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Continuing Education Course #354  
Mechanical Fatigue of Metals

1. Which of the following statements is true regarding the two types of fatigue?
  - a. The low-cycle (LC) type includes few cycles and low cyclic stress levels
  - b. The high-cycle (HC) type include many cycles and high cyclic stress levels
  - c. The high-cycle (HC) type includes many cycles and low cyclic stress levels
  - d. The low-cycle (LC) type includes many cycles and high cyclic stress levels
2. Which of the following three approaches to design and analysis of fatigue are normally used?
  - a. Working stress, S-N and strain-N
  - b. S-N, Finite Element Analysis (FEA) and Linear Elastic Fracture Mechanics (LEFM)
  - c. S-N, strain-N and LEFM
  - d. strain-N, FEA and static ultimate tensile strength (UTS) of the selected alloy
3. In which approach to fatigue design and analysis is it assumed that a detectable size fatigue crack already exists?
  - a. FEA
  - b. UTS
  - c. LEFM
  - d. S-N
4. Which of the following features of fatigue on a metallic fracture surface indicate where crack growth stopped for a short or extended period or where the magnitude of the stress changed significantly?
  - a. Ratchet marks
  - b. Beach (or arrest) marks
  - c. Striations
  - d. Dimples
5. Which of the following statements about ratchet marks on a fracture surface that failed due to fatigue is true?
  - a. They may be seen only when viewed in an SEM
  - b. They are smaller than striations
  - c. They are raised ridges of metal perpendicular to the fracture surface. Each mark separates two sites of crack origins when those origins are on the same radial plane through the metal's outer surface.
  - d. They are always seen when corrosion fatigue has occurred
6. The horizontal section of an S-N curve for a given metal is known by which of the following designations?
  - a. Fatigue limit (or endurance limit)
  - b. Fatigue strength
  - c. Maximum allowable cyclic stress
  - d. Net acting mean stress
7. During design against fatigue for a desired number of cycles when using the S-N approach, the minimum theoretical criterion for an acceptable design is that the working stress for the alloy selected must meet which one of the

following?

- a. It must be less than the fatigue strength of the alloy as defined in lab fatigue tests using common conditions
  - b. Its value must be below the final adjusted S-N data line for the given alloy
  - c. The factor of safety used (if not mandatory) must be in the range of 1.0 - 2.0
  - d. Its value must be less than the ultimate tensile strength of the alloy as defined by static testing
8. After common fatigue laboratory testing and best curve fitting, the plotted S-N line through the scattered data points at different stress levels provides which one of the following reliabilities?
- a. 30%
  - b. 70%
  - c. 50%
  - d. 90%
9. When dislocations move (slip) in a metal's internal crystalline structure during initial fatigue loading, this creates which of the following features on the metal's outer surface?
- a. Notches and tiny corrosion pits
  - b. Extensions and notches
  - c. Extensions and intrusions
  - d. Striations and intrusions
10. Defining the rate of crack growth is critical, along with other measures, in which of the following approaches to fatigue design?
- a. Low-cycle (LC) fatigue
  - b. Linear elastic fracture mechanics (LEFM)
  - c. High-cycle (HC) fatigue
  - d. Corrosion fatigue
11. Which of the following statements regarding the Marin procedure used to adjust common lab-generated fatigue limit data is not true?
- a. The effects of net mean stress and notches can be estimated
  - b. The effects of service component size and service temperatures can be estimated
  - c. The effects of service alloy surface roughness and desired reliability of the component can be estimated
  - d. The effects of the type of service loading and service temperatures can be estimated
12. High service temperatures and fatigue acting together can introduce considerable complexity to predicting alloy fatigue failures. This is because the action of creep in a metal gets underway at about which of the following percentages of a metal's melting point?
- a. 20%
  - b. 70%
  - c. 50%
  - d. 35%
13. The value of the miscellaneous-effects factor in the Marin procedure,  $k_M$ , is used to estimate the influence on lab-generated fatigue limit data for all of the following areas except for this one area?
- a. Metallurgical characteristics of the steel being used
  - b. The size of the actual component used in service
  - c. Potential corrosion effects
  - d. Other effects present in the given application
14. Higher alloy strength and ductility are both important to resist failure by fatigue. However, which of the following statement is most helpful in assessing these metallurgical properties for a specific application?

- a. Alloy strength and ductility are equally important in both HC and LC fatigue applications
  - b. Generally high alloy strength is more important than high ductility for HC fatigue applications
  - c. Generally high alloy strength is more important than high ductility for LC fatigue applications
  - d. The importance of high alloy strength is that it allows local yielding without nucleating a fatigue crack
15. Which of the following statements is true?
- a. Internal discontinuities in a metal, for example inclusions, are more common in the wrought form of the metal than in the cast form
  - b. Internal discontinuities in a metal are beneficial because they raise its fatigue resistance
  - c. Internal discontinuities in a metal are not important because all fatigue cracks nucleate on the metal's surface
  - d. Internal discontinuities in a metal are harmful because they lower resistance to fatigue
16. Which of the following statements about corrosion fatigue is true?
- a. Alloys still fail with corrosion acting but higher levels of cyclic stress are required
  - b. Only plain carbon steels experience corrosion fatigue
  - c. Very corrosive environments are necessary for corrosion fatigue to occur
  - d. Many alloys will no longer have the clear fatigue limit they previously had
17. Which of the following describes the essential and simultaneous components that are needed for corrosion to occur?
- a. High temperature and an oxidation chemical reaction
  - b. An oxidation and a reduction chemical reaction
  - c. Saltwater and a chemical reduction reaction
  - d. High temperature and vacuum conditions
18. Resistance to corrosion fatigue is likely to be most effective based on applying which of the following actions?
- a. Use a chromium or nickel plated alloy
  - b. Raise the temperature of the service environment
  - c. Use a material that contains sufficient levels of alloying elements, e.g., chromium, nickel and molybdenum and other elements in its composition to resist the specific corrosive medium
  - d. Decrease the cyclic stress frequency in operation, e.g., lower the RPM's of a rotating shaft
19. The Goodman diagram confirms that as magnitudes of  $S_{MEAN}$  increase, the fatigue limits of alloys defined in lab fatigue tests using common conditions (after Marin adjustments) are influenced in which one of the following ways?
- a. They remain unchanged on a S-N plot
  - b. They are reduced (or lowered) on a S-N plot
  - c. They are increased (or raised) on a S-N plot
  - d. The ultimate tensile strength,  $S_{UTS}$ , of the alloy as defined in a static test, determines results
20. Which of the following statements is true?
- a. The Walker equation and the Goodman method for defining the effect of  $S_{MEAN}$  are equally accurate
  - b. The Walker equation includes the effect of  $S_{MEAN}$  as well the effects of a macro-scale notch
  - c. The Goodman method for the effects of  $S_{MEAN}$  also includes the effects of a macro-scale notch
  - d. The effects of a macro-scale notch are not included in either the Walker equation or the Goodman method
21. The value of the cyclic stress concentration factor,  $K_f$ , used in fatigue design depends on three of the following four variables. Which variable is not directly used to establish  $K_f$ ?
- a. The constant stress concentration factor applicable to the largest notch,  $K_t$
  - b. Maximum cyclic stress acting in the application,  $S_{MAX}$

- c. The net mean stress acting in the application,  $S_{MEAN}$
- d. The notch sensitivity of the alloy being used,  $q$

22. When an alloy does not produce a true fatigue limit in fatigue tests, but only steadily decreasing fatigue strengths as the number of cycles increase, a substitute for its fatigue limit is generally assumed to be its minimum fatigue strength at this approximate value of  $N$ ?

- a.  $10^4$
- b.  $10^{12}$
- c.  $10^8$
- d.  $10^2$

23. Which of the following statements regarding factors of safety,  $FS$ , to use in design against failure by fatigue is true?

- a. The  $FS$  used in fatigue design is generally larger than the  $FS$  used in static, constant stress applications
- b. The  $FS$  used in fatigue design is generally smaller than the  $FS$  used in static, constant stress applications
- c. Working stresses depend primarily on the ductility of the selected alloy, not the  $FS$
- d.  $FS$  values are typically in the range of 1.5 – 2.5

24. Which one of the following statements about cyclic stress parameters  $S_A$  and  $\Delta S$  is true?

- a. When both are in the compressive range, alloy fatigue resistance is decreased
- b. The magnitude of  $S_A$  or of  $\Delta S$ , when each is in the tensile range, is inversely proportional the possible alloy fatigue life when other variables are constant
- c. Increasing the cross-section dimensions of the cyclic stressed component will increase both parameters
- d. Using a higher strength alloy will increase both parameters

25. The ideal last step in design for fatigue resistance should be to confirm that which one of the following actions was taken?

- a. All effects of corrosion have been prevented by appropriate actions
- b. Cyclic tensile stresses have been minimized and net mean stresses,  $S_{MEAN}$ , have been maximized
- c. A full-scale prototype of the designed component has been tested in fatigue tests that included all conditions to be encountered in actual service
- d. It has been confirmed that the working stress used does not exceed the fatigue limit of the selected alloy as defined in common laboratory fatigue tests

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