Report on Vibratory Stress Relief

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Reading, PA

READING CRANE JOB

THE ROSE CORPORATION, a large-scale job shop, subcontracted VSR Technology to stress relieve a mild steel weldment, a 135-ton capacity lifting component for a READING CRANE AND ENGINEERING overhead crane. The workpiece had an overall size of 17' X 15' X 2', and weighed 23,600 lbs.

For this job, VSR Technology used its latest model stress relief system: the VSR-8000 System. The VSR Treatment Chart shown in this report was downloaded from the VSR-8000 System's touch-screen computer.

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After evaluating various stress relieving methods and stress relieving vendors, READING CRANE of Reading, PA specified that the VSR Technology Group provide on-site stress relief service for a series of 135-ton capacity lifting components. The contract to produce these components was awarded to THE ROSE CORPORATION, also of Reading, PA, a large-scale job shop with extensive experience serving heavy industry.

These mild steel fabrications were 17' X 15' X 2', and weighed 23,600 lbs.

VSR SETUP

The workpiece was placed on 3 isolation load cushions. One of the cushions (circled) was placed midway down one side (beneath the 5" thick lifting lug, see Figure 1), while the other two were placed at the midway balance point along each end. This load cushion arrangement minimized the damping of the workpiece, thus allowing maximum flexure to occur during the VSR Process.

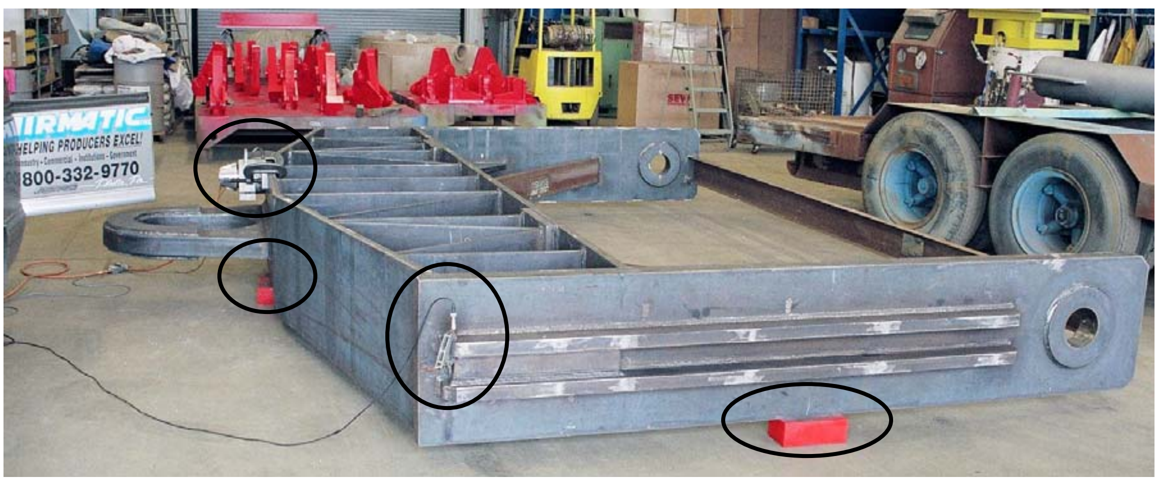

Figure 1: VSR SETUP. **The vibrator (circled) was placed above the lifting lug, and clamped using the front flange of the BL-8 Vibrator. The BL-8 Vibrator has two sets of mounting flanges, which allows effective orientation of the Vibrator relative to the workpiece.**

An accelerometer was placed on the corner of the workpiece (circled, left foreground, Figure 1), and oriented to be most sensitive to vertical deflection.

The Vibrator's unbalance was initially adjusted to a low setting of 10% of the BL-8's available 4.0 in-lbs. This generated only a small degree of resonance during a sweep thru the vibrator speed range where resonating took place (no resonances were detected above 5000-RPM). An unbalance setting of 40% caused more resonating, but also caused excessive power to be fed to the Vibrator (which has full electronic protection). A setting of 20% of 4.0 in-lbs., ie, 0.8 in-lbs, proved ideal – it caused resonating without excessive vibrator power.

VSR TREATMENT

The VSR-8000 System uses resonant frequency vibration to cause flexure of the workpiece, this mechanical flexure is the means of causing internal rearrangement of the material (ie, plastic flow) thereby lowering the severity of residual stresses. Although other forms of vibration, and even randomly generated mechanical excitation, can cause stress relieving to occur, independent research has shown that resonant frequency vibration causes the greatest and fastest degree of stress relief.

Monitoring resonant frequency vibration data during stress relieving also provides the clearest indication of stress relief progress: The major change in resonance pattern that takes place during effective stress relief is growth of the resonance peaks. A secondary response is the shifting of the resonance peaks, most often in the direction of lower frequency (exceptions being significant change in workpiece shape, which is often indicated by shifting in the opposite direction: See VSR Job Report: ARGONNE NATIONAL LABORATORY in our On-Line Library). Continuous monitoring of the tops of resonance peaks, along with the resonance frequencies, provides the most comprehensive real-time monitoring of the progress of a vibratory stress relief treatment.

The VSR-8000 System displays the acceleration amplitude of workpiece. Acceleration measurement is used, rather than deflection or velocity, because it is proportional to the force the workpiece undergoes, based upon Newton's 2nd Law: $F = ma$ (where F is force, m is mass, and a, acceleration.) Acceleration has been shown to be the most scientifically-based parameter to monitor during a vibratory stress relief treatment.

The workpiece acceleration data, along with Vibrator input power, is plotted vs Vibrator frequency. In the VSR Treatment Chart shown in Figures 2 & 3, the upper portion of the screen displays the workpiece acceleration data. The lower portion, whose full-scale is labeled 100% (equals full capacity of vibrator motor [3 HP or 2.3 kW]), displays a plot of the Vibrator input power.

After finding that a 20% unbalance setting generated significant workpiece resonating, a Pre-Treatment Scan was performed to plot the workpiece's initial resonance pattern. Pre-Treatment Scans are done in green (using traditional terminology: Before stress relief the workpiece would be "green", like a newly poured casting is "green", meaning full of stress).

The Pre-Treatment Scan, as displayed on the VSR-8000's touch-screen computer, is shown in Figure 2.

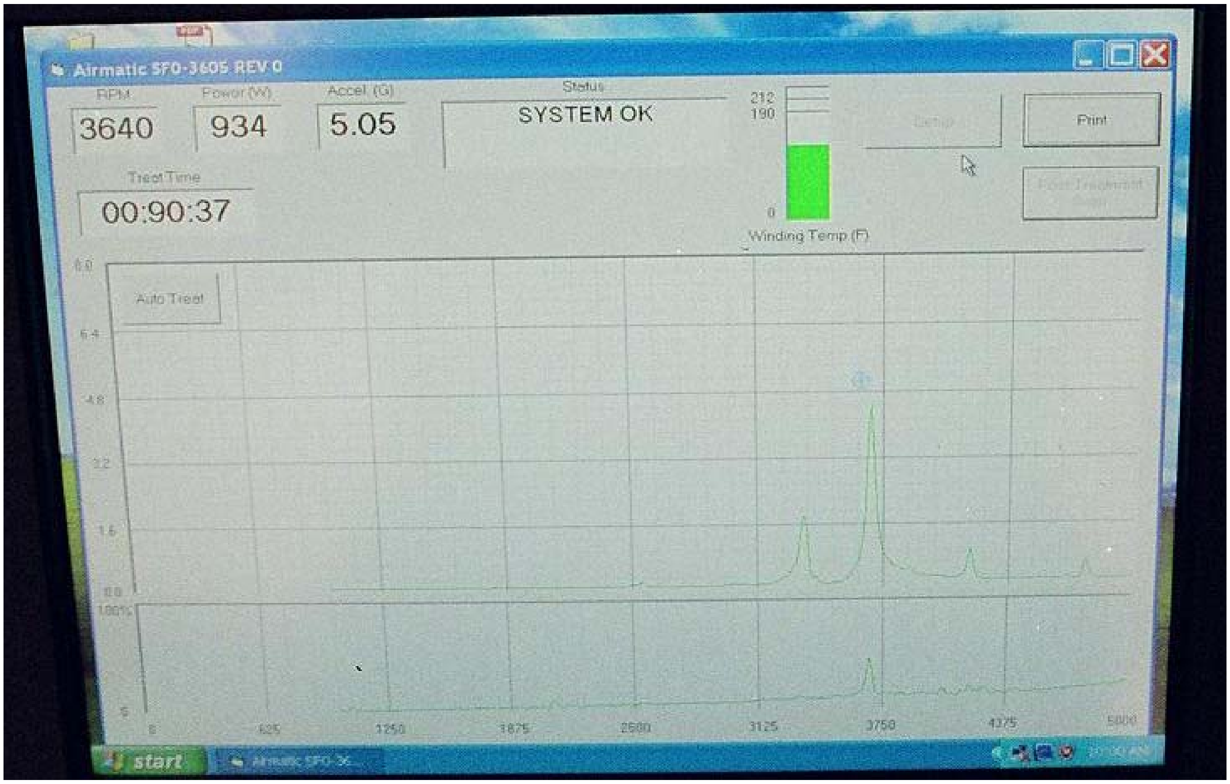

Figure 2: PRE-TREATMENT SCAN. **This shows workpiece's initial resonance pattern. At time photo was taken, VSR Treatment was underway, as indicated by the vibrator RPM (upper left corner) reading 3640, and the real-time cursor (circled blue cross) being above the large peak, and slightly to the left. The height of the peak at this time was 5.05 g, but it eventually grew to more than 6.5 g before stabilizing.**

During VSR Treatment, each of the three resonance peaks was tuned upon. Each peak grew 25 – 35%, especially the one at 3640 RPM, which was the largest of the three. Modest shifting of approximately 35-RPM to the left also took place. Peak growth was fast in the beginning of treatment, but slowed and stabilized during the 7 – 10 minute treatment periods of each peak.

After stability at each peak was achieved, a Post-Treatment Scan was performed, which documents the extensive change in the resonance pattern.

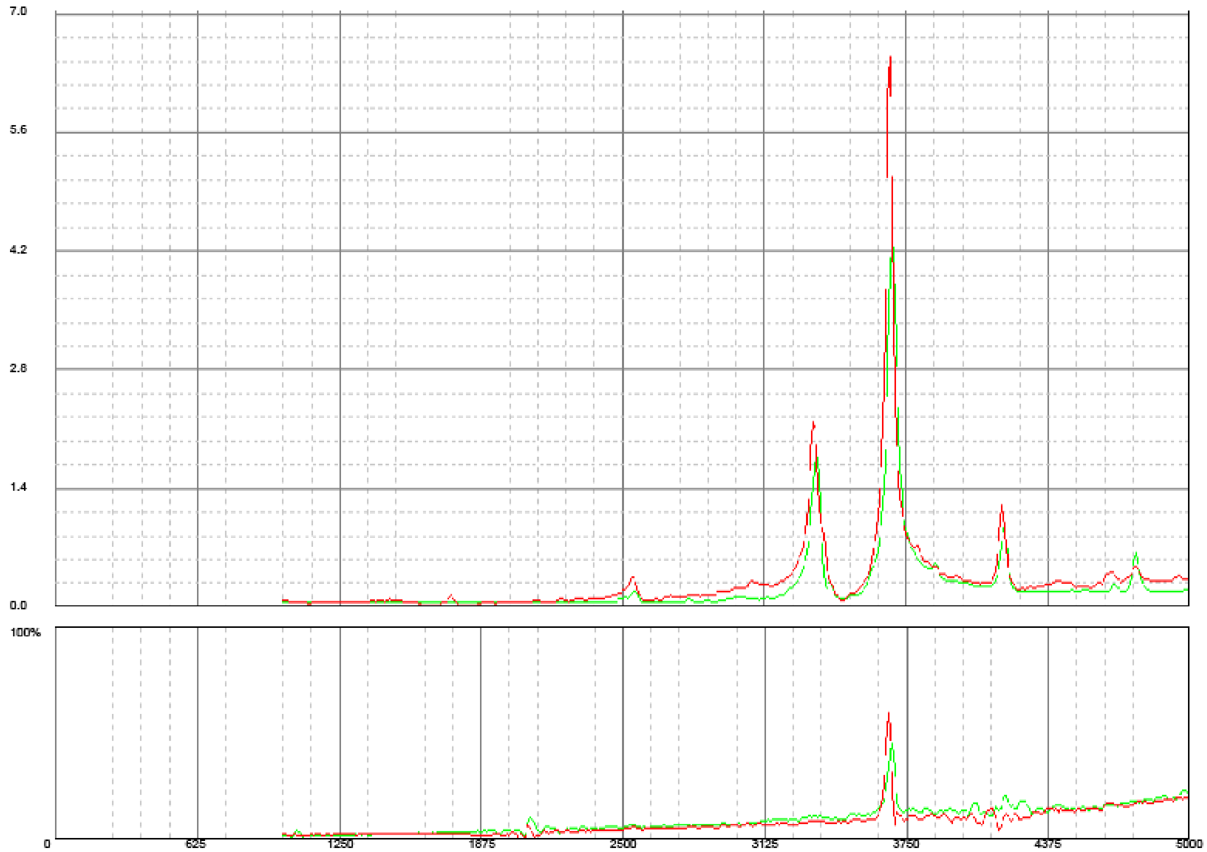

Figure 3: VSR TREATMENT CHART. **The growth of the resonance peaks, followed by stable resonance peak data, documents the effective of the VSR Process.**

CONCLUSION

As a result of the extensive and clear change in the resonance pattern of this workpiece, followed by resonance data stability, this fabrication should prove dimensionally and mechanically stable. Initial indication of this point occurred when the workpiece's bracing (see Figure 1) was removed, and no discernable or measurable distortion resulted. Thus was avoided any need for heat-straightening or other costly steps that would have reintroduced stress into this component and caused production delay.

Bruce Klauba has a degree in Physics and a Level II Vibration Analysis Certification from the American Society of Non-Destructive Testing (ASNDT). As a pioneer in the cause and effect of Vibratory Stress Relief, Mr. Klauba was named chief inventor (*Klauba et al.*) in U.S. Patent 4,381,673, which is both an equipment and process patent describing advances in the technology. He has authored numerous articles and original research papers on the subject, which have been published in leading magazines and periodicals. Published papers include:

1. "Use and Understanding of Vibratory Stress Relief", *Productive Applications of Mechanical Vibration*, 1983, American Society of Mechanical Engineers.
2. "Vibratory Stress Relief: Methods used to Monitor and Document Effective Treatment, A Survey of Users, and Directions for Further Research", 2005, *Trends in Welding Research*, ASM International.

A co-author in both papers, Dr. C. Mel Adams, is a leading authority in metallurgy and co-founder of MIT's Welding Research Department. In addition, Mr. Klauba has extensive experience in designing, building, and troubleshooting Industrial and Commercial Electrical Controls with a focus on extending the performance and reliability of Electric Motors and the systems they power.

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