UNIVERSITY OF ÇUKUROVA
INSTITUTE OF NATURAL AND
APPLIED SCIENCES

MSc THESIS

Zehan KESİLMİŞ

UTILIZATION OF ULTRASONIC ENERGY IN TEXTILE WET PROCESSING

151536

DEPARMENT OF ELECTRICAL AND
ELECTRONICS ENGINEERING

ADANA,2004

ÇUKUROVA ÜNİVERSİTESİ

FEN BİLİMLERİ ENSTİTÜSÜ

UTILIZATION OF ULTRASONIC ENERGY IN TEXTILE WET PROCESSING

Zehan KESİLMİŞ

YÜKSEK LİSANS TEZİ

ELEKTRİK-ELEKTRONİK MÜHENDİSLİĞİ ANABİLİM DALI

Bu tez 16/08/2004 Tarihinde Aşağıdaki Jüri Üyeleri Tarafından Oybirliği/Oyçokluğu İle Kabul Edilmiştir.

İmza:....................	İmza:....................	İmza:....................
Yrd.Doç.Dr.Murat AKSOY	Prof.Dr.Süleyman GÜNGÖR	Doç.Dr.Osman BABAARSLAN
DANIŞMAN	ÜYE	ÜYE

Bu tez Enstitümüz Elektrik-Elektronik Anabilim Dalında hazırlanmıştır.
Kod No: 2388

T.C. ÇUKUROVA ÜNİVERSİTESİ FEN BİLİMLERİ ENSTİTÜSÜ MÜDÜRLÜĞÜ 1923

Prof. Dr. Fikri AKDENİZ
Enstitü Müdürü

Bu çalışma Çukurova Üniversitesi Bilimsel Araştırma Projeleri Birimi Tarafından Desteklenmiştir.
Proje no:MMF2003YL33

ABSTRACT

MSc THESIS

UTILIZATION OF ULTRASONIC ENERGY IN TEXTILE WET PROCESSING

Zehan KESİLMİŞ

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

INSTITUTE OF NATURAL AND APPLIED SCIENCES

UNIVERSITY OF ÇUKUROVA

Supervisor: Assist. Prof. Dr. Murat AKSOY

Year: 2004, Page: 31

Jury: Assist. Prof. Dr. Murat AKSOY

Prof. Dr. Süleyman GÜNGÖR

Assoc. Prof. Dr. Osman BABAARSLAN

In this study, it is attempted to designing and realizing ultrasonic cleaning system that will be used to remove weakly bounded dye particles on new colored fabrics. In order to achieve desired goal, ultrasonic cleaning system will be design and simulate in finite element method simulation program.

Application fields of ultrasonic energy are very wide. These are medical, military, marine, chemistry and cleaning. Ultrasonic cleaning systems consist of at least one ultrasonic transducer, ultrasonic generator and cleaning tank. Ultrasonic transducer converts electrical signals to mechanical vibration at ultrasonic frequencies.

Keywords: Ultrasonics, Simulation, Piezo transducer

ÖZ
YÜKSEK LİSANS TEZİ

ULTRASONİK ENERJİNİN TEKSTİL YAŞ İŞLEMLERİNDE KULLANIMI

ZEHAN KESİLMİŞ

ÇUKUROVA ÜNİVERSİTESİ FENBİLİMLERİ ENSTİTÜTÜSÜ
ELEKTRİK-ELEKTRONİK MÜH. ANABİLİM DALI

Danışma: Yrd. Doç. Dr. Murat AKSOY
Yıl:2004, Sayfa: 31

Jüri: Yrd. Doç. Dr. Murat AKSOY
Prof. Dr. Süleyman GÜNGÖR
Doç. Dr. Osman BABAARSLAN

Bu tez çalışmasında yeni boyanmış kumaş üzerindeki gevşek bağlı boya partiküllerini ultrasonik yöntemle sökecek bir temizleme cihazının imalatı hedeflenmektedir. Bu hedef gerçekleştirilirken transducer modellemesinde ve simülasyonunda sonlu elemanlar metoduyla çalışan simülasyon programları kullanılacaktır.

Ultrasonik enerjinin tıp, ordu, denizcilik,kimya,temizlik gibi çok geniş kullanım alanları vardır. Ultrasonik temizlik sistemleri bir ultrasonik jeneratör en az bir ultrasonik transducer ve bir temizleme kazanından oluşmaktadır. Üretilen sinyaller ultrasonik transducerler tarafından mekanik titreşimlere çevrilmekte ve ortama uygulanmaktadır.

Anahtar kelimeler: Ultrasonik, Piezo transducer, Simülasyon

ACKNOWLEDGMENTS

I would like to express my gratitude to my supervisor Assist. Prof. Dr. Murat AKSOY for his guidance, suggestions, valuable information and supports. Without his supervision, motivation and help this study wouldn't be done.

A special thanks goes to Assoc. Osman BABAARSLAN for providing me valuable information and help.

Finally, I would like to thank my wife, Eylem KESİLMİŞ for her patience and support during the writing of thesis. I wouldn't have been in this position if I hadn't had the support and best wishes from my family, especially my mother, Hanife KESİLMİŞ. I would like to dedicate this work to my family.

CONTENTS **PAGE**

CONTENTS **PAGE**

LIST OF FIGURES **Page**

1.INTRODUCTION

Ultrasonics is the study of sound waves of frequencies higher than the upper hearing limit of human ear and has become synonymous with the applications and effects of ultrasonic vibration for other purposes than the excitation of the hearing mechanism. (William W. Seto 1971)

Pierre and Jacques Curie published the first experimental demonstration of a connection between macroscopic piezoelectric phenomena and crystallographic structure in 1880. Their experiment consisted of a conclusive measurement of surface charges appearing on specially prepared crystals (tourmaline, quartz, topaz, cane sugar and Rochelle salt among them), which were subjected to mechanical stress. These results were a credit to the Curies' imagination and perseverance, considering that they were obtained with nothing more than tinfoil, glue, wire, magnets and a jeweler's saw.

The first serious applications work on piezoelectric devices took place during World War I. In 1917, P. Langevin began to perfect an ultrasonic submarine detector. His transducer was a mosaic of thin quartz crystals glued between two steel plates, mounted in a housing suitable for submersion. Working on past the end of the war, they did achieve their goal of emitting a high frequency "chirp" underwater and measuring depth by timing the return echo. The strategic importance of their achievement was not overlooked by any industrial nation, however, and since that time the development of sonar transducers, circuits, systems, and materials has never ceased. (Mason, T.J (a), 1991)

Ultrasonic energy is widely used in ultrasonic cleaning, plastic welding, sonochemistry, medical and marine applications.

Sonochemistry is application field of ultrasound in chemistry. Positive effects of ultrasound to chemical reactions are:
(Mason, T.J (a), 1991) (Mason, T.J (b), 1991)

- Increasing the reaction speed
- Reducing costs
- Reducing reaction time
- Increasing efficiency of catalysts

Sonography is a technique that uses ultrasound signals to view hard to reach body areas. In scanning with ultrasound, high-frequency sound waves are transmitted to the area of interest and the returning echoes. After detecting and analysis of these echoes some image can be produce.

Purpose of the ultrasonic energy in underwater conditions is detecting objects. This is similar to radar for detecting objects in air. This technology is guided to the submarines under the deep sides of the oceans. Radars or other navigation systems are useless in these conditions. Otherwise ultrasonic energy can be useful to mapping the floor of the deep sea and detecting fishes or oil deposits beneath the ocean floor.

Aim of this study is realize an ultrasonic cleaning system. In order to do that, all of the components of ultrasonic cleaning systems will introduce in chapter 2. Types and feature of ultrasonic cleaners was introduced in chapter 3. Components of ultrasonic cleaning system are introduced in chapter 4. Simulation of Piezo transducer in finite element method program is widely explained in chapter 5.

2. INTRODUCTION TO ULTRASONIC CLEANING

Ultrasonic energy can able to reach internal areas of objects, which are not accessible using other methods such as brushing or conventional cleaning methods. In all industrial areas to get detailed cleaning ultrasonic energy is suitable. Ultrasonic cleaning is effective and using lower chemical concentrations and lower temperatures than alternative cleaning technologies. Usage of ultrasonic energy in the cleaning applications will reduce costs. In the ultrasonic cleaning system parts of every object can be cleaned effectively and without the risk of damage. Studies have shown that ultrasonic cleaning may be the lowest cost alternative compared to maintenance (Arseven R. M. 1998)

2.1 Cavitation

Characteristic property of water is that it is nearly incompressible. If a sound wave propagates through such a medium, areas of negative acoustic pressure cause the cavitation bubbles. These water vapor filled bubbles grow first during the negative acoustic pressure cycle and then collapse rapidly when the pressure of the sound wave is reversed. This collapse accompanies a violent implosion of the bubble, generating fluid jets and shock waves, which propagate into the fluid.

The micro agitation occurring in the vicinity of the cavitation bubble effectively displaces soil particles, which are bound to the fabric by ionic or cohesive forces.

In the same manner, cavitation also helps accelerate the dissolution of soluble contaminants.

It is certainly one of cavitations most beneficial attributes that this agitation takes place not only at the textile surface, but also deep within the structure of fabric. The waves interact with liquid media to generate cavitation implosions. High intensity ultrasonic waves create micro vacuum bubbles in the liquid medium, which grow to maximum sizes proportional to the applied ultrasonic frequency and then implode, releasing their energies.

At 28 kHz the bubble size is roughly 170 microns in diameter. At a higher frequency of 68 kHz, the total time from nucleation to implosion is estimated to be about one third of that at 25 kHz.

At different frequencies, the minimum amount of energy required to produce ultrasonic cavities must be above the cavitation threshold. In other words, the ultrasonic waves must have enough pressure amplitude to overcome the natural molecular bonding forces and the natural elasticity of the liquid medium in order to grow thecavities.

2.2 Cleaning time and temperature relationship

Researches on ultrasonic cleaning shows that in the ultrasonic cleaning process, increment of the value of the detergent is positively affected the total cleaning process. But there will be no positive effect like this in the traditional cleaning system. (Arseven.R. M. 1998)

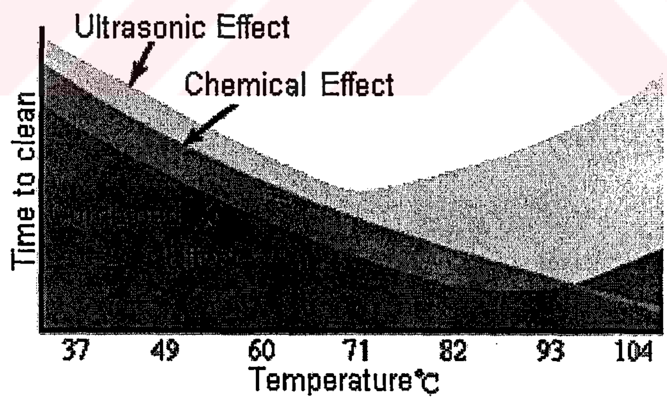

Figure 2.1. Temperature / Time to Clean Graph
(www.pmrsystems.com)

As shown in Figure 2.1 cleaning process time will be increase when the ultrasonic energy used by self over the 71 $°C$ temperatures and when the chemical cleaning process used by self there will be reverse proportion between cleaning time and temperature. As shown in figure2.1 shortest cleaning time is in combine effect. Combine effect is using chemical and ultrasonic effect same time in same environment. In order to using combine effect shortest cleaning time will be achieve by using to 82 to 93 $°C$.

2.3 Effects of Cavitation in Ultrasonic Cleaning

In cleaning process it is necessary for the solvent to contact with contaminant. In cleaning process a saturated layer develops at the interface between the cleaning chemistry and the contaminant as shown figure 2.2. Once saturated layer has existed, cleaning stops, as the saturated chemistry can no longer attack the contaminant. Cleaning chemistry cant reach the contaminant.

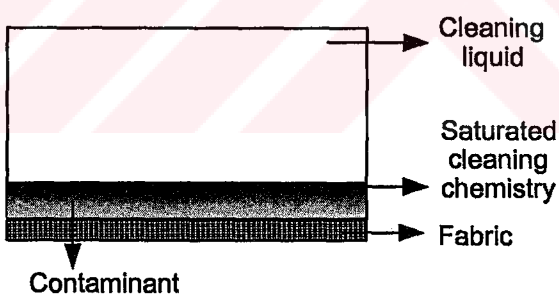

Figure 2.2 Contaminated Fabric

Ultrasonic cavitation and implosion effectively displace the saturated layer to allow fresh chemistry to come into contact with the contaminant remaining to be removed. This is an especially beneficial when irregular surface or internal passageways are to be cleaned.

For water, the minimum amount of energy needed to be above the threshold was found to be about 0.3 and 0.5 watts/cm^2 per the transducer radiating surface for 20 kHz and 40 kHz, respectively. The energy released from an implosion in close area to the surface collides with contaminants, allowing the detergent or the cleaning solvent to displace it at a very fast rate.The cumulative effect of millions of continuos tiny implosions in a liquid medium is what provides the necessary mechanical energy to break physically bonded contaminants, speed up the hydrolysis of chemically bonded ones and enhance the solubilization of ionic contaminants.The chemical composition of the medium is an important factor in speeding the removal rate of various contaminants

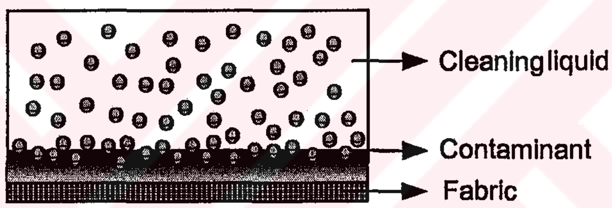

Figure 2.3 Effect of Cavitation on Fabric

Because of surfaces aren't flat. Conventional cleaning methods can useless in some conditions but ultrasonic energy develops cavitation in cleaning liquid to increase cleaning effect. Ultrasonic energy can effect hard to reach areas of the objects

3. ULTRASONIC CLEANING SYSTEMS

Components of an ultrasonic cleaning system are a cleaning tank that holds the cleaning liquid, at least one ultrasonic transducer (Piezo or magneto) and ultrasonic generator. These parts are almost fundamental in ultrasonic cleaning systems.

3.1 Tabletop Ultrasonic Cleaners

Small tabletop ultrasonic cleaners are suitable for cleaning small parts and accessories such as jewels, small gun parts, and metal parts of eyeglass. This cleaner consists of a built in ultrasonic generator, ultrasonic transducer and small sized cleaning tank. Power consumptions of that kind of cleaners are very low thanks to small tank volumes (approximately 500mL). Ultrasonic power requirement of tabletop cleaners are low respect to industrial cleaners.

Figure 3.1. Tabletop Ultrasonic Cleaner
(www.Bransonultrasonics.com)

3.2 Industrial Ultrasonic Cleaners

Tank dimensions and tank volume of industrial ultrasonic cleaners are very big respect to tabletop cleaners. For this reason needed amount of ultrasonic power is bigger than all other.

Some Industrial Ultrasonic cleaners have got additional parts such as drying, rinsing tanks, loading and unloading mechanism that allows to automation. In Continuous cleaning process loading mechanism is very important feature especially such fabric cleaning systems.

The frequencies used for ultrasonic cleaning range from 20 kHz to 100 kHz. The most commonly used frequencies for industrial cleaning are those between 20 kHz and 50kHz. Frequencies above 50kHz are more commonly used in small tabletop ultrasonic cleaners such as those found in jewelry stores and dental offices.

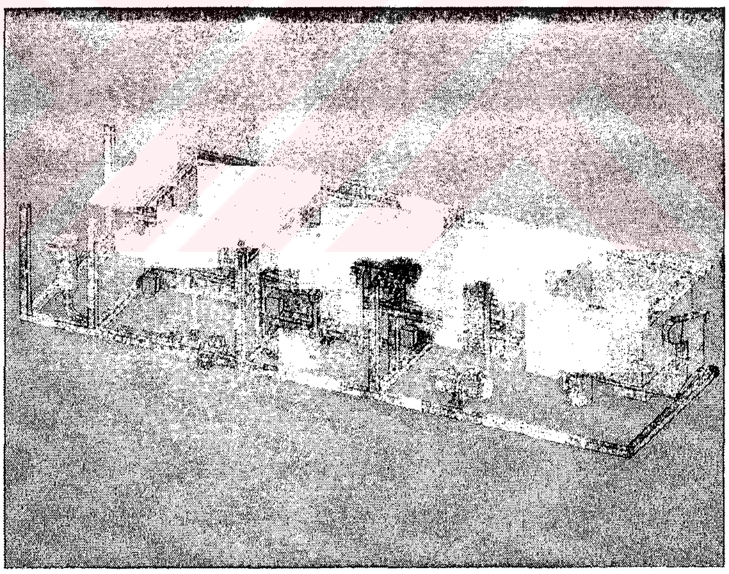

Figure 3.2. Industrial Ultrasonic Cleaner
(www.Mpi-ultrasonics.com)

3.3 Materials of Ultrasonic Cleaners

3.3.1 Ultrasonic Transducers

Purpose of transducer is converting electrical energy to mechanical vibration, which is in ultrasonic frequencies. In generally Piezo and magneto transducers are widely used in ultrasonic cleaning applications. Working principle and features are different from each other. But they can accomplish the same task.

3.3.1.1 Magnetostrictive Transducers

When a rod of magnetizable material is exposed to a magnetic field, which varies in magnitude, the rod changes in length. An alternating current passing through a coil surrounding such a rod will cause it to vibrate longitudinally.
This small forced vibration amplitudes will increase very greatly if the frequency of the applied current coincides with one of the normal longitudinal modes of vibration of the rod. Ultrasonic sound of this frequency is radiated. (William W. Seto, 1971)

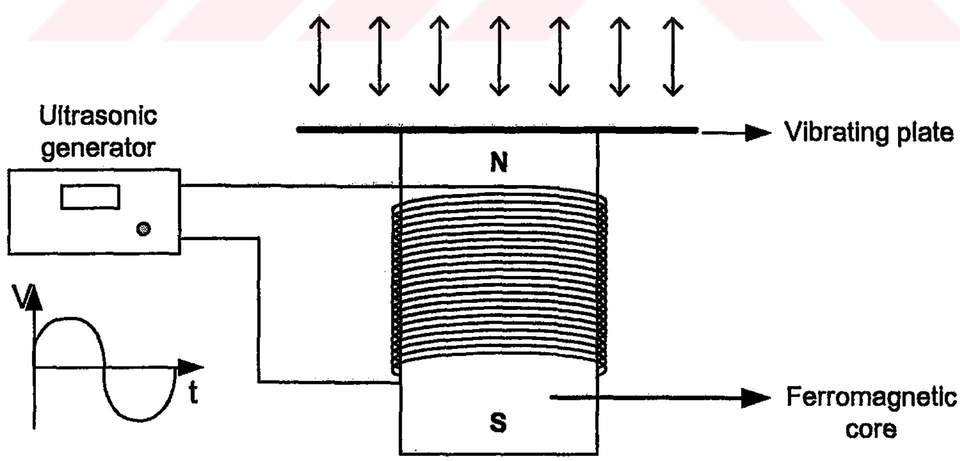

Figure 3.3 Magnetostrictive Transducer

3.3.1.2 Piezo Transducers

Piezoelectric transducers are usually made from quartz, tourmaline, Rochelle salt, ammonium di-hydrogen phosphate, barium titanate and ceramic having strong ferroelectric properties. (William W. Seto, 1971)

Figure 3.4 illustrates design of Piezo transducer. Piezo transducers can be built around PZT4 or PZT8 Piezo crystal materials. The design shown in Figure 3.4 consists of two PZT rings clamped between two end pieces by means of a bolt.

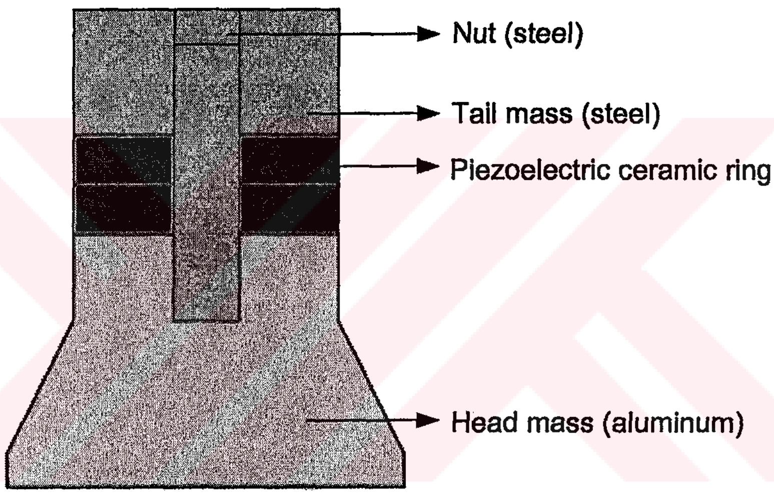

Figure 3.4. Piezo transducer

Sound velocity in Piezo transducer is approximately 3200 m/s. To reach the required output power level, the ultrasonic transducer would need a large surface area. The resulting single piece ceramic block can present manufacturing problems. And such blocks might be relatively inefficient. In a Piezo transducer, the stress amplitude reaches a maximum in the centre, the two end portions acting mainly as inert masses. These end portions can therefore be replaced by metal parts, which are cheaper and have a higher mechanical quality factor.

3.3.2 Introduction Piezoelectric Material

3.3.2.1 Piezo Effect

Piezo material is such that when it is subjected to a mechanical load, it generates an electric charge. This effect is usually called the "Piezo electric effect". Conversely, when piezoelectric material is stressed electrically by a voltage, its dimensions change. This phenomenon is known as the inverse Piezo electric effect. (Qing-Hua Qin 2001)

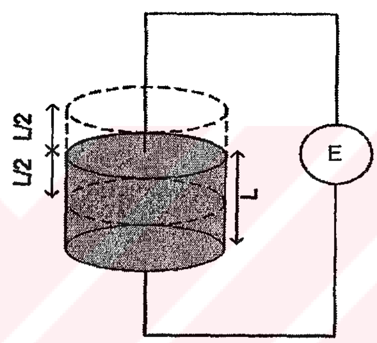

Figure 3.5. Piezo Transducer
(William W. Seto, 1971)

3.3.2.2 Electrical Model of Piezo Transducer

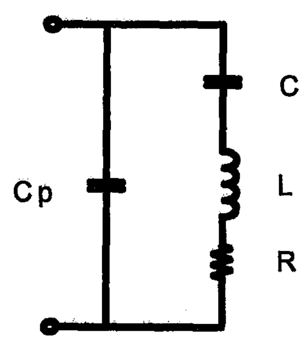

Figure 3.6. Electrical Model of Piezo transducer
(William W.Seto, 1971)

The frequencies of the electrical resonance and anti-resonance are given by the following equations (which assume a small series resistance R):

$$f_{resonance} = \frac{1}{2\pi\sqrt{LC}} \text{ Hz} \quad (1) \qquad f_{anti-resonance} = \frac{1}{2\pi\sqrt{L\frac{C.C_p}{C+C_p}}} \text{ Hz} \quad (2)$$

3.3.3 Ultrasonic Generator

The block diagram of an ultrasonic generator as shown in figure 3.7. The ultrasonic generator is built up Power supply, Sine wave generator and Power output stage with matching transformer. Sine wave generator generates the main signal. Power amplifier converts the power of sine wave signal to required level to supply transducers. Power supply unit provides electricity needed by amplifier and signal generator. (Morgan Electroceramics Technical Publications, 2004)

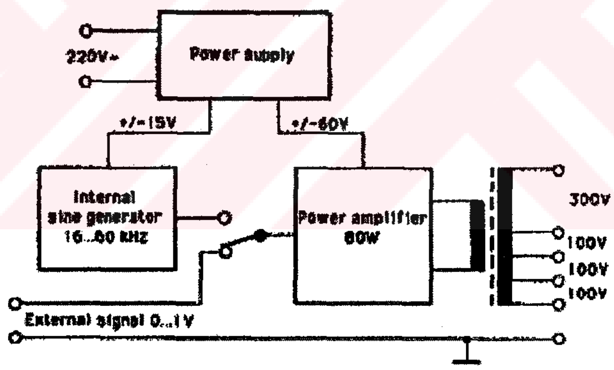

Figure 3.7. Block Diagram of Ultrasonic Generator
(Morgan Electroceramics Technical Publications, 2004)

3.3.4 Cleaning Tank

Cleaning tank is a passive component of ultrasonic cleaning system but it's important. Purpose of the cleaning tank is holding all of the components except ultrasonic generator. In some cleaners (such as tabletop cleaners) tank holds the ultrasonic generator. Also all to cleaning process realize in the cleaning tank. Fabric that will be clean travels in the cleaning tank one side to other side. In the cleaning tank fabric is meets the water and ultrasonic energy. This section is the heart of the cleaning process. Ultrasonic energy removes weak bounded paint particles. End of the traveling fabric leaves the cleaning tank.

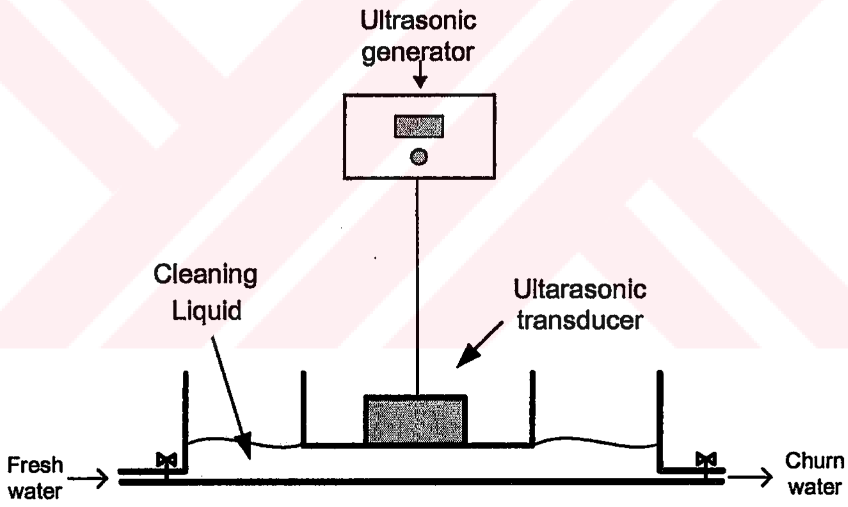

Figure 3.8. Ultrasonic Cleaning System

4. FINITE ELEMENT METHOD SIMULATION

In the field of Engineering Design we come across many complex problems, the Mathematical Formulation of which is tedious and usually not possible by analytical methods. At such instants we resort to the use of Numerical techniques. Here lies the importance of Finite element method (FEM), which is a very powerful tool for getting the Numerical solution of a wide range of Engineering problems. The basic concept is that a body or structure may be divided into smaller elements of finite dimensions called as "Finite Elements". The original body or structure is then considered as an assemblage of these elements connected at a finite number of joints called as "Nodes" or "Nodal Points". The properties of the elements are formulated and combined top obtain the properties of the entire body.

The equations of equilibrium for the entire structure or body are then obtained by combining the equilibrium equation of each element such that the continuity is ensured at each node. The necessary boundary conditions are then imposed and the equations of equilibrium are the solved to obtain the required variables such as Stress, Strain, Temperature Distribution or Velocity Flow depending on the application.

Thus instead of solving the problem for the entire structure or body in one operation, in the method attention is mainly devoted to the formulation of properties of the constituent elements. A common procedure is adopted for combining the elements, solution of equations and evaluation of the required variables in all fields. Thus the modular structure of the method is well exploited in various disciplines of Engineering. (Tirupathi R. Chandrupatla, Ashok D. Belegundu, 2001)

With start of project we were looked for the powerful and reliable simulation program. After a literal search some programs are go to the fore. These are ANSYS ATILA and GiD.

ANSYS finite element analysis software enables engineers to perform the following tasks:

- Build computer models or transfer CAD models of structures, products, components, or systems.
- Apply operating loads or other design performance conditions.
- Study physical responses, such as stress levels, temperature distributions, or electromagnetic fields.
- Optimize a design early in the development process to reduce production costs.
- Do prototype testing in environments where it otherwise would be undesirable or impossible (for example, biomedical applications).

The ANSYS program has a comprehensive graphical user interface (GUI) that gives users easy, interactive access to program functions, commands, documentation, and reference material. An intuitive menu system helps users navigate through the ANSYS program. Users can input data using a mouse, a keyboard, or a combination of both.

ANSYS is the well-known and useful finite element method simulation program. But it was very hard to obtain demo or student version. So we can't obtain demo or educational version of ANSYS. After all we choose the ATILA simulation program to simulating our system.

ATILA can be used with GiD program. GiD is a pre/post-processing program. That program creates complex geometries, generate a mesh on them, and finally view the results of the analysis. Also GiD supports various problem types. These are ANSYS5.5, ATILA, Caltep200, Nastran2, Ramseries2, Ramseries4, Ramseries5 and Tdyn4.

Features and Purposes of These Plug-ins:

- Tdyn is a three-dimensional environment for fluid-dynamic and heat-transfer analysis (CFD) based on the Finite Element Method.
- Ram series is a three-dimensional structural analysis environment for calculations of solid elements based on the Finite Element Method.

NASTRAN Interface is an application acting as a bridge between the pre/post-processing program GiD and the most popular commercial NASTRAN codes. (www.gid.cimne.upc.es)

4.1 GiD Personal and Postprocessor

GiD has been designed as a universal, adaptive and user-friendly graphical user interface for geometrical modeling, data input and visualization of results for all types of numerical simulation programs. Typical problems that can be successfully tackled with GiD include most situations in solid and structural mechanics, fluid dynamics, electromagnetic, heat transfer, geo-mechanics, etc. using finite element, finite volume, boundary element, finite difference or point based (mesh less) numerical procedures

GiD is ideal for generating all the information (structured and unstructured meshes, boundary and loading conditions, material types, visualization of results, etc.) required for the analysis of any problem in science and engineering using numerical methods. GiD is extremely easy to adapt to any numerical simulation code. (www.gid.cimne.upc.es)

In fact, the user to read and write data in an unlimited number of formats can define GiD. GiD 's input and output formats can be customized and made compatible with any existing in-house software. The different menus for data input and results visualization can be tailored to the specific needs and desires of the user.

The development of GiD has been focused on the needs of the user and on the simplicity, speed, effectiveness and accuracy the user demands at input data preparation and results visualization levels. GiD support various problem types these problem types are work like package programs in side the GiD graphical interface.
In this thesis working used problem type is ATILA. (www.gid.cimne.upc.es)

4.2 Modeling Sandwich Piezo Transducer in GiD

Designing and simulation in GiD consists of two-sub division. These are pre and post process. Preprocess covers drawing the cross-section of transducer, definition of used material (such as Aluminum, steel, Piezo) meshing. Post process covers calculating and obtaining result.

Modeling Piezo transducer task begins with plain screen in GiD environment. After choosing ATILA tool in menu a new tool bar appears left hand side of the screen. This tool bar is very simple and very skilful.
In order to simulate sandwich type Piezo transducer project begins with drawing cross-section of transducer. In figure 4.1 cross-section of sandwich Piezo transducer is given.

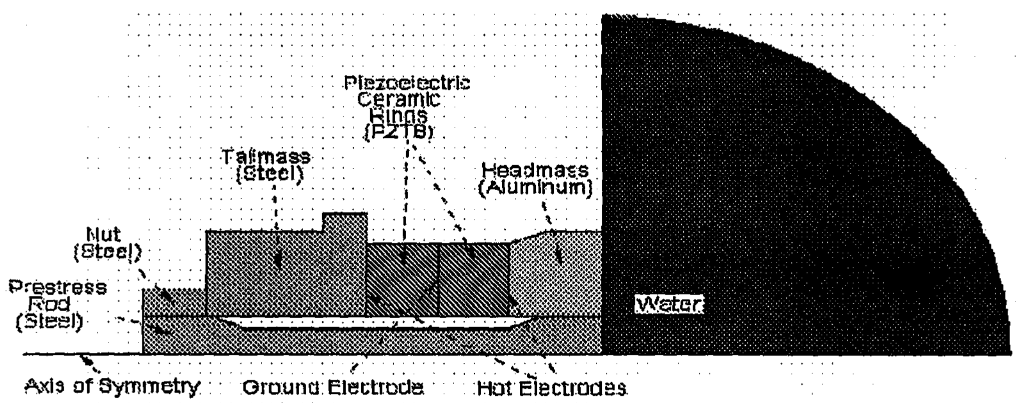

Figure 4.1. Cross-section of Piezo Transducer
(www.gid.cimne.upc.es)

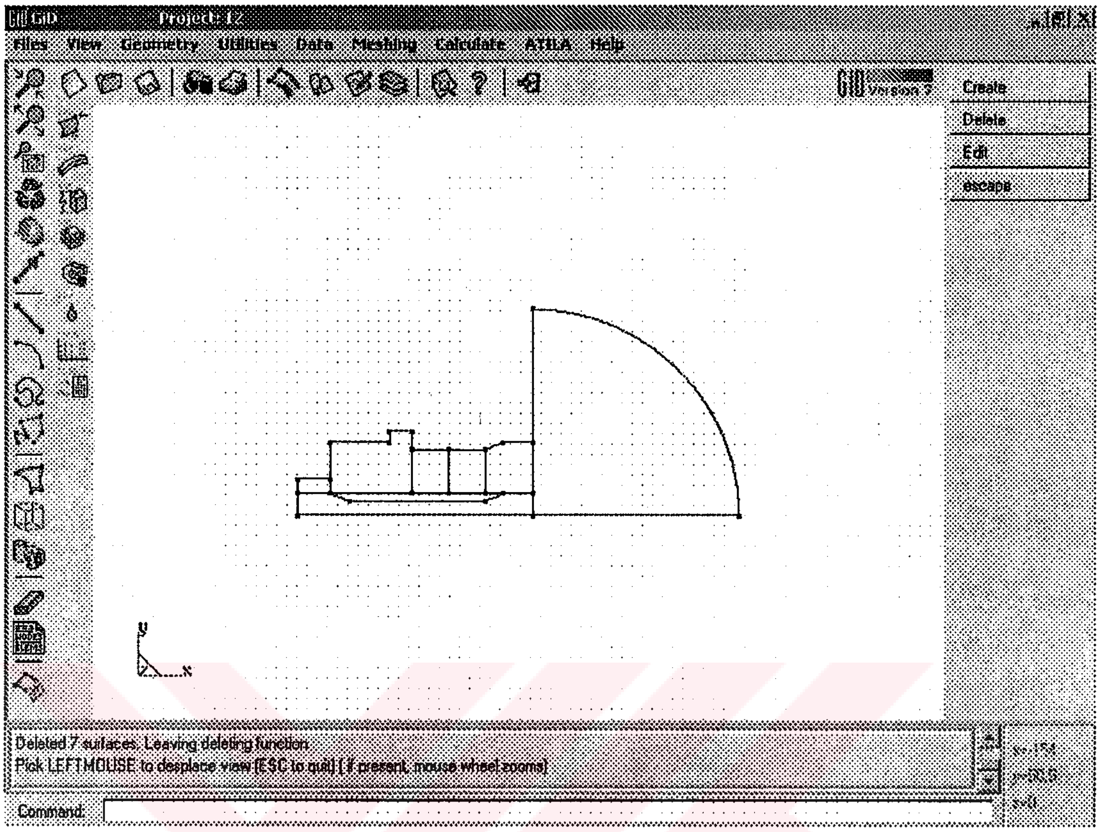

Figure 4.2. Drawing of Piezo Transducer

After drawing cross-section form of transducer, next step will be assignment of the surfaces. To perform this task "create-Nurbs surfaces" command or "surface" button will helpful. After assignment of all the surfaces drawing of Piezo transducer is shown figure 4.3. When the surface task accomplished, assignment of material can start.

In the material assignment section user can use button that found in ATILA tool with name of "assign elastic material". All of material in Piezo transducer can be found in this sub menu. Form of drawing illustrated picture after the assignment of materials. As illustrated in the figure 4.4 Piezo transducer consist of aluminum, steel and Piezo material.

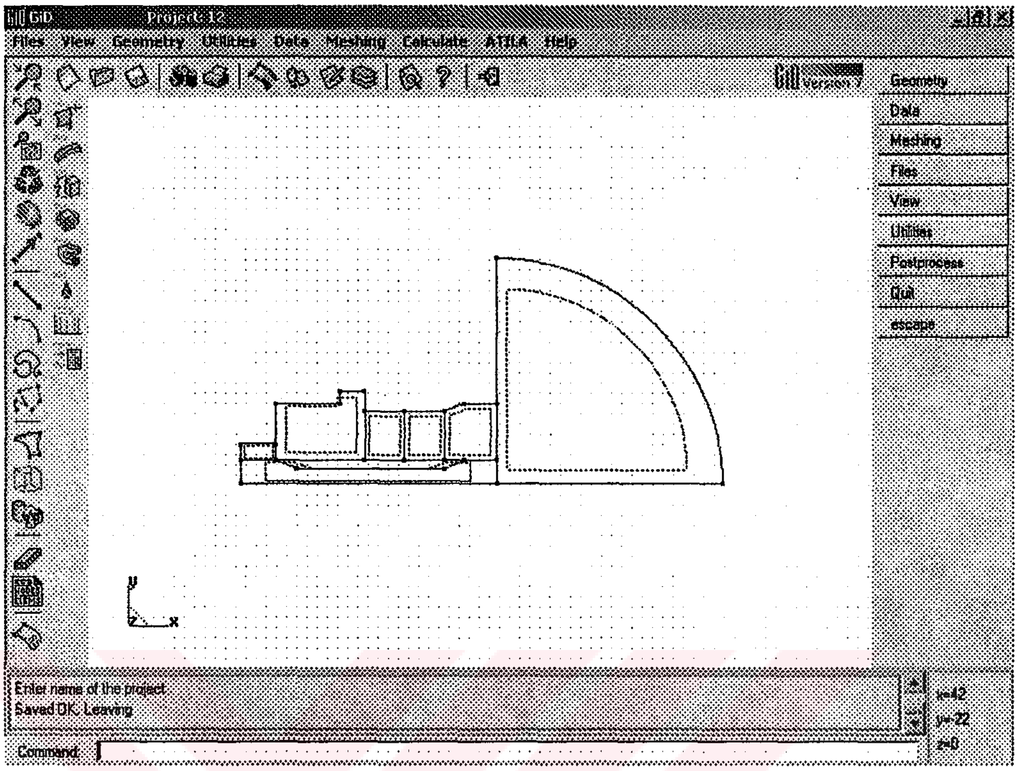

Figure 4.3. Piezo Transducer with Surfaces

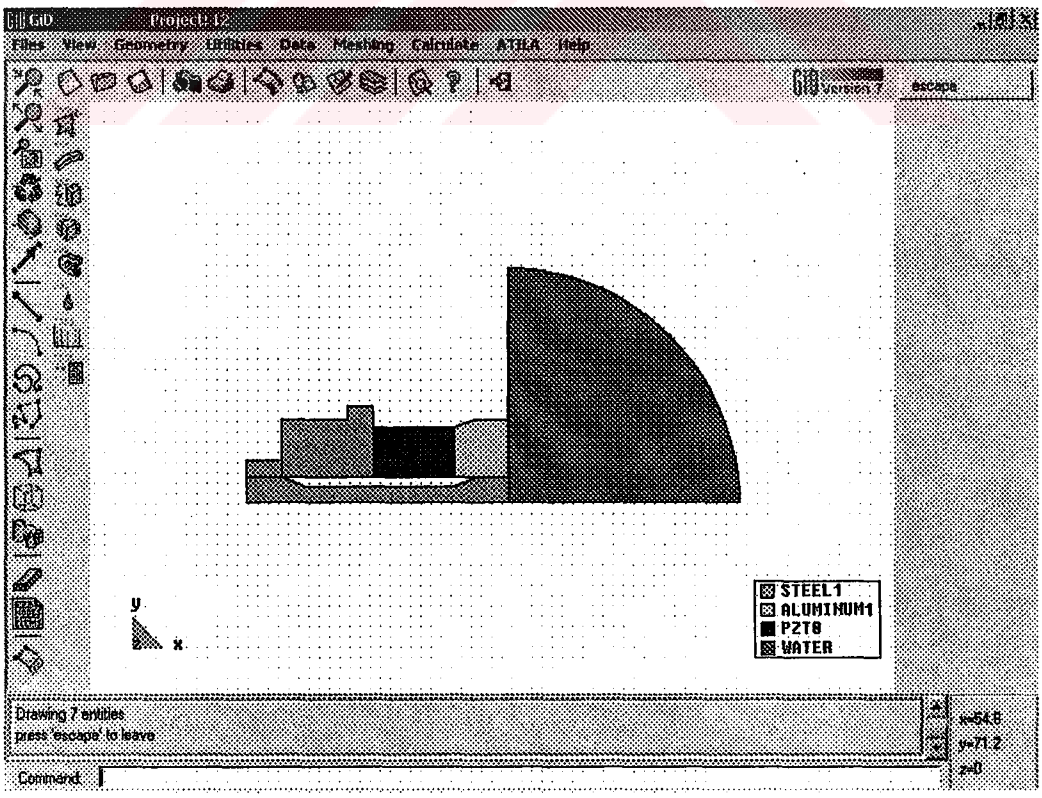

Figure 4.4. Materials on Piezo Transducer

In all simulation tasks meshing is indispensable. Academic demo version of GiD is allows just 300 nodes. This restriction affects the resolution of results. Meshed view of transducer is illustrated in figure 4.5.

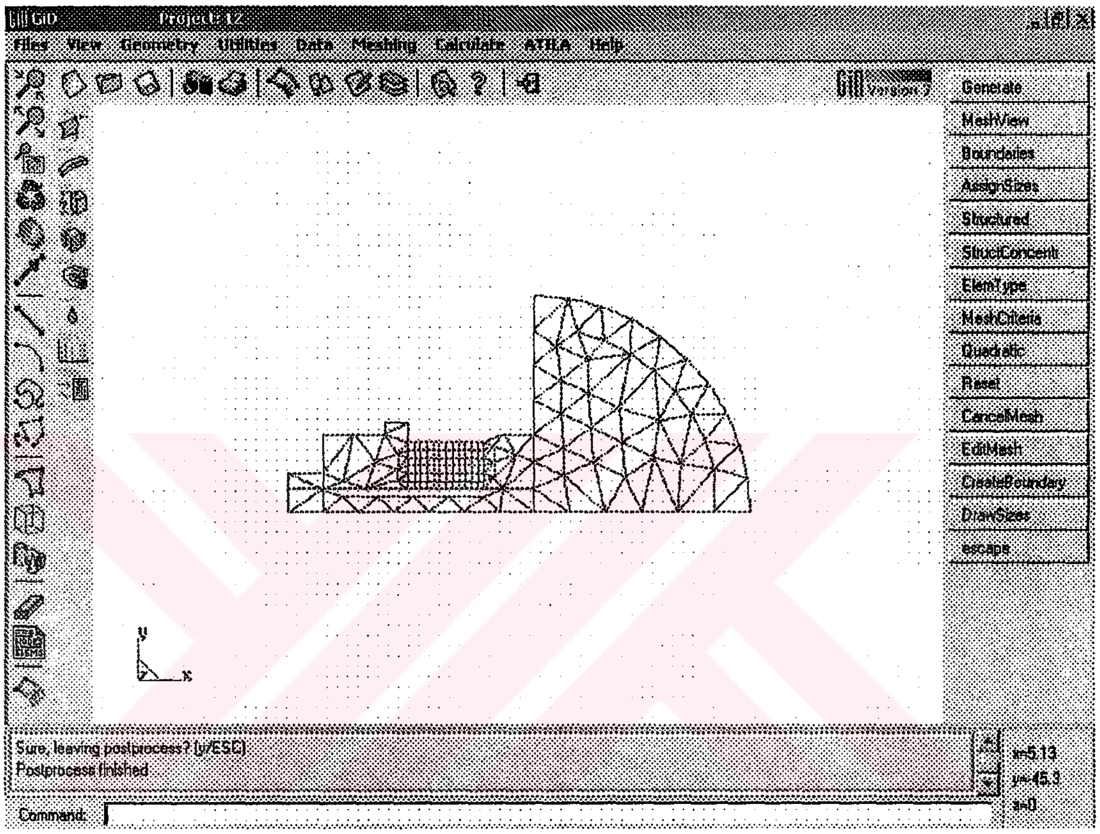

Figure 4.5. Mesh view of Piezo Transducer

After completing the meshing section next task will be “calculate”. By using calculate menu, user can begin and manage the analysis of the problem. Calculate section is end part of preprocess. After the calculate process user can switch the environment to post process by using postprocess button.

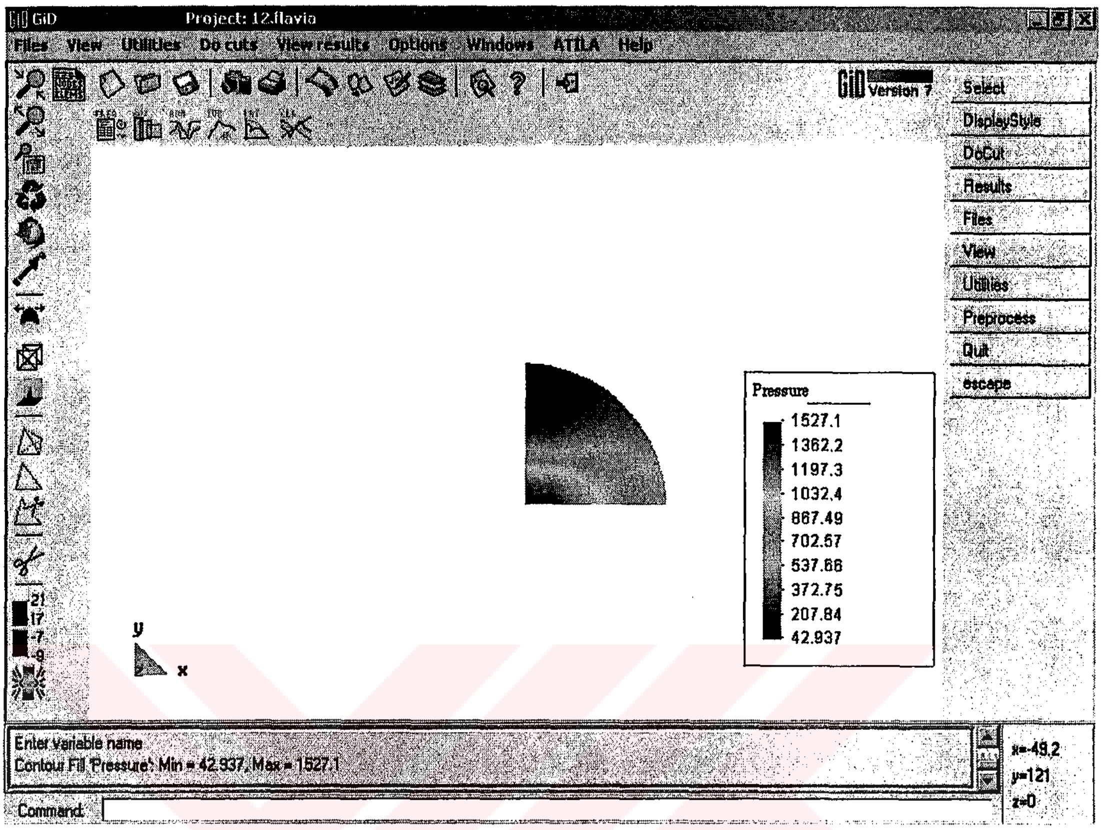

Figure 4.6. Fluid Pressure Results

User can use the "view results" pull down menu to view simulation results. Results are fluid pressure, potential, displacement, stress of Piezo material. After giving "view results" command by using menu button a new window will pop up. This window is illustrated in the figure 4.6. Working frequencies was determined in designing section. Frequencies are listed in the step menu

4.3 Results of simulation

Simulation output format is fluid pressure. Arranged output graph is illustrated in figure 4.7.

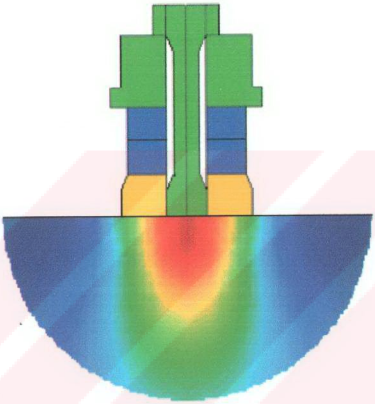

Figure 4.7. Pressure Distribution Under Piezo Transducer

Ultrasonic power distribution graph is colored from red to black. This means powerful areas illustrated with red color and weak areas are illustrated with black color. Red areas are can be useful in view point of ultrasonic power but area of red is very narrow. Best result can be taken by using green area. Because green area is wide respect to all other areas and power of green satisfactory to cleaning. To using green area total distance between fabric and transducer must be 2.5 cm.

5.DESIGNING AN ULTRASONIC CLEANING SYSTEM

Beginning of the design first problem was determining the cleaning volume. This parameter was very important than other. So total ultrasonic power can calculate from this parameter. Overall cleaning volume can be calculated by subtraction the cylinder and other components volume from tank volume.

Power/volume graph is used to determine right power value in our cleaning system. This graph obtained end of the cleaning experiments. To obtain best cleaning results there are several factors. One of them is ultrasonic power. Our cleaning tank is little bit short than original industrial cleaning system. Because of all the experiments made in laboratory environment and there is some space limitations.

After the construction of cleaning tank total liquid capacity is appears. Liquid capacity value is equals to total tank volume minus all other component volume inside the tank such as cylinder.

Total ultrasonic power can determine helps by graph, which is shown below. Cleaning tank capacity is approximately 20 liters. Volume of the cylinders inside of the tank is 5 liters. From this basic equation total liquid capacity is 20 liters.
Required total ultrasonic power is 15 (watt/liter) x 20 (liters) = 300 Watts.

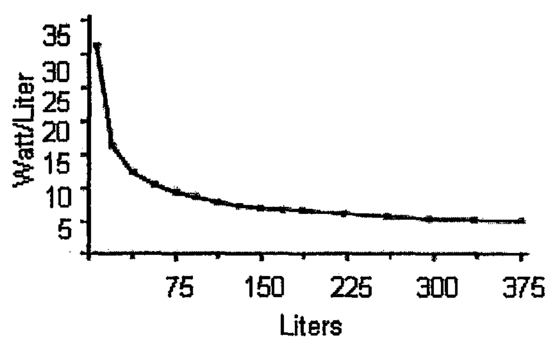

Figure 5.1. Watt-Liter Graph
(www.Pmrsystems.com)

5.1 Multi-tank Ultrasonic Cleaning System

Multi-tank ultrasonic cleaners include an ultrasonic cleaning tank, followed by a rinse tank. Typical designs include the cleaning tank, 1 or 2 rinse and 1 pre wash tank to remove detergent residues and improve cleaning effect some designs can have a drying tank. To obtain best result from ultrasonic cleaning system a rinse tank and a pre wash tank added to ultrasonic cleaning system.

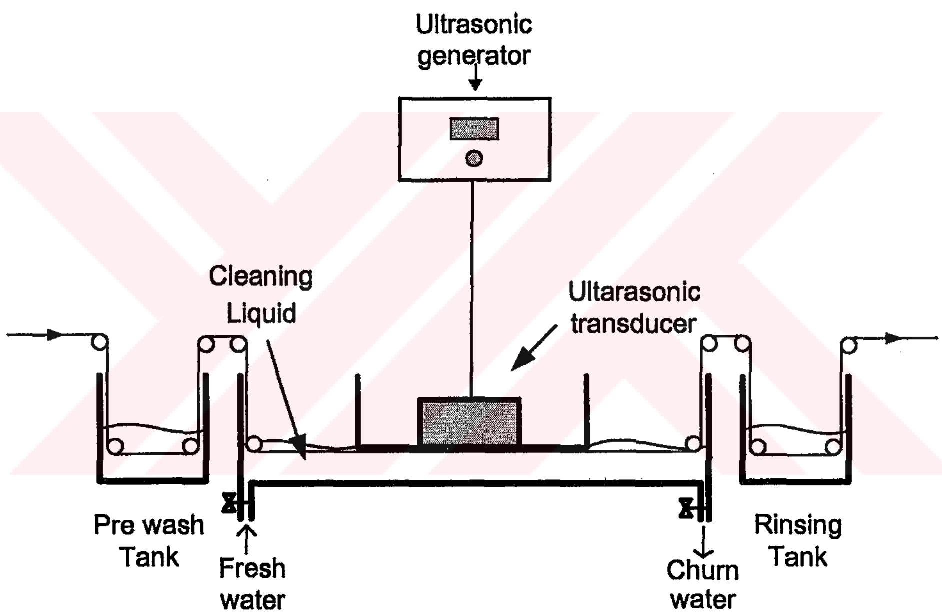

Figure 5.2. Multi-tank Ultrasonic Cleaning System

6.RESULT and CONCLUSION

The goal of this thesis is designing and realizing ultrasonic cleaning system that will be used to remove weakly bounded paint particles on new painted fabric. The behaviour of ultrasonic transducer in water environment has been investigated and illustrated by computer simulations.

Ultrasonic cleaning system consists of Piezo transducers, ultrasonic generator and cleaning tank. Because of long life and efficient Piezo transducers was selected. Piezo electric transducer contains two Piezo ceramic rings, which are clamped together. From 20 to 40 kHz frequencies are common in cleaning operations.

Applied total ultrasonic power selected from watt/liter graphic (figure-5.1). For example 20 liters water volume required 300W ultrasonic power.

To eliminate dead zones in cleaning area sweep function of generator was used. This function was one of the methods that were increasing the total cleaning quality.

In order the cleaning process, water pressure below the transducer is' not homogenous. Therefore for reaching the optimum cleaning effect transducer housing is very important. The optimum transducer housing has been selected by results of computer simulations. The ATILA/GID finite element method simulation program was used for fine cleaning system design. In chapter 4 all the simulation process was explained.

To detect success of the experiment, fastness tests was used. In early days of project to reducing time consumption and costs aluminum foil test was used. The aluminum foil test is a simple and quick way to evaluate ultrasonic power. Also we used aluminum foil to detect ultrasonic power distribution.

Aluminum foil is very sensitive material to physical force. After applied ultrasonic power form of the aluminum foil illustrated is below. Ultrasonic power can change physical form of aluminum foil in a few minutes. This is very short time respect to other detecting methods. To detect power distribution aluminum foil were putted in the cleaning tank instead of fabric.

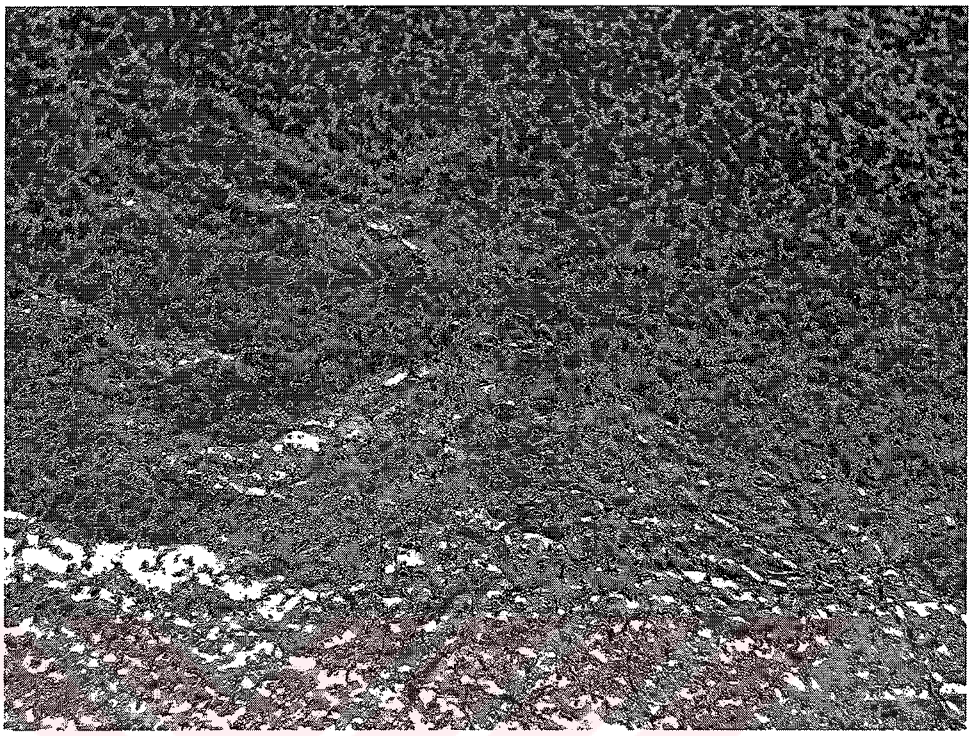

Figure 6.1. Effect of Ultrasonic Energy on Aluminum Foil

This test method gave very quick response respect to fastness tests. The performed experiment results confirmed that the ultrasonic cleaning system is successful.

REFERENCES

ARSEVEN, R., M., 1998. Tekstil materyallerinin yıkama proseslerinde ultrasonik enerjinin kullanımı.

FAO fishing manuals, 1980. Echo sounding and sonar for fishing.

IRVING, B., Crandall, 1927. Theory of vibrating systems and sound. Macmillan and Co.,

MASON, T., J., 1991(a). Practical Sonochemistry. Ellis Horwood,

MASON, T., J., 1991(b). Advantages in Sonochemistry vol 2. J. AI Press Horwood,

MORGAN ELECTROCERAMICS TECHNICAL PUBLICATIONS, 2004.yayımlanmamış

QING, Hua Qin, 2001. Fracture mechanics of piezoelectric materials. WIT Press,

URICK, R., J., 1975. Principles of underwater sound.

TIRUPATHI, R., CHANDRUPATLA, A., D., BELEGUNDU, 2001. Introduction to Finite Elements in Engineering .

WILLIAM, W., Seto, 1971. Theory and problems of acoustics. McGraw-Hill,

www.Pmrsystems.com

www.Bransonultrasonics.com

www.mpi-ultrasonics.com

www.gid.cimne.upc.es

BIOGRAPHY

Zehan KESİLMİŞ was born in Tarsus on November 11th, 1978. He received B.Sc. degree in Electrical and Electronics Engineering Department of Sakarya University in 2001.Then he joined Çukurova University Electrical and Electronics Department as an MS student.

APPENDIX

Fastness Tests

Results of all experiments were obtained after fastness test. Fatness is strength of product of textile to production and environment conditions. There different standards to determine fastness of products. Features of products can be convertible by using these standards.

Types of fastness tests are Washing, Dry Cleaning, Water, Perspiration, Rubbing, Perborate (for bleach-containing detergents), Chlorinated Water (for swimming pools), Gas Fume Fading and Print Durability.

Many textile properties are important to the final customer. Some are highly specialized in nature, but there is a core series of tests that are applicable throughout the textile industry, across all the world's major markets.

Color Fastness

Colorfastness is a term that describes the propensity of an article to change or lose color when treated in a certain way. It can be a particular problem with lower cost materials and processes, where insufficient care has been taken during dyeing, or sometimes because of the limitations of technology. In general, the tests measure the degree to which the color changes when treated in a way that simulates the conditions of use. Many tests also measure the degree to which the color may re-deposit on uncolored fibres in the same environment: white underwear becoming colored pink when washed with a red sweater, for example.

A piece of the material is cut to a specific size for the test, and exposed to the environment in question - or to a simulation of this, such as a solution that mimics the properties of human perspiration, for example. If staining is to be measured, then multi-fibre ribbon or standard adjacent fabric is also included. The test is conducted in special machinery where the degree of agitation and heat is controlled, and the duration of the test is fixed.

Light fastness

All dyes will fade when exposed to sunlight. The poorest do so very quickly, and it is possible (though uncommon) for a dyed article to fade noticeably during drying on a washing line in bright sunlight. Any reputable retailer would, however, regard such a level of performance as quite unacceptable. Testing provides an objective framework for what is acceptable.

The standards set for resistance to fading from exposure to light will depend on the article being tested, and a reasonable estimation of the use to which that article is put. Thus the standard to which most clothing is produced is lower than that for furnishing fabrics and carpeting. One of the highest standards is that set for car upholstery.

Method

The samples are placed in special holders and exposed to artificial daylight produced by a special light source, which mimics the action of sunlight, but in a more intense manner so as to speed up the fading effect. Special colored markers are usually used to ensure that the amount of treatment meets a defined level, and the degree of fading found in the test specimen is expressed in relation to these

Standard testing - General Physical Testing

Many different pieces of equipment are available for assessing the strength properties of textiles. For wovens, strength is usually measured by pulling the fabric apart (tensile testing) or by tearing it, or both.

Pilling

Often garments develop unsightly 'bobbles' of fibre, which are attached to the surface of the fabric. This is called pilling. These pills may sometimes be of a slightly different color from the main fabric, and can ruin the wearability of the article. They may also be present on bed sheets where they generate an uncomfortable 'gritty' feel. They are caused by fibres being released by the fabric and becoming entangled on the surface of the article, usually as a result of a rubbing action between two layers of fabric. Sometimes they can capture fibres from other garments during washing or wearing, thus producing differtly colored pills. The cause is generally the type and quality of the fibre and the construction of the fabric.
Pilling is tested in various ways, but usually the methods consist of a device where the fabric samples are able to rub against one another in either a random or semi-random manner for a specific time. The pilling is graded by comparing against photographs showing different degrees of pill formation. The apparatus shown above for abrasion is one test machine, which can be used to measure pilling, though many designs exist.