VIBRATIONAL CONDITIONING OF METALS

This alternative to conventional thermal stress relief can be successfully used if established procedures are followed

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Induced vibrational energy is used to obtain three primary benefits in metals. These are identical to those obtained by conventional thermal stress relief

- Reduction in distortion during machining
- Reduction in distortion over time
- Reduction in weld cracking over time (increased service life)

Some heat treaters who have installed vibrational conditioning equipment report increased sales. Important factors in these success stories include the method's ability to treat large components and to treat components at the job site. Some also have discovered that vibrational conditioning prior to conventional heat treating decreased distortion during heat treatment — by as much as 90%. This phenomenon is not clearly understood, but should be researched by the ASM Heat Treating Society.

Metallurgists define "stress relief" in scientific terms, while vibrational conditioning advocates use the term as a marketing phrase to denote a similar performance outcome.

When it looks at vibrational conditioning, the metallurgical community understands that there is a beneficial effect. Now a scientific explanation is needed. Once one has been developed and accepted, use of vibrational conditioning will expand, particularly among the 50% of metalworking which does not now use any form of stress relief . . . but should.

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Successful procedure outlined

What follows is our description of the ideal vibration treatment procedure. It is based on 35 years worth of results from the field.

Vibrational conditioning — our Meta-Lax metal relaxation process — uses a sinusoidal vibration waveform. We induce energy to create a vibration amplitude that is below the harmonic amplitude. A dwell time of 30 minutes to several hours, depending on the component's strength, elastic modulus, and size, is maintained to allow internal stresses to redistribute and balance themselves.

Two principles are observed:

1. Vibration energy is induced into and absorbed by the metal at a frequency just below the peak. This is the proper frequency for best results. (Vibrating at the peak amplitude frequency causes plastic deformation and fatigue.).

In Fig. 1, the straight line (E) represents the constant rise in vibrational energy output as the frequency of vibration increases. The curved line (A) represents the amplitude profile of a metal component vibrating at the same frequencies. Note that the metal part initially resists the energy. Then, at a certain frequency, the energy overcomes the resistance and the amplitude rapidly increases or "jumps" to create a harmonic (resonant) condition. The maximum differential of energy output to work done (amplitude) is at a frequency immediately before the harmonic (X). That frequency will be used to determine the dwell time.

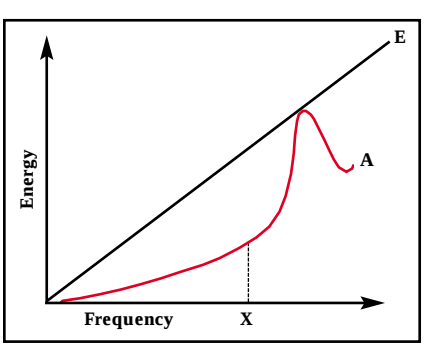

Fig. 1— Straight line E represents the constant rise in vibrational energy as the frequency of vibration increases. Curved line A represents the amplitude profile of a metal component vibrating over the same frequency range. The metal part initially resists the vibrational energy. Then, at a certain frequency, the energy overcomes the resistance and the amplitude rapidly increases or "jumps" to create a harmonic (resonant) condition, under which stresses will be relieved.

2. This principle was developed to determine how much conditioning time is required to provided sufficient treatment. The required conditioning (dwell) time is defined as that needed for the harmonic peak frequency to relocate and stabilize. The basic formula: Frequency = (Supporting System x Strength x Elasticity) ÷ ([Vibrating Weight + Eccentric Weight / Vibrator Location] x Length).

If the harmonic (or resonant) frequency changes after a vibration dwell, then the only value that can change is elasticity, and that means that the residual stress has been reduced.

Benefits summarized

If properly performed using the procedures outlined here, the Meta-Lax process may dramatically reduce or eliminate residual stresses. These benefits are among those that have been reported:

- Up to 95% less distortion in machining
- Up to 98% less distortion over time
- Less cracking over time, resulting in a service life increase of up to 300%

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