VIII Fracture and Fatigue

1. Fracture

1.1 Ductile and Brittle Transition

Depend on temperature materials can show different mechanical properties.

- Brittle fracture at lower T.
- Ductile failure at higher T.
- eg :The liberty Ships suffered brittle transition fractures on North Atlantic.

2. Fatigue

2.1 Reasons

- Failure by cyclic loading at stresses below tensile stress and usually below yield stress.
- Caused by the nucleation and growth of a crack.
- Below critical size, crack initiation is relatively slow while failure occurs when crack reached the critical size.
- eg :Fatigue cracks initiated from high stressed window corners being cyclic loaded.

2.2 Fatigue Testing

2.2.1 Fatigue Test

- The cyclic applied loading is compressive /tensile or only tensile.
- It contains
  - Cyclic uni-axial loading
  - Wohler rotational bending
  - Bend Test
  - Beam Loading

2.2.2 Rotating shafts and Fatigue Tests

- Rotating bend test
  Stress range s=σ_r

- Appearance of fatigue failures
  - Macro:beach marks
  - Micro: striations
  - Little necking
  - Crack run from free surface where stress concentration exist.

2.2.3 Variable Amplitude Loading :Miner's Law

- Consider a component at stress for cycles $n_1, n_2 ... n_n$, if the life stress on each level is N_1, N_2, N_N, Then the Miners rule states that:

$$\sum_{j=1}^{j=n} \frac{n_j}{N_j} = 1$$

- Fatigue is accumulation of damage or ductility
- Loading is fully reversed with no mean stress or strain
- Change the loading level does not alter proportion of life remaining.（only depend on the material)
  eg :
  If we use a third of the component life up at one stress level , it will be same as other level.(same as strain)

2.3 Corrosion Fatigue

- Do not have a corrosion fatigue as a common fatigue
- Can occur in aqueous,gas and liquid metal systems.