D. Sonoluminescence Welding and Cutting

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Introduction:

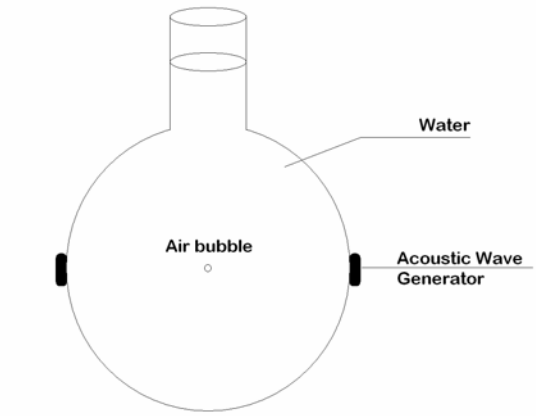
Sonoluminescence is the phenomenon of production of high intensity light in water when an imploding bubble is excited by sound. This paper throws light upon the application of sonoluminescence in the field of welding and cutting. This paper opens extensive ideas to apply sonoluminescence phenomenon in the field of underwater welding. The paper begins with a brief overview of the existing underwater welding technology followed by the concept of sonoluminescence phenomenon. The paper contains a central discussion upon the application of sonoluminescence phenomenon in the field of welding and cutting.

Existing underwater welding technology:

Underwater welding is used for underwater fabrication works. Existing techniques of underwater welding includes performing welding with direct exposure to the wet environment (Wet welding) or welding in a dry chamber created near the area to be welded (Dry welding). Wet welding is basically a manual metal arc welding done under water. Electrode with D.C straight polarity is used. The possibility of safety problems and leakage of current resulting in deterioration of copper cables can be minimized with proper precautions. However the difficulty of maintaining an arc under water and Hydrogen-Embrittlement (due to entrapment of hydrogen in the weld metal due to dissociation of water vapour) cannot be avoided. Dry welding is carried out in a chamber, filled with gas, around the structure to be welded. The expensive nature of the welding limits its application compelling us to an alternate underwater welding technique.

Sonoluminescence:

Sonoluminescence occurs when gas bubbles in water, while being excited by sound vibrations of ultrasonic frequency, implode so strongly that the energy focusing leads to light emission. The diameter and life of the light emitting spot is found to be much less than that of the bubble. Thus, this concentration of energy is both spatial and temporal in nature. This light emitting spot is known to contain tremendous temperature and pressure. They are primarily classified into Single Bubble Sonoluminescence (SBSL) and Multi Bubble Sonoluminescence (MSBL). SBSL, as the name indicates, is produced using only one acoustically trapped and periodically driven gas bubble. MSBL is just the opposite, where more than one bubble is collapsed. The phenomenon o Sonoluminescence has so far been found to occur only in water. Also for some unknown reasons, the intensity of the light emitting spot is found to increase if a noble gas is passed into the water used. The imploding bubble has a general tendency to implode near any metallic surface and leave the surface in extremely hot conditions. Sonoluminescence, though known to found a very complex mechanism, can be produced very easily, using a simple setup, the schematic diagram for which is shown.



Sketch of a typical setup for generating Sonoluminescence bubble

Sonoluminescence Welding:

The process of applying sonoluminescence in the field of welding involves heating of the metal above its forge temperature and applying a percussive force to bond them. i.e. This welding is a type of pressure welding. The process is quite simple. The two pieces to be welded are kept close and are connected to transducers that produce vibrations of any required frequency. The gap between the two surfaces to be welded is filled with water and the transducers are turned on. When the frequency and amplitude of the sound produced by the transducers are set right, sonoluminescent flashes occur between the surfaces and heats them. When the temperature of the surface reaches the required temperature, the percussion force (preferably a magnetic impulse) is applied and the two parts are welded.

Sonoluminescence has a property of rearranging the dendrite structures of the surfaces it hits, thus making the welded joint a better one, quality wise. The Heat Affected Zone is also extremely small (just a small layer on the surface), thus reducing the possibility of any upsets during the process. The instruments required for the welding of the two parts can be easily constructed and would also be very cheap. Also there is no need of any flux while welding these two parts, but just the presence of water as mentioned above which makes the process very much suitable for underwater welding. The process would be extremely effective if used for spot welding the metals. The process would naturally be safer than the existing wet MMA welding since there is no direct exposure of any electrical arc. Safety insulation dressing for the diver/welder and equipments for protection from electrical shock can consequently be reduced. The overall process cost, thus would be very cheap compared to the existing Wet/Dry MMA techniques.

Sonoluminescence Cutting:

When a metallic surface is exposed to a sonoluminescence bubble, it doesn't completely melt the surface, but leaves the surface in extreme conditions. Under such conditions the bonding forces (near the sonoluminescence flash) holding the metallic atoms together are completely dissipated and are rearranged. Though for a short interval, the atomic forces in the vicinity are weakened by the sonoluminescence flash. In order to apply this phenomenon in the field of cutting, a stress field needs to be passed over the region to be cut. This calculated stress field makes sure that when the

atomic bonds are weakened by the sonoluminescence flash, they are separated far enough so that they don't recombine. The tool used is a wire that which is connected to the transducer. The frequency of the transducer is carefully controlled so that the sonoluminescence flashes produced have the highest possible intensity. The tool is slowly inserted in as the metal surface gets separated, thus proceeding to cut in to deeper thickness. Thus the atoms can be separated or cut by the application of sonoluminescence. The process would be very precise, accurate, and above all very cheap. There is no loss of the tool by any wearing process and the process itself is very simple and effective.

Scope of further studies:

This paper is mainly a theoretical exposition of welding and cutting using sonoluminescence phenomenon. Sonoluminescence phenomenon is in its rudimentary state providing wide scope for research and further development. Though the process is quite simple to handle, it has one of the most complex mechanism. A proper understanding of the phenomenon and its effects can open wide gamut of technological progression. Studies have been carried out at many places to understand this phenomenon and many theories have been put forth to understand its mechanism. The need to understand the exact tendency of the bubble to collapse at the surface of various metals at various conditions, and the various effects it tends to create is very important. Studying the possibilities of furthering the intensity of the flash would be very useful. Automation of the overall process would be very simple and cheap. Thus Sonoluminescence phenomenon is a potential mine of explosive innovation capable of instigating radical changes in the field of welding and cutting..

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References:

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