W. M. Murray, by permission of The MIT Press, Cambridge, Massachusetts, copyright 1952)

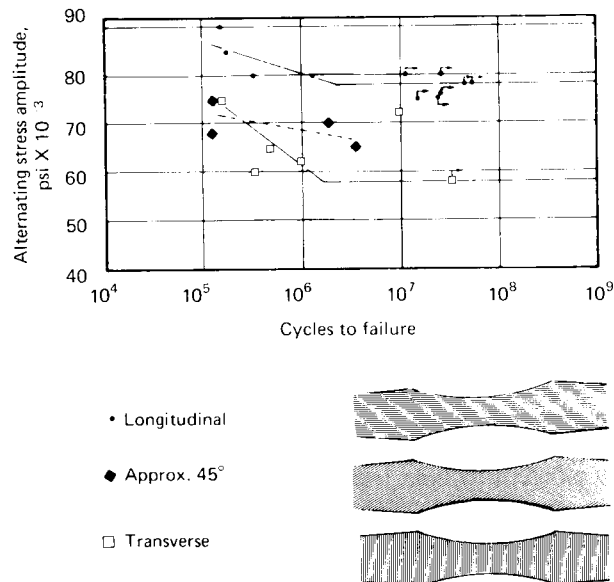


FIGURE 7.20. Effect on the $S-N$ curve of grain flow direction relative to longitudinal loading direction for specimens machined from crankshaft forgings. Nominal composition: 0.41 percent carbon, 0.47 percent manganese, 0.01 percent silicon, 0.04 percent phosphorus, 1.8 percent nickel. $S_u = 139,000$ psi, $S_{yp} = 115,000$ psi, $e(2.0$ inches) = 20 percent. (Data from ref. 22)

CONCENTRATORS

FACTORS THAT AFFECT *S-N-P* CURVES

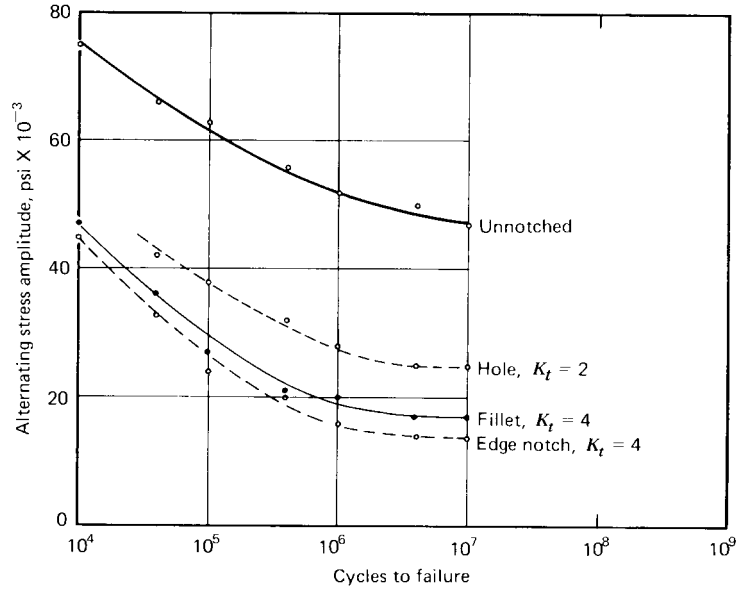


FIGURE 7.29. Effects of geometrical discontinuities on the *S-N* curve of SAE 4130 steel sheet, normalized, tested in completely reversed axial fatigue test. Specimen dimensions (t = thickness, w = width, r = notch radius): Unnotched: $t = 0.075$ inch, $w = 1.5$ inches. Hole: $t = 0.075$ inch, $w = 4.5$ inches, $r = 1.5$ inches. Fillet: $t = 0.075$ inch, $w_{\text{net}} = 1.5$ inches, $w_{\text{gross}} = 2.25$ inches, $r = 0.0195$ inch. Edge notch: $t = 0.075$ inch, $w_{\text{net}} = 1.5$ inches, $w_{\text{gross}} = 2.25$ inches, $r = 0.057$ inch. (Data from ref. 6)

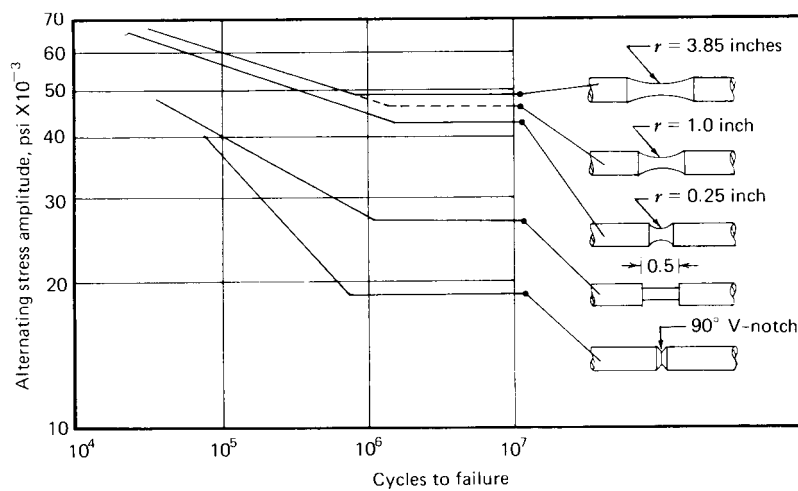


FIGURE 7.31. Effects of various geometrical discontinuities on the *S-N* curve of a 0.49 percent carbon steel, water quenched and tempered at 1200°F . Stock size was 0.40 inch, machined to nominal specimen size of 0.275 inch diameter. (Data from ref. 27)

SENSIBILITA' ALL'INTAGLIO

$$= > f$$

fattore teorico di concentrazione delle tensioni

fattore di riduzione della resistenza a fatica

$$f = 1 + (\quad - 1)$$

fattore di sensibilità all'intaglio

STRESS CONCENTRATION FACTORS AND NOTCH SENSITIVITY

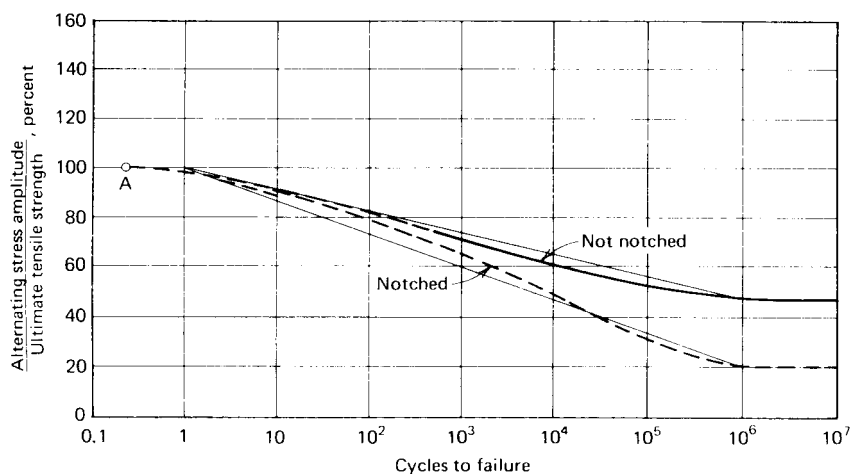


FIGURE 12.15. *S-N* curves for notched and unnotched specimens subjected to completely reversed axial loading. (After ref. 11, *Fatigue and Fracture of Metals*, by W. M. Murray, by permission of The MIT Press, Cambridge, Massachusetts, Copyright 1952.)

FINITURA SUPERFICIALE

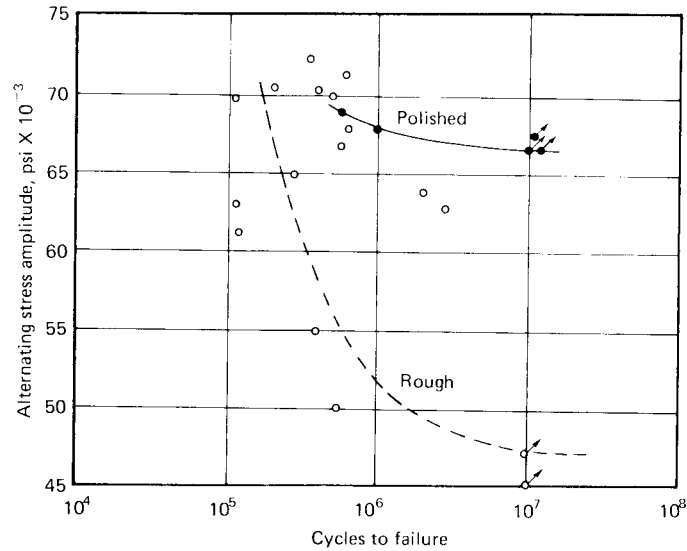


FIGURE 7.35. Effects of polishing die marks from the surface on the S - N curve of heat-treated chromium-molybdenum aircraft tubing. Tube dimensions: 0.5-inch O.D. with 0.065-inch wall. Heat treatment: oil quench 1625°F, draw 650°F.

CONDIZIONAMENTO

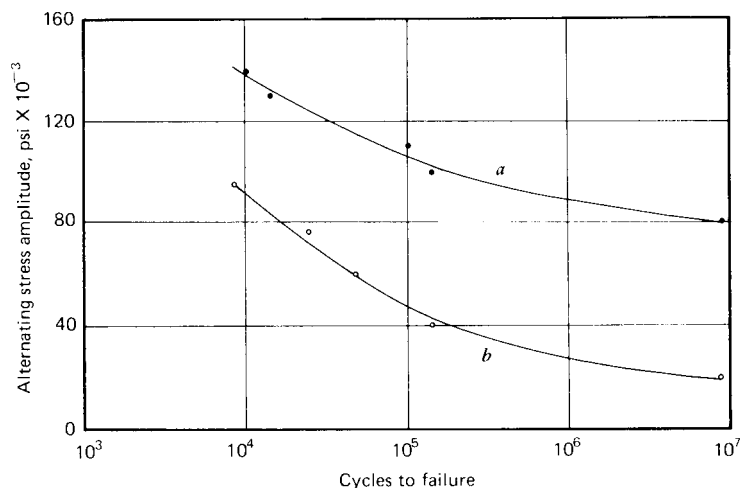


FIGURE 7.42. Effects of cold-rolling threads before and after heat treatment on S - N curve for 220,000 psi ultimate strength bolts. (a) Rolled after heat treatment. (b) Rolled before heat treatment. (Data from ref. 16; with permission from John Wiley & Sons, Inc.)

FREQUENZA

FACTORS THAT AFFECT *S-N-P* CURVES

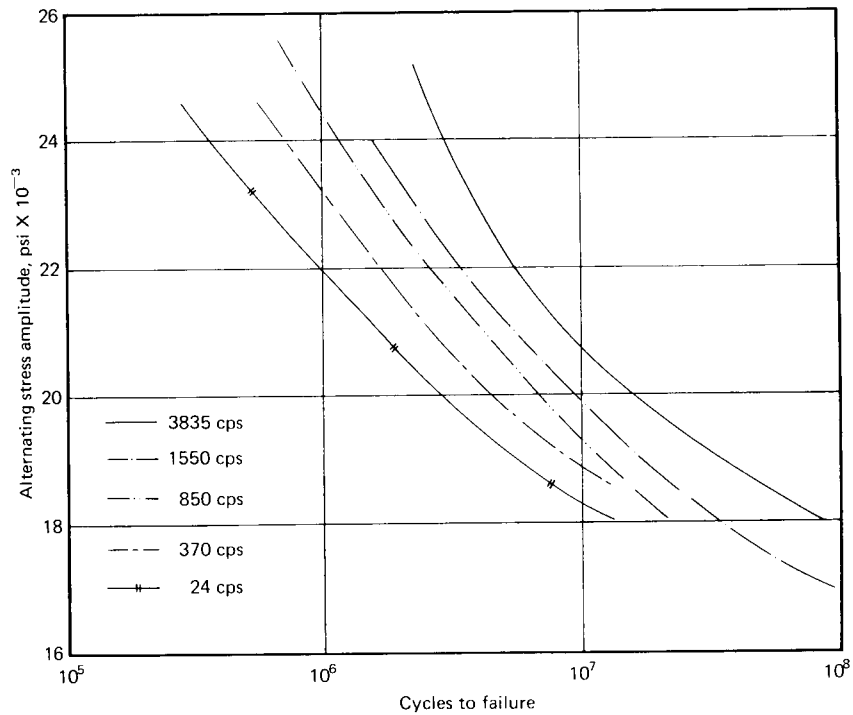


FIGURE 7.54. Effects of operating speed on the *S-N* curve of Hiduminium R.R. 56 aluminum alloy. (Data from ref. 8, p. 368)

TRATTAMENTI TERMICI

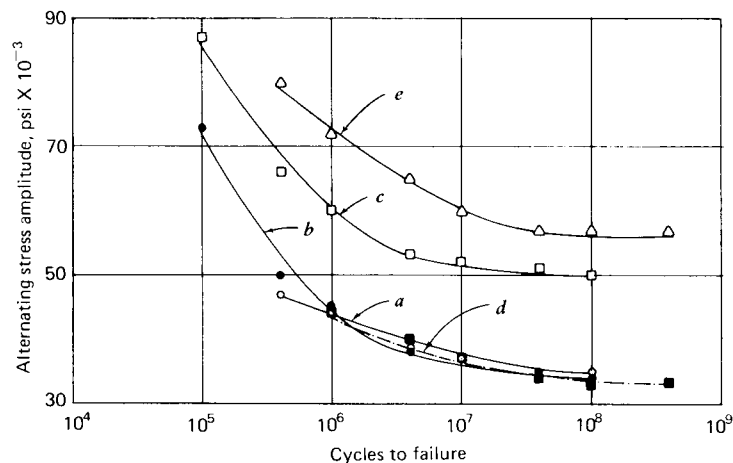


FIGURE 7.23. Effects of heat treatment on the *S-N* curve of carbon steel. (a) Carbon steel (0.35 C, 0.55 Mn, 0.19 Si), annealed. (b) Carbon steel (0.36 C, 0.61 Mn, 0.019 Si), 1550°F, furnace cooled. (c) Carbon steel (0.36 C, 0.61 Mn, 0.019 Si), 1550°F, water quenched at 900°F, furnace cooled. (d) Carbon steel (0.37 C; 0.58 Mn, 0.16 Si), 4 inch billet, normalized, 1495°F, furnace cooled. (e) Carbon steel (0.37 C, 0.38 Mn, 0.16 Si), 4 inch billet, 1550°F, water quenched at 1050°F, air cooled. (Data from ref. 6)

EFFETTO DEL CICLO DI CARICO

DIAGRAMMA DI GOODMAN-SMITH

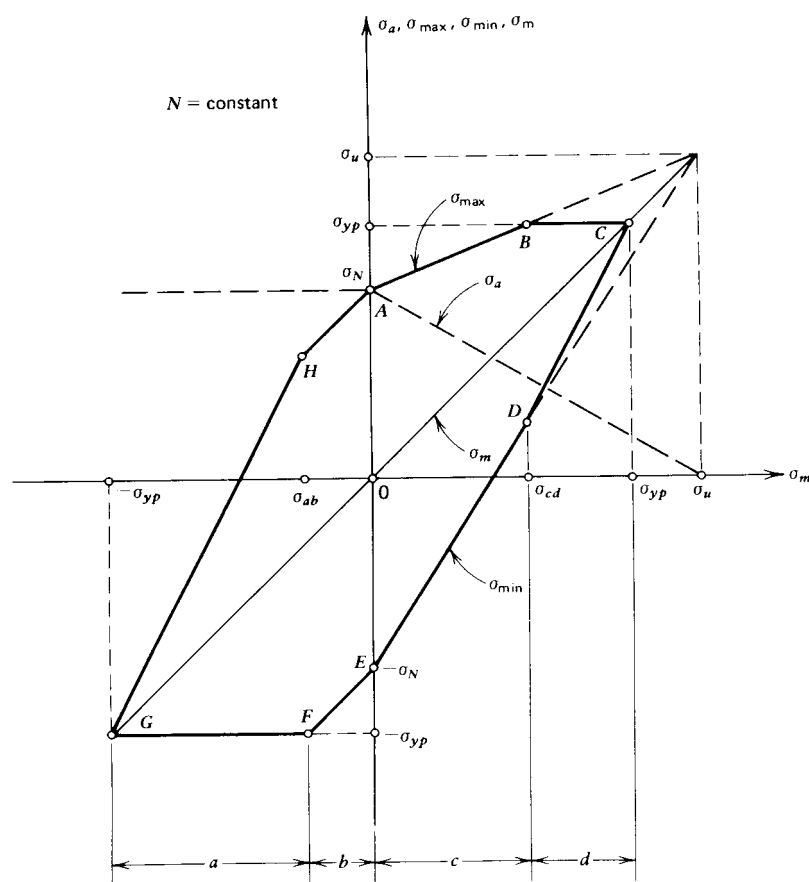


FIGURE 7.63. Modified Goodman range-of-stress diagram for fatigue failure in N cycles.

USURA

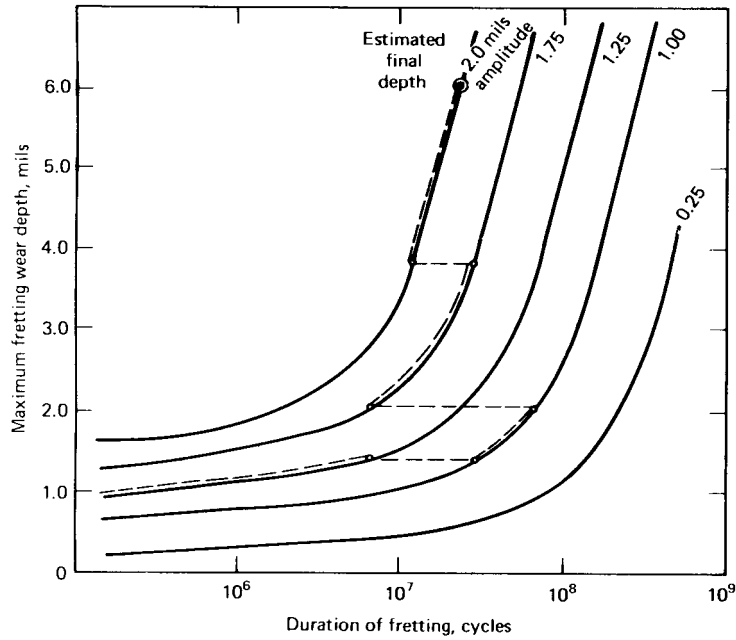


FIGURE 14.11. Wear depth as a function of number of cycles of fretting for several fretting amplitudes.

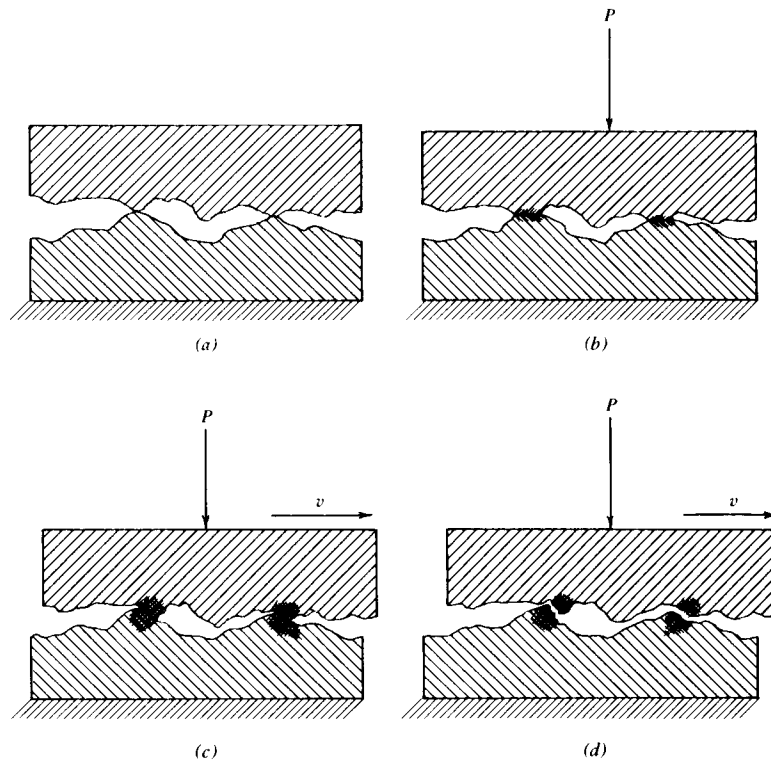
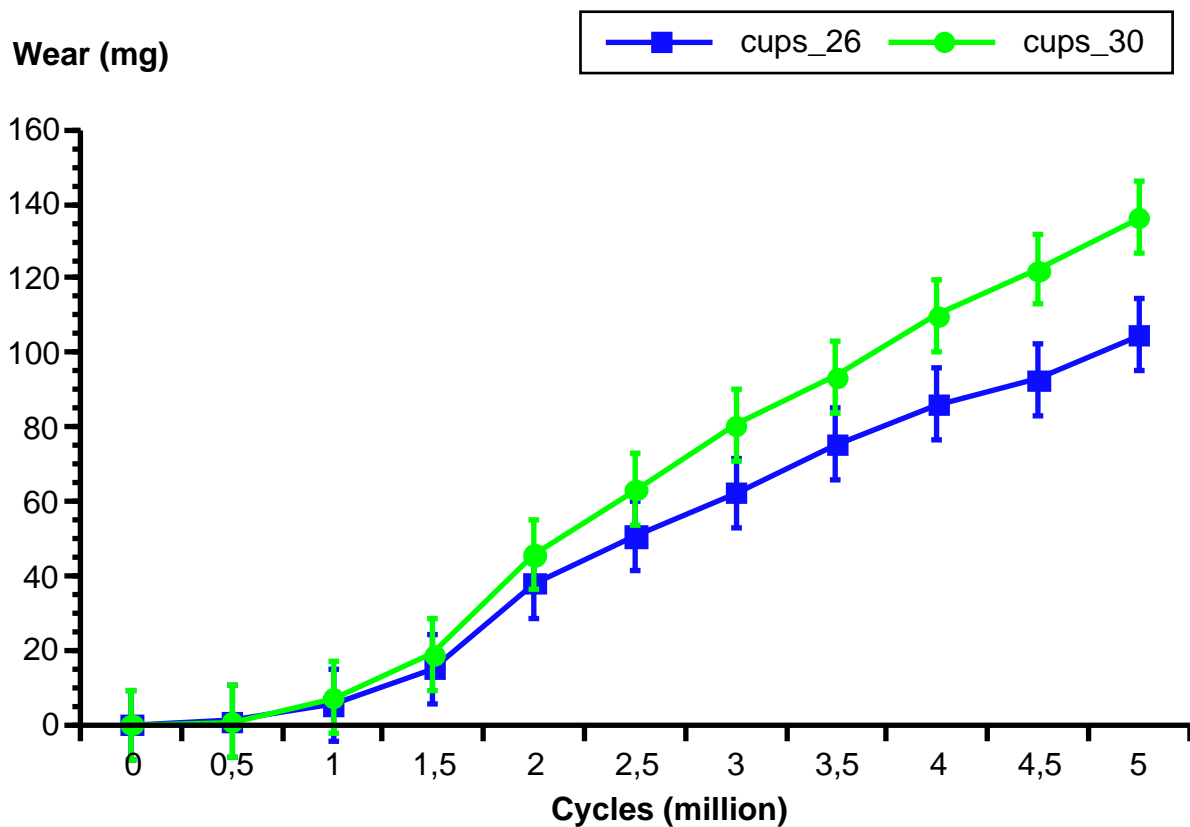
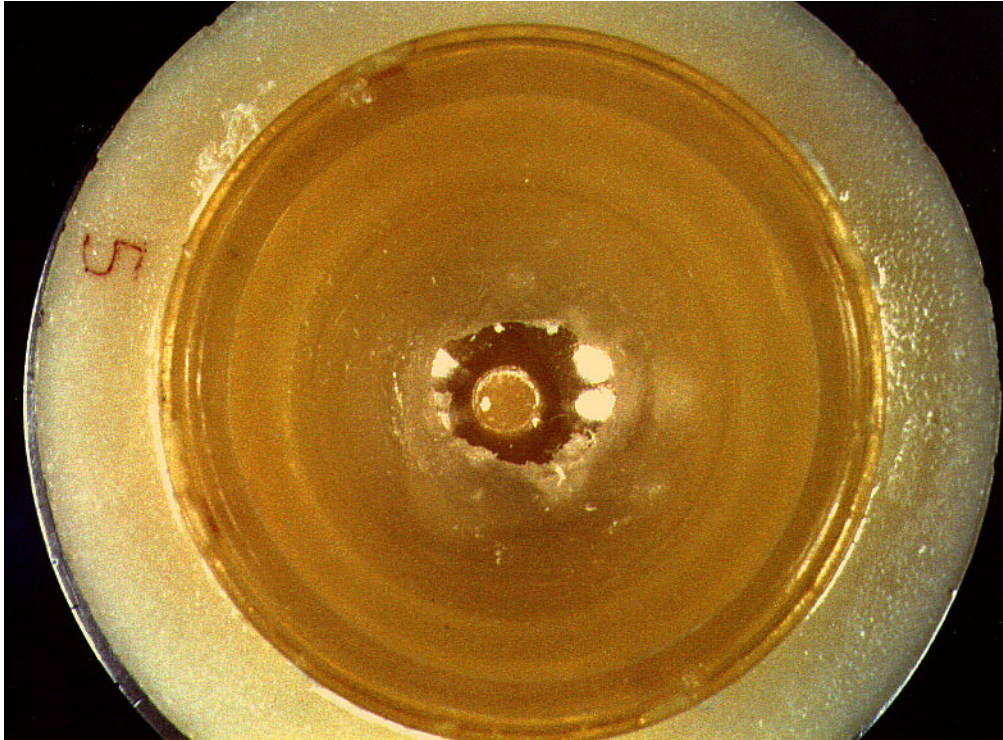


FIGURE 17.1. Contact between two solid bodies and the transfer of a particle by adhesive wear. (a) Unloaded surfaces in contact. (b) Applied load P causes plastic flow and cold welding. (c) Sliding motion and load produce strain hardening. (d) Particles transferred by rupture of asperity below weld junction.

USURA DEGLI ACCOPPIAMENTI ARTICOLARI



FRETTING

IL FRETTING E' QUASI SEMPRE ASSOCIATO CON FENOMENI DI CORROSIONE E/O DI USURA

- FATTORI DI INFLUENZA

- CINEMATICI

- AMPIEZZA DEL MOTO DI SFREGAMENTO
- IL NUMERO DI CICLI DI FRETTING
- LA FREQUENZA DI SFREGAMENTO

- TENSIONALI

- INTENSITA' DELLA PRESSIONE DI CONTATTO
- LO STATO DI SOLLECITAZIONE

- DEL MATERIALE

- I MATERIALI A CONTATTO
- LA LORO FINITURA SUPERFICIALE

- AMBIENTALI

- LA TEMPERATURA NEL PUNTO DI FRETTING
- L'AGGRESSIVITA' DELL'AMBIENTE

FRETTING IN PROTESI MODULARI

