META-LAX Stress Relief and Weld Conditioning Process

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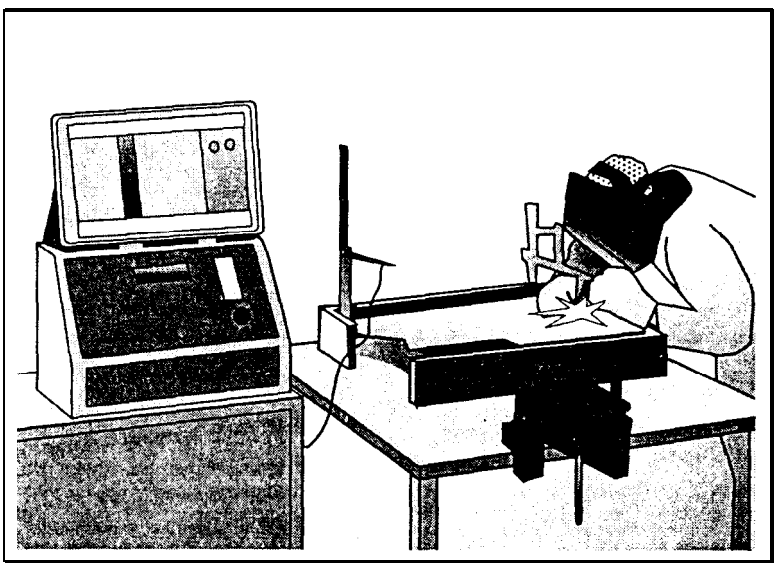
META-LAX *is a patented quiet, vibrational stress-relieving process for neutralizing undesirable thermal stress in* metal *structures during fabrication The process uses precise, nondestructive low-frequency vibration.*



META-LAX Process Used During Welding

Introduction

Common fabrication of metal structures and components using high-temperature methods, such as machining and welding, frequently introduces thermal stresses that manifest themselves in various ways. This can include material distortion, crack propagation at welds, and other undesirable characteristics that are usually reduced by heat treat stress relief. The power and labor/handling requirements of these heat treatments contribute to high production costs and the wasteful use of energy.

Concept Description

The META-LAX process accomplishes stress relief by inducing a mechanical energy into a workpiece through vibration. Different levels of induced energy will have different effects on metal. With vibration, as with heat, there is an optimum energy level that will cause stress relief. All metal components exhibit harmonic and nonharmonic responses to external energy input. The amplitude of displacement of the metal component is a function of the induced vibration frequency.

When the frequency of vibration is increased, the metal dissipates the induced energy through internal friction and results in lower amplitudes. The amount of energy being dissipated by the metal is its stress-relief potential. This dissipated energy reaches a maximum at and near the leading portion of the harmonic curve ("subharmonic"), which is the optimum stress-relief vibration frequency. Beyond this range, the metal component cannot dissipate the induced energy and responds with a violent reaction (higher amplitudes), which is usually observed as bouncing, with high noise levels. Beyond the harmonic range, the metal regains its capability to dissipate the induced energy, which results in lower amplitudes.

If the metal component contains thermally induced stress, the harmonic curve will be out of location when compared with its natural location in a stress-free state. Upon

META-LAX stress-relieving, the initial harmonic curve shifts to and stabilizes in a new location which is its natural frequency location. The equipment used for the process consists of a direct-current force induction unit, a custom-designed and patented control transducer, and an electronic console to analyze, monitor, and control the frequency input.

The system electronically determines the harmonic frequency of the part, then induces a lower frequency to achieve stress relief through molecular action. This process can be used during metal fabrication or welding. The weld-conditioning application relieves thermal stresses as they are being introduced during weld solidification. This process minimizes or eliminates weld cracking and distortion.

Economics and Market Potential

The META-LAX process can be applied to a wide range of metals, including low- and medium-carbon steel, tool steel, aluminum, stainless steel, cast iron, and some exotic metals. META-LAX is applicable to a spectrum of processes including weldments, castings, forgings, and other fabrication/hardening processes. The process offers many advantages over conventional stress relieving:

- no treatment distortion
- 95% less processing cost
- 98% less processing time
- 41% less machining time
- 200% fatigue life improvement
- 84% less distortion
- 95% less weld cracking
- 66% less preheat (up to 177°C)
- less weld porosity
- no limit on size or weight.

The process is particularly applicable to die casting to quality-check stress relief on new incoming dies prior to use, to apply periodic stress relief to the dies, and to stress-relieve during repair welding.

When used to stress-relieve one weapons system for the U.S. Army, the META-LAX process reduced annual energy costs by $230,000. In another case, a weld company saved an average of $243,000 annually using the META-LAX process over thermal stress relieving.

Bona1 Technologies has introduced META-LAX equipment into a number of industries. Several models of production equipment are available, ranging from portable to automated systems. META-LAX has wide applicability throughout the metal fabrication industry. With significant savings in energy consumption and the potential for increased productivity of metal fabrication, the META-LAX process can further enhance the U.S. preeminence in manufacturing.

Key Experimental Results

Traditionally, internal stresses are removed by heat treating the metal, bringing its temperature up to a specified level, and then cooling it as slowly and evenly as possible. Testing demonstrated that heat treating large pieces of steel was expensive, time-consuming, and inconsistent if the heat treater did not cool the metal properly. Nonthermal stress relief alternatives were researched, including resonant vibration energy in Bonal's precision machining environment. The vigorous testing indicated that resonant vibration, as a stress-relief method, was only 40% effective and definitely not appropriate for quality work. Other organizations abandoned interest in all vibration studies but Bonal continued developing and perfecting the use of vibration for stress relief.

During 18 months of testing, Bonal isolated the set of critical factors that formed the basis of effective use of vibration for consistent stress relief. Bonal identified the subharmonic level of vibration as the critical factor for effectiveness; competitors were using the highest portion of the harmonic curve with less success. Testing was continued to verify the capabilities and limitations of subharmonic energy. Limitations were identified with both cold-worked material and copper. The technology has since been taken to Ford and General Motors for testing and demonstration. Bonal participates in testing at companies across the U.S., and companies send samples to Bonal for stress relieving.

Future Development Needs

Today research and development of the META-LAX technology are conducted extensively in Bonal's machining facility so that results can be evaluated in a practical applications environment. Bonal has two computerized models for demonstration; a third computerized model is being developed. The META-LAX process is extremely versatile because of the size range to which it can be applied: from very small parts to parts as large as rock crusher tonnage.

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Compiled by
Pacific Northwest Laboratory for the U.S. Department of Energy, Innovative Concepts Program 590240. This flier was printed on recycled paper.