Sound advice

A simple method of generating ultrasound could make it easier to incorporate a sonic homogeniser into a coatings plant, creating many opportunities to improve production efficiency with low maintenance overheads.

Most engineers are familiar with ultrasonic energies being used for cleaning parts, welding plastics, or perhaps even for performing medical examinations. This energy is produced by transducing piezoelectric generated vibrations and applications of ultrasonic energies include the production of emulsions and dispersions.

This technique has been tested in the laboratory to make small quantities of dispersions and its use in paint systems have been investigated over the years. Scale up efforts have proven to be very costly in both capital investment and in power demands. However, the development of mechanical generation of ultrasonic energy as compared to transduced electronic systems have changed all that, proving to be very efficient.

MECHANICAL ULTRASOUND

One of these methods provides a means for material to be in direct contact with high-energy cavitational forces. It does not involve high electrical energy or a complicated generating mechanism.

This method provides a means for high intensity and economical processing of large amounts of materials by a direct translation of kinetic energy produced in a pump to cavitational ultrasonic energy. This energy is created in tandem with high-pressure homogenisation, and the system provides complete and instantaneous emulsions and dispersions, perfect for those applications requiring high intensity mixing.

The material is pumped through a specially shaped orifice at high velocity of 300 feet per second or more, forming a flat stream. The jet of material then impinges on a knife-like blade, which creates waves or vortices of ultrasonic energy running perpendicular to the flow. The pressure drop created by the orifice and the ultrasonic cavitational forces combine to create a high-energy mixing effect (**Figure 1**). Pressures starting at 200 PSI to as high as 5000 PSI with flow rates up to 250 GPM or greater are capable.

Detailed evaluation of the phenomena occurring in the region of the blade shows that a vibration tends to set up, forming a cavity more rapidly than the liquid can fill, essentially stretching the liquid. Dissolved gasses in the liquids will relieve this stress by forming bubbles that expand very quickly.

One twenty thousandth of a second later the bubble collapses. This alternating expanding and collapsing develops a pressure differential shock wave that has been measured as high as 500,000 PSI. When dissimilar liquids are passed through this cavitational field, fine particle size emulsions are formed. If finely divided solids are passed through the system, dispersion of solids tends to take place.

Apart from laboratory testing to determine the optimum operating pressure, there are two ways of adjusting the energy being produced. One is the blade to orifice distance, which leads to generation of maximum acoustic energy. The optimum location will vary with temperature, viscosity, thixotropy of the system, density, as well as the nature of the system itself.

The other parameter is related to the backpressure. It has been found that if a small amount of backpressure is imposed downstream of the orifice, acoustic energy is increased substantially. There are also different Sonolator designs, each built to address different flow rates and pressure requirements. The basic Sonolator system consists of a PD pump (of any sort), motor, gear box to create pump speed, the Sonolator and instrumentation, such as the Acoustic Intensity Meter, which can monitor the level of cavitation, ensuring reproducibility from one batch to the next.

APPLICATIONS IN PAINT SYSTEMS

Sonolation has been applied successfully to a variety of products produced by the paint industry. Achievements related to improved level of dispersion or substantial economic savings, usually reduced manpower, processing time or both.

Paint industry interests are becoming broader and extend beyond traditional paint manufacturing

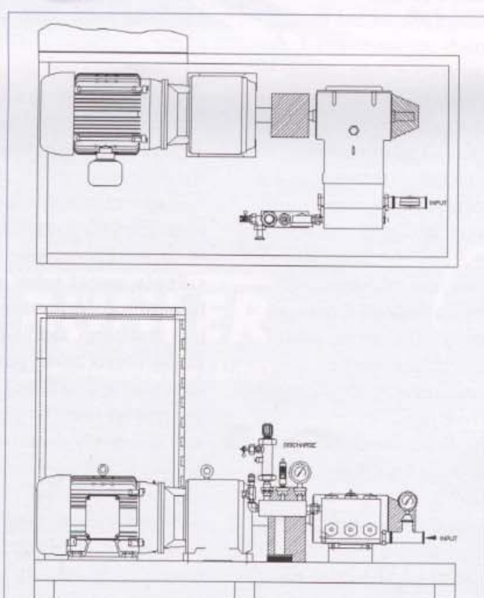

Figure 1: The Sonolator is an in-line homogenising device that employs high pressures and ultrasonic cavatational energy to create emulsions and dispersions.

The ultrasonic conversion of energy within the liquid stream is accomplished by a physical phenomenon known as jet-edge tone.

A stream of process liquid is subjected to extreme pressure and shear when forced through the specially engineered orifice. The process material is then projected at a velocity of 300 feet per second or more over the edge of the blade. Between the orifice and blade, the jet of liquid sheds vortices perpendicular to the original flow vector.

The alternating shedding patterns create a steady, ultrasonic oscillation within the liquid. The stresses set up within the fluid by these ultrasonic oscillations cause the fluid to cavitate.

The pressure and high level of cavatation, shear, and turbulence within the Sonolator's mixing chamber are responsible for de-agglomerating product particles and emulsifying liquids.

Figure 2: Fumed silica dispersions; Resin manufacturers need a better way to disperse fumed silica into their resin systems as a thickening and anti-sag agent. The Sonolator provided better dispersion, smaller particles sizes and tighter particle size distribution at less than 500psi.

and into fields related more towards coatings. These applications include polyester resin fiberglass systems, including gel coats; casting of methacrylates; electrocoating of metal parts; and so on.

RESIN BASED SYSTEMS

A growing area of resin applications is that of polyester resins in reinforced fiberglass structures for fabricating tanks, structural and decorative panels, and so on.

Finely divided colloidial silicas usually provide thixotropic properties. These silica additives tend to agglomerate and settle out, giving the polyester resin uneven viscosity build up and poor uniformity. High intensity mixing is required to give the material homogeneity and the use of Sonolation has provided an economical means of providing this high intensity energy (**Figure 2**).

A rough pre-mix can be passed through the Sonolator once, providing good uniformity. A simply designed system at low capital investment is capable of operating at high capacity throughputs.

PIGMENT DISPERSIONS

Resin and plastics has attracted paint manufacturers to the casting of acrylic sheeting. Here, proper dispersion of colours is very important, especially in the display sign industry. Cavitational energy, as provided by the Sonolator provides excellent result at very low cost by improving the dispersion of the ultimate size pigment particles.

A simple and rapid technique where the pigment plasticizer is wetted out in a mixture of plasticizer, monomer, and resin syrup, and then pre-mixed, diluted to a final desired concentration and then Sonolated for one half hour on a recirculation loop.

An 8-10 hour process is reduced to 30 minutes. Pigment dispersion is improved to the extent of reducing rejects dramatically. The Sonolator pump is then used to transfer the finished dispersion to holding tanks or storage. The metering devices and closed loop pipe work make the process clean, rapid, economic, and virtually automatic.

When manufacturing colour-pigmented products involving dispersing solids within a liquid, the system may be susceptible to colour drift caused by flocculation of pigments. These problems stem from incompatibility of tinting colour in pigmented bases or incompatibility with the resin systems. The may also be related to incomplete wetting out of pigments caused by adsorption of air on pigment surfaces, not completely eliminated during dispersion.

It is known that cavitation has a de-aerating effect. In the case of Sonolation passing incompletely wetted pigments through the cavitational envelope probably results in elimination of adsorbed gases from pigment surfaces, thus providing the route for complete wetting.

By that same mechanism, flocculated resins or other incompatible combinations tend to be deflocculated and blended thoroughly.

The Sonolator has been used successfully in four different ways to develop colour fully:

- **continuous processing of paint and addition of tinting colours;**
- **redispersion of flocculated paint constituents;**
- **processing finished paint to complete deaeration**
- **the production of fines in tinting concentrates.**

An economical processing system can be set up where the paint to be tinted is charged into one tank and the tinting colour charged into a second. The paint is recirculated in its part of the system while the tinting colour is injected through a feed valve into the Sonolator with the recirculated paint. This method of tinting colour addition yields a completely dispersed colour with no flocculation, and by creating the maximum number of fines, yields paint with colour fully developed.

Data developed from all of these systems indicates that cavitation energy is able to deagglomerate flocculated pigment particles of the type used in most trade sales paints.

Sonolation tends to deaerate liquid systems. On pigments being wetted out, adsorbed air on pigment surfaces is deadsorbed and surfaces are wetted rapidly and completely.

The preferred technique calls for addition of pigment to solvent in a typical make-up tank with Sonolation provided in a recirculation loop in the presence of only a small percentage of resins in order to keep viscosity low and enhance the rate of wetting out.

After deagglomeration has been complete, the balance of the resin formulation and other additives can be made rapidly and the batch completed in the same make-up tank while colours are fully developed.

Sonolation represent a rapid, simple method of speeding up the rate of manufacture of trade sales paints without the addition of complicated high cost equipment. Power requirements are low, and the simplicity of the equipment proved for quick and easy clean-up.

ELECTROCOATING

As in resin systems, Sonolation has found acceptance in areas such as electrocoating paint systems. In this process, a system similar to the electroplating of metals is used. A dip tank is filled with an emulsion paint, with water as the continuous phase. Positively charged objects are dipped into the paint that has been charged negatively, causing migration of the nonvolatile portion (resin and pigment) of the paint to the object where it is deposited and it subsequently adheres. This requires very careful control on two counts.

- **The level of nonvolatile solids must be held constant, being replaced constantly at the same rate as they are removed.**
- **Replacement solids are usually provided in the form of a concentrated paint, which tends to flocculate and lump, settling in the dip tank or adhering to the object being painted, giving a non-uniform appearance and thus causing rejects. The regenerating system must be able to add solids continuously and in a finely dispersed form.**

Since the Sonolation phenomenon is a continuous steady state system, it lends itself admirably to the dispersion of regenerating nonvolatiles in electro-coating. A recirculation loop can be designed from the dip tank through the Sonolator and back to the dip tank with paint metered automatically

Figure 3: dual feed system for silicone oil emulsions

A Silicone processing company needed an on-demand approach that would reduce operator involvement, reduce waste and improve process efficiencies.

Dual-feed on-demand Sonolator System:
This system was economical and highly mobile, allowing it to be connected anywhere in the plant.

Each stream was metered and monitored w/in 0.5% accuracy by Sonolator controls and instrumentation.

- ***Mixing cycles reduced***
- ***Operator involvement reduced***
- ***Water not in a tank allowing for larger runs***
- ***Material transfer times eliminated***
- ***Cooling time eliminated as finished material was at filling temp***

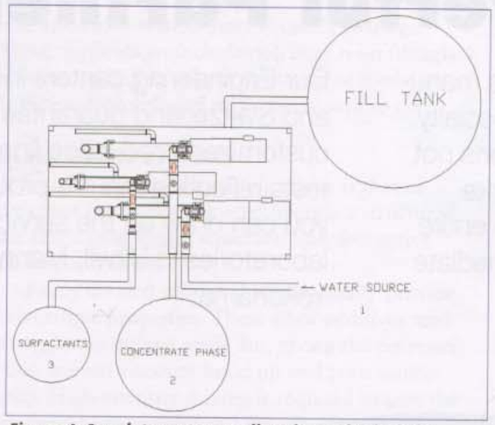

Figure 4: Sonolator systems allow for multiple-feed processing, where several process streams of phases can be metred and emuslified simultaneously.

into the system, balanced against the rate of removal from the dip tank itself.

THICKENERS AND EMULSIONS

In most aqueous paint systems, thickeners such as methylcellulose, carboxy methyl celluose, and so on, are used for viscosity control. Complete swelling and solution of some of these thickeners is usually time consuming.

Often the time required to accomplish this step is the longest single operation in the entire process. Under the influence of high pressure and ultrasonic cavitation, these particles, which are swollen in water, are quickly dispersed so that the swelling takes place in a very short time span, shortening the total processing time dramatically.

Although easy to make by established conventional methods, these do require careful preparation of constituents in a selected order of addition. First, pigments are dispersed in water with wetting agents, antifoaming agents, and other additives found in the formula.

Titanium dioxide pigments are usually dispersed first and then the extender pigments added. In many cases the order and rate of addition of these pigments is critical. A long period of time is consumed using high-speed mixing equipment to complete the wetting out and dispersion process.

Latex emulsion is then added, accompanied by a much lower level of mixing energy in order to avoid coagulation or breaking of the latex emulsion. After which thickeners may be added to bring the viscosity of the finished product up to the proper level.

Predispersion of these thickeners is usually done separately. This entire operation requires careful control, and is usually accompanied by problems like foaming, aeration, incomplete wetting out of pigments, and so on. Colour development may not be complete because high levels of work cannot be accomplished once the latex is added.

Sonolation has shown that a good deal less attention is needed to be given to complete wetting out of pigments and order of addition of materials. Thickening agents can be pre-dispersed in the same equipment. Once a rough pre-mix has been brought together and pigments coarsely dispersed, circulation through a Sonolator provides complete development of the finished product properties.

Latex emulsions have not been broken in such treatment. Since the Sonolator system is closed, no aeration or foaming problems occur. The Sonolator offers techniques that permit less labour, shorter batch cycles, and simpler formulation procedures. Substantial production capacities are possible with little capital investment.

Aqueous paints based on resin systems other than latex emulsions involve emulsification of various resin bases, lending themselves naturally to Sonolation for development of small resin particle size for stable emulsions as well as optimum dispersion of pigments.

The dual-feed scenario (**Figure 3**) in which an oil phase and water phase are metered together in a balanced manner, with the pigment dispersion following or proceeding, providing an economic advantage to be gained by allowing the paint manufacturer to purchase resins and carry out their own emulsification rather than pay higher material costs associated with purchased systems.

OVERVIEW

Use of high-pressure ultrasonic cavitation represents an efficient and simple form of high intensity mixing. Other devices such as impact energy generated in piston homogenisers or high shear energy from colloid mills or other mill types usually require high-energy input, high capital investment, and high maintenance costs. In most instances processing procedures are limited to batch style operations. Very often, a good deal of energy is lost in friction resulting in excessive heating.

Sonolation provides high intensity mixing at any given throughput. Flow rates can be adjusted to meet the flow rates of other machinery such as filing equipment. Most any job can be performed in a single pass offering faster processing or more complete processing. Steps that have taken several hours are now reduced to much shorter times.

Multiple-feed offers a whole world of processing efficiencies, allowing for even more efficient use of existing tank space by increasing throughput without adding more tanks (**Figure 4**).

LOW MAINTENANCE

Since the Sonolator operates solely with pressure as its energy source, scalability from the lab to production is simple and seamless. The same goes for repeatability. Simply maintain the optimum pressure and you will get the same results time after time, also reducing potential for waste.

A Sonolator system is easy to clean and inexpensive maintain. It can be disassembled, cleaned and reassembled in less than 10 minutes. The commercially available pump and motor are essentially the only moving parts, offering low maintenance costs and low power consumption.

A system is easy to automate with a simple PLC. You can monitor and control your optimum pressure, flow rate, and call for more materials from secondary vessels or tanks.

Sonolation offers a path toward increased plant capacity with little capital investment; an investment that should be able to be recouped rapidly in lower labor requirements, shorter batch cycles, and simplified processing techniques. **APCJ**

Author: Kurt Limbacher,
Sonic Corporation, Stratford, Connecticut 06615, USA
Tel: +1 203 375 0063
Email: kurt.limbacher@sonicmixing.com
Website: www.sonicmixing.com