RSRM Ultrasonics GmbH

High Power Ultrasonic Impact Treatment

A new innovative ultrasonic method

OVERVIEW

Ultrasonic Impact Treatment (UIT), Ultrasonic Impact Peening (UIP), Ultrasonic Hammer Peening, Ultrasonic Needle Peening (UNP), Ultrasonic Peening (UP), and High-Frequency Mechanical Impact (HFMI) processes can be used to describe the same technology using high power ultrasonic systems to make surface impact peening treatments.

Ultrasonic Impact Peening is a cold working process that uses high frequency and high-velocity impact of a hard metal tool tip to plastically deform a material in order to introduce beneficial compressive residual stresses. These residual compressive stresses are produced by work hardening with the intent to replace residual tensile stresses in metal surfaces and welded joints. In weld joints, one significant objective is to improve the fatigue strength of welds that may be subject to dynamic stress conditions and susceptible to stress cracking.

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.

Benefits of Ultrasonic Peening (UP, UIT, UIP, UNP, HFMI):

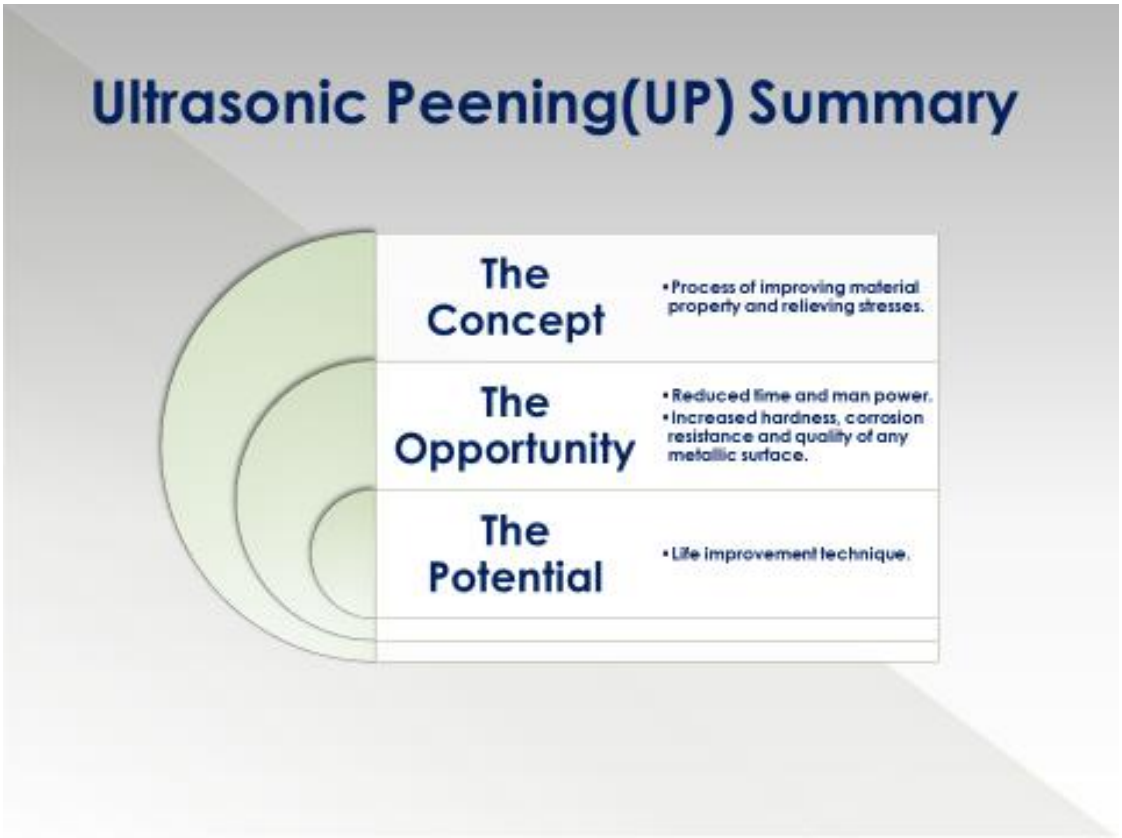
- life extension of critical a components and welded assemblies
- improves weld joints for extended life
- weld treatment speed is typically in the range of 30-60 cm/min (1 – 2 ft/min)
- recondition problem welds and weld repairs
- reduces fatigue fracture and failure
- prevents stress cracking and corrosion cracking
- improves metal characteristics and performance
- removes inconsistencies in metals
- life extension saves on downtime and replacement cost

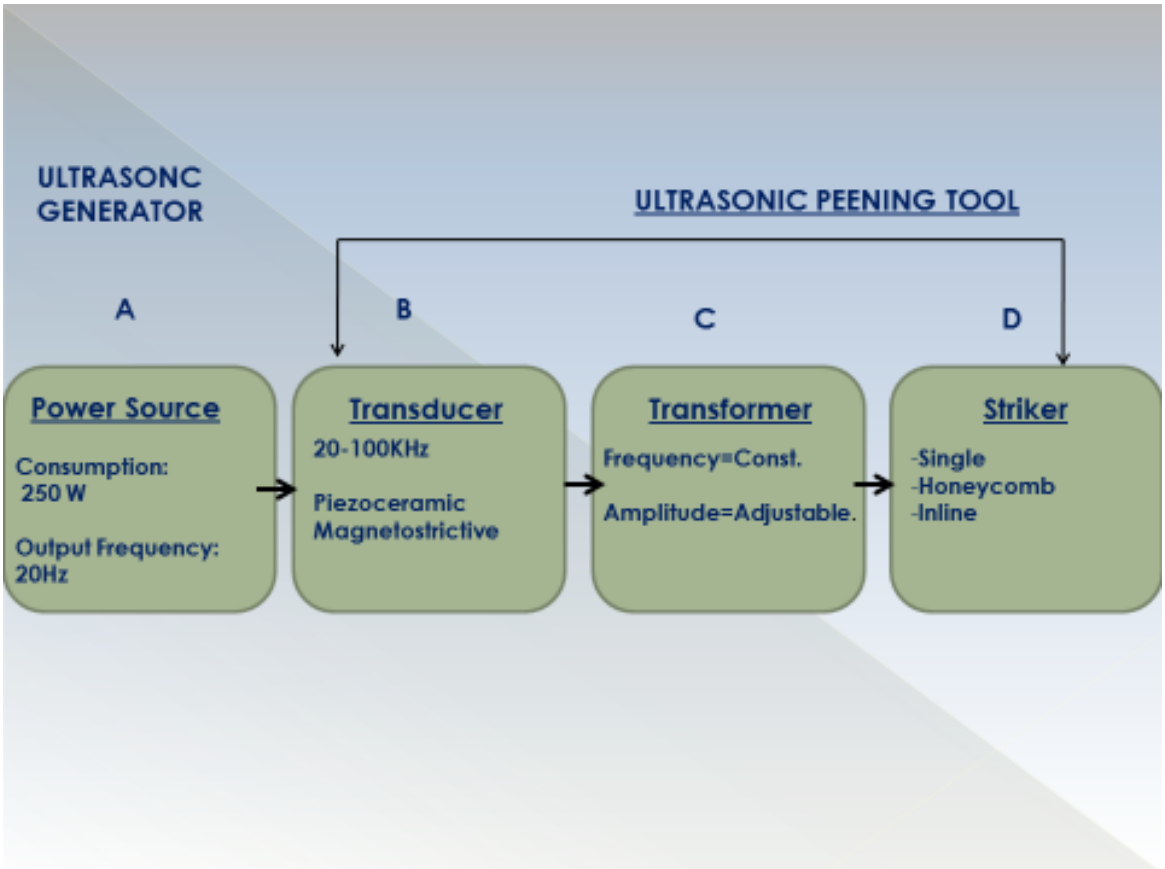
Why is Ultrasonic Impact Peening better than conventional Air Hammer Peening Tools?

- Ultrasonic Impact Peening requires only moderate pressure applied by the operator to the work piece and will provide a uniform treatment that is critical to the process finish. Air Peening Hammers require strong pressure applied to the base metal side in order to minimize deviations due to vibration.
- Conventional Air Hammer Peening is relatively slow and efficient work is not possible. Ultrasonic Impact Peening can be two to four times faster with significantly improved results.
- Because Ultrasonic Impact Peening tools produce significantly less vibration and noise the work environment is more comfortable and allows for extended work periods. Air Hammer Peening tools create significant noise and vibration to the operator hand and arm thereby limiting the daily working time.

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.

- 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 50%.
- 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 to apply technique on the welded structures.




ULTRASONC GENERATOR
ULTRASONIC PEENING TOOL
A
B
C
D
Power Source
Consumption: 250 W
Output Frequency: 20Hz
Transducer
20-100KHz
Piezoceramic Magnetostrictive
Transformer
Frequency=Const.
Amplitude=Adjustable.
Striker
-Single
-Honeycomb
-Inline


Single and multi-strikers working heads.
Single
Single
Inline
Honeycomb

The Ultrasonic Peening Device

The Ultrasonic Peening device (total weight - 5 Kg) includes,

1. The hand tool (with a piezoelectric transducer) is easy to use. It has a number of different working heads designed for several industrial applications. The weight of the hand tool is 2.2 kg.

2.The Ultrasonic Generator has a power consumption of 250 W and an output frequency of 20 Hz. The weight of the

generator is 2.3 kg.

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 / RESULT	GRINDING	SHOT PEENING	HAMMER/ NEEDLE PEENING	THERMAL STRESS RELIEF	TIG DRESSING (GTAW)	ULTRASONIC PEENING
Increase Fatigue Resistance.	*	*	*	*	*	*
Increase Corrosion Resistance.		*				*
Decrease Residual Deformation.			*	*		*
Decrease Residual Weld Stress.				*		*

Surface Treatment

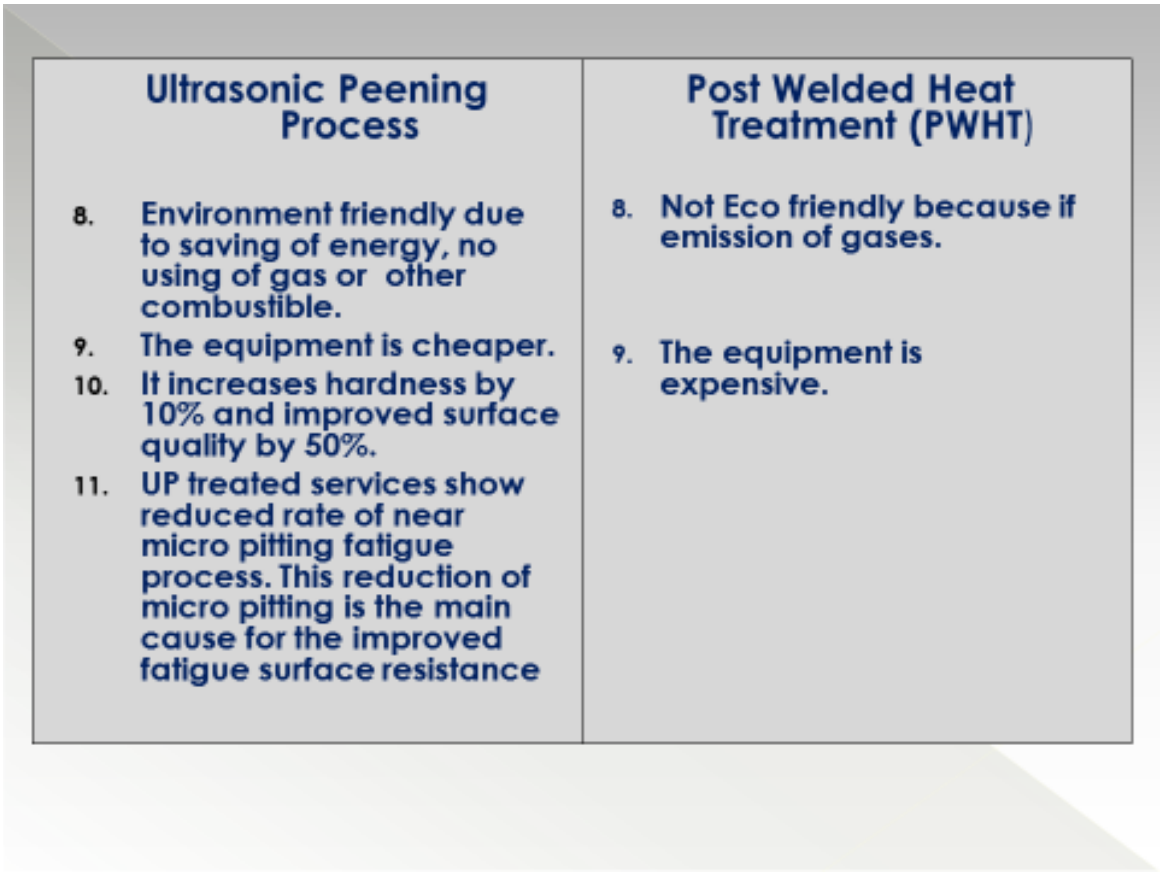
Original surface of spring steel "as received" condition. Magnification 8x.	Surface of spring steel after treatment with the UP technique with "treatment A" conditions. Magnification 8x.	Surface of spring steel after treatment with the UP technique with "treatment B" conditions. Magnification 8x.

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 time
6.6 ± 2.1 Ra(μ)	4.4 ± 0.4 Ra(μ)	2.9 ± 0.3 Ra(μ)

Comparison Of UP Process VS PWHT

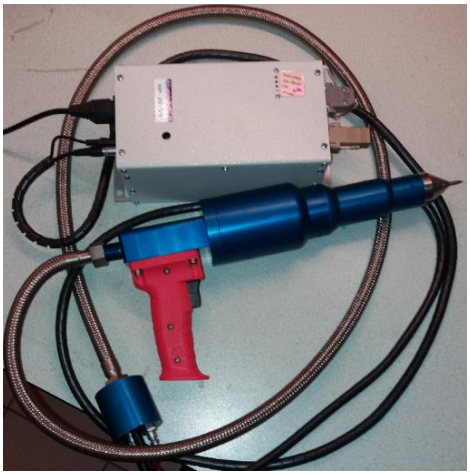
Ultrasonic Peening Process	Post Welded HeatTreatment (PWHT)
1. Reduction of tensile residual stresses. Introduction of compressive stresses.	1. Reduction of tensile residual stresses. Introduction of compressive stresses.
2. Improves breetle facture resistance of welded joints.	2. Improves brittle facture resistance of welded joints.
3. Improves the toughness of weld metal and heat affected zone.	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.	4. Useful for highly stressed nodal welds greater than 40 mm thick and other welds greater than 50 mm thick.
5. Easy to apply due to the fact that UP equipment is small and/ or versatile even for places of difficult access.	5. Difficult to apply on welded structures.
6. Shorter time required for treatment, less energy used during treatment.	6. Longer time required for treatment, more energy used during treatment.
7. Treatment can be applied locally or partially.	7. Difficult to apply locally or partially.



THE PRODUCT

THE ULTRASONIC IMPACT PEENING SYSTEM INCLUDES AN ULTRASONIC GENERATOR POWER SUPPLY CONNECTED BY A CABLE HOSE TO THE TOOL HOUSING THAT CONTAINS AN ULTRASONIC TRANSDUCER ASSEMBLY AND THE IMPACT PIN(S). THE TOOL-HOUSING TIP HOLDING THE IMPACT PIN(S) IS REPLACEABLE AND CAN BE DESIGNED IN A WIDE RANGE OF OPTIONS TO ALLOW FOR ONE OR MANY PINS IN VARIOUS ARRANGEMENTS TO ADDRESS MANY DIFFERENT APPLICATIONS. THE TOOL HOUSING CAN BE OPTIONED FOR HAND-HELD OPERATION OR MOUNTING TO A ROBOTIC ARM FOR AUTOMATED APPLICATIONS.

Our design team can provide custom pins and pin holders for most any application. We offer standard tool designs working at 20 kHz and 35 kHz. Other custom frequency system are available on demand.



Specification, advantages and properties:

1. MPI 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 can be very high and strong). It also has and stronger pulsing momentum (at least two times), than anybody else.

2. MPI's peening operating regime is frequency-modulated what has advantages regarding faster and stronger stress relief (compared to competitors).

3. MPI peening presents Single-piston peening concept based on the patent applications:

   a) European Patent Application: EP 1 060 798 A1. Unidirectional single piston ultrasonic transducer. Applicant: Prokic Miodrag, MP Interconsulting, 8.06.1999 – 20.12.2000
   b) European Patent Application (related to MMM technology): EP 1 238 715 A1
   Multifrequency ultrasonic structural actuator
   Applicant: Prokic Miodrag, MP Interconsulting, 5.03.2001 – 11.09.2002
   Single-piston agitation is penetrating much deeper than double-piston concepts of all other peening tools from competitors.

4. MPI Peening generator keeps frequency and power control during peening in heavy-duty conditions what is very difficult for standard ultrasonic generators.

5. Operating life: almost unlimited. Apparatus is very robust and almost indestructible, compared to competitors. Applicable in very long continuous operating regimes (it has forced air-cooling for very long and heavy duty operations).

6. Modular design concept, with easy replaceable hammering pins, and handy for manual operations.

7. Can be applied with robotic arm.
8. Rated watt consumption 400-600W.
9. Operation ultrasonic frequency 20 kHz (higher frequencies also available).
10. Bias current 7A.
11. Oscillation amplitude of wave guide edge 25-30 μm.
12. Treatment speed in manual mode 0,3 - 0,7 m/min.
13. Overall dimensions of manual tool 455x180x75 mm.
14. Manual tool's weight 3,5 kg
15. Tool's axial clamping force 20-40 N.
16. Cooling air input.
17. Single pin and multi-pin heads.
18. Needle diameter 2 to 5 mm

Ultrasonic generator spec.:

1. Output voltage 600-1200 V
2. Main supply voltage 230V 50/60 Hz
3. Operational frequency range 17.5 - 21 KHz

The power supply equipment is the heart of the UP system and is based on proprietary MMM Technology, which produces high efficiency active power in wide-band sonic and ultrasonic vibrations. The peening tool is enabled to produce proprietary "single-piston" peening action, and every other peening tool known from other sources (from competitors) is based on double-piston action. In essence, by utilizing the proprietary peening action, a much deeper metal penetration (up to factor 2) is achieved.

Our design team can provide custom pins and pin holders for almost any application. We offer standard tool designs working at 20 kHz and 35 kHz.

Enhance low and high cycle fatigue and has been documented to provide increases of up to ten times greater than non-treated ultrasonically peened.

4 Pin In-Line Tip

6 Pin Circular Tip

Ultrasonic peening treatment can:
Release harmful tensile residual stress,
Decrease stress concentration in a treated weld toe zone
Increase repair life from months to years
Prevent fatigue and fracture of welded joints
Make grain refinement and Grain size reduction
Enhance low and high cycle fatigue and has been documented to provide increases up to ten times greater than non-treated ultrasonically peened

PEENING PROCESSING PRACTICES (see the pictures below)

PROBLEMS, APPLICATIONS & SOLUTIONS

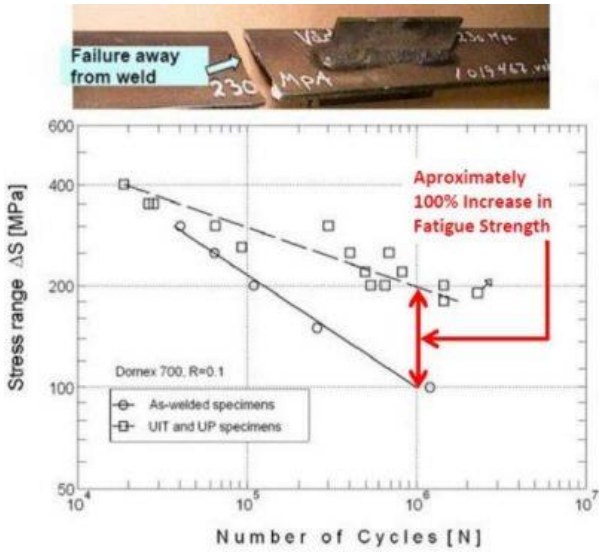
ULTRASONIC IMPACT PEENING (UIP, UIT, UP, UNP, HFMI) IS TYPICALLY A POST-WELD TREATMENT THAT USES A HIGH POWER ULTRASONIC HAMMER TO TREAT THE WELD AND IS MOST COMMONLY FOCUSED ALONG THE WELD TOE. THE MECHANISM IS SIMILAR TO HAMMER PEENING HOWEVER ULTRASONICALLY ACTIVATED PEENING TOOLS OFFER AN IMPROVED, MORE CONSISTENT, AND FASTER TREATMENT. WELD TOE TREATMENT SPEED IS TYPICALLY IN THE RANGE OF 30-60 CM/MIN (1 – 2 FT. /MIN).

Ultrasonic Impact Treatment of the weld toe, the transition area between the weld and base metal, produces a smoothed radius that reduces the local stress concentration. The depth of the radius should be in the range of 0.5 – 0.7 mm. Due to the deformations produced in Ultrasonic Peening shallow surface cracks in welds are easily repaired. When done properly the process offers significantly improved fatigue strength.

Example Applications:

- Weld Joint Treatment (see below ….)
- Offshore Oil FSO & FPSO Vessels and Drilling Rig – Life Extension (see below)
- Wind Turbine Tower – Life Extension (see below ….)

- Rail Structures – Weld Fatigue Strengthening – – Life Extension (see below ….)
- Ultrasonic Hammer Peening for Tool & Die Polishing and Hardening (see below)
- Abrasion Resistance, Corrosion Resistance, Fatigue Life Extension, Increased Hardness



Example: Floating Storage, Offloading (FSO & FPSO) Vessels, and Drilling Rigs:

Weld joints on offshore rigs are subject to constant stress and strain due to rough sea conditions. The same is true for Floating Production Storage and Offloading (FPSO) vessels that are additionally subjected to the stresses of the cyclical loading, especially in fatigue prone areas. As the rig and vessel welds approach the end of their known fatigue life our clients are faced with the challenge of repairing and maintaining failing weld joints. Normal repairs to these high stress joints are often temporary and not sufficient for long term operation. By using our Ultrasonic Peening technology to dress repaired welds and also treat undamaged welds in high stress areas our clients can reset the fatigue life and add up to fifteen years of additional service life.

THE SOLUTION

Ultrasonic peening can be the best option for fatigue life improvement of FSO & FPSO welds in high stress areas. The Ultrasonic peening technique involves the cold working of the weld toe and weld face and can improve the fatigue strength of full penetration weld configurations by up to four times.

Welds identified at particular points of structural integrity are targeted for Ultrasonic Peening treatment. The fatigue life extension of those specific welds will offer a general life extension of the offshore structure or vessel. This type of treatment is currently used to avoid or prevent fatigue cracks in high stressed weld connections in offshore structures.

If required our service partners can be contracted to perform this type of ultrasonic peening treatment in almost any offshore environment, confined or not, with or without rope access.

Fatigue Life Extension

Running at 100% production capacity for months at a time takes a massive toll on equipment and components in this demanding industry that has little tolerance for downtime. Our ultrasonic peening will combat downtime by offering a portable solution

that improves problem areas, extends weld life and increases corrosion resistance in an easy to use, cost effective package.

Extended Life

Today's mature assets, heavy equipment, and infrastructure are expected to perform at a higher level for longer periods of time. Fatigue life is constantly pushed to the limit, and design breakthroughs in materials and processes drive this demand even higher. Service life extension of these assets is more critical than ever. UIT offers a way to extend the life of structures and components whether utilized in situ, or in the design phase.

Ultrasonic Peening is used to avoid fatigue cracking

Ultrasonic Peening treatment can often be used in any accessible area where relatively high stresses are present. The ultrasonic peening treatment will significantly help prevent fatigue cracks during the remaining service life of the installation. The treatment is so effective that it could extend the service life of any full penetration weld configuration by at least four times.

Treatment can, for example, be carried out as a preventative or maintenance measure during a scheduled tank inspection thereby providing an easy way to avoid the onset of fatigue cracks in areas with difficult access such as inside cargo tanks. As the treatment targets only areas of high risk for fatigue cracks to develop it is relative quick work and can be done in approximately the same time as it takes the inspection work to be finished. Our ultrasonic peening technology gives offshore operators a pro-active solution for fatigue related structural integrity challenges. By using ultrasonic peening the rig manager or the structural integrity engineer will be able to eliminate frequent shutdowns for structural repairs.

Ultrasonic Peening saves time and money

Preventative treatment or proper post weld repair treatment will protect future uptime and result in significant time and money savings.

Wind Turbine Towers

Both land based and offshore wind turbine towers are subject to cyclical loading caused by gusting winds and rotor vibrations. Floating offshore towers are additional subject to sea waves. These conditions create high stress conditions for tower structure welds that require special consideration and solutions to enhance weld joint fatigue strength.

While some conventional solutions offer a bit of added fatigue strength none offer the proven and superior results achieved by Ultrasonic Impact Peening. UIP offers rapid and efficient weld toe reshaping that seals surface cracks, makes metal gain refinement, improves residual stress and gives significant fatigue strength improvement.

By targeting weld joints in high stress areas, Ultrasonic Impact Peening can double the fatigue strength offering significant life extension of tower structures.

Railway Structures – Weld Fatigue Strengthening

Railway structures, as with all welded structures, are designed with a limited life span that is highly dependent on the fatigue strength of welds that are subject to dynamic stress conditions. In many cases, that life span may be significantly reduced because the original structure designs were based on short-sighted requirements that underestimated the number of train rail cars used and the frequency of use. Due to normal aging and the added stresses compounded by the added train weight and frequency of use many railway structures have prematurely reached or are approaching their end of life.

Ultrasonic Impact Peening is known solution for life extension of welded structures. It can stop crack propagation from the weld toe and slow propagation from the root as it passes through the treated toe zone. A railway structure may be inspected for cracking and treated by UIP while under live load conditions. Identified critical weld areas may be treated with UIP as a preventative measure to reset and make life extension of the welds.

UIP offers significant cost savings over other conventional solutions by eliminating the cost of added materials and providing a rapid treatment solution.

UIP will significantly improve the performance of welds and extend the fatigue life.

Ultrasonic Hammer Peening for Tool & Die Polishing and Hardening

Ultrasonic Impact Peening may be adapted for use in tool & die polishing and surface hardening.

UIP provides plastic deformation via the tool tip repetitive impacts and can offer many beneficial effects on the surface layers of various metallic materials. Effects include changes to the surface nanocrystalline structure, surface compressive residual stresses, work hardening of the surface, and surface deformation smoothing.

From crankshafts and brake rotors to structural weldments, ultrasonic peening offers solutions that have never been available before to the Transportation industry. Enabling improvements in design to reduce weight and fuel consumption.

Abrasion Resistance

Components in the military and aviation are challenged every day by some of the most extreme, demanding and severe environments in the world. Since lives depend on the reliability of these components, maintaining peak performance is a top priority. Frequently, equipment maintenance must be performed away from home and under less than ideal conditions. Our Ultrasonic peening provides a portable solution to impart compressive stresses in damaged components, increase the life of fatigue-limited components, increase material hardness and inhibit corrosion.

Corrosion Resistance

Ultrasonic peening has been shown to extend the life of bridges and other structures by a number of decades. UIT offers a portable solution that is fast, easy to use and has been added to the codes that govern bridge maintenance.

Distortion Mitigation

From decreasing downtime by tripling the life of a drive shaft to reducing costs by alleviating repetitive weld repairs, UIT brings measurable value to the manufacturing environment.

Decreased Downtime

Any measure that can decrease downtime is a valuable investment for companies and industries that acutely understand that time is money.

Improved Reliability

Having the confidence that your equipment will perform when called upon is priceless. UIT increases this confidence level by improving on weak points.

Reduced Cost

UIT provides cost reductions through a number of different approaches, such as use of a less expensive material, reduced weight or by avoiding major maintenance dollars through increased reliability.

PEENING EFFECTS AND BENEFITS

- Machine parts and die to a semi-finished tolerance
- High quality stamping dies without complex and expensive manual polishing
- Polish and harden tool & die in one operation
- Minimize lubricants to remove stamped parts

MPI design team can adapt our technology to your robotic application and design tips to your requirements. We can offer custom tip shapes, modify the impact force, and provide a range of multi-pin tips.

OFFSHORE DRILLING RIGs and welds are exposed to continuous beating and an enormous stress. Ultrasonic peening will extend fatigue life of aging offshore drilling rigs, resetting fatigue life to zero and allowing twenty additional years of profitable operating service life.

AGING OFFSHORE INFRASTRUCTRES are gradually reaching the end of their operating lives. Users are interested in extending the operational lives of mentioned structures. Ageing is the most interesting situation regarding offshore infrastructures, since it should maintain its structural integrity by extending the fatigue life, what is possible by applying ultrasonic peening.

- REFURBISH OLD MATERIALS AND PREVIOUS REPAIRS
- PREVENT CRACKING FROM FATIGUE AND STRESS
- IMPROVE FATIGUE LIFE OF WELDED JOINTS AND STRUCTURES
- INCREASE RETURN ON INVESTMENT IN AGING ASSETS
- REDUCE REPLACEMENT OR REDESIGN COSTS
- INCREASE SAFETY WITH IMPROVED STRUCTURAL INTEGRITY