Material Science

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Chapter 8. Failure

Highlights, Motivation and Critical Concepts:

Failure – inability of a component to perform as expected - can cause heavy loss of lives, wealth and even may jeopardize the society! Even though the causes of failure are known, prevention of failure is difficult to guarantee. General causes for failure include: improper materials selection, improper processing, inadequate design, misuse of a component, improper maintenance, etc. As it is almost impossible to prevent failure, it can be still good enough to predict the failure. For this, an engineer needs to understand the origin of failures, and probable corrective methods to prevent failure under different conditions like static/cyclic load, ambient/elevated temperatures, etc. There been many varieties of failures like buckling, fracture, creep, etc. This chapter is intended to explain the basic of different forms of failures, their origin, crack propagation if exists, identifying specific features those can help in predicting the eventual failures.

Multiple Choice Questions' Bank:

1. Failure due to excessive deformation is controlled by ______________.

(a) Material properties (b) Design & Dimensions (c) Both (d) None

2. Failure due to excessive deformation is controlled by ______________.

(a) Yield strength (b) Tensile strength (c) Young's modulus (d) All

3. Time dependent yield is known as

(a) Fracture (b) Fatigue (c) Buckling (d) Creep

4. Cleavage fracture appears

(a) Bright (b) Dull (c) Difficult to identify (d) None

5. Usually materials with following crystal structure fail in ductile mode

(a) FCC (b) BCC (c) HCP (d) None

6. Brittle fracture is more dangerous than ductile fracture because _______________.

(a) No warning sign
(b) Crack propagates at very high speeds
(c) No need for extra stress during crack propagation
(d) All

7. Fracture voids usually form at

(a) Inclusions (b) Second phase particles (c) Grain boundary triple points (d) All

8. Fracture stress (σ_f) is proportional to

(a) crack length (b) 1/crack length (c) $(\text{crack length})^{1/2}$ (d) $(\text{crack length})^{-1/2}$

9. Fracture toughness is measured in terms of

(a) Strain energy release rate (b) Stress concentration factor (c) Both (d) None

10. In fracture mode-II, fracture surfaces

(a) shear parallel to edge of crack
(b) shear perpendicular to edge of crack
(c) displace normal to each other
(d) None

11. Fracture toughness, K_{IC}, decreases with

(a) increasing temperature
(b) increasing strain rate
(c) increase in yield strength
(d) increase in grain size

12. DBTT for ceramics is in the range of _________ X T_m.

(a) 0.1-0.2 (b) 0.2-0.3 (c) 0.3-0.5 (d) 0.5-0.7

13. Following impurity decreases DBTT for steels

(a) Mn (b) P (c) Si (d) Mo

14. Fatigue strength for non-ferrous materials in defined at _______ stress cycles.

(a) 10^3 (b) 10^5 (c) 10^7 (d) 10^9

15. The following equation defines S-N curve

(a) Paris equation (b) Basquin equation (c) Andrede equation (d) Garofalo equation

16. Creep rate in ternary stage __________.

(a) Decreases (b) Constant (c) Increases (d) None

17. Ternary stage creep is associated with ____________.

(a) Strain hardening (b) Recovery (c) Necking (d) None

18. Total strain range in a creep test

(a) <1% (b) around 10% (c) around 50% (d) > >50%

19. Creep mechanism that is operational at stresses $10^{-2} > \sigma/G > 10^{-4}$ _____________.

(a) Dislocation creep (b) Dislocation glide (c) Diffusion creep (d) GB sliding

20. Most often machine components fail by

(a) Buckling (b) Creep (c) Fatigue (d) All

21. If the surface crack causing fracture in a brittle material is made twice as deep, the fracture strength will

(a) decrease by a factor of $\sqrt{2}$
(b) decrease by a factor of 2
(c) decrease by a factor of 2^2
(d) No change

Answers:

1. c
2. c
3. d
4. a
5. a
6. d
7. d
8. d
9. c

10. b
11. b
12. a
13. a
14. c
15. b
16. c
17. c
18. a
19. a
20. c
21. a