CAVITATION EROSION OF ULTRASONIC PROBES

Sonics & Materials, Inc., www.sonics.com

Ultrasonic probes, sometimes referred to as horns, are one half-wavelength long tools that act as mechanical transformers to increase the amplitude of vibration generated by the converter. They are fabricated from high grade titanium alloy Ti-6Al-4V because of its high tensile strength, good acoustical properties at ultrasonic frequencies, high resistance to corrosion, low toxicity and excellent resistance to cavitation erosion.

The longitudinal vibrations generated by the converter are amplified by the probe and transmitted into the liquid as ultrasonic waves, consisting of alternate expansions and compressions. The pressure fluctuations give birth to microscopic bubbles (cavities), which expand during the low pressure phase and implode violently during the high pressure phase. As the bubbles collapse, millions of shock waves, micro streams, eddies and extremes in pressure and temperatures are generated at the implosion sites. Although this phenomenon, known as cavitation lasts but a few microseconds and the amount of energy released by each individual bubble is minimal, the cumulative amount of energy generated is of such high magnitude that no known solid material is able to resist its destructive effects.

The level of cavitation within a liquid is very much dependent on the surface tension of that liquid and the higher the surface tension the more intense the cavitation. Although water is often chosen as the liquid of choice because it is a great medium for sonic dispersion, consideration should be given to the fact that an ultrasonic probe will typically erode 5 times faster in water than in organic solvents.

PROBE PERFORMANCE DEGRADES IN PROPORTION TO THE DEGREE OF ROUGHNESS OF THE TIP SURFACE, UNTIL A POINT IS REACHED WHERE THE LEVEL OF ENERGY TRANSMITTED INTO THE LIQUID IS SIGNIFICANTLY LESSENED. Polishing the tip with abrasive paper or cloth will extend the life of a lightly eroded tip. A severely eroded tip may be given to a machinist with the explicit instruction to remove ONLY the contaminated area. An ultrasonic probe is a finely tuned tool, much like a musical tuning fork. The removal of too much material from the end of the probe will shorten its length, change its resonant frequency and cause the ultrasonic generator to go into an overload condition or fail. For that reason the machining procedure can ONLY BE PERFORMED ONCE. Following this procedure, the probe should be checked, as outlined below, to ensure that it is still vibrating within the acceptable frequency range.

NOTE

Although resurfacing will extend the life of an eroded probe and improve its performance, a resurfaced probe will not perform as effectively as a new one. It is therefore recommended that for critical applications, a probe be replaced with a new one for optimum performance.

To check the probes for resonance, set the amplitude on the power supply to 100% (to 40% with microtip) and observe the display. With the probe in air (out of the liquid) the wattage reading should be less than 15 watts (less than 5 watts with a microtip). If higher readings are obtained, the probe (microtip) should be changed.

In order to address the destructive effects of cavitational erosion, a great number of coatings have been experimentally applied to ultrasonic probes. Unfortunately, it was determined that they too were subject to cavitation erosion and they did not appreciably extend the life of the probe.