The cost effective alternative to heat treatment

Job Story on Vibratory Stress Relief
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Product Group Manager

S. W. HOOPER (SWH) is a manufacturer of rotary design paper pulp pumping systems. SWH's pumps use a 316 stainless steel, fin-rotor design: the operating fins provide the pumping action. The Rotor consists of two heavy-wall cones and one lighter-wall cone; the three cones are arranged concentrically and held together by the fins.

Machining the as-welded rotors to acceptable tolerances had been a challenge for SWH Machinists; the combination of variations in cone wall thickness, and the severe shrinkage that stainless undergoes during weld-puddle solidification, result in an extremely "live" part. The use of thermal stress relief yielded insignificant results because thermal treatment has a very modest effect on stainless steel (the highest temperatures that can be used during thermal treatment don't promote a sufficient amount of plastic deformation within the material to cause stress relief).

SWH purchased a VSR 752 Vibratory Stress Relief System for these Rotors and other workpieces in 1990, and since then predictability during and after machining has improved dramatically. In fact, tolerance specifications - on a production basis - were tightened by a factor of 2, since the turned outer fin surfaces were held concentric with the hub bore, to within +/- 0.005"

Because of both the complexity of the workpiece and its modest size, the primary challenge when implementing the VSR Program was to develop an effective means of fixturing these components. Fixturing is required when either the workpiece is too small to allow direct mounting of the Vibrator, or when the workpiece configuration makes direct mounting impractical. Both conditions were present at SWH.

When designing a VSR Fixturing Method, the design must meet two criteria:

1. Good mechanical transfer of the dynamic load from the Vibrator to the workpiece.

2. Minimal dampening of the workpiece, so as to allow *resonance* to occur.

Unfortunately, the objectives of these two criteria are often at cross purposes. Increasing the mechanical connection between the Fixture and the workpiece, *eg*, by adding additional clamping, often increases workpiece dampening to unacceptable levels. The goal is to achieve both objectives, without having the success of one detract from or eliminate achieving the other.

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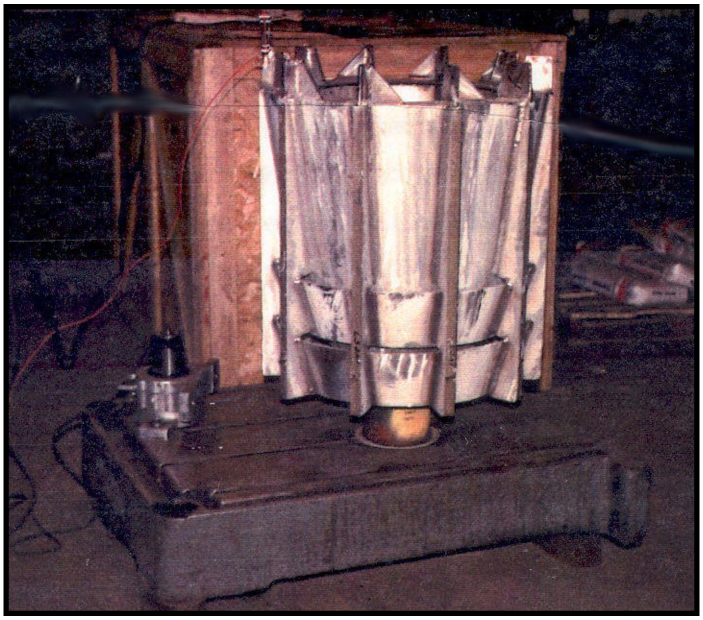
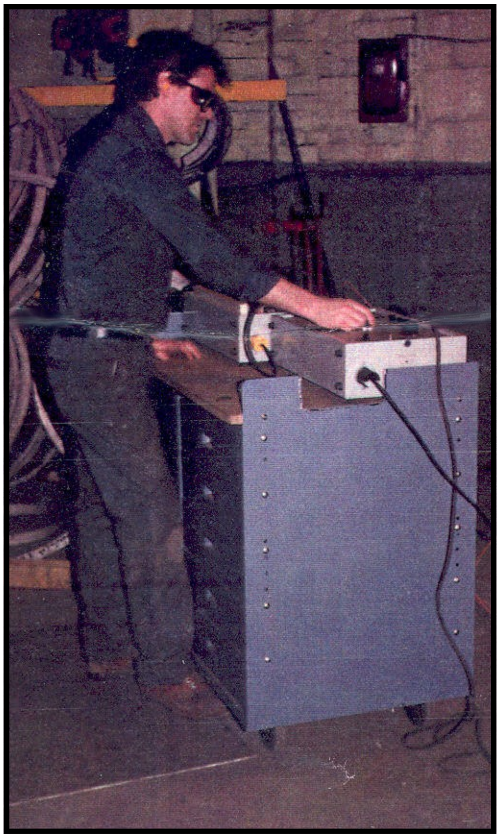
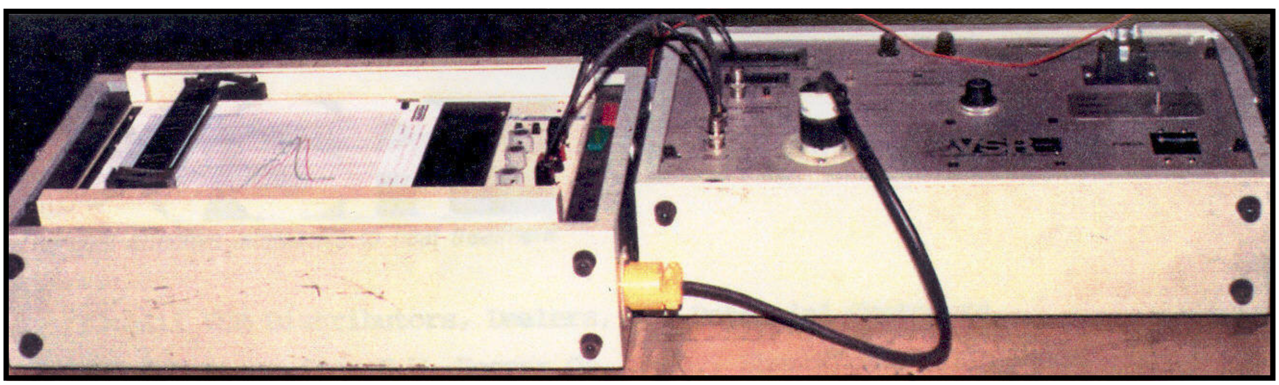


S. W. HOOPER paper pulp pump rotor is made of 316 Stainless Steel. Fabrication consists of three types of cone shaped cylinders, which differ greatly in wall thickness. These three sections are welded to the Rotor's fins. When operating, the fins provide the pumping action. The clearance between the fins and the pump housing is very close, so as to provide the greatest efficiency in pumping. The design requires very tight tolerances of both the concentricity of the outer fin surfaces and the Rotor's hub. Using the VSR Process, SW was able to improve this tolerance to + / - 0.005", more than 2x that of previously achieved results.

NB: **This photo illustrates the absolute need for a Vibrator with dual sets of mounting flanges; by using the face mount flange we align the Vibrator's axis of rotation with the rotor's center line. In this mount position (as opposed to the side mount flange position) the Vibrator was both more**



SWH Operator putting the VSR 752 System through its paces – guaranteeing that SWH's machine shop will achieve its Quality Assurance Goals.



VSR-752 Control Console and Plotter. Plotter has completed VSR Treatment Chart #1

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For this rotor configuration, the answer was to use a 2" dia. mounting stud to firmly clamp onto the hub, so that the remainder of the Rotor was free to vibrate. A thick, round spacer was placed between the Rotor and the base, and the stud passed through it. It is important to have only clamped surfaces in contact with the workpiece or Fixture. Surfaces that are either in very close or direct contact, but not clamped, will "clap" during vibration, causing erratic data that can't be interpreted accurately. As on other jobs, a right sized base and the right tooling made loading and unloading the Rotors into the Fixture easy.

Using their VSR 752 System and this fixturing method, SWH undertook their first production run hoping to achieve the, previously unattainable, target tolerance of 0.010" concentricity between the hub bore and the Rotor's fin. The result: an average tolerance of 0.0058", over a sample size of 15 rotors.

On succeeding production runs, SWH recorded the movement that took place in the *resonance peak pattern*, based on different welding techniques that were utilized. Using the feed-back from the VSR Treatment Charts, a specific welding method evolved that allowed average machining tolerances to be lowered even further, to < 0.005".

This illustrates a unique benefit of using the VSR Process: because the VSR Treatment Charts are real-time documentation of workpiece response to stress relief, the Charts also provide a feedback mechanism that enables a modification of related manufacturing methods, and procedures. These modifications can enhance quality goals, by allowing easy identification or isolation of the weak link in the production process. Similar logic can be applied in deciding when to insert a VSR Treatment into the machining cycle. For instance, if a workpiece has considerable stock removed during rough machining, or undergoes T-slotting, is it a good candidate for two VSR Treatments? Viewing the VSR Treatment Chart of the rough machined workpiece will answer that question. If the Chart shows significant movement of *resonance pattern* (*eg*, half or more than that which occurred during the first treatment), it would be prudent to perform two VSR Treatments, especially if tight tolerances are required. Since a VSR Treatment typically takes less than two hours, and re-machining of a critical workpiece can take two days or more, today's forward looking companies make the judicious decision to use two VSR Treatments to avoid unnecessary costs.

The "trial-and-error" approach to testing different manufacturing methods can be substantially reduced using a new tool - VSR TECHNOLOGY's Vibratory Stress Relief System.

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
3. 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.

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