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METAL MATERIAL CLEANER BY APPLIED HIGH FREQUENCY ULTRASONICS

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Abstract

This research article presents metal material cleaner by applied high frequency ultrasonics is one choice to utilize the sound energy. This method is to transfer ultrasonics energy to the cleaning unit.In this research, the IC# SG3525A is used to generate frequency at 28 kHz. The IC#TLP250 is a optocoupler which is used to interface between the output of the IC#SG3525A and the input of the isolated drive circuit. The high frequency circuit is used to drive the gate of Power MOSFETs#IRFP450 in half-bridge Inverter circuit. Then, the output signal is transferred to high frequency transformer to step up the voltage. After that, the receiving A/C 350 watt drives the seven ultrasonic transducers in order to transfer electric energy to mechanical vibrating energy by the frequency of ultrasonics. In addition, there is a timekeeper to control the work duration. This metal material cleaner by ultrasonic can increase the ability of cleaning for the huge material parts and it can be used in another cleaning industry.

Keywords: *cleaner, metal material, high frequency, ultrasonics, electric energy*

Introduction

Ultrasonic cleaning in the industry has been around since 1950. The early use of ultrasonic power was in the fields of electronics, lighting, visual and functional. For the pharmaceutical industry, for example, hospital and surgical glass cleaning, camera lens, filter, electronic printing, ball bearings, engine partsand temperature changer.

Ultrasonic cleaning works well with sound-reflecting objects such as metal, glass and plastic. Ultrasonic cleaning saves time. It can clean in difficult and impossible tasks and other cleaning methods including cleaning of parts of the crevice or small niche of the material, and clean equipment not to be damaged by scratches. The principle of cleanliness is to send ultrasonic waves to the medium with the object to be cleaned. Most intermediates are liquid. It is used as a liquid because the sound waves can move in the liquid better than in the air. When the waves go into the liquid the particles in the liquid will vibrate with high frequency then the dust or dirt in the object to clean it out.

Most industrial cleaning machines have a capacity of 5 - 150 liters and most of the cleaning today is using transducers at frequencies between 20 kHz and 50 kHz.

In solid environments two types of elastic waves can be propagated - longitudinal and transverse. Each waveform corresponds to its own oscillation velocity. The velocity of the longitudinal waves is determined using ultrasound generating devices by means of transducers which transmit such waves reflecting the opposite surface of the sample relative to the surface on which the touch probe is placed.

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Materials and Methods

Ultrasonic cleaning

Cleaning technology is in the process of changing the use of chlorine-containing vapors. Fluorine is the standard solution for most industries being popularity reduced especially for use in ecological benefits. While cleaning is increasingly needed in many industries such as the electronics industry cleaning is always important. Entrepreneurs have supported more this kind of technology development. It seems that developing new technologies requires a lot of clean-up. As a result, the cleaning industry has progressed rapidly over the years. Many advances have been made in the use of ultrasonic technology.

Non-destructive cleaning industry is replacing the use of breakers to remove impurities. Although cleaning the use of chemicals containing petroleum or containing most of the water will not affect the environment. However, the cleaning efficiency is lower than the solvent used, which makes it inadequate for some applications. And now, ultrasonic energy has been used extensively in cleaning as it is a fast and efficient way.

The benefits of ultrasonic cleaning and purification

To clean up dirt must have soluble properties. As the soil type is dissolved or replaced. Soil is not soluble or has two properties, like tiny particles that cannot be dissolved. Solvent, such as oil or grease, and ultrasonic energy, have the advantage of increasing the melting speed and replacement of small particles. In addition Ultrasonic waves are also useful in cleansing. It can be used to clean many chemicals used in cleaning and the residue inside the system quickly and completely.

To get rid of dirt with soluble the used solvent must be exposed to dirt to melt that dirt. But during the solvents is dissolved dirt it appears a layer of saturated between the surfaces of the dirt. And solvents cannot reach and dissolve dirt.

Cavitation and Implosion created by ultrasonic waves destroy such layer. Solvents then can touch and melt dirt. This method is ideal for cleaning up rough surfaces, cavities or holes in the inside of the device.

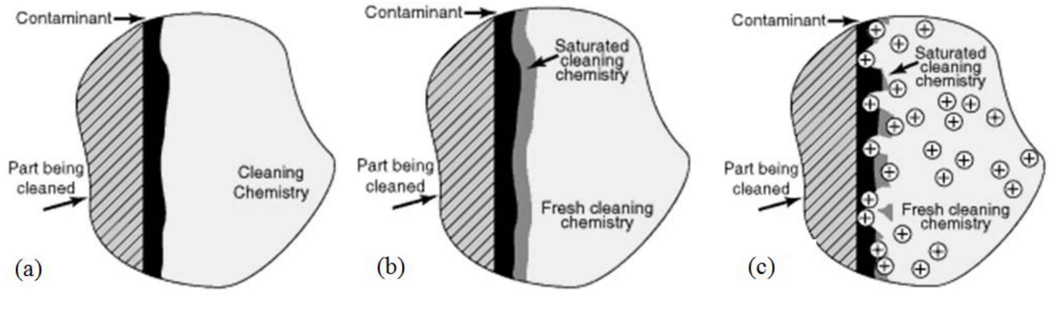

Fig.1. (a) Cleaning process**, (b)** Happen of transparent layers and (c) Destruction of the layer between the dirty surface and the solvent

Ultrasonic waves

It improves the speed of cleaning by dissolving certain types of dirt due to loose sticking of small particles with ionic strength, so this dirt can be eliminated by destroying gravity between the particles. Ultrasonic waves create cavitation and implosion to dissipate gravity between small particles. Dirt particles such as dust fall off the surface of the piece. And to get rid of dirt effectively, the medium (coupling medium) must be able to make the particles wet.

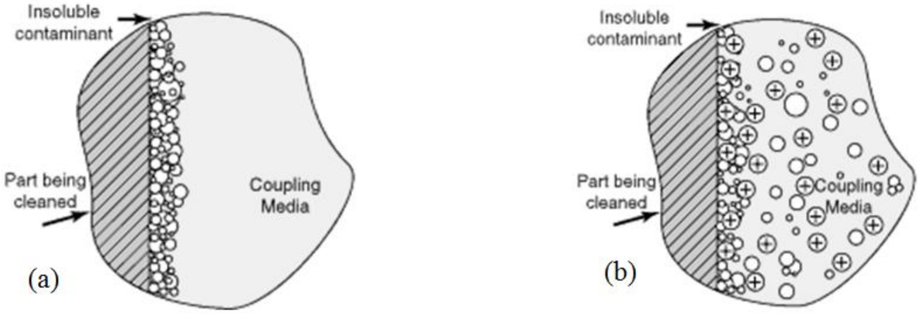

Fig. 2. (a) Particles of impurities attached and (b) Particles of impure impurities [1]

Ultrasonic Transducers

Ultrasonic transducers, which are used today, are of two types, the Magnetostrictive and the Piezoelectric Transducer, which differ in the way they are used to convert electrical energy into mechanical energy. (shaking)

Piezoelectric

The piezoelectric transducer transforms the AC power into direct mechanical energy by using a piezoelectric effect, which makes some materials change size and vibration. By passing electricity through the material, high-frequency ultrasonic power is transmitted from the ultrasonic generator to the piezoelectric transducer, and the transducer supplies the high-frequency energy it receives to be vibration and vibration size. The quake will be magnified. The rhythmic movement of the two materials is the steel back mass and the aluminum coupling mass. The vibration is then transferred to the fluid medium.

In the early days, materials were used to create Piezoelectric effect inside the transducer is quartz and barium titanate which it has brittle and unstable properties, making this type of transducer not popular. But today the material used is ceramic which is stronger higher performance and more stability. These materials are the result of efforts by the US Navy to develop sonar systems from 1940 to 1949, and today the piezoelectric transducer has been used for cleaning purposes.

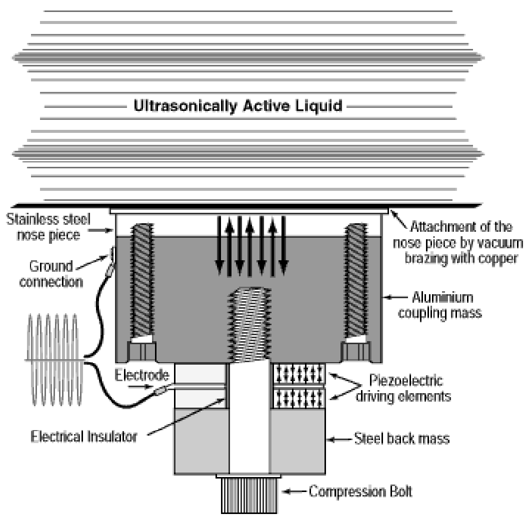

Fig. 3. Piezoelectric Transducer

Design and construction

Control circuit design.

Frequency Design for IC#SG3525A

By configuration calculate the R_T from the equation

$$f = \frac{1}{C_T(0.7R_T + 3R_D)} = \frac{1}{0.7C_T R_T} \tag{1}$$

$$R_T = \frac{1}{0.7 \times f \times C_T} = \frac{1}{0.7 \times 28000 \times 0.01\mu F} = 5.102k\Omega \tag{2}$$

Thus, when adjusting the R_T value of 5 kΩ, the 28 kHz frequency is used. In this research, the resistor value is adjusted to 10 kΩ.

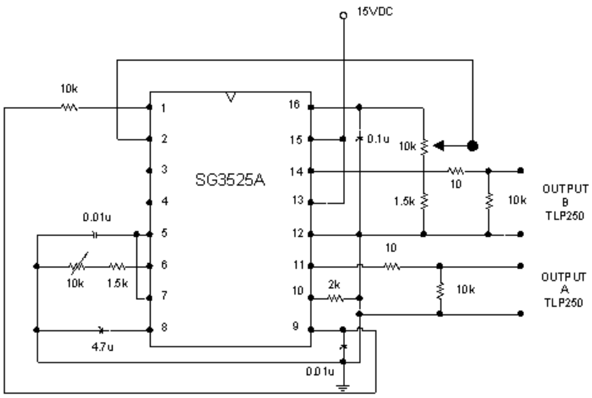

Fig. 4. Connecting the IC#SG3525A

Gate circuit design

Since ground is very important in the control and power sectors, the ground will not be connected. This research then uses the optocouple #TLP250 as the control link to the Power MOSFETs as shown in Fig.5.

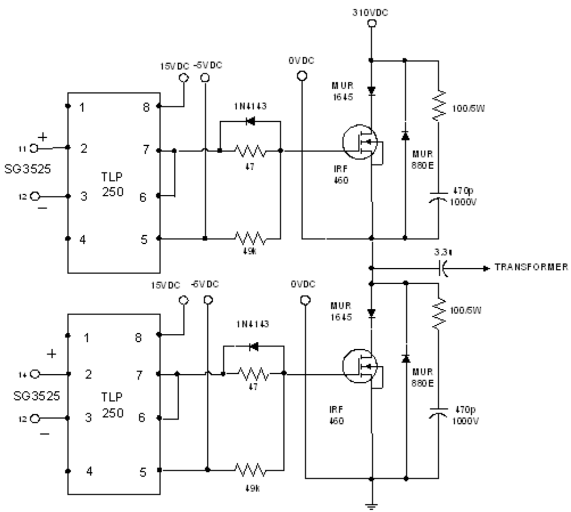

Fig. 5. Gate drive circuit

Structure of industrial ultrasonic wave washers. It contains the following components.

(1). Transducer drive circuit
(2). Ultrasonic transducer
(3). Cleaning tank part
(4). High frequency high voltage switching power supply

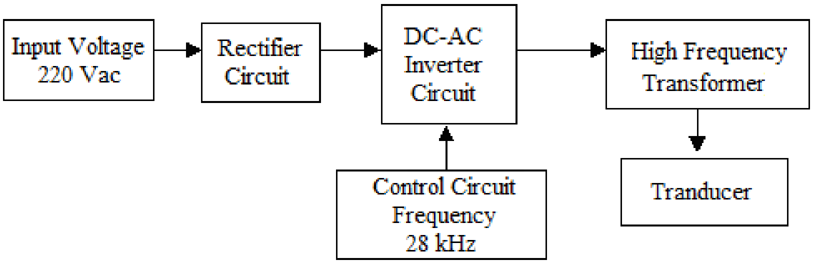

Fig. 6. Block diagram of high frequency high voltage switching power supply

High frequency high voltage switching power supply circuit.

In this study, the IC#3525A was used in the control circuit in the voltage mode. This is Pulse Width Modulator with a constant slope. The pulse output period can be determined from the values of R_T and C_T from the outside at pin 5 and pin 6, with a flywheel circuit. High frequency Transformer#FAT183 is a pressure booster. The switching frequency is 28 kHz.

Results and Discussion

Tests of measurement of Ultrasonic Transducer Parameters

The purpose is to determine the frequency of ultrasonic transducer responds and gives maximum power.

Test Equipment:

(1). Ultra Sonic Transmitters 1 head
(2). Hewlett Packard Network Analyzer 8751A

Test procedure:

(1). Reset the machine.
(2). Set the sweep frequency from 25 kHz to 50 kHz.
(3). Record the frequency of ultrasonics transducer into the test table.

Table 1. Parameters of ultrasonics transducer

The number of times in tests Transducer	The frequency with which the value of the maximum response (kHz)
1	28.932
2	28.687
3	28.687
4	28.762
5	28.604
6	28.755

From Table 1, when testing the parameters of the ultrasonic transducers at the average frequency of 28.738 kHz is the maximum power frequency. And concluded that the ultrasonic transducer is equal to 28 kHz

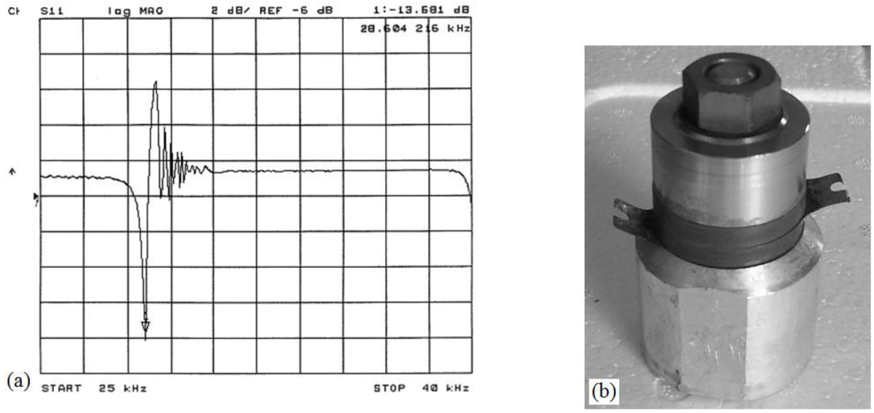

Fig. 7. (a) Ultrasonics frequency response graph transducer and (b) Ultrasonics transducer used in power 70 watts per head

Table 2. Electrical parameters of high voltage switching power supply (Using a fixed 28 kHz frequency)

$V_{in(rms)}$ (V)	$I_{in(rms)}$ (A)	P_{in} (W)	PF	$V_{out}(V_{p-p})$
220	1.91	348.76	0.83	992

Electrical parameter in Table 2.

$V_{in(rms)}$ is the input voltage of the high voltage power supply.

$I_{in(rms)}$ is the alternating current of the the high voltage power supply.

P_{in} is the input power of the the high voltage power supply.

PF is the power factor of the high voltage power supply.

V_{out} is the output voltage of the high frequency transformer while distributing for ultrasonics transducer.

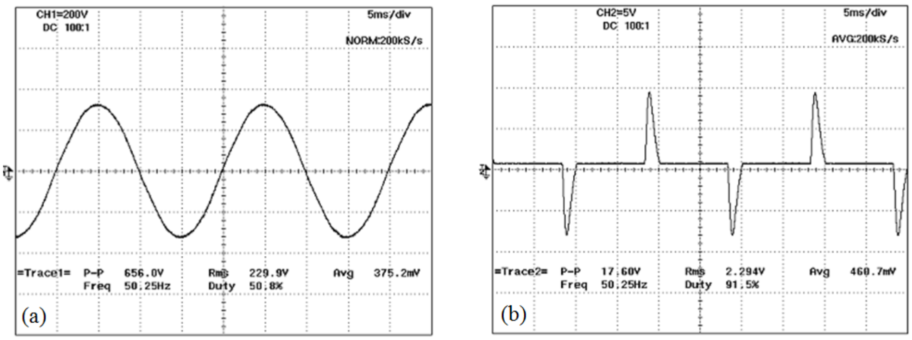

Fig. 8. (a) System input voltage signal while driving an ultrasonics transducer using probe x 100 and (b) Signal input current of the system while driving an ultrasonic transducer using current probe 10 mv/A

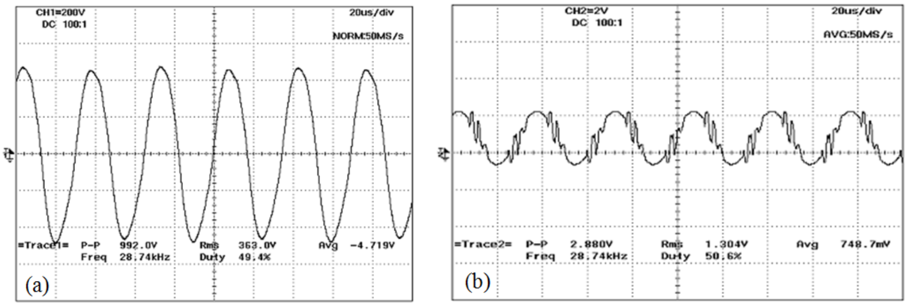

Fig. 9. (a) High frequency transformer output signal with probe x 100 and (b) High frequency transformer output current with current probe 10 mv/A.

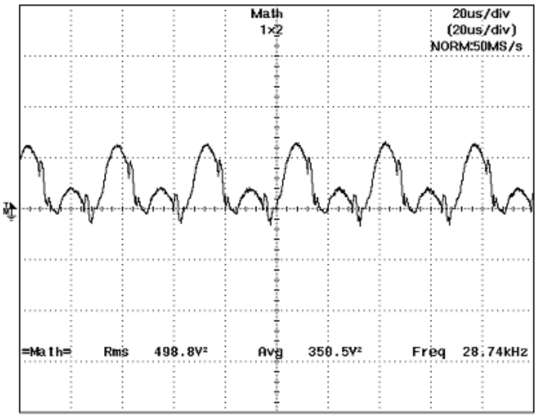

Fig. 10. High frequency transformer output power using Probe x 100 and current probe 10 mV/A.

Testing of small plate washing metal material by the power of ultrasound sonic.
Various types of dirt cleaning tests are available the following steps of test:

(1). Turn on the small motor cleaner created.
(2). Take a small engine parts wash simultaneously by using water as an intermediary.
(3). Set cleaning time about 5 minutes.
(4). Save the results in Table 3 by checking cleanliness of the engine parts.

Table 3. The results of cleaning various dirt's of the metal material parts.

The dirty kind	time (minutes)	Performance Cleaning
Rust	5	70%
Oil stains	5	90%

The cleaning performance is calculated from the weight of the engine parts before and after cleaning it used to calculate performance.

$$\% \text{ Performance} = (\text{after cleaning} / \text{weight before cleaning}) \times 100 \qquad (3)$$

From Table 3, it took 5 minutes to clean, because the 5 minute test would be the best time to clean the workpiece. If it lasts longer or less the workpiece is not clean as it should.

Conclusion

Partial cleaning is to test metal material (engine part) with ultrasonic wave energy. The test is divided into two main parts: Part 1 was tested to find the frequency appropriate to the efficiency of ultrasonics transducer. The test result was a suitable frequency of 28 kHz and the second was tested for the percentage of washing performance. The result is a clearer percentage of rust. The appearance of oil stains and rust stains are structurally of different molecules. Therefore, this ultrasonic wave has a high performance ideal for use to clean metal material.

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