UNIT-2 (DESIGN FOR FLUCTUATING LOADS)

Design for Fluctuating Loads Cyclic stresses, Fatigue and endurance limit, Stress concentration factor,Stress concentration factor for various machine parts, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria

Q No-1: What is stress concentration & stress concentration factor? What are the causes of stress concentration and how we can reduce it?

Ans: Stress concentration:-

- A stress concentration (often called stress raisers or stress risers) is a location in an object where stress is concentrated.
- Generally stress is concentrated due to irregularities present in the component and abrupt changes of the cross-section.

Stress concentration factor *(K_t)*:-

- Stress concentration factor (K_t), is a dimensionless factor which is used to determine concentrated stress in a material or machine element.
- It is defined as the ratio of the highest stress in the element to the reference stress.

$$K_t = \frac{\sigma_{max}}{\sigma_{ref}}$$

- Reference stress is the total stress within an element under the same loading conditions without stress concentration.
- So concentrated stress can be calculated by multiplying reference stress with the stress concentration factor**.**

Causes of stress concentration:-

Abrupt change in section: Stress is also concentrated due to abrupt change in section so a fillet radius is provided so that the cross-section may change gradually and reduce stress concentration.

Discontinuities in component: Discontinuities due to oil holes, keyways, splines and screw thread also generate stress concentration in the machine component**.**

Variation in properties of material:-In practice material properties are varies from one end to another end due to manufacturing defects (like air holes, cavities, internal cracks etc.) present inside the components.

These defects act as discontinuities in component and cause stress concentration.

Machining scratches:-Any scratches on surface act as surface irregularities, which cause stress concentration.

Methods of reducing stress concentration:

- Providing a fillet radius so that the cross-section may change gradually.
- Using an elliptical fillet.
- Using a number of small notches rather than a long one, if a notch is unavoidable.
- Using narrow notches rather than wide notches, if a projection is unavoidable.
- Using stress-relieving grooves.

Q No-2: What are fluctuating and repeated stresses? Draw a stress-time curve for fluctuating and repeated stresses **2013-14**

Ans: The stress induced due to dynamic load is called cyclic stress. There are three types of mathematical model for cyclic stress.

i. Fluctuating or alternating stress
ii. Repeated stress
iii. Reversed stress

Fluctuating or alternating stresses:-

- It varies in a sinusoidal manner with respect to time.
- It has some mean value as well as stress amplitude.
- The stress can be compressive or tensile or partly tensile and partly compressive stress.

Repeated stress:-

- It varies in a sinusoidal manner with respect to time, but the variation is from zero to some maximum value.
- It has zero value of minimum stress therefore stress amplitude is equal to mean stress.

Reversed stress:-

- It varies in a sinusoidal manner with respect to time, but it has zero mean stress.

Q No-3: What is fatigue failure of a material? Explain the mechanism of such failures.

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Ans: Fatigue: Fatigue is a phenomenon associated with variable loading. Just as we human beings get fatigue when a specific task is repeatedly performed, in a similar manner metallic components subjected to variable loading get fatigue, which leads to their premature failure under specific conditions.

Fatigue Failure

- A machine component which is subjected to repeated or cyclic stressing are found to have failed even when the actual maximum stresses were below the ultimate strength of the material, sometimes at stress values even below the yield strength.
- This phenomenon of decreased resistance of material to fluctuating stress is called fatigue failure.

Fatigue Failure- Mechanism

- A fatigue failure begins with a small crack. The crack usually develops at a point of localized stress concentration.
- Once a crack is initiated, the stress concentration effect become greater and the crack propagates.
- Consequently the stressed area decreases in size, the stress increase in magnitude and the crack propagates more rapidly. Until finally, the remaining area is unable to sustain the
  load and the component fails suddenly.

Fatigue Failure Stages

Thus three stages are involved in fatigue failure namely

-Crack initiation
-Crack propagation
-Fracture

Crack initiation:

- Areas of localized stress concentrations such as fillets, notches, key ways, bolt holes and even scratches or tool marks are potential zones for crack initiation.
- As a result of the local stress concentrations at these locations, the induced stress goes above the yield strength.
- As a result notch like discontinuity in the material.

Crack propagation:

- This further increases the stress levels and the process continues, propagating the cracks
  across the grains, slowly increasing the crack size.
- As the size of the crack increases the cross sectional area resisting the applied stress decreases and reaches a thresh hold level at which it is insufficient to resist the applied
  stress.

Final fracture:

- As the area becomes too insufficient to resist the induced stresses any further a sudden fracture results in the component.

Q No-4: What are the various factors that reduce Fatigue strength of materials? What factors should be considered while designing against Fatigue? 2010-11

Ans. Factors that reduce Fatigue strength of materials:

1. Size of the components
2. Shape of the components
3. Surface finish
4. Temperature of material
5. Notch sensitivity of the material

Factors Considered While Designing Against Fatigue: The following modifying factors should be considered while designing against the fatigue:

- Size factor
- Surface finish factor
- Temperature Factor
- Reliability factor
- Modifying factor for stress concentration
- Environmental factor
- Application factor etc.

In addition to above factor the type of loading that is repeated, fluctuating or completely reversed load.

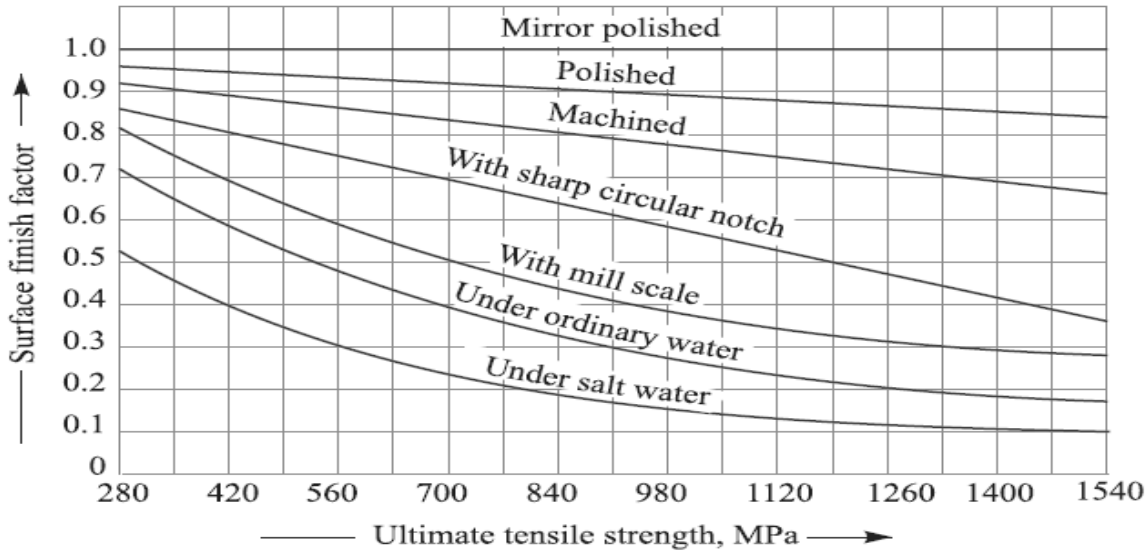
Size Factor: If the size of the standard specimen is increased, then the endurance limit of the material will decrease. This is due to the fact that a longer specimen will have more defects than a smaller one.

Let *Ka* = Size factor.

- The value of size factor is taken as unity for the standard specimen having nominal diameter of 7.5 mm.
- When the nominal diameter of the specimen is more than 7.5 mm but less than 50 mm, the value of size factor may be taken as 0.85.
- When the nominal diameter of the specimen is more than 50 mm, then the value of size factor may be taken as 0.75.

Surface Finish Factor: for a mirror polished material, the surface finish factor is unity. The value of surface finish factor can be taken from design data book.

Let K_b= Surface finish factor.



Reliability factor (K_c):-

Reliability (R) %	K_c
50	1
90	0.897
95	0.868
99	0.814
99.9	0.753
99.99	0.702
99.999	0.659

Modifying factor for stress concentration (K_d):-

The endurance limit is reduced due to stress concentration. To apply effect of stress concentration a modifying factor is used which is denoted by K_d .it can be defined as:-

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

Where K_f is fatigue stress concentration factor.