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CARPENTERIA METALLICA BOVESANA

STRESS RELIEF PROCESS

FOR ELECTRO-WELDED METAL STRUCTURES

THROUGH VIBRATION

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VIBRATION STRESS RELIEF PROCESS
"Vibration Stress Relief" or VSR

The term **Vibration Stress Relief (often abbreviated as VSR)** identifies a metal-physical method of dimensional stabilisation of a metal component or structure by means of forced vibration.

STABILISATION BY VIBRATION TO PREVENT DEFORMATION DURING MACHINING

During and after the mechanical machining of rolled, cast, forged or welded parts, whether steel, ferrous or non-ferrous metals, significant deformations often occur. Thanks to special production methods and, above all, the reduction of stress states by means of heat treatment, the required tolerances can in many cases be achieved, but, in addition to the costs due to thermal energy, transport costs and the associated manual labour, this type of treatment in turn leads to deformations and oxidation of the machined parts.

The VSR system achieves a reduction in anisotropic stress states and thus dimensional stabilisation through vibration. Thus, during machining, transport, loading and unloading, no deformations of any kind occur.

THE STABILISATION PROCESS

Each part is treated at particular resonance frequencies, determined using special equipment. The duration required for each treatment is determined by the results of successive, continuous measurements. Once the stabilisation is achieved, this can be technically controlled by reducing the current consumption absorbed by the vibrator.

However, it becomes significantly obvious in the prevention of critical deformations during and after machining. This result should be the decisive argument when assessing the cost-effectiveness of the VSR process. No deformations occur during vibrational treatment, as no plastic sliding occurs in the workpieces on a macroscopic level, because the main residual stress usually varies very little. This means that the equipment, since it does not intervene in the first-order stress states, is not able to solve the so-called 'stress corrosion' problems as required by the standard rules for pressure equipment. But this is far from being a limitation.

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THE PHYSICAL METAL PROCESS

The propagation of vibrations is dampened by anisotropic stress states, which are then the cause of deformations of machined parts due to fibre breaks. This 'internal friction' arises especially at critical points with a high level of residual stress. Three-dimensional vibrations facilitate a non-unidirectional relaxation of the fibres, homogenise transverse sliding, and are responsible for a slight atomic diffusion, with the consequent effects of relaxation and stabilisation of the parts. The damping characteristics and applied vibrational energy thus decrease to a minimum level that cannot be further altered.

By using 'resonance frequencies', the damping is particularly high and the reduction of residual stress is very intense, so that these frequencies, in the range above 100 HZ, are sought by means of an accelerometer. The instantaneous energy absorbed by the vibratory motion is indicated by an ammeter, and the results are recorded on a recording sheet, or recorded via a multi-channel printer. After the detection of 4-6 resonance frequencies, the parts to be treated are placed under vibration at these values until the current absorbed by the vibrator decreases to a lower level that remains constant (at least 5 minutes of treatment for each frequency). The latest series range of our equipment has a microprocessor that can automatically detect typical frequencies. Looking at the ammeter again after treatment at each individual frequency, a reduction of 10 to 40 per cent of the current absorbed by vibrator motion can usually be observed, thus proving the stabilisation achieved. In the case of a second treatment, even if the vibrator is placed elsewhere on the workpiece, this reduction in motor current is not noticeable.

By using the VSR process during welding, the deformation usually resulting from residual stress states can in many cases be minimized, just as the risk of cracks in the case of special steels.

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DEFORMATION PROBLEMS

Nowadays, even heavy metal works are manufactured considering precision as a key factor. Their final construction tolerances are often formulated in microns. But, generally speaking, what is machine tool precision worth for, if the material does not maintain its dimensions and when deformations occur during welding due to material instability?

THE FOLLOWING PROBLEMS ARE A MATTER OF CONCERN FOR YOUR COMPANY, TOO?

1. Have you examined the impact of transport on production costs, downtime, oven use and energy consumption?
2. Are oxidised surfaces and increased tool consumption after heat treatment an inconvenience for you?
3. Have you been forced to design a part to fit the dimensions of the oven or perform an uneconomic division of the part into several sections in order to be processed?
4. Have you found it hard planning to reach "point 0" when parts are deformed during production and heat treatment, despite appropriate precautions, or when you have had to straighten them again despite the risks of such a procedure?
5. Have you faced any complaints due to deformations although the parts passed the final inspection without any objections?
6. Do you remember the inconvenience of having to get parts off the production lines and having to handle, check and perhaps straighten them?
7. Would you prefer to avoid straightening because of the risks caused to the material?

The VSR process is the right answer for you and many other satisfied customers.
You can enjoy the benefit of low-cost technology, plus "ENERGY SAVING".

Stress-related problems are shown through:

- changes in longitudinal dimensions,
- misaligned holes,
- lack of circularity in machining,
- non-parallel or misaligned surfaces or edges,
- non-identical end surfaces,
- shafts and axes with unacceptable tolerances.

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METHOD OF STABILISATION THROUGH HOMOGENISATION OF RESIDUAL STRESS

If a periodic external force sets a metal structure under vibration at a defined amplitude and low frequency, the vibration is transmitted through the entire structure according to the law of mechanical oscillations. If the structure is isolated and there is no damping, the vibration will continue indefinitely even without energy input. The characteristic of metals to transform mechanical energy into heat, even with alternating stresses well below the theoretical macroscopic yield point, is due to internal friction or damping.

The exact elastic limit which in many cases lies well below the value we calculate is due to microplastic deformations under high elastic stresses. These plastic deformations lead to contractions at the yield point under fatigue load and this can only occur by giving rise to new dislocations. But at very low stresses such as those resulting from vibrations, damping is caused by thermal, magnetic or atomic processes. It is expressed by a certain phase angle between the applied stress and the resulting strain, as a decrease of the stress itself and thus relaxation.

During vibration, the damping does not depend on the amplitude of the oscillation but only on the dimensionless constant of the modulus of elasticity, the vibration frequency and the relaxation time. Consequently, the vibration can produce the desired action without damaging the material structure and without producing fatigue fractures or breaks, working at low amplitudes and low energy use until the resonance frequencies, as mentioned above, are determined. The reduction does not occur uniformly across the metal lattice but mainly where uneven stress situations are located. Thus, friction is generated at these points and a higher level of local energy is acquired, which allows one-way stress reduction, especially in those areas affected by dislocations or other 'crystalline' defects characterised by residual and anisotropic stress states. The energy expended in this homogenisation must be replaced by the energy supplied by the motor. Consequently, the current consumption of the motor can be a measure of the residual stress state. When a decrease in current utilisation is measured thereafter compared to the beginning of the vibration cycle, and when this absorption does not decrease any further, stabilisation has been achieved.

At this point, no further deformations can occur even if the workpiece is subjected to machining. Stress reduction through vibration is an operation which requires one single part-time worker, an advantage in line with cost-reduction, as well.

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VIBMATIC 6000 - Certificato del Trattamento / Stress relief report

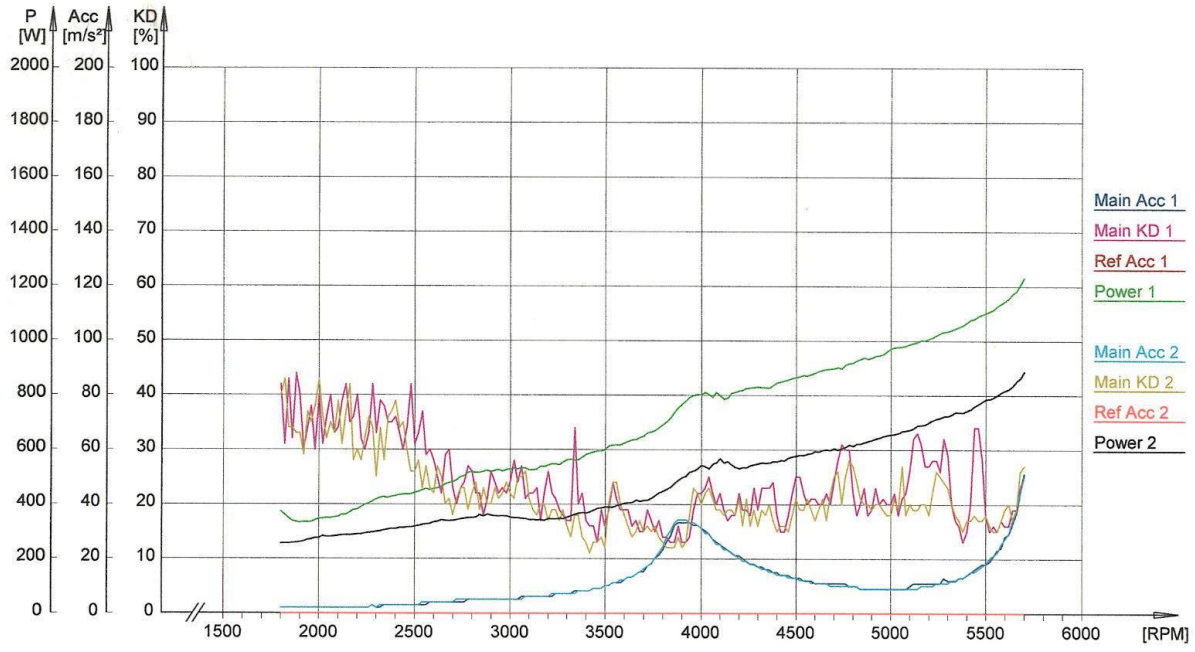
28.Feb.2007 11:00

Pezzo / Workpiece ID	
Numero di Serie / Serial Nr.	vsr 01/02-07
Disegno / Drawing	Collaudo
Descrizione / Description	Spalla dx
Materiale / Material	Fe430
Peso / Weight	700 kg
Eccentricita´ / Excentric	20 %
Trattamento / Processing	Auto / IP-5

Dati di lavoro / Working

Nr. di giri [UPM] Speed [RPM]	Durata [min] Working time [min]	KD Iniziale [%] Start KD [%]	KD Finale [%] End KD [%]
5140	17,17	33	19
4740	07,50	31	20
4040	04,83	25	23
3540	02,17	24	24
3340	01,83	34	18

Bearbeiter / Operator _____



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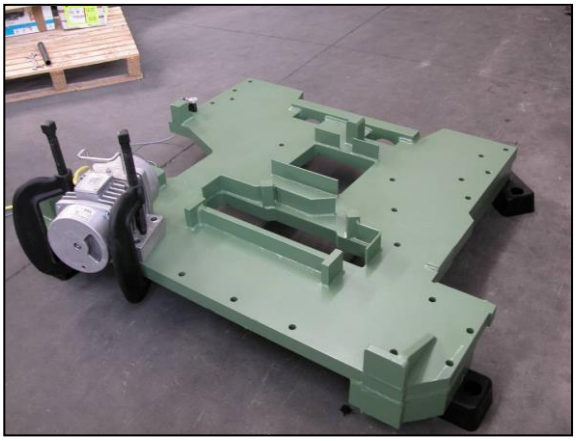

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