**Fundamentals of Ultrasonic Cleaning Technology2004 1/4 2012/9/18**

**China's Explosively Developing Ultrasonic Cleaning Machine Market More than 2,000 ultrasonic cleaning machine manufacturers with a market size of more than 65 billion yen, and many of them have more than 1,000 employees. May 10, 2012**

**Introduction.**

Here, I would like to discuss the latest ultrasonic cleaning technology.
 But first, I would like to clarify my position on cleaning technology and environmental issues.
 One of the biggest challenges facing mankind in the 21st century is the global environmental problem.
 China, which has the largest population on earth and is now developing as the world's manufacturing factory, has an environmental problem, which in turn is an environmental problem for the earth.
 Cleaning technology is also a technology to consolidate and transfer various environmental burdens, i.e., materials to be removed that have been created by the survival and activities of mankind.
 Therefore, cleaning technology, which is indispensable for China's industrial development, must also actively contribute to the preservation of the global environment.
 The cleaning technology required in China today must be a comprehensive technology that helps preserve the environment and foster industry based on the above perspectives.

We must not forget the historical lessons of the CFC.

［China does not need the same cleaning technology used in the developed world.]

Among these, I am convinced that ultrasonic cleaning technology, if used correctly and efficiently, can contribute to China's economic development and help protect the global environment [a technology that is still in its infancy].

**What is ultrasonic cleaning?**

This is due to a misunderstanding of its basic understanding. Ultrasonic cleaning systems have made rapid progress in accordance with advances in peripheral technologies and user demands. transport technology, instrumentation technology, and sheet metal welding technology.

However, there has been no significant change in the basic content of ultrasonic cleaning technology, with only a few exceptions. Even if the appearance and transport technology change, ultrasonic cleaning technology will not be able to meet the demands of the times unless there is fundamental innovation in ultrasonic cleaning technology.

In order to fully utilize the innovative ultrasonic cleaning technology for the new era, it is first necessary to have a deep understanding of what ultrasonic cleaning is, why it removes dirt and why it does not, and to dispel misconceptions about its principles.

Ultrasonic cleaning is a cleaning method that emits powerful ultrasonic waves into a liquid and uses the impact force generated when cavities are created and extinguished. If cavities are not generated, it cannot be called ultrasonic cleaning. Therefore, the basic requirement for understanding and effectively using ultrasonic cleaning is to correctly understand cavities and the phenomena of cavity generation and annihilation (cavitations). A powerful sound wave of 20 KHz or higher, i.e., ultrasonic waves, is irradiated into the liquid. When sound pressure changes above a certain level in the liquid, so-called cavities are generated.

Cavities are composed of a large number of vacuum nuclei (microcavities), the overall size of which varies depending on the frequency and the magnitude of the sound pressure change, but at a practical level it ranges from about 100 microns to a few dozen millimeters.

They come in a variety of shapes and can be roughly classified into gas nebula type [Photo 1] and globular nebula type [Photo 2]. In order to distinguish cavities from cavities generated by sound pressure changes other than ultrasound, I call them cavities (microvacuum nuclei).

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| ガス星雲 Gas Nebula [Photo 1 | 球状星雲型 Globular nebula type [Photo 2 |

Cavities (groups of micro vacuum nuclei) are repeatedly generated and annihilated as follows.

At 25 KHz, let me explain.

1. **［Generation process] Positive shock wave**

During the initial sound pressure reduction process (1/200,000 of a second), numerous microvacuum nuclei are generated in the cavity generating region. The microvacuum nuclei continue to coalesce and grow until they reach their maximum at three to four hundred thousandths of a second, and become a mass of a dozen or more microvacuum nuclei that are attached to each other like clusters of grown grapes.
 This process is a high-speed ejection of liquid from the cavity region, and if the cavity is 6 mm in outer diameter, the liquid moves about 200 m/sec outside the maximum cavity, or a shock wave is generated.
 This is called a positive shock wave. The size of the shock wave is determined by the size (shape) of the cavity and the speed of liquid movement.
 The liquid (space) confined between the microvacuum nuclei is subjected to high pressure. This process is responsible for one part of the cleaning power of ultrasonic cleaning. However, if the pressure wave is merely in one direction, dirt may be trapped in some cases. The next step in ultrasonic cleaning is the pressurization process.

1. **［Extinction process] Negative shock wave**

During the depressurization process, the growing microvacuum nuclei shrink without changing their position from the cavity center. After approximately 200,000/6 seconds, the microvacuum nuclei are annihilated.
 To be precise, the annihilation time is faster than the time from the generation to the growth maximum.
 In contrast to the generation process, a high-speed movement of liquid toward the center of the cavity occurs.
 Observations have measured a speed of about 220 m/sec. The liquid between the microvacuum nuclei is depressurized, expanded, and then subjected to the shock wave and turbulent concentration of the liquid at high velocity and high pressure during a period of 200,000ths of a second or two. In this process, the shock wave directed toward the center of the cavity is called a negative shock wave.
 This is the source of the cleaning power and a characteristic of ultrasonic cleaning.

1. **［Cavity migration] Cleaning and diffusion**

The biggest misconception in ultrasonic cleaning technology is the illusion that the visible bubbles, which are generated when ultrasonic waves are applied to a liquid, are cavities (groups of microvacuum nuclei) generated by the ultrasonic waves described above.
 Most cleaning solvents other than water contain large amounts of air. Alcohols, chlorinated solvents, hydrocarbon solvents, and all other solvents that can be and are used for cleaning have an oxygen dissolution rate of 20 mg/ℓ or more.
 When irradiated with powerful ultrasonic waves, the pressure change causes the dissolved air to deflate and form bubbles that burst at the surface of the rising liquid! It does not disappear or shrink in the liquid. This is called ultrasonic gas aeration.
 The air that has escaped from the liquid is re-dissolved from the liquid surface, and the bubble generation phenomenon by ultrasonic waves (ultrasonic bubbling or ultrasonic gas aeration) persists. The good news is that the tiny air bubbles generated by the ultrasonic bubbling are generated from the ultrasonic vibration surface and serve to effectively block and absorb the ultrasonic waves.
 It does not generate the cavities that should be generated by ultrasound.
 Without countermeasures for these bubbles, it would be squeamish to compete with ultrasonic oscillators in terms of frequency and oscillation method.

1. **The biggest misconception in ultrasonic cleaning**

The biggest misconception in ultrasonic cleaning technology is the illusion that the visible bubbles that are generated when ultrasonic waves are applied to a liquid are cavities (microvacuum nuclei) generated by the ultrasonic waves described above.
 Most cleaning solvents other than water contain large amounts of air. Alcohols, chlorinated solvents, hydrocarbon solvents, and all other solvents that can be and are used for cleaning have an oxygen dissolution rate of 20 mg/ℓ or more.
 When the air is irradiated with powerful ultrasonic waves, the pressure change causes the dissolved air to deflate, form bubbles, rise to the surface, and burst at the surface of the liquid! The bubbles do not disappear or shrink in the liquid. This is called ultrasonic gas aeration.
 The air that has escaped from the liquid is re-dissolved from the liquid surface, and the bubble generation phenomenon by ultrasonic waves, ultrasonic bubbling (or ultrasonic gas aeration), persists. The good news is that the tiny bubbles of air that are generated at this time originate from the vibrating surface of the ultrasound and serve to effectively block and absorb the ultrasound waves.
 They do not generate the cavities that would otherwise be generated by ultrasound.
 It is absurd to compete with ultrasonic oscillators in terms of frequency and oscillation method without taking countermeasures against these bubbles.

 In non-water ultrasonic cleaners without measures to reduce dissolved air, more than 99% of the ultrasonic energy is lost on the vibrating surface! (measured by the author)
The reason this has not been a problem in non-water cleaning is that the cleaning agents themselves have some cleaning power, and therefore have been overlooked, but these are not rough times. Cavities generated by ultrasonic waves are high-speed phenomena that are created and extinguished more than 20,000 times per second, and are not visible to the human eye as bubbles? They are not a phenomenon visible to the human eye as bubbles, etc. When visible bubbles are observed during ultrasonic oscillation, it should be considered that most of the ultrasonic energy is not used in the ultrasonic tank and has disappeared.

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