Fatigue Life Improvement of Welded Structures By Ultrasonic Needle Peening

Abstract
Conventional Hammer Peening is a well-known post-weld treatment for fatigue life improvement. This method is applied to the weld toe only.

Ultrasonic Needle Peening (UNP) (also called Ultrasonic Impact Treatment (UIT) or High Frequency Mechanical Impact (HFMI)) is a process achieving the same effect, but with much process control compared to conventional needle peening. UNP is also faster and far less harmful for the operator. Moreover UNP process can be used by any operator after only one day of training. For these reasons many industries have shown a strong interest for this innovative technology.

This document describes SONATS research, in-field experiences and knowledge about Ultrasonic Needle Peening. It is dedicated to any people (engineers, welders, operators, controllers) who are interested in this process.

NOTE: Many designations are used to describe the process which consists in using high frequency mechanical vibrations to put in movement impactors or needles to throw against the metal surface area to be treated:
- UIT for Ultrasonic Impact Treatment,
- UNP for Ultrasonic Needle Peening,
- UP for Ultrasonic Peening,
- or HFMI for High Frequency Mechanical Impact treatment).

In this document we will, most of time, use “Ultrasonic Needle Peening” or “UNP”.

2. UNP Effects
According to P. J. Haagensen and S. J. Maddox, “The weld toe is a primary source of fatigue cracking because of the severity of the stress concentration it produces”. For this reason, the weld toe can be considered as a “notch”.

Hammer Peening or Needle Peening is an ancestral process, which consisted in striking manually a weld by the means of a hammer, to improve its surface finish and resistance. Later, pneumatic and magnetostrictive tools have been developed to help the operator. Nowadays, the principle is still the same but the equipment design has been improved. The latest technologies are using piezo effect for electrical to mechanical vibration. The vibrating element, named Sonotrode, is then use to provide the kinetic energy to a needle (or impactor). Thanks to those modern tools, the influence of the operator on the process application is close to zero, with little efforts and high treatment speed.

Research about UNP started in the late fifties and sixties in the USSR. Extensive research have been carried out later in the nineties, on structural steels, high strength steel and aluminum, showing each time a high level of improvement in term of fatigue life. In 1996, the International Institute of Welding published a specification and in 1999 the first “Guide for application of UIT”.

On this basis, many industries started to pay attention to this effective and user-friendly post-weld improvement techniques. The weld toe improvement methods rely on two main principles:
- Weld toe geometry modification
- Residual Stresses Modification

Ultrasonic Needle Peening acts on both phenomenon to finally achieve high level fatigue life improvement of the treated welded detail.