Give Your Machines a Voice

SmartDiagnostics® Application Note

Damage Accumulation

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Background

This document details the theory and practical application of Damage Accumulation, an intelligent machine health metric developed for SmartDiagnostics® to provide early warning of conditions that will shorten the life of industrial machines.

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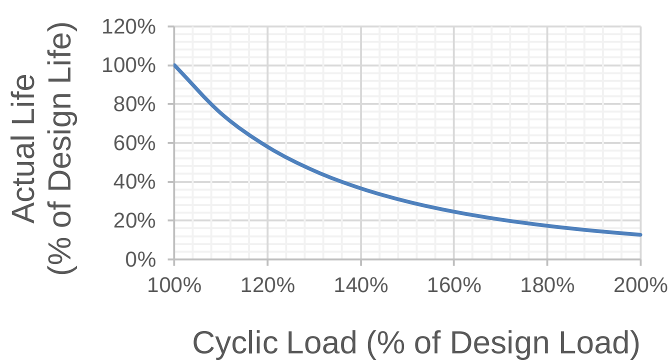
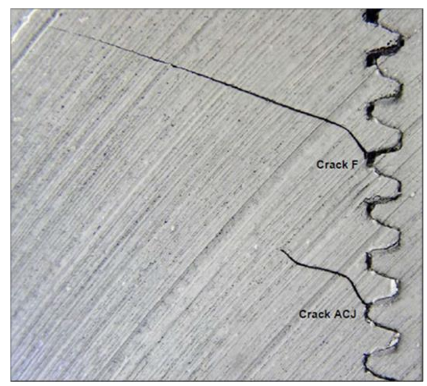
Overview

KCF's SmartDiagnostics® system is designed to provide early warning of conditions that are detrimental to the health of industrial machines. Damage Accumulation is a key indicator developed by KCF Technologies for early detection of damaging vibration conditions that will shorten the life of a machine. The Damage Accumulation calculation is based on metal fatigue theory, in which repeated loading cycles on a part cause the formation of cracks, which then propagate to failure.

The classic, extreme example of metal fatigue is a paper clip: If you bend a paper clip back and forth a few times with very high stress at the same spot, a crack will form and it will break along the bend line. This is called Low Cycle Fatigue, in which the extreme loading causes premature failure. High Cycle Fatigue is much more common in industrial machines, meaning a similar type of failure will occur if you bend the paper clip many, many times at a much smaller amount. The amplitude of the stress is exponentially proportional to how fast the part will fail, as shown by this chart, which illustrates that doubling the load on a part can reduce its life by 90%.



Reduction of Part Life Due to Fatigue



Example of Fatigue Crack Growth

By measuring the magnitude and frequency of deformation, it is possible to calculate a rate at which the part is being damaged, and how quickly it can be expected to fail relative to a normal part experiencing typical loads as designed. Damage Accumulation sums up all the tiny deformation events caused by vibration, and calculates a rate at which the part is being damaged. The calculation takes into account both:

- **Severity** of vibration (Amplitude of each cycle)
- **Frequency** of vibration (Number of cycles)

Other, more traditional vibration indicators will fail to highlight damaging vibration conditions that can be quickly detected by Damage Accumulation. For instance, RMS vibration will not reliably detect brief, high-amplitude impact events since a short-duration event will not appreciably move the average amplitude of a relatively long sample set. Similarly, peak vibration will be unable to distinguish between a single high-amplitude spike vs. a repetitive, high amplitude vibration, even though the repetitive vibration will be causing much more damage and drastically reducing the life of the machine.

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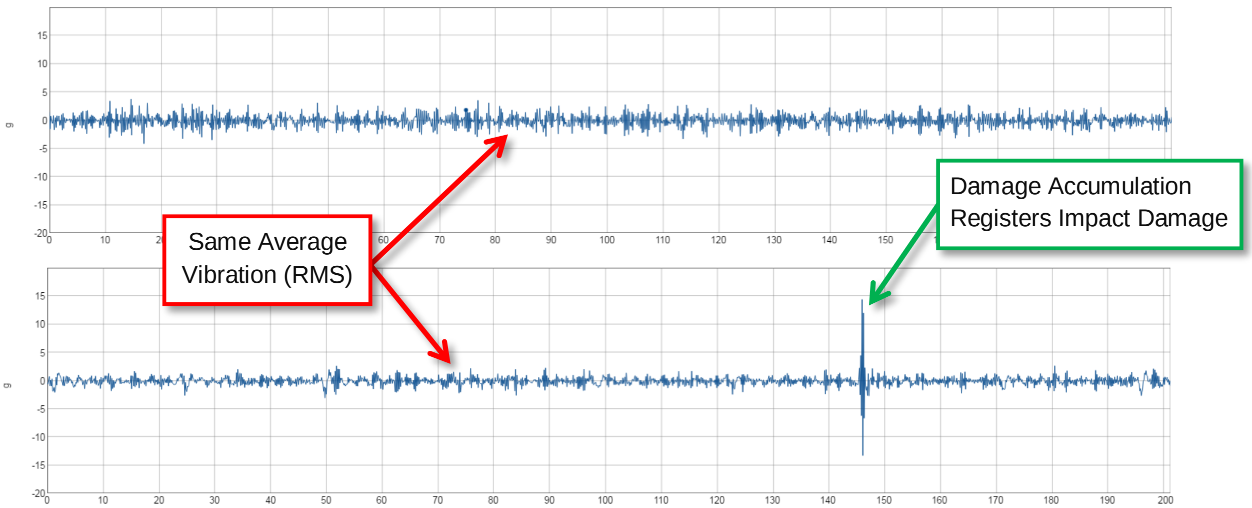
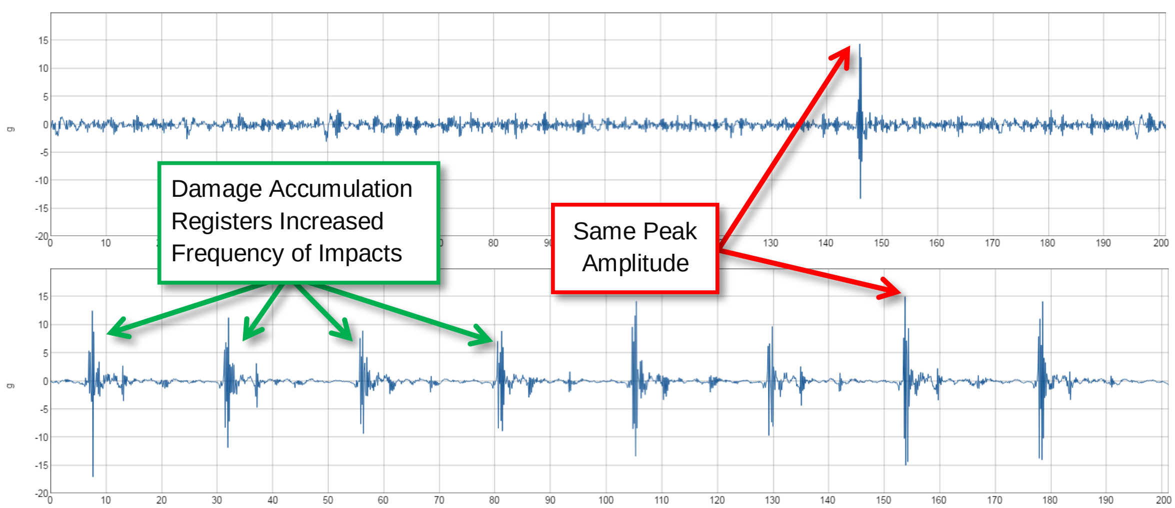
Example I: The two samples below have virtually identical RMS values since the impact energy in the second sample is concentrated in a very small time interval. However, Damage Accumulation detects a major difference since it takes into account magnitude of individual oscillations during each sample, highlighting the brief, damaging impact event whose magnitude is **6 times higher than normal**.



Example II: The two samples below show the same peak amplitude, so a Peak Vibration indicator would miss the fact that the second sample has repeated impacts vs. one isolated incident. The cycle-counting nature of the Damage Accumulation shows a major difference between these two samples since **damaging impacts are occurring at least 8x as often** in the second sample.



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