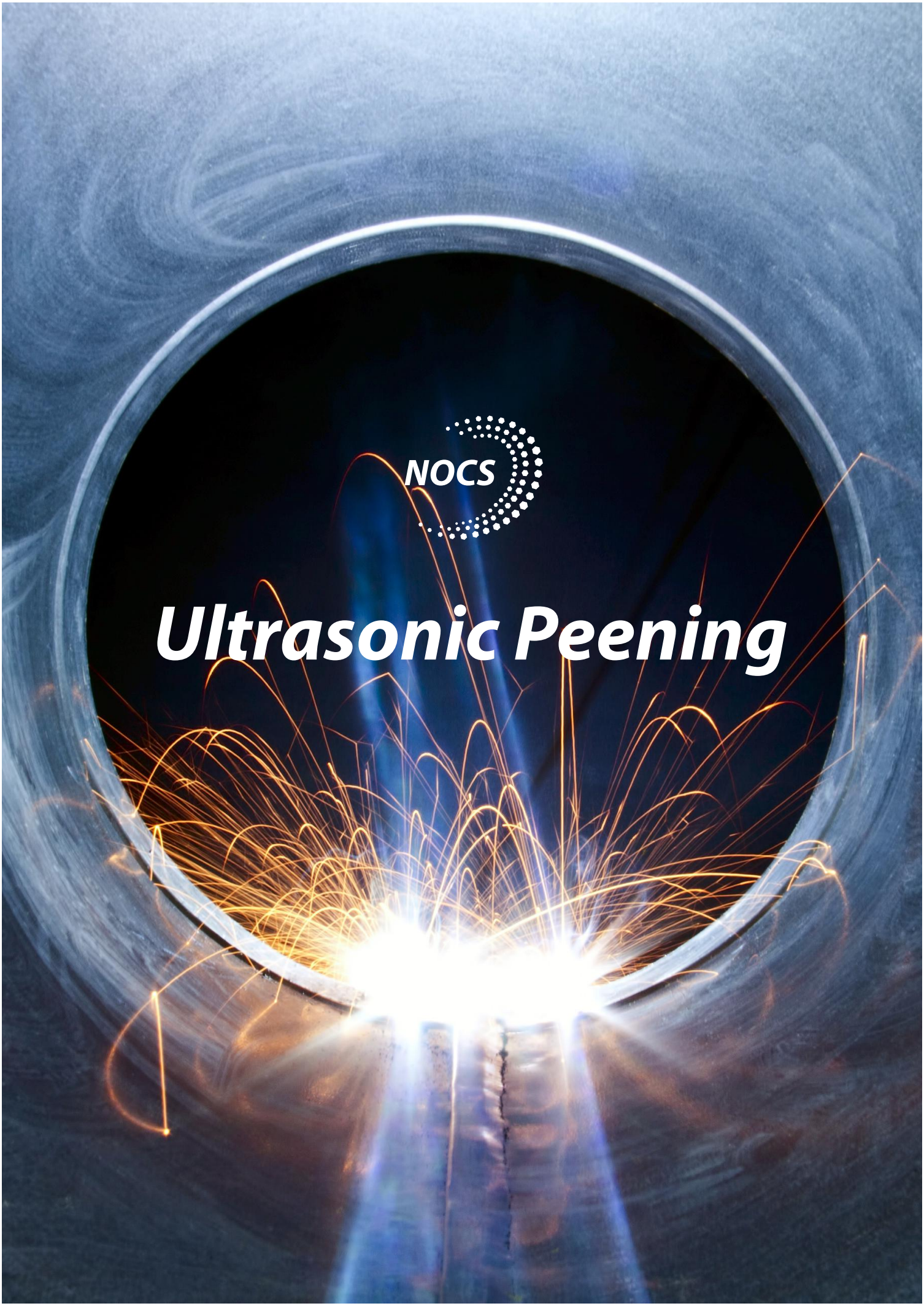
NOCS
Ultrasonic Peening

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Ultrasonic Peening Technology

NOCS, Norway

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Introduction

Many structural weldments – Ships , Offshore platforms , cranes , bridges , big reservoirs , big metallic constructions and machinery , antennas , and other structures are subject to the action of large number of cyclic loads during service. The development of fatigue fractures amounts to approximately 30% of the total premature failures in these structures.

The fatigue limit of butt welds in different strength classes of steel established by the criterion of fatigue crack initiation is reduced to 32% to 46% of the fatigue limit of corresponding parent metal with a rolled surface . Similarly , the fatigue limit of lap joints with longitudinal fillet welds under cyclic stress conditions constitutes only 20% to 40 % of the fatigue limit of the corresponding parent metal.

Advantages and Properties

Portable peening tool

- **NOCS peening tool has 2 times higher, initial oscillating amplitude of ultrasonic transducer, compared to any other peening tool produced worldwide (meaning hammering, penetration impact depth is very high and strong). Ultrasonic transducer is oversized (3kW) in order to resist heavy loading conditions.**

- **NOCS peening operating regime can be frequency-modulated what has advantages regarding faster and stronger stress relief (compared to competitors).**

- **NOCS peening tool is producing very strong pulsing or hammering (directly realizing plastic deformation), and reacts like single piston, high amplitude actuator. Peening tools from other sources react like double piston and low amlitude actuators. Single piston actuators have longer and stonger penetration of ultrasonic or mechanical pulsating energy, deeper excitation, what is better for stress relief.**

- **Operating life: almost unlimited. The tool is robust, compact and designed for industrial use, compared to competitors in the marked. Applicable in very long continuous operating regimes (it has forced air-cooling for very long and heavy duty operations).**

- **Can be applied with robotic arm.**

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Ultrasonic Peening (UP) Treatment Process

- It is a fatigue life improvement technique of welded structures by application of ultrasonic and mechanical impulses at the high stress locations in the weld. As a result of ultrasonic and mechanical impulses the welded metal is modified at the atomic- and/ or metallurgical- level.
- It introduces compressive residual stresses (up to 900Mpa at and near the surface), increases hardness, corrosion resistance and improve the quality of the surface.
- It increases hardness by 10% and improved surface quality by 60%.
- Reduces stress concentration associated with weld local geometry.
- Creates plastic deformation strain hardening in a surface layer (up to 0.7 mm in depth).
- It improves the fatigue life of the structure by approximately a factor of 10. This improvement is mainly because of reduction of tensile stresses, introduction of compressive stresses, increase in hardness and improvement of surface quality.
- Ultrasonic peening treatment can be applied to a wide range of metals including steel, cast-iron, aluminum, inconel, titanium, stainless steel and bronze.
- For cylindrical parts the UP treatment is also available due to possibility of rotation of the component. Hence UP device designed for robotic use can easily be adopted to lathes and milling machines.
- It is the most efficient and easy application technique on welded structures.

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Construction and HES Improvement

Concept

- Process that improve material property and relieving stresses from structural welds.

Opportunity

- Reduced time and man power.
- Increased hardness, corrision resistance and quality of any metallic surface.
- Safeguards HES regulations.
- No vibration damage to operator.

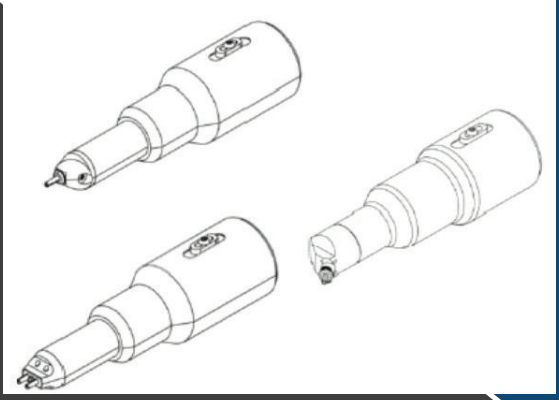
Potential

- Life improvement technique.
- Cost reduction.
- Product quality.

High Power Ultrasonics (UP)

They involve power levels of hundreds to thousands of watts, and the ultrasonic system operates in frequency ranges from 15 kHz to 100 kHz.

Typical amplitudes range from about 10 to 40 microns. Such ultrasonic system operating at 20 kHz creates a cyclic acceleration of around 50,000 g (g=9.8 m/s2). These high power Ultrasonics are very advantageous in ultrasonic peening of metals and welded elements. For the metal treatment special high strength material strikers are made of different shapes. Peening is the combined effects of high frequency impacts (more than 20 kHz) by the special strikers and the simultaneous exposure to ultrasonic oscillations of the treated material, producing unique beneficial effects in metals and welded components.



UP Head piece.

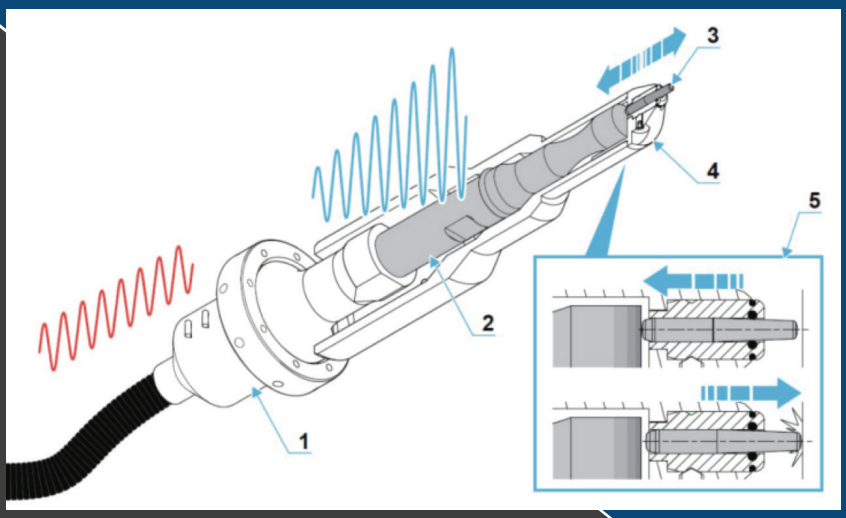
NOCS Ultrasonic Peening device.

Peening Head

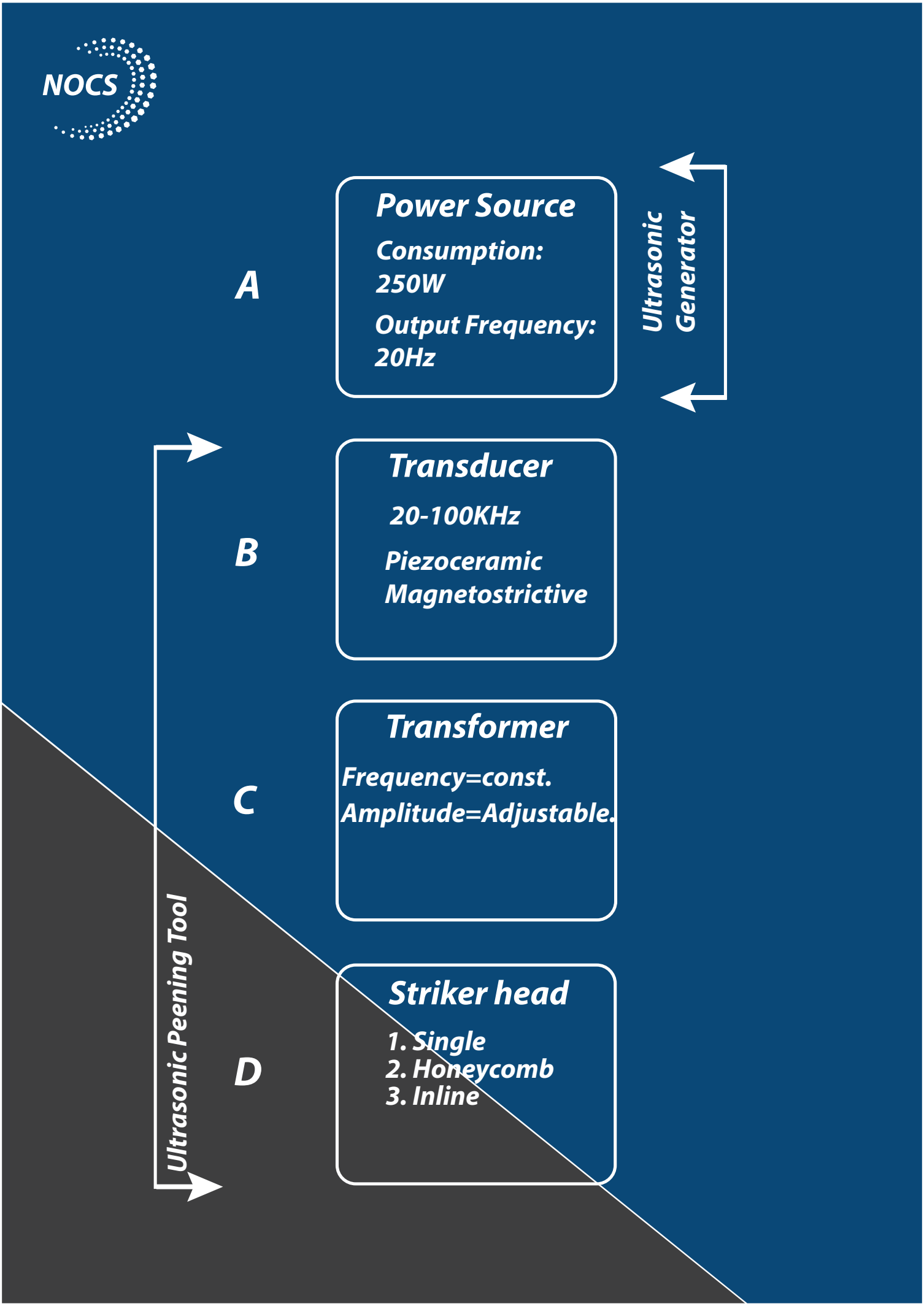
The ultrasonic vibration frequency of the sonotrode is the same as the converter but the impactor is uncoupled from the Sonotrode (therefore the impact frequency is lower than the ultrasonic frequency). By pressing the tool on the weld toe, the operator forces the needle to come in contact with the vibrating sonotrode, to nally strike the weld toe with a lower frequency than the vibration frequency of the sonotrode.

A smooth and complete continuity of groove should be produced by the operator on the weld toes. Thanks to the consistent peening impact frequency and amplitude, the equipment allows a much quicker process without harmful conditions for the operator. Low frequency pneumatic tools lack of control on impact frequency and amplitude, and induce harmful peening conditions which make it difficult for operator to achieve a bright and continuous groove. The following scheme presents the acoustic elements and the impactor location.

Acoustic elements inside the (UP) peening head



1. **Piezo-electrical converter**
2. **Sonotrode**
3. **Specific Impactor (Or Needle)**
4. **End piece (to guide the Impactor)**
5. **This little scheme illustrates the movement cycle of the impactor inside the end piece.**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A
Power Source
Consumption:
250W
Output Frequency:
20Hz
Ultrasonic
Generator
B
Transducer
20-100KHz
Piezoceramic
Magnetostrictive
C
Transformer
Frequency=const.
Amplitude=Adjustable.
D
Striker head
1. Single
2. Honeycomb
3. Inline
Ultrasonic Peening Tool

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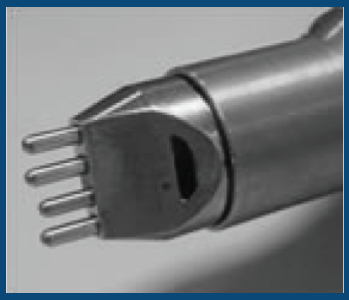
Single and multi-striker UP heads.

In order to achieve maximum and best possible transferring of the ultrasonic oscillation energy and simultaneously achieve the optimal and/ or desired surface deformation, e.g. shape, depth, etc, different shapes for multi-strikers are developed.

Single

Honeycomb



Inline

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Comparison of post weld treatment

Ultrasonic Peening is an advanced technology that modifies the physical and metallurgical properties of the treated component. While some fatigue life improvement techniques relies on the change of the geometrical shape of the weld toe (grinding, TIG dressing, etc), others relies on the introduction of compressive residual stresses (hammer peening, spot heating, etc).

The Ultrasonic Peening treatment achieves simultaneously the improvement of weld toe geometry and the deep introduction of beneficial compressive residual stresses, during the same work operation.

Technique and Result	Grinding	Shot Peening	Hammer/ Needle Peening	Thermal Stress Relief	TIG Dressing (GTAW)	Ultrasonic Peening
Increase Fatigue Resistance.	●	●	●	●	●	●
Increase Corrosion Resistance.		●				●
Increase Residual Deformation.			●	●		●
Increase Residual Weld Stress				●		●

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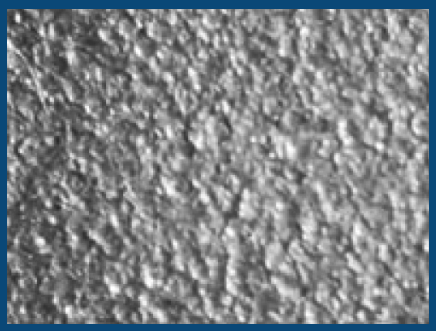
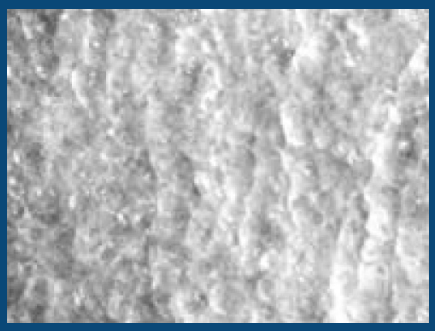
Surface Treatment



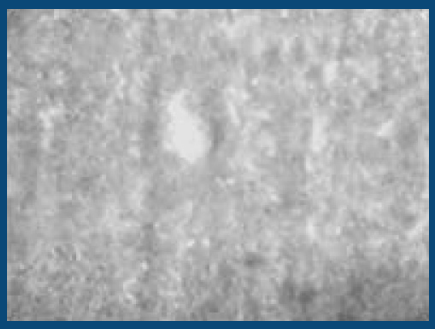
Orginal surface of spring steel "as received condition".

Magnification 8x



Surface of spring steel after treatment with the UP technique with "treatment A" conditions.

Magnification 8x



Surface of spring steel after treatment with the UP technique with "treatment B" conditions.

Magnification 8x

Surface Roughness Measurement Results:

Surface roughness of material measured "as received" condition.	Surface roughness of material measured after UP treatment for shorter time.	Surface roughness of material measured after UP treatment for longer
6.6 ± 2.1 Ra(μ)	4.4 ± 0.4 Ra(μ)	2.9 ± 0.3 Ra(μ)

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Comparison Of UP Process VS PWHT

Ultrasonic Peening Process

1. Reduction of tensile residual stresses. Introduction of compressive stresses.
2. Improves breetle facture resistance of welded joints.
3. Improves the toughness of weld metal and heat affected zone.
4. Useful for weld thickness up to 12 mm. For 40 mm thick weld the treatment could be applied after every weld pass.
5. Easy to apply due to the fact that UP equipment is small and/or versatile even for places of difficult access.
6. Shorter time required for treatment, less energy used during treatment.
7. Treatment can be applied locally or partially.
8. Environment friendly due to saving of energy, no using of gas or other combustible.
9. It increases hardness by 10% and improved surface quality by 60%.
10. UP treated services show reduced rate of near micro pitting fatigue process. This reduction of micro pitting is the main cause for the improved fatigue surface resistance.

Post Welded Heat Treatment(PWHT)

1. Reduction of tensile residual stresses. Introduction of compressive stresses.
2. Improves brittle facture resistance of welded joints.
3. Improves the toughness of weld metal and heat affected zone.
4. Useful for highly stressed nodal welds greater than 40 mm thick and other welds greater than 50 mm thick.
5. Difficult to apply on welded structures.
6. Longer time required for treatment, more energy used during treatment.
7. Difficult to apply locally or partially.
8. Not Eco friendly because if emission of gases.
9. The equipment is expensive.

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System specifications

Overall Dimensions
Dimensional size hand tool : 455x180x75mm
Dimensional sizes Ultrasonic Generator: 300x100x100mm
Needle diameter: 2.0 - 5.0mm

Weight
Manual tool weight(hand tool): 2.2kg
Ultrasonic Generator: 2.3kg

Power Requirements
Operation ultrasonic frequency: 20kHz
Watt consumption: 400-600W
Current: 7A

Ultrasonic generator
Output voltage: 600-1200V
Main supply voltage: 230V 50/60Hz
Operational frequency range: 17.5 -21 KHz (factory adjusted)

Other Parameters
Oscillation amplitude of sonotrode edge: 25-40mμ
Treatment speed manual mode: 0.3 - 0.7 m/min
Tool´s axial clamping force 20-40N

Cooling by compressed air.
Modular design concept.
Easy replaceble hammering pins.


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