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"MACROSONICS"

# Some Applications in Industry of High-Power Ultrasonics

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The development of magneto-strictive equipment driven by thyristor generators has made possible a wide variety of industrial processes using high power ultrasonics, some of these are now fairly well known, the last two are very new.

1) Cleaning and de-scaling.
2) Disintegration and emulsification.
3) Drilling and polishing.
4) Welding.
5) Powder flow.
6) Cutting.

Before these subjects are described in greater detail a brief description of magneto-strictive transducer systems used for this work will, no doubt, be helpful in understanding the applications.

Fig. 1 shows a typical transducer/probe system using bar transducers. Here the thyristor generator provides an output to the transducer coils of:- a) Magnetising current.
and b) Pulsed current at correct frequency.

The frequency chosen is usually 20kHz but for some applications e.g. cleaning 13kHz may be used. Output is variable in power and frequency, power to suit the task and frequency to match the resonant frequency of the transducer/probe system it is feeding. The two types of current flow in the same pair of wires, separation is effected by a blocking choke in the generator.

In this example several bar transducers are used, see fig. 2, they consist of nickel alloy laminations about $\frac{3}{8}$" wide 20 thou. thick, resin bonded to form a $\frac{3}{8}$ square bar which are attached by brazing to a screwed steel stub. Their length is half wave, therefore 20kHz bars are about 5" long and 13kHz are about 7" long. These are screwed into the probe, usually made of stainless steel, which is again a half wave length. Halfway along the probe is the nodal point and at this point the mounting flange is arranged. Various combinations of bars are used, for a 2" dia. probe 3 bars are used, for 3" dia. probes six are fitted and one bar only, as used on the 50 watt units, is fitted to a $\frac{3}{4}$" dia. probe.

The nodal flange enables rigid mountings to be used without loss of energy due to damping. Coils wound on formers are fitted to each bar, these coils are usually series wound.

A variant of this system using window stack transducers, see fig. 3, is employed in most equipment where very high energy levels are required. These consist of nickel laminations of rectangular shape with a centre slot. In this type the coils are wound on each leg and the stack is attached to the probe by induction brazing to ensure a good acoustic joint between the nickel and stainless steel.

(1) Cleaning and de-scaling

This is certainly the earliest as well as the most general use of high power ultrasonics for industrial purposes. References to this application date back to 1949, in those early days high frequency crystals were used in conjunction with thermionic valve generators. Good results were obtained only where small components were cleaned in solvents, heavier work was only possible after the introduction of lower frequency transducers of both magneto-strictive and sandwich crystal types. It is now current practice to use magnetostrictive transducers at 13 and 20kHz also crystal transducers at 20 and 25kHz for tasks involving aqueous media. For work requiring chlorinated and fluorinated solvents 20, 25 and 40kHz are used, the latter frequency is mainly now used for delicate tasks such as these encountered in the electronic industry. In all cases the cleaning is effected by cavitation forces produced by the ultrasonics.

Whichever system is used the transducers are mounted in the base or side of the cleaning tank according to the orientation of the components to be cleaned which are then suspended in the tank filled with a suitable liquid. In most cases the liquid used is a hot detergent solution, the components must be immersed in such a way that they are within the beam of the probes and that no air is trapped in them. Air is a most effective barrier of sound energy and its presence will prevent cleaning taking place.

Ultrasonic cleaning is now well known in medium and heavy engineering as well as light engineering. The robust nature of the equipment gives reliability factors which are acceptable for continuous plant operation as found, for example, in the wire and steel industry.

On the plant shown in fig. 5, Rolls Royce RB 211 engine parts are being cleaned, this particular plant has an ultrasonic output of 12kW at 13kHz and is capable of cleaning all current British engine components including Concorde, some of the latter are over 6ft. in diameter. In this plant a system known as zone cleaning is used whereby the components are slowly rotated past banks of probes placed in several different planes in the tank.

The system lends itself to conveyorisation and only requires that the parts to be cleaned are transported through the irradiated zone, it is not neccessary that they dwell in the zone. In most cases only short cleaning times are required these are of the order of a few seconds.

In the wire industry, for example, multiple strands of up to 30 or 40 wires can be successfully cleaned or de-scaled at speeds up to 200 fpm. The technique which has proved to be the most economical is to mount opposing banks of probes in the same plane as the wires in a shallow tank, see fig. 6. De-scaling of carbon steel wire after patenting is carried out in water after a short acid dip. De-soaping of stainless steel wire to remove insoluble lubricants is usually carried out in warm weak nitric acid solution.

(2) Disintegration and Emulsification

Equipment is available with power levels from 50 watts up to 400 watts and usually takes the same form, see fig. 7. The probe is reduced in diameter to give a suitable concentration of energy, these are from $\frac{1}{8}$ dia. up to 1" for larger models. In nearly all equipment the frequency is 20kHz, since very high energy concentrations are concerned heating of the sample to be treated can be a problem. In such cases water cooled vessels are employed and with these protracted treatment is possible. Typical applications are in biological and geological departments, the equipment usually is mounted on a bench stand with provision to treat samples in beakers, versions are available where the probe is hand-held for use in traversing immersed objects such as large bones or mineral samples.

(3) Drilling and Polishing

This refers to equipment designed for working very hard materials as, for example, diamonds, ceramics, glass and sintered materials.

Diamond wire die drilling and polishing equipment is now becoming very widely used, the economics of the process are most favourable in comparision to conventional methods. Low power equipment is effective on diamonds, on tungsten carbide very much more power is neccessary

The technique is to fit tools into the probe made of brass or steel shaped to suit the hole required. The abrasive is applied as a slurry, a controlled light feed pressure is provided by the adjustable counterbalance. For circular holes, as in die work, the worktable is rotated at about 50 rpm to ensure a good surface finish, see fig. 8.

(4) Welding

Excellent welding of foils and thermo-plastic materials is possible with ultrasonics. The equipment employed is similar to that used for drilling purposed with the exception that the tool must be brought into contact with the work under considerable pressure to give energy transfer.

(5) Powder flow

Low frequency vibrators have been used for many years in connection with problems of bridging and "rat-holing" of powders in hoppers. Recent developments using 20kHz vibrators are showing considerable promise, their function does not require physical isolation of the hopper, the ultrasonic vibration is of such low amplitude that this is not essential.

The development in this field began with the discovery of the coupling bar attachment system, see fig. 9, whereby the probe/transducer system is not damped even when attached, usually by welding, to a massive hopper. The effect of ultrasonic vibration on the hopper wall is to lessen friction between the powder and the wall. By varying the power level of such a system flow can also be regulated. Very large hoppers require an array of probes, usually several are driven from one generator.

(6) Cutting

This process is at an early stage of industrial use and is being applied to improvement of cutting soft, sticky materials. The principle is again one of friction reduction caused by low amplitude vibrations. It is being used principally in the confectionery industry but has many applications in other industries.

These six categories cover the principal industrial uses of high power ultrasonics. There are others, of course, two examples of these are ultrasonic machining, tube drawing, and irradiation of metal melts which are all in development or later stages. New developments are taking place all the time and it is the writer's opinion that there are still many fields of use to be discovered for this very interesting type of equipment.

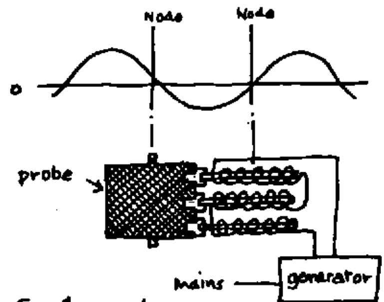


fig 1 probe

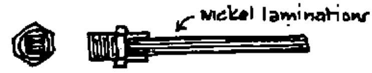


fig 2 transducer bar

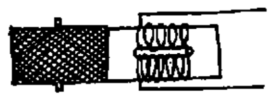

fig 3 window stack

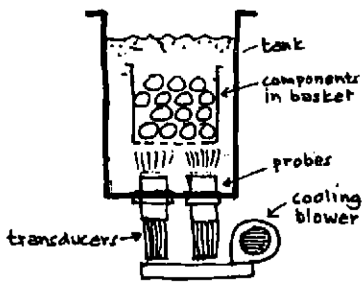


fig 4 cleaning tank

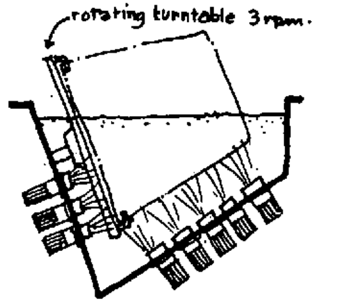


fig 5 cleaning plant for engine parts

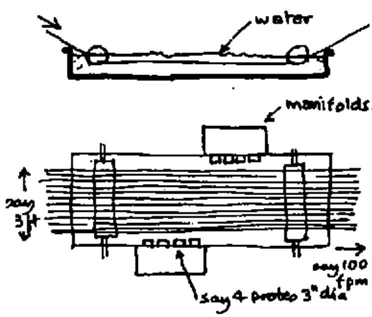


fig 6 wire descaling line

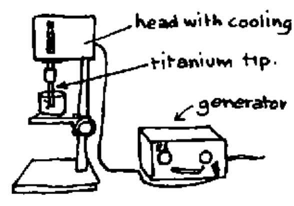


fig 7 disintegrator

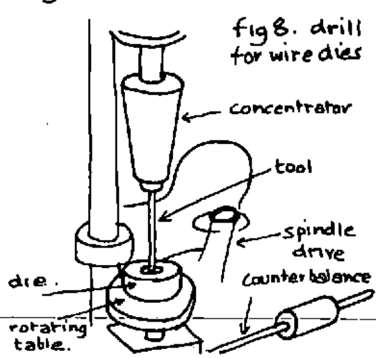


fig 8. drill for wire dies

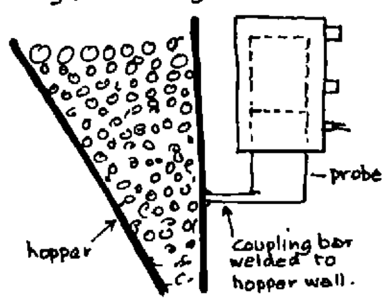


fig 9. powder flow.