Fatigue Failure Mechanism

Engineers learn to calculate stresses for a variety of loadings – simple tension, beam bending, torsion, and others. For fatigue loading situations, parts are commonly designed with maximum stress less than the ultimate tensile stress by a safety factor of 8 to 10. Nevertheless, parts fail. The fracture surface often shows a characteristic signature of crack growth followed by fast fracture. The fatigue crack propagation portion is sometimes called a *fatigue clamshell fracture* due to its appearance.

Three types of fatigue failure are usually distinguished:

Cracked Structures

Cracks exist prior to loading, due to the manufacturing process. This is common in large, welded structures such as bridges and ships. In this case, the life of the structure is controlled by the rate at which the preexisting cracks grow.

Low Cycle Fatigue Failure

Low cycle fatigue failure is considered less than $\sim 10^4$ cycles to failure. This occurs in applications where parts are sometimes overloaded past the yield stress. The fatigue life (cycles to failure) is analyzed in terms of the small plastic strains that occur during overloading.

High Cycle Fatigue Failure

For cycles to failure greater than $\sim 10^4$ cycles, the life of the part is controlled primarily by the time to nucleate a crack at the surface. During service, maximum stress is held below the yield stress. This is common in vibrating structures, especially rotating shafts. We look in more detail at high cycle fatigue in the remaining portions of this section.