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LEAD INDUSTRIES ASSOCIATION, INC.

292 MADISON AVENUE

NEW YORK 17, N.Y.

March 30, 1962

SUBJECT: LEAD ZIRCONATE TITANATE

To Members of the Lead Industries Association, Inc:

Attached is a reprint from the February 1962 issue of "Ceramic Age" of an article describing the use of lead zirconate titanate in ultrasonic cleaning devices. This article was based on the paper presented at the last annual meeting of L.I.A.

We believe that it is a useful, handy and condensed treatment of this subject which we will use for distribution at our trade show exhibits, such as the Design Engineering Show, and in answering inquiries on this subject.

Very truly yours,

Executive Vice President

RLZ:mk
Enc.

Look Ahead with Lead

LIA24802

PZT Transducers Help Broaden Market for Ultrasonic Cleaning

By: H. F. Osterman
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Ultrasonic cleaning is a complex phenomena which in the simplest sense can be considered as an excellent scrubbing action. The speed and efficiency of an ultrasonic cleaning operation depend upon the amount of cavitational energy or activity, the physical and chemical properties of the cleaning solution and the nature of the soil as well as the part being cleaned.

Sound waves in a liquid can be considered as alternate compressions and rarefactions. Cavities are formed when the sound energy level is sufficient to stress the liquid beyond its tensile strength during the rarefaction phase. As the pressure swings positive, the cavities collapse upon themselves creating high, instantaneous pressures. Shock waves emanate from the point of implosion. The rate at which these cavities form and implode is proportional to the sonic frequency, which normally is between 20,000 and 40,000 cycles per second.

The expansion and collapse of a cavity in a liquid is known as cavitation and causes a strong mechanical scrubbing action which occurs at any surface in the cavitating liquid. Factors controlling cavitation in a liquid include surface tension, vapor pressure, density and viscosity. In a given liquid these factors tend to optimize in a particular temperature range to produce the greatest cavitational energy and thus the most intensive scrubbing action. This scrubbing action, for all practical purposes, can be considered mechanical erosion.

In actual use the scrubbing effect of cavitation is usually combined with the action of aqueous or solvent cleaning solutions so that the advantage of both cleaning processes are obtained. In addition to mechanical scrubbing, cavitation also tends to speed-up cleaning or solvent action by reducing chemical concentration gradients, removing reaction products and maintaining a fresh supply of solution at the cleaning interface.

An ultrasonic generator is used to convert line current into radio frequency current at the desired frequency, which subsequently is converted by a transducer into sound or mechanical energy at the same frequency.

Adapted from a paper presented before the 32nd annual meeting of the Lead Industries Association held in Chicago, May 3, 1961.

Transducers fall into two main classes: piezoelectric and magnetostrictive. In the first instance a material which changes dimension in the presence of an electrical field is utilized. In the second the material is influenced by a magnetic field. Due to the large difference in conversion efficiencies, 70% to 90% for electrostrictive compared with 20% to 40% for magnetostrictive, we utilize transducers of the electrostrictive type.

Initially, barium titanate was used as the active material, but it had two major drawbacks: its inability to operate continuously above 160 F and poor maintenance characteristics from the standpoint of transducer rebuilding costs.

The use of PZT (lead zirconate titanate) has eliminated these problems. Although more expensive than barium titanate, it is capable of handling much greater power inputs. A unique sandwich type design, which clamps a relatively small amount of PZT between metal plates, has yielded a transducer element with:

1) Electrical to mechanical conversion efficiency of 90% compared with 70% for Barium Titanate
2) Operating temperatures in excess of 200 F.
3) Low maintenance costs.

Transducer elements in their manufactured form cannot be used directly in a liquid. It is for this reason that they are normally protected by a stainless steel or other chemical resistant alloys. Multiple elements are attached to a stainless steel housing by a special bonding technique, which combines high mechanical strength with good acoustic efficiency. The section of the housing which is in contact with the liquid on one side and the elements on the other is called the radiating surface.

Since ultrasonic cleaning is mechanical erosion, it is easy to realize that a radiating surface will erode. As it roughens it loses its ability to efficiently radiate energy. Long term experience indicates an effective transducer life of 6,000 to 9,000 hours, after which it is necessary to rebuild them.

Transducers utilizing PZT can be rebuilt at 20% of their initial cost as compared with 80% rebuilding costs for older type transducers. This fact well justifies the use of PZT, since it has made possible large installations which would not be economically feasible using ordinary transducers, due to high rebuilding costs.

From a capital investment standpoint, the higher operating efficiency of PZT transducer elements has made possible a reduction in cost since a larger amount of the incoming line power is converted to useful mechanical energy. These cost reductions will broaden the use of ultrasonic cleaning which is competitive with more conventional forms of cleaning.

END

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