

Outline Of Potential Applications For High Powered Ultrasound In Recycling

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High-power ultrasonics is a new powerful, technology that is not only safe and environmentally friendly in its application but is also efficient and economical. It can be applied to existing processes to reduce or eliminate the need for chemicals and/or heat application in a variety of industrial processes. This in itself can help reduce the environmental impact that modern industry has on the planet. But it is also a powerful tool in the recycling, detoxification and purification of waste products.

Innovative Ultrasonics Pty Ltd

Innovative Ultrasonics Pty Ltd is a company specializing in the development of high-powered ultrasonics in new and existing applications. Dr Darren Bates, who has a PhD in the application of high-powered ultrasound in industrial applications, is at the forefront of the ultrasonics industry on a global basis. Working with clients around the world on a consultancy basis, and in touch with the latest advancements in the ultrasonic equipment market, Dr Bates is highly experienced in the application of ultrasound from research and development stages, through pilot trials to full scale operation at industrial level.

High Powered Ultrasound

The use of high-power ultrasonics in industry is rapidly expanding throughout Europe and North America. The applications for which high power ultrasound can be used range from existing processes that are enhanced by the retro-fitting of high power ultrasonic technology, through to the development of processes up to now not possible with conventional energy sources.

There is a wide range of possible applications for high power ultrasound in all industries. And as a 'clean' technology, the use of ultrasound is expected to rapidly increase in importance throughout the world. The UK Department of Trade and Industry has described it as a 'key technology for the future'. The scope and potential in recycling and detoxifying waste products is only now being realized.

History

Until recently, most progress in the field of ultrasound was known as sonochemistry and had been carried out only at laboratory level with limited work being scaled up for use on a commercial basis. Conventional ultrasonic systems have been developed and are commercially used for cleaning, plastics welding, medical therapy and non-destructive testing. However **high power ultrasound** is a recent innovation in ultrasound technology and is much more versatile in its application. It is only during the last 5 years that advances have been made such that this revolutionary new energy source can be put to effective use in an industrial setting.

Ultrasound

Ultrasound is simply sound waves at a frequency above the threshold of human hearing. It can be subdivided into three frequency ranges:

- ◆ Power ultrasound (20 - 100kHz)
- ◆ High frequency ultrasound (100kHz - 1MHz)
- ◆ Diagnostic ultrasound (1 - 10MHz)

Ultrasound achieves its chemical or mechanical effects by generating bubbles within a liquid/slurry reaction medium; a process called cavitation.

The sound acts as a source of vibrational energy, which causes the molecules in the liquid to vibrate. This alternately compresses and stretches the liquid's structure to produce the bubbles. These bubbles are then subjected to those same vibrational stresses within the liquid and the bubbles eventually collapse. The conditions within these collapsing bubbles can be dramatic, with temperatures of 5000K and pressures of up to 2000 atmospheres. As they collapse, the bubbles release energy. This is the energy that is utilized to accelerate the rate of a chemical reaction, create new reaction pathways or even generate different products from those obtained under conventional conditions.

Power ultrasound (20-100kHz) is used for most sonochemical applications, but because cavitation can be produced using sound at frequencies from within the audible range right up to higher frequencies such as 2MHz, the frequency range used for sonochemistry is expanding. But most reaction processes will operate at their optimum at 20kHz, as this is the frequency at which the maximum energy can be attained.

The use of ultrasonics in industrial processes has two main requirements; a liquid medium (even if the liquid element forms only 5% of the overall medium) and a source of high-energy vibrations (the ultrasound). The vibrational energy source is called a transducer and there are two main types; piezoelectric and magnetostrictive, the latter being less adaptable but more powerful than the former. Piezoelectric transducers are the most commonly used.

The technology in the development of commercial-standard ultrasonic equipment is developing at great pace and no novel process for the application of ultrasound in industry is now impossible with ultrasonic equipment manufacturers willing to build new designs according to the requirements of customers.

Benefits of using high powered ultrasound

The high power ultrasound process provides the following benefits:

Environmentally responsible

- ◆ chemical-free
- ◆ can be applied to existing chemical-based processes to reduce the amount of chemicals required
- ◆ non-thermal
- ◆ can be applied to thermal reactions in place of heat
- ◆ Low running costs: lower operating costs than the alternatives
- ◆ ie although the capital cost of the high power ultrasound equipment is higher than eg ultraviolet equipment, the operating cost in terms of both power consumption and maintenance costs, is considerably less:
- ◆ ultrasound: 0.18cents (ie \$0.00.18) per 1000 litres
- ◆ ultraviolet: 0.54cents (ie \$0.00.54) per 1000 litres
- ◆ ozone: 1.10cents (ie\$0.01.10) per 1000 litres
- ◆ Enables processes not possible by conventional methods, for instance the recycling / re-using of waste products such as fly ash

High power ultrasound equipment:

- ◆ modular
- ◆ easily installed
- ◆ easily operated
- ◆ same reactors suitable for both small and large operations
- ◆ low maintenance costs

Applications of high powered ultrasound in recycling

As an illustration of the type of uses that high power ultrasound can be applied to, following are some examples of applications where high-powered ultrasound can be utilized in the recycling of organic products and associated industries:

1) Pathogen Destruction

Innovative Ultrasonics Pty Ltd has a patent application filed entitled "Apparatus for and Method of Destroying Pathogens". We have spearheaded a one-step process capable of destroying E. coli, salmonellae, Ascaris, giardia and cryptosporidium cysts and poliovirus. Proprietary studies in water, wastewater and foods have also demonstrated the ability of the ultrasonic technology and equipment that we are using, to destroy/breakdown organic pesticides, blue-green algae, remove heavy metals, destroy aquatic nuisances such as zebra mussel from river water.

The applications for this technology are vast and include:

- Potable water purification
- Sewage sludge purification

- Effluent treatment from industrial abattoirs, intensive animal industries, food processing industry
- Treatment of ballast water from ships
- Treatment of river water prior to use in for instance, hydro-electricity plants to remove the aquatic nuisances such as zebra mussel
- This same technology can also be applied as a cold pasteurisation process for food products such as meat, vegetables, fruit, fruit juices, seeds.

2) Treatment of sewage sludge and industrial effluent

The benefits of treating sludge and effluent with high-powered ultrasound include:

- Pathogen destruction
- Removal of pollutants such as pesticides, heavy metals etc
- Enhanced sludge dewatering and sedimentation of sewage sludge
- Enhancement of the anaerobic digestion process in sewage sludge
- Utilisation of the residual gas potential in digested sludge by ultrasonic disintegration
- Prevention of the build up of bulking or floating sludge which usually consists of large populations of thread bacteria.
- Pathogen destruction in green waste, food waste, reject and by-product material, manure
- Cleaning of contaminated soils/earth
- Enhancement of composting processes

3) Paper Industry

High-powered ultrasound can be utilized in the paper industry and the paper recycling industry for:

- Extraction of dirt, oil, printed inks, colorants, even lacquer from paper for recycling
- Enhance the breakdown of wood chip into pulp or the breakdown of used paper into pulp for reprocessing into recycled paper
- Utilized to beat pulp fibres and enhance fibrillation of the pulp fibres
- De-gassing of the pulp to prevent lines/watermarks that mean the finished paper is unusable and must be recycled or classed as waste

4) Cleaning

High-powered ultrasound can be used for surface cleaning of dirt or contaminants on organic based materials

It can also be used for stripping paints, lacquers, metallic coatings from plastics so that the plastic can be re-melted, moulded and extruded into new plastic components that are not contaminated with residue from the earlier use.

5) Oil Wells

The application of high power ultrasound has been put to good use helping to solve an environmental problem on offshore drilling rigs in the oil industry.

During drilling, a complex mixture of components known as 'drilling mud' is injected into the bore hole to act as a lubricant and flotation agent. After use, the 'mud' together with the earth from the drill hole must be thoroughly cleaned of oil before it can be dumped at sea.

Existing cleaning technologies result in the formation of small agglomerates which sink to the sea bed and which accumulate around platform legs, presenting a problem to sea life and to rig maintenance.

Using high power ultrasonics, systems have been developed for the on-site de-agglomeration of the cleaned mud. The mud is passed through high intensity ultrasonic flow cells, which substantially reduce the particle size. As a result, when mud is jettisoned from the oilrig, it disperses across the seabed and does not accumulate around the platform.

This de-agglomeration / particle size reduction technology could be applied equally well in a vast range of industrial processes.

6) Steel Industry

Ultrasound has been found to be beneficial in aspects of steel production. The use of high-powered ultrasound results in enhancement of the pickling process, reduction in the acid required in the treatment baths and an overall reduction in energy costs

7) Electricity Generation Industry

Innovative Ultrasonics Pty Ltd has a patent application filed entitled “The use of high powered ultrasound in the rehabilitation of fly ash”.

Innovative Ultrasonics Pty Ltd has developed a process using high powered ultrasound to take fly ash, a waste product from power stations, and recycle / reprocess into high value inorganic fillers / pigments / additives for the paint, plastics, paper and composites industry.

It is becoming clear that the value of applying high-powered ultrasonics to industrial and recycling technology has not yet been fully realised. The use of this new energy source to enhance and clean up existing industrial processes, for developing new, environmentally responsible industrial processes and to enable recycling procedures not possible with current technology, has yet to be explored to its full potential.