a major role in eliminating or reducing regions of stress risers and concentrations. It is not uncommon to have the design life of a vessel cut in half by poor design details. Although it is not possible to eliminate all stress risers and concentrations, some design details to be avoided are as follows;

1. Use integral construction
2. Avoid fillet welds for attachments to pressure boundary
3. Avoid reinforcing pads
4. Avoid threaded connections
5. Avoid partial penetration welds
6. Avoid stud bolt connections
7. Avoid nozzles in knuckle region of heads

In fatigue service the localized stresses at abrupt changes in thickness, abrupt changes in section, such as at a head junction or nozzle opening, misalignment, defects in construction and thermal gradients are the significant stresses. In general it is always beneficial to minimize peak stresses to the lowest level possible. Peak stresses often become the key stresses involving a fatigue analysis. Peak stresses occur at stress concentrations due to;

1. Fillet welds - high stress at corner of welds
2. Changes in thickness
3. Offset plates
4. Change in geometry
5. Welds attaching clips
6. Welds attaching nozzles

In welded regions, the influencing factors are unknown at the design stages, so they must be compensated for in overall safety factors applied to the procedure. The weld influencing factors are as follows;

1. Local surface notches such as weld bead roughness, weld ripples, undercut, local shrinkage grooves, local root concavity and welding start/stop craters.
2. Variation of the material properties in the various weld zones.
3. Residual stresses
4. Internal defects
5. Weld repairs

In addition Section VIII, Division 2 contains data for smooth bar design fatigue curves and welded joint fatigue curves. The curves represent testing conducted in air, and can be adjusted for the effect of corrosive environments. In general, corrosive environments have a strong, detrimental effect on fatigue behavior. Fatigue cracks in corrosive environments can occur at lower stress ranges; they can occur earlier and propagate faster. Corrosion can cause pitting, non-uniform wall thickness, crevices, gaps, and cracks... all of which reduce fatigue life.

Fabrication tolerances can be equally important details. Normal tolerances for vessels are not adequate. The ASME tolerance for out of roundness of 1% is not always acceptable. Peaking and banding tolerances may need to be much lower than the Code allows. Offsets between plates should be carefully controlled.

Additional factors for carbon steel vessels in cyclic service:

1. Vessels shall be PWHT
2. Material to be normalized
3. Material to be fine grain practice (7 or finer)
4. Plate material shall be 100% UT examined
5. All welds full penetration
6. All main seams ground flush
7. All attachment welds, internal or external, shall be ground smooth or contoured

In actuality, the surface finish, geometry, welded condition, temperature, environmental properties, and non-uniform material properties are drastically different than the test samples. As such, the ASME Code modified the data from the smooth bar fatigue curves by 2 on strain (or stress), or 20 on the number of cycles, whichever was more conservative.

Histograms

A histogram should be developed for each vessel to better assess the quantity of cycles the vessel or component will be subjected to. The purpose of the histogram(s) is to break down the loading history into individual cycles. The loading histogram should be determined based on the specified loadings provided in the UDS (User's Design Specification). The loading histogram should include all significant operating loads and events that are applied to a component. Examples of various histograms are given below.

Cycle Counting Methods

Section VIII, Division 2, Annex 5-B gives procedures for developing a histogram as well as two procedures for