Fretting Corrosion

Fretting corrosion has been the cause of countless failures at the contact points of machinery components. (Click**here** to see several clear photos of fretting which resulted in fatigue fracture). The ***ASM Handbook on Fatigue and Fracture*** defines fretting as:

"Fretting is a special wear process that occurs at the contact area between two materials under load and subject to minute relative motion by vibration or some other force." (**ref-3:9:321**).

When two pieces of material, pressed together by an external static load, (for example, bolted flanges, riveted lap-joints, press-fits such as a gear or bearing on a shaft) are subjected to a transverse cyclic loading, so that one contacting face is relatively displaced cyclically parallel to the other face, in the presence of high contact stress, wear on the mating surfaces occurs. If the magnitude of the displacement is less than about 0.003 inches, the wear is termed "fretting".
Fretting occurs by contacting asperities on the mating surfaces continually welding together then breaking. That leads to surface pitting and the transfer of metal particles from one surface to another. In addition, the small fragments of metal which are broken off oxidize, forming oxide particles which, for most engineering metals, are harder than the mated parts. These particles become trapped between the mating surfaces and cause abrasive damage and scoring.
Briefly, the characteristics of fretting are:

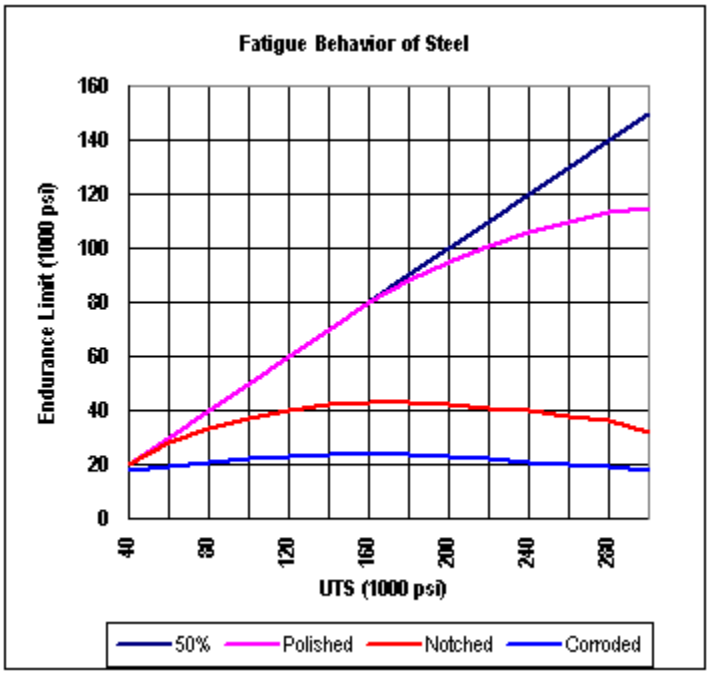
1. It is most serious when oxygen is present, although it can also occur in an inert gas;
2. It is worst under perfectly dry conditions;
3. It increases with contact load, slip amplitude, and number of oscillations;
4. Soft materials generally exhibit more susceptibility to fretting than do hard materials of a similar type;
5. Lubricants, particularly when used with surface treatments such as phosphating, reduce fretting damage.

It is interesting to note that there is disagreement in the reference literature on the effectiveness of lubrication. Reference **3:9:324** says: *"The introduction of a*

lubricant into the interface ***can*** *make matters worse by increasing the relative slip"*.

Fretting appears to be particularly aggressive in cases of disks (gears, pulleys, wheels, flywheels, bearings, hubs, etc.) which are press-fit (shrink-fit) onto shafts which are subjected to reversing bending stress, and worse yet under the added influence of vibration. The stress concentration which occurs where the shaft just meets the disk compounds the problem.

Under fretting conditions, fracture cracks can initiate at very low stresses, well below the fatigue limit of non-fretted specimens. Fretting corrosion can reduce the endurance limit of steels to as little as 18% of their original values. The greatest reduction in fatigue strength occurs when the fretting process AND cyclic stressing are applied simultaneously. The fact that fatigue cracks can form under low nominal cyclic stresses in areas where fretting is occurring is dramatically illustrated by the well-known low fatigue limit of a shaft having a pressed-on bearing.(**ref-3:8:365**)



This plot illustrates the dramatic effect that fretting has on the fatigue life of steels. The line titled "Corroded" mirrors the shape of the "notched" curve, but is much lower. The corroded curve shows that, for a badly corroded surface (fretting, oxidation, galvanic, etc.) the endurance limit of the material starts at around 20 ksi for materials of 40 ksi **UTS** (50%), increases to about 25 ksi for

materials between 140 and 200 ksi**UTS**, then decreases back toward 20 ksi as the material **UTS** increases above 200 ksi.

Prevention of fretting fatigue in the design process is essential. Although there is ample descriptive material on the mechanism and examples of fretting, there is limited availability of generalized techniques or modeling methodology for the prediction of crack initiation due to fretting. Testing is usually required to find and validate a solution to a fretting problem.
This information has been excerpted and condensed from four different reference works: **ref-2:3**, **ref-2:5**, **ref-3:8**, and **ref-3:9**.

Source:

http://www.epi-eng.com/mechanical_engineering_basics/fretting_corrosion.htm