Job Story on Vibratory Stress Relief

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KASGRO RAIL CORPORATION is a manufacturer of heavy load, platform railcars. Using VSR TECHNOLOGY'S Vibratory Metal Stabilization Process enables KASGRO to meet target dimensional tolerances, which, prior to effective stress relief with the VSR Process, caused problems during either the assembly or test loading phases of manufacturing.

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KASGRO RAIL CORPORATION is a manufacturer of open platform Railcars. Among the challenges KASGRO, like many manufacturers, has faced was the need to achieve increasingly tight dimensional tolerances. For KASGRO, this aspect of their QA Program required focus on Railcar Platform camber (the slightly arched surface of the Platform), since the 100,000 lb capacity Railcars they build, modify or repair are unique in their load balance requirements. Proper balancing of any fully loaded Railcar is a major contributor to safe transit, but on KASGRO's Railcars the requirements are particularly stringent because the Railcars are used for transport of heavy loads, such as earth moving and mining equipment. The Railcar's load balance system includes a weight adjustment system, along with a bubble type level indicator. Predictable Platform camber flexure plays an important role in such balancing.

Due to weld stresses induced during fabrication, however, a significant number of Platform workpieces would distort during test loading, often resulting in unacceptable changes in camber. Typically, heat straightening would be used as a corrective measure, but the torch pattern produced during straightening would generate additional residual stresses, subjecting the workpiece to a high risk of further distortion. Frequently, a repeat of the test loading would require yet another heat straightening. Heat straightening, like most corrective measures, is expensive to perform, normally not accounted for in production cost estimates, and, unfortunately, more akin to art than science. These added costs have to be reduced or eliminated to compete in today's global economy. KASGRO knew there had to be an economical way to stabilize the Platform without incurring not only the increased energy costs and time consumed, but also the adverse effects such as scaling, distortion, and metallurgical changes in the microstructure associated with Thermal Stress Relief.

KASGRO solved their problem by using VSR Technology's VSR-752 Vibratory Metal Stabilization (VMS) System to stress relieve the Platform. Among the characteristics of a properly stress relieved workpiece is its virtually perfect elastic behavior. When such a workpiece is subjected to a mechanical load (within design limits), it will return to its original shape when unloaded. "Live" parts, on the other hand, often change shape under load *(eg,* the test loading), when subjected to either temperature variations, or curing.

Using the VSR Process all but eliminated dimensional change during assembly, test loading, and transport. Some changes in shape were observed during Treatment: deflections of 3/16" over the Platform's 60' length occurred, although most changes were <1/8". These changes are five times lower than what occurred during test loading before using the VSR Process, and were considered inconsequential by KASGRO Engineers.

An overview of the VSR Treatment of a Platform is shown in Photo 1. The initial step involved isolating the workpiece on four (4) Load Cushions. The Cushions were strategically located under the workpiece: in from the outside corners, under the center 1/3rd of the workpiece to allow the greatest *resonance frequency* response during treatment.

During *resonance*, a distinct pattern of high and low amplitudes develop on the workpiece. This amplitude pattern is easy to identify on a workpiece with a large, flat, horizontal surface, by sprinkling powder or granular material, *eg*, sand, Oil Dry, or shot peen, on the workpiece; then, during *resonance*, the material is driven off areas of high amplitude, and gathers in areas of low or nominal amplitude. We call this pattern that the material forms a *nodal pattern.* These field demonstrations of nodal patterns generated on a workpiece receiving VMS Treatment give evidence to several important considerations which must be addressed in system set-up and operation:

- Nodes are rarely, if ever, at the corners of a workpiece, but are typically centrally located.

- The Nodes are good locations for the Vibrator and Load Cushions, but bad locations for the Accelerometer. In fact, the Load Cushions must not be placed beneath the corners of a workpiece since such cushion placement will cause vibration dampening which will prevent the *resonances*. Vibration dampening will make it impossible to stabilize (stress relieve) the workpiece.

- If a peak in Vibrator input power, which often accompanies a peak in acceleration, is severe enough to cause the Vibrator to shut-off (the system has a built-in over-power protection feature), moving the Vibrator to a Node will eliminate the problem.

Next the Vibrator was clamped within the center 1/3rd of the Workpiece (*see* Photo 2). Correctly placing the Vibrator on the workpiece is necessary if the *resonance* data is not clear. Incorrect Vibrator placement, such as on a corner, subjects the Vibrator to such high amplitude that the severe flexing competes with the System's servo-motor drive circuitry for speed control. Operators are trained to avoid such a set-up by observing the *resonance* pattern and the Vibrator's power input level, both of which are displayed on the Console. Vibrator orientation is also important. That's why every VSR Vibrator has 2 sets of flanges (side mount and face mount): in the event that the only mounting surface available on a workpiece offers an orientation that won't allow the workpiece to resonate, the Vibrator has a second set of mounting flanges. The Accelerometer (an acceleration sensor) is clamped onto the corner of the workpiece (*See* Photos 1 & 2).

With these steps of the set-up completed, the Vibrator's unbalance, which is adjustable over a 20:1 range, was adjusted to a relatively low 2 in-lbs. of unbalance, about 60% of the Vibrator's range.

VSR Treatment is accomplished by tuning to each *resonance* peak and dwelling on it, while watching the Console for either growth to a higher amplitude (movement upwards), or shifting to a lower *resonance* frequency (movement to the left). Often these two changes come in combination, which was the case, with each of the *resonances* displayed on the Chart seen on Page 7. Whether a peak grows or shifts depends on the type or nature of the *resonance*, specifically, whether it is bend or torsional, sum or difference, harmonic, or some combination; VSR Equipment has been designed to track and address any or all of these changes. Stability of the resonance pattern due to VMS is indicative of dimensional stability in the workpiece.

It is helpful not only for the Operator and his Supervisor, but also for documentation purposes that "progress dots", *ie,* dots made during treatment, be marked to show both the pattern of peak growth and/or shift. Some progress dots are visible on the Chart. The close-up photos (Photos 2 & Photo 4) of the Console and XY Plotter show the moment when the peak, with the Vibrator at ≈4,000 RPM, had grown to 4.81g. A Progress Dot early in the sequence of increasingly higher dots can be seen where the remark "4.81g'" is noted. The highest progress dot associated with this peak occurred at 5.73g.

If a second VSR Treatment had been performed after the one presented on the Chart, and if the Operator had followed proper procedure by dwelling upon the peaks as long as they continued to grow or shift, then the second Treatment would show very little growth or shifting activity. The changes shown on this Chart (≈25% growth in peak height, and ≈ 1% shift to lower resonance frequencies), would be about 10 times less on the second Treatment Chart. This demonstrates the excellent control and repeatability of the VSR 752's instrumentation: the Vibrator's servo-motor drive controls the vibrator speed to within ± 0.1%; the data sent to the recorder is accurate to 0.06%; long term drift of the Accelerometer amplifier is < 0.3%; the Operator can adjust vibrator speed in 5-RPM increments.

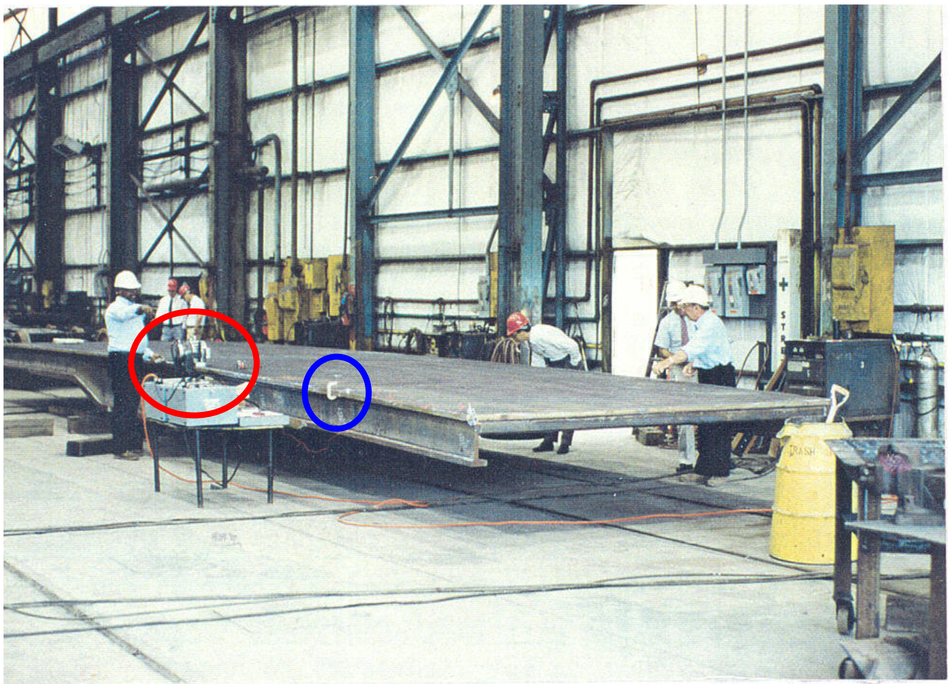
In summary, VSR TECHNOLOGY's Vibratory Metal Stabilization System has provided KASGRO – as it has with many manufacturers of large equipment with increasingly critical tolerance requirements a viable method of containing costs, maintaining manufacturing control, and improving quality. We're proud of the role we've played in the manufacturing process of this Industry Leader.

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.

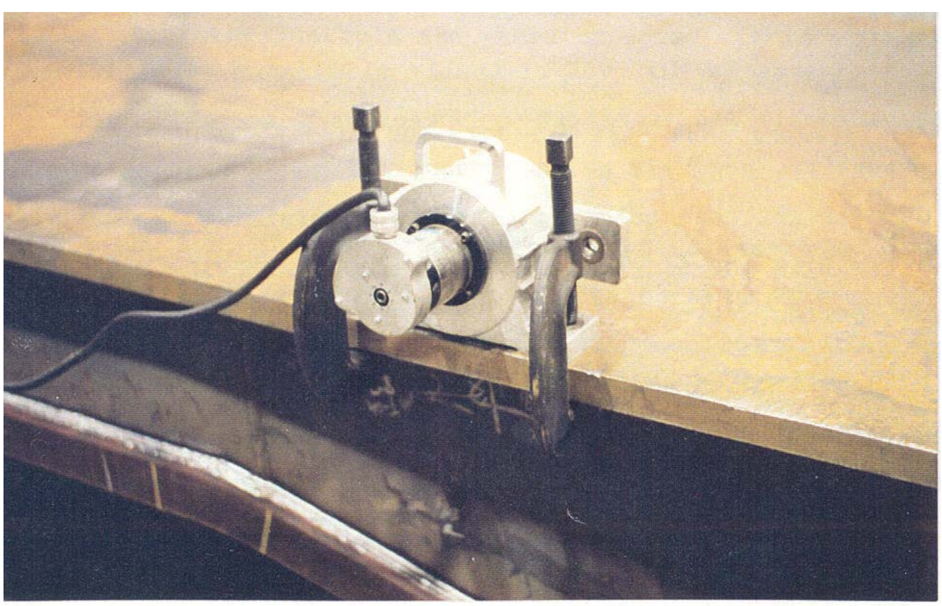
A co-author in both papers, Dr. C. Mel Adams, is a leading authority in metallurgy and co-founder of MIT's Welding Research Department. In addition, Mr. Klauba has extensive experience in designing, building, and troubleshooting Industrial and Commercial Electrical Controls with a focus on extending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

PHOTO #1



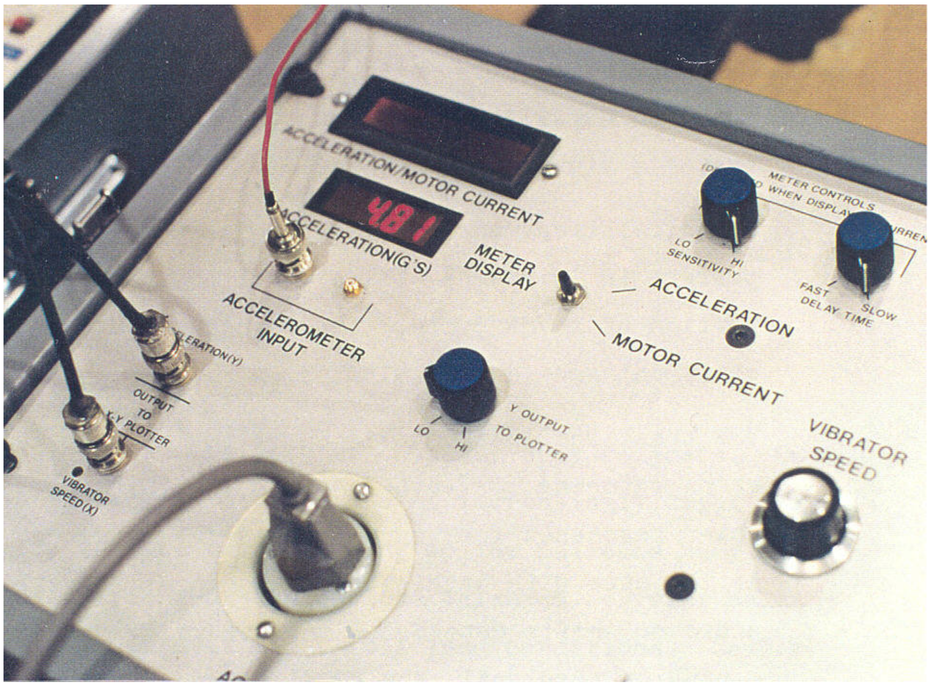
Overview of set-up for VSR Treatment on this Railcar Platform. The Vibrator is visible on left (red circle); the Accelerometer on its clamp is in the near corner (blue circle).

PHOTO #2



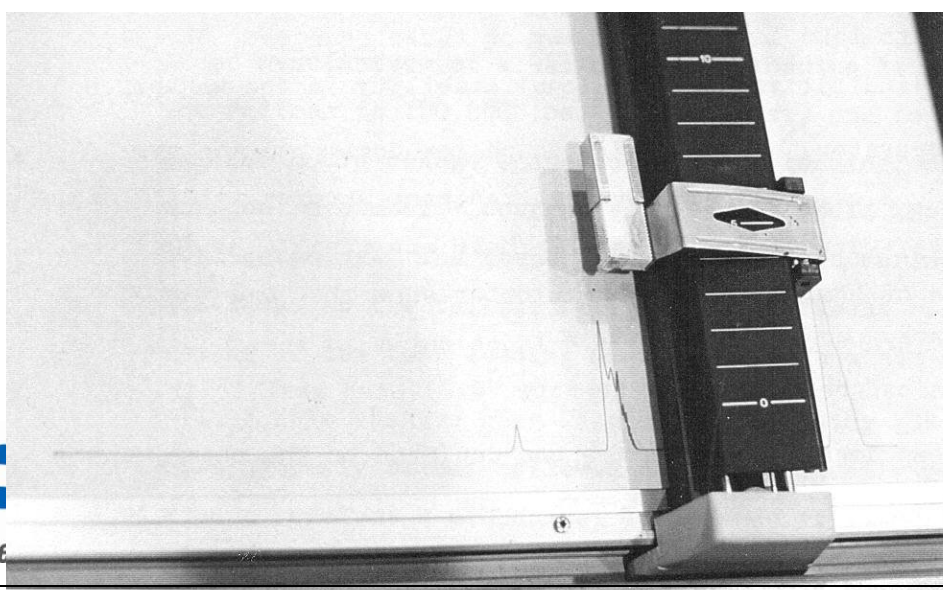
The System's MV2 Vibrator clamped to the Platform. Note the dual sets of mounting feet (side and front flanges) which enable the proper orientation of the Vibrator relative to the workpiece, even if there is only one mounting location available.

PHOTO #3

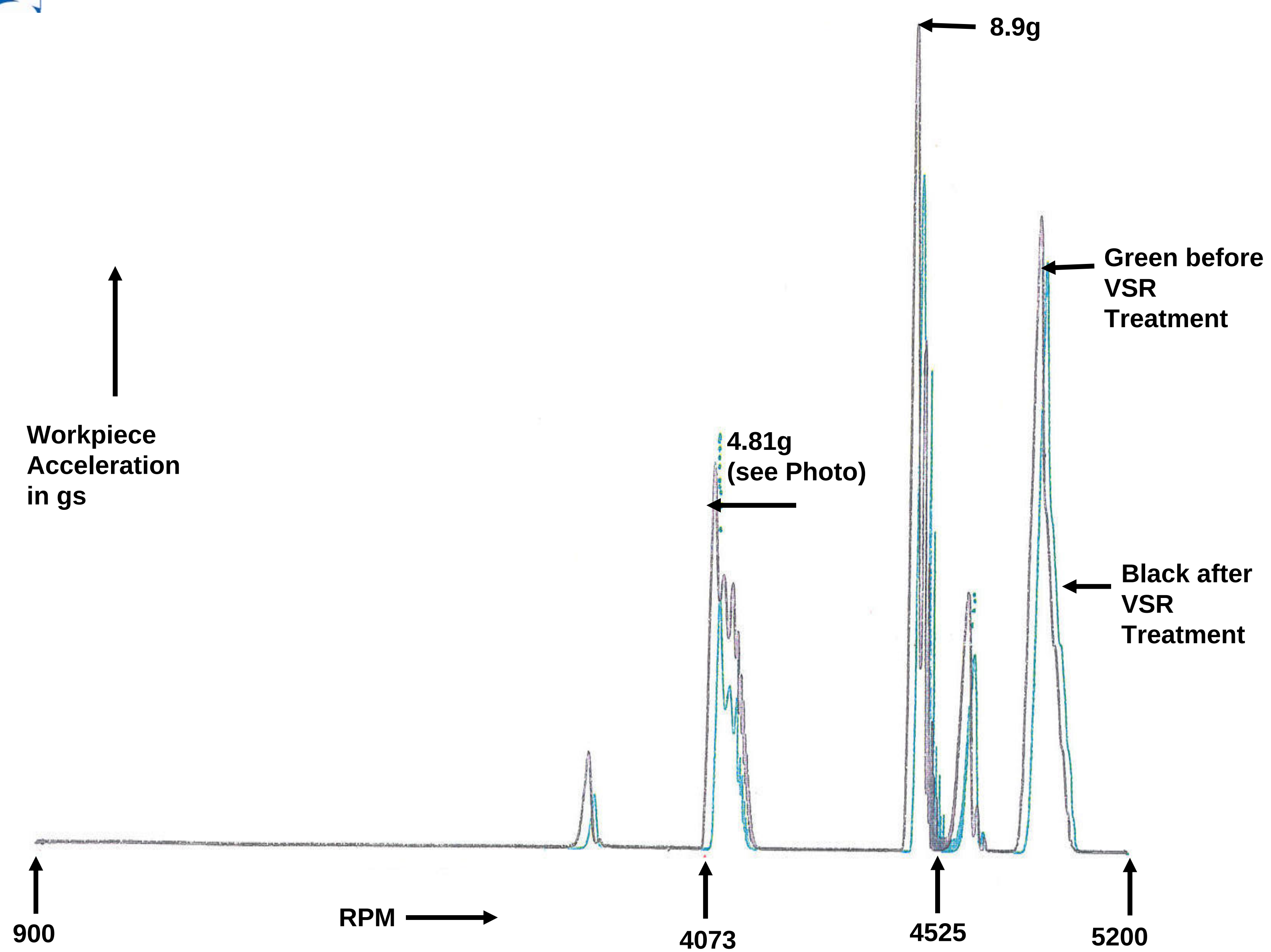


The System's MX 752 Control Console and XY Plotter. The Console's ACCELERATION DISPLAY (above) shows 4.81g which is real-time readout in engineering units of acceleration. The Plotter (below) is indicating that the Vibrator is tuned upon a second resonance peak, which is growing. The initial resonance pattern is green. This is all the Operator needs to start the Treatment cycle. This initial resonance pattern is recorded automatically and takes about 6-minutes.

PHOTO #4



Completed VSR Treatment Chart. The total time for System set-up, performing and documenting the VSR Treatment, and System knock-down was less than 3-hours.



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