The cost effective alternative to heat treatment

Job Story on Vibratory Stress Relief
Prepared by Bruce K. Klauba
Product Group Manager

MORRISON-BERKSHIRE (MB) is a manufacturer of large Roll Systems used in the Textile Industry. These Rolls use a dual shell design, with channel welded to the outside of the inner shell. The Channel between the shells transfers pumped oil during operation. MB offers the shells in both low-carbon and stainless steel, and manufactures them in sizes up to 6' OD, and up to 60' L. Both straightness and roundness tolerances are critical, typically ± 0.010" over the full length.

To maintain a leak-proof seal between the outer shell and channels, the outer shell segments (up to 20' L after rolling) are pulled taut and welded in place. The combination of the residual stresses in the flat plate, the rolling stresses, the welding stresses, plus the pre-load from the application of the outer shell result in, from a dimensional stability viewpoint, an extremely "live" part. Using the Thermal Stress Relief Process on these Rolls was not practical because:

- The sizes of the Rolls make furnace availability limited, and transport expensive.
- Descaling the walls of the oil channel is virtually impossible.
- The stainless steel Rolls will only respond to a thermal treatment temperature that threatens the Rolls' chemistry.

Further, although MB made every effort to minimize the amount of stock removal necessary to "true-up" a Roll, even this minimal amount on a 1,700 sq ft Roll surface is notable. Unfortunately, this stock removal caused – *especially on stainless shells* – significant levels of machining stresses. Heat straightening was sometimes used prior to machining, or at some intermediate machining stage, which generated additional stresses that wreaked havoc on subsequent machining efforts. MB knew there had to be a better way, and an engineering investigation led them to Vibratory Stress Relief as a more viable option to Stress Relieve these rolls.

Vibratory Stress Relief came into its own in the early 80's, when it was discovered that there was a change in the rigidity of a metal component when the residual stress levels were decreased. This change (a reduction) in rigidity, took place whether the stress relief occurred in a furnace, while stored outside for curing, during transport, or during vibration.

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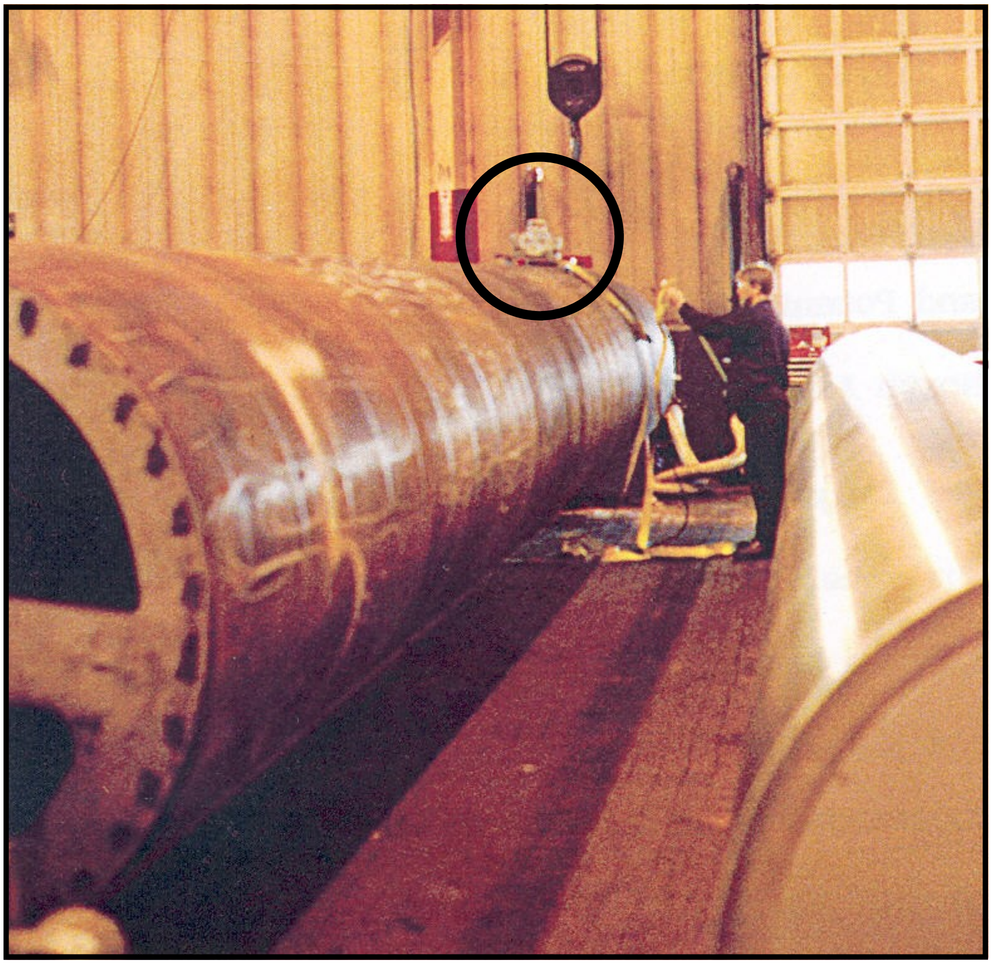
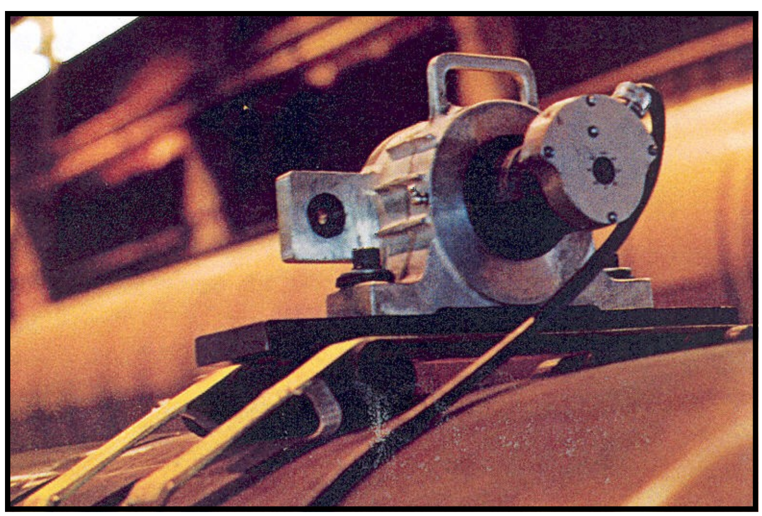
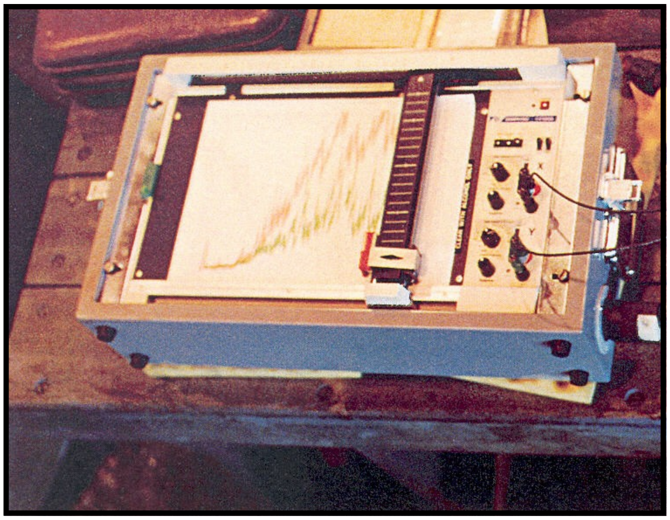
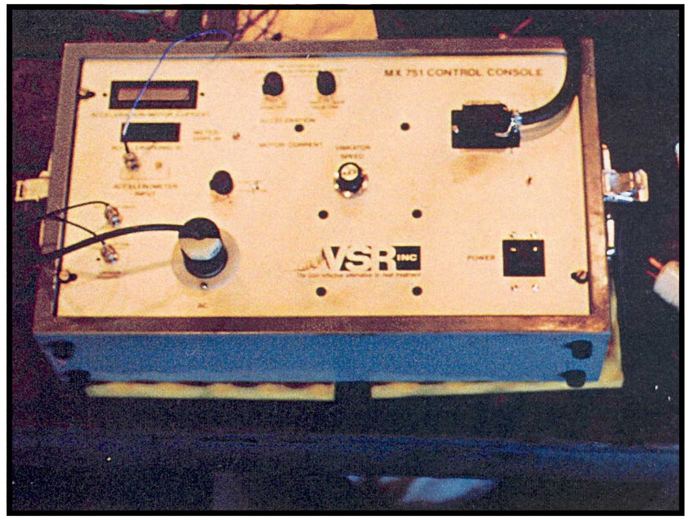


MB's operator is in the process of the VSR System setup for this 60' L, 6' OD, double walled, stainless steel Roll. The Roll must be machined to tolerances of straightness and roundness in the order of 0.010", full length. Load Cushions were positioned along the Roll's length 1/3 in from each end. In this unique application the Vibrator (circled) had to be attached to a mount plate which was then securely attached to the workpiece.

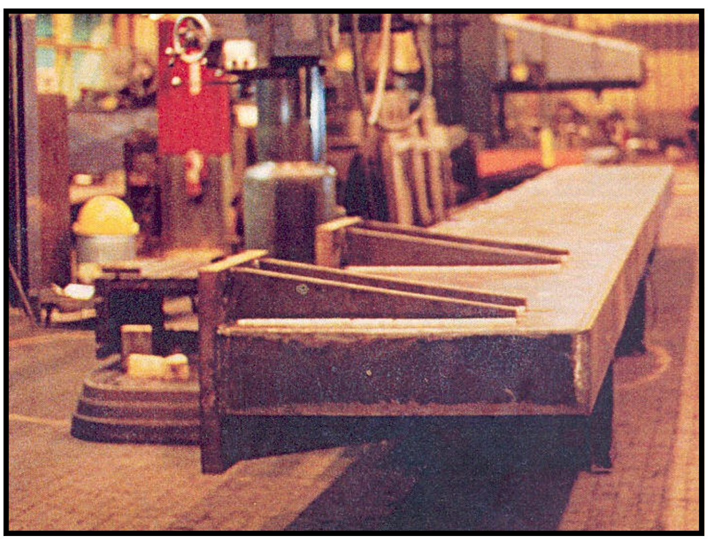
VSR Technology's Vibrator includes: a Servo Drive with Tachometer feedback circuitry for tight speed regulation; an adjustable unbalance (20:1 Range) for variable force output; 2-sets of Mount Feet to ensure correct mounting orientation.







The Control Console (Right Photo) automatically scans the workpiece and generates a pre-treatment scan (green) and post-treatment scan (red) on the X-Y Plotter (Left Photo). The Plotter's X-Axis is Vibrator frequency; the Y-Axis is workpiece Acceleration, *ie*, response to vibration. The difference between the pre and post-treatment scans is due to Stress Relief. The stability of the final scan indicates dimensional stability.



This is the fabricated Roll System's base, which is another component MB stress relives with the VSR 752 System. This is a good example of a workpiece which required the alternative second set of mounting feet to correctly orient the Vibrator so that the workpiece can be brought into resonance. Dual sets of mount feet are a unique feature of all VSR Technology Vibrators which are engineered to allow versatile mounting to accommodate various workpiece configurations.

The lowering of a workpiece's rigidity can be detected in two ways: (1) a reduction in the force needed to achieve a bending moment, such as used in a cold straightening process; (2) achieving resonance peaks that are either higher in amplitude, or lower in frequency, or a combination of both. These changes can be both observed and documented using the VSR Process.

In order to achieve Vibratory Stress Relief, reaching *resonance* is key. Both the setup and treatment methods utilized in the VSR Process were designed to: (1) maximize the effects of vibration; (2) monitor the effects of vibration in real-time; (3) document the changes in resonance pattern that accompany effective stress relieving.

The VSR Process setup involves isolating the component on correctly placed, dense rubber cushions, and strategically locating and firmly attaching both the Vibrator and an Accelerometer (a vibration sensor). Next, the system operator performs an initial scan and automatic plotting sequence. The operator can then see the vibrator frequencies that produce stress relief, and he knows when the treatment is complete by the changes in the workpiece's response to vibration. This response to vibration is demonstrated as:

1. The growth of the resonance peaks (which eventually stabilize) to higher amplitudes;
2. The lowering of the resonance frequency (which eventually stabilizes);
3. A combination of both responses.

These changes are all consistent with the reduction of the workpiece's rigidity to its final level (down from the temporary rigidity level caused by residual stress).

Since the VSR Process can be both monitored and documented, the operator is empowered to: (1) evaluate the System setup; (2) determine if there is a need for additional treatments after rough machining, or heat-straightening, or induction or flame hardening; (3) make an informed decision about the viability of using the VSR Process for other types and sizes of workpieces.

At MORRISON-BERKSHIRE, as with an increasing number of firms manufacturing medium to large precision components, VSR TECHNOLOGY is the answer!

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 ", 1983, *Productive Applications of Mechanical Vibration*, ASME.
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. Mr. Klauba, in addition, 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.