Title: Electrical Discharge Machining in DC Motors

Industry: Steel | Machine: Roll Stand DC Motors | Technology: Vibration Analysis

Purpose: This case study highlights the process involved with identifying motor bearing defects created by Electrical Discharge Machining (EDM) as the root cause of ongoing failure of DC motors that were powering Roll Stands at a Steel Mill, as well as the subsequent setting of specific fault alarms in both vibration and shaft voltage levels.

Overview: Rolling element bearings, such as those found in DC motors, consist of four clearly differentiating components: inner race, balls or rollers, cage and outer race. Damage these elements will generate characteristic fault frequencies in the vibration spectra that allow for quick and easy identification of the defects present. In this case, the baseline data collected contained Ball Pass Frequency Outer (BPFO) - meaning damage to the outer race of the roller element bearing was present. The damage to this bearing was the direct result of Electrical Discharge Machining (EDM). If left unaddressed, defects such as this can and often do lead to catastrophic motor failure.

Findings: There were a total of 28 DC motors at this facility, ranging from 500 to 1000 HP. Baseline readings showed that a large number of the motors had BPFO present at low amplitudes in the standard vibration Spectrums **(Figure 1)**, significant BPFO & Waveform impacting in the PKVue Data **(Figure 2)**, and elevated HFD values **(Figure 3)**.

These baselines triggered the need for a quick look at the high frequency ranges, which produced some rather dramatic results around 120k CPM.

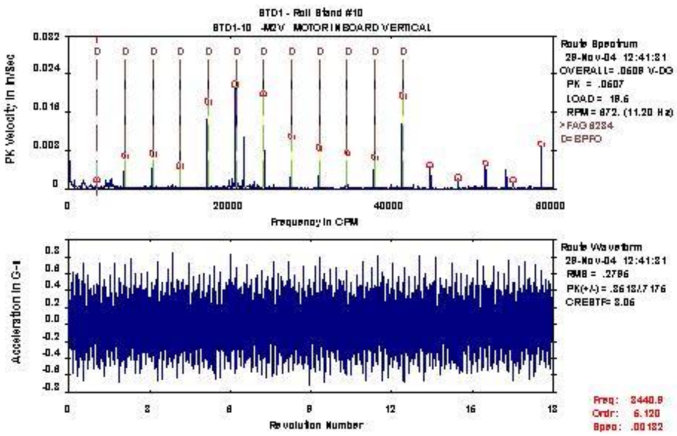

Figure 1: Baseline STND Vibration

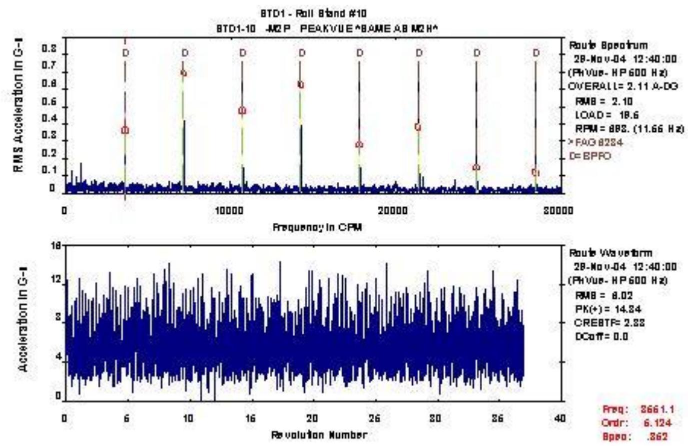

Figure 2: Baseline PKVue

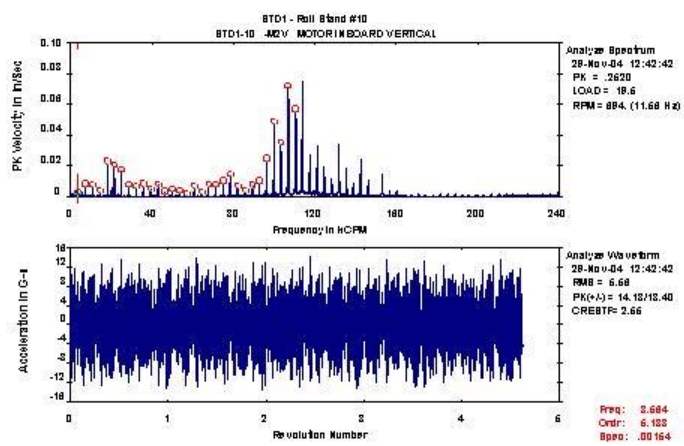

Figure 3: Baseline High Frequency

Based solely on the baseline data, one could determine that Electrical Discharge Machining (EDM or Fluting) was occurring in some of the motors. An in-depth look at all the high frequency Spectrums gathered during the baseline survey **(Figure 4)** helped to isolate the motor with the highest amplitudes, thereby giving us an idea as to where the high frequency bandwidth alarms should be set. At this time, a work request to replace the most effected motor was submitted to the customer.

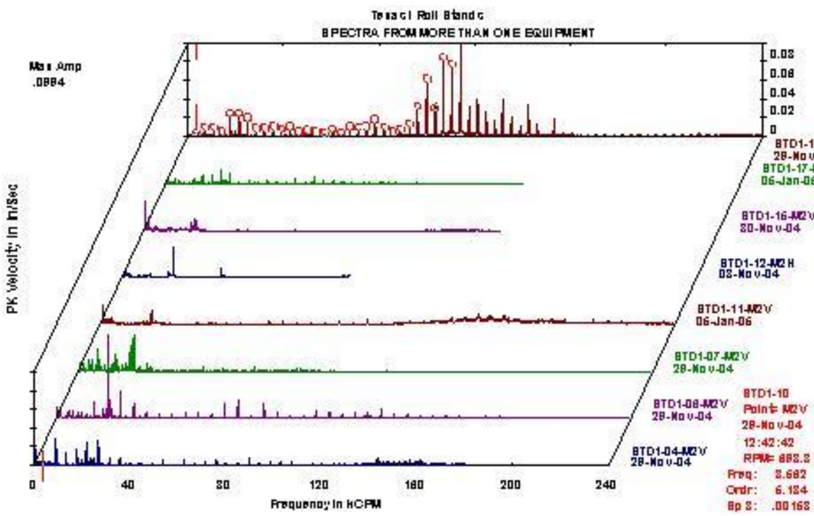

Figure 4: Baseline High Frequency Data Comparison

Analysis: Over the next couple of months, the motor with the largest amplitudes was closely monitored. All vibration trends indicated that the defect was worsening, but the customer was reluctant to change the motor because it had been in service for less than one year. Since the motor was still under warranty through a local re-wind shop, the customer requested that the re-wind shop look at the motor.

A “vibration tech” from the motor shop came out and submitted a report to our customer indicating that there were **no defects** in the motor, basically undermining all the data IVC had presented.

Knowing the “devil” remained in the details of the data, we devised a plan to capture even more advanced, comprehensive data to further prove to our customer that the motor in question was heading toward catastrophic failure.

The addition of AP & AL sets for the specific vibration frequencies associated with EDM **(Figure 5)** were introduced into the condition monitoring program, as well as AP & AL sets for Shaft Voltage readings **(Figure 6)**. (Note that the Shaft Voltage readings were taken with standard route-based data collection instrumentation & a custom Shaft Rider)

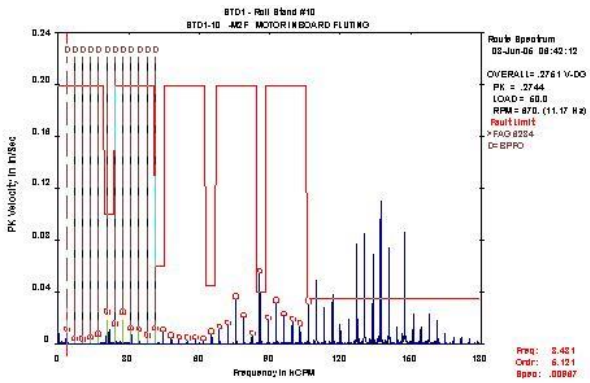

Figure 5: EDM Spectrum

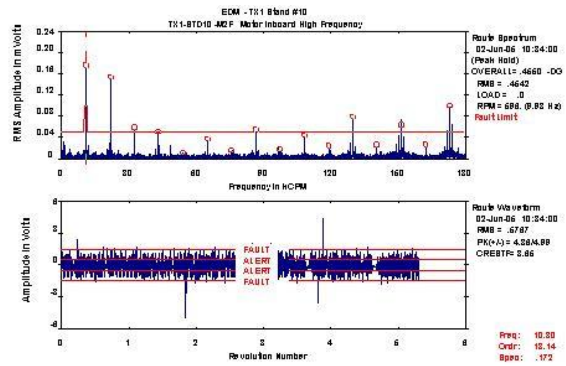

Figure 6: Shaft Voltage

Now being monitored with very specific fault alarms (both in vibration & shaft voltage levels), the new data trends **(Figures 7 and 8)** completely substantiated the fact that a severe defect was present in the motor in question.

After a few more months of monitoring, the motor was re-evaluated by the same local re-wind shop. This time however, the findings concurred that there was in fact a defect in the motor bearings, though they categorized it as "small". (Note that the motor was no longer under their warranty.)

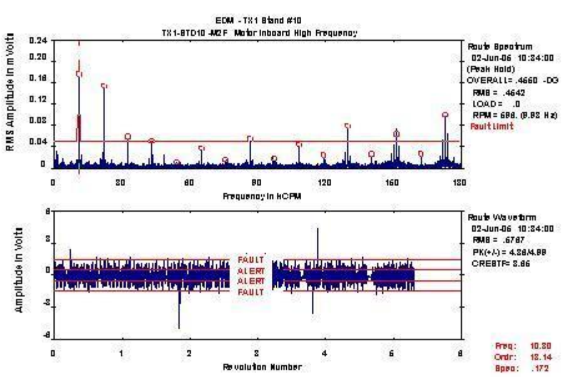

Figure 7: EDM Trend 1

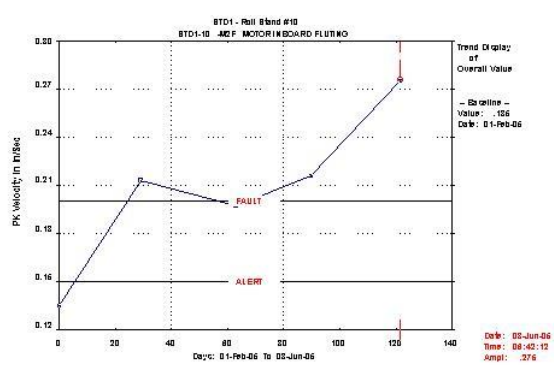

Figure 8: EDM Trend 2

Result: The motor was finally replaced eight months after the initial work request was written to repair it. Re-qualification with vibration analysis **(Figures: 9 and 10)** and shaft voltage tests **(Figures: 11 and 12)** confirmed that the new motor had no defects and the potential for EDM was no longer existent.

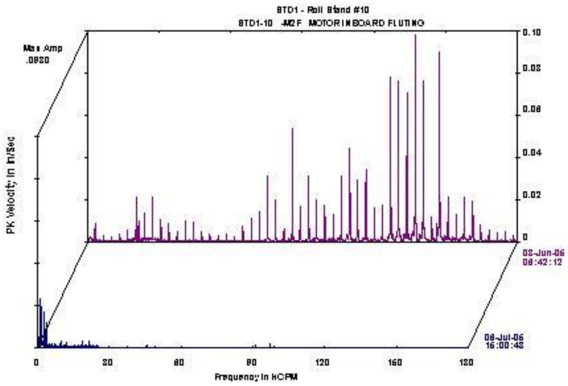

Figure 9: EDM B/A

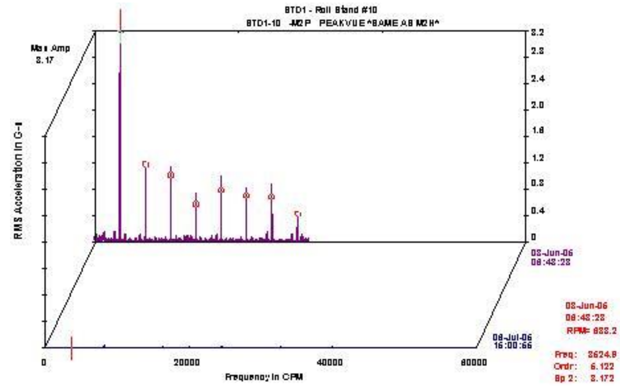

Figure: 10: PKVue B/A

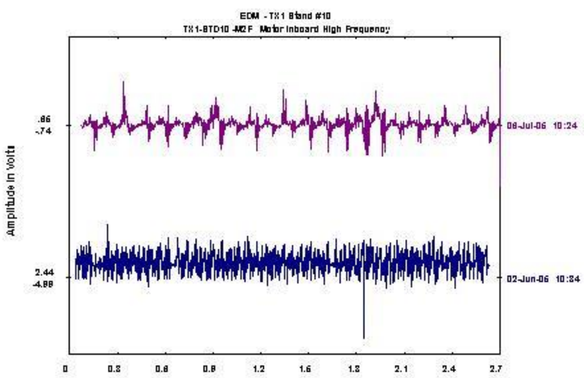

Figure 11: Shaft Voltage Waveform B/A

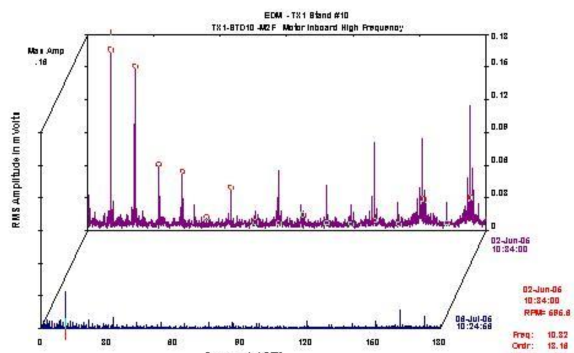

Figure 12: Shaft Voltage Spectrum B/A

Once the bearings from the old motor were returned to the plant, EDM was confirmed as the root cause for the bearing defect **(Figure 13 and 14).** The long-term solution to prevent this failure mode from occurring again was to implement better grounding devices and change the bearing types used in these motors. The implementation of these two strategies has subsequently eliminated EDM driven failures in these motors and subsequently lessoned the need to continue utilizing route-based measurements specifically used to target EDM occurrences.

Figure 13: STD 10 EDM

Figure 14: STD 10

About IVC Technologies

IVC Technologies is dedicated to helping our customers achieve optimal efficiencies through condition-based monitoring (CBM) utilizing our highly experienced and certified CBM analysts, cutting-edge PdM technologies, and equipment with unsurpassed analytic capabilities. Our Advanced Testing Group (ATG) is comprised of the foremost leading experts in the diagnosis of the most complex problems plaguing industry today.