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Ultrasonic Peening of Parts and Welded Elements

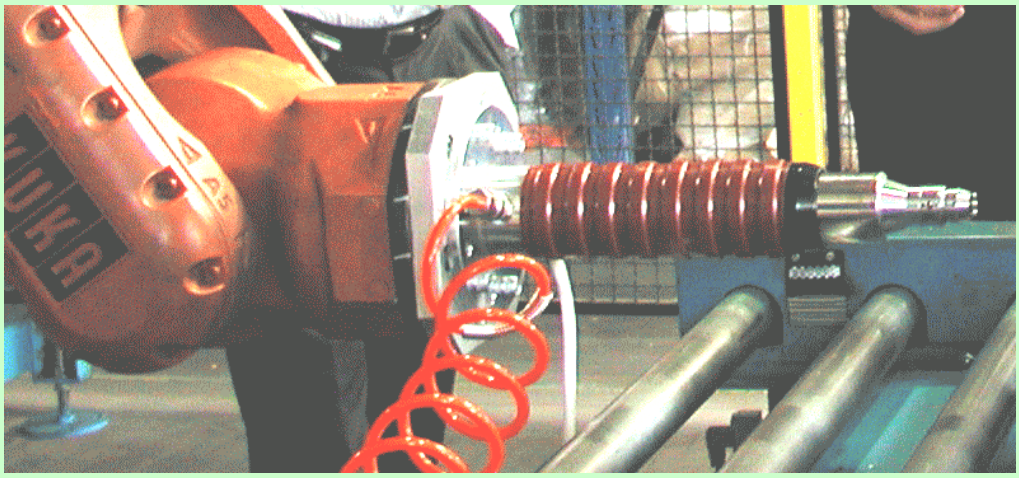
Intense levels of high frequency acoustic energy or high power ultrasonic (HPU) have found practical use in many industrial processes, of which cleaning, welding and drilling are well-known examples. In most industrial applications, high power ultrasonic involves power levels of hundreds to thousands of watts, and ultrasonic systems are operating in the frequency ranges from 15 kHz to 100 kHz. Typical amplitudes range from about 10 to 40 microns. Such ultrasonic system operating at 20 kHz is creating a cyclic acceleration of around 40,000 g (acceleration of gravity).

One of the promising directions in using of the HPU for industrial applications is the Ultrasonic Peening (UP) of materials, parts and welded elements. The UP produces a number of beneficial effects in metals and alloys. Foremost among these is increasing the resistance of materials to surface-related failures, such as fatigue, fretting fatigue and stress corrosion cracking. During the different stages of its development the UP process was also known as ultrasonic treatment (UT), ultrasonic impact technique/technology/treatment (UIT), ultrasonic impact peening (UIP).

Use of basic UP system for fatigue life improvement of tubular welded joint

The UP technique is based on the combined effect of high frequency impacts of special strikers and ultrasonic oscillations in treated material. The developed system for UP treatment includes an ultrasonic transducer, generator and a laptop (optional item) with software for UP optimum application - maximum possible increase in fatigue life of parts and welded elements with minimum cost, labor and power consumption.

The beneficial effect of UP is achieved mainly by relieving of harmful tensile residual stresses and introducing compressive residual stresses into surface layers of metals and alloys, decreasing of stress concentration in weld toe zones and enhancement of mechanical properties of the surface layers of the material. The UP treatment is the most efficient technique for increasing the fatigue life of welded elements as compared to such existing improvement treatments as grinding, TIG-dressing, shot peening, hammer peening, etc.



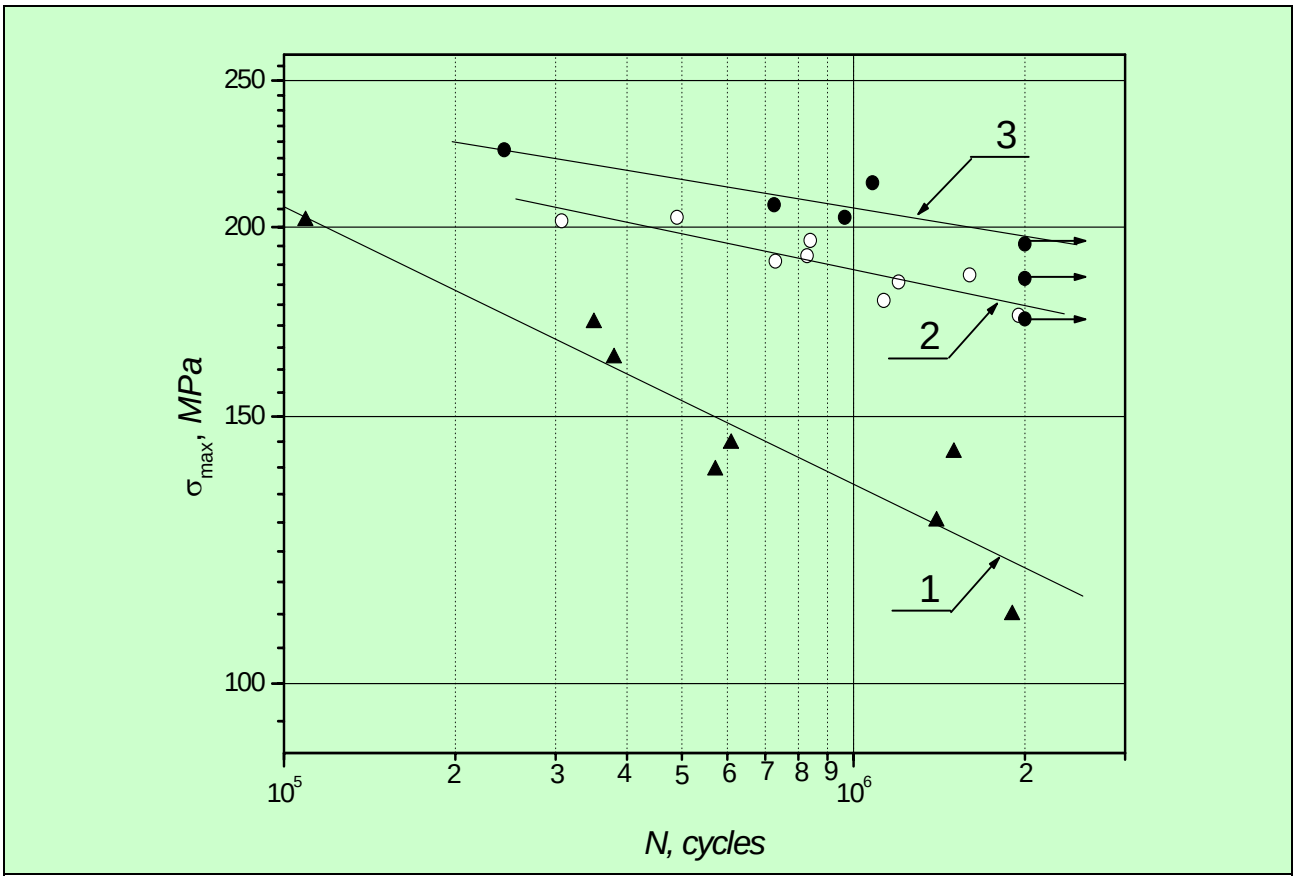
UP system installed on a robot for automotive application

The UP technology is considered as a leading technology in the application of HPU for fatigue life improvement of parts and welded elements because of the following factors:

1. The UP technology is based on more than 30 years of extensive experience and knowledge of an international group of experts in application of HPU for improvement of quality and service life of parts and welded elements. The first publications of the group on relieving of residual stresses in welded elements by UP are dated back to 1974.

2. The design of the UP equipment is based on "Power on Demand" concept. The power and other parameters of UP equipment correspond to the necessary changes in residual stresses, stress concentration and mechanical properties of the surface layers of materials to attain maximum possible increase in fatigue life of welded elements. The basic UP system covers most of the applications in fatigue improvement with the power consumption of 300-500 watts. More powerful UP systems are also designed and produced on request.

3. The effects of different improvement treatments, including the UP treatment, on the fatigue life of welded elements depend on the mechanical properties of used material, the type of welded joints, parameters of cyclic loading and other factors. For effective application of the UP, depending on the abovementioned factors, a software package for Optimum Application of Ultrasonic Peening was developed that is based on an original predictive model. In the optimum application, a maximum possible increase in fatigue life of welded elements with minimum time-, labor- and power-consumption is thought.



Fatigue curves of large-scale welded samples (transverse non-load-carrying attachment, R=0):
1 – in as welded condition, 2 – UP was applied before fatigue testing,
3 – UP was applied after fatigue loading with the number of cycles corresponding to 50% of expected fatigue life of samples in as-welded condition

One of the examples of effective application of UP is the fatigue life improvement of welded elements of highway and railway bridges. It was shown that UP treatment of about 100 mm of a weld in the end zones of the welded stiffeners leads to a significant increase of the fatigue life of the considered welded element and could eliminate the fatigue crack origination. During the rehabilitation of a highway bridge over Ohio River the total length of UP treated welds was about 500 meters and more than two thousands welded elements that are critical from fatigue point of view were UP treated.

The developed computerized complex for UP was successfully applied in different applications for increasing of the fatigue life of welded elements, elimination of distortions caused by welding and other technological processes, residual stress relieving, increasing of the hardness of the

Ultrasonic Peening of welded elements of a highway bridge

surface of materials and surface nanocrystallization. The areas/industries where the UP was applied successfully include: Railway and Highway Bridges, Mining, Construction Equipment, Shipbuilding, Automotive and Aerospace.

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