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Study and Analysis of Effect of Ultrasonic penetration in Alkaline Solutions with Reference to the pH Value at Steady State Conditions

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Abstract- The universe is fully resourcing of energy; certain energy resources can be achieved in the form of wave, heat radiation vibration etc. The ultrasonic mechanism is one of the important artificial resources of energy which produced by the vibration generated from natural acoustics (sound) in the form of waves. However, almost all chemical industries use aqueous based solutions for the purpose of chemical products which have a difference in ionic concentrations, which is called pH. This pH value of the acid and base is so universally ranged from 0-14. To control or achieve precise value of the pH, the very common and traditional method is used known as acid or base reaction. In this method acid and base is added to maintain the pH. Due to the addition of the acid or base volume of the batch solution increases and also reaction takes place it will become cost effective.
However, this paper presents to overcome such difficulties to maintain the pH value by penetration the ultrasonic waves of certain frequencies. The paper focuses on prototype experimentation on various alkaline solutions and particular juice of fruits and vegetables and recorded its pH value after treatments. This paper also explained the cause of change in pH value on account of its penetration. Various samples have been tested on account of its further uses and typical applications. This research paper finally concludes that the ultrasonic penetration technique is giving the best alternative solution to control the pH without using the addition of acid and base solutions. It has been revealed that this method is efficient and beneficial than the said traditional method of for control of pH in steady state condition.

Index Terms- pH, ultrasonic, frequency, acid, base

1. INTRODUCTION

It is known that sound is due to vibrations of one or another kind of particles interact with each other. Ultrasonic is a branch of acoustics deals with the artificial modified acoustic model. Various study and research show that the ultrasonic wave is nothing but the sound energy whose frequency is greater than 20 KHz. This is where the sonic range ends, and here the ultrasonic range begins. Ultrasound is used in the electronics, navigation, industrial, and security applications. Ultrasound is used in medical field to view internal organs of the human body. Ultrasounds are nothing but mechanical waves which generate compression and shear movements of the particles and hence it transmits energy.
Theory and practical experience of various study and references prove that emerging effect of ultrasonic can give chemical, biological and physical effect into the certain medium. For instance emulsion, dispersion, cavitation, molecular and ionic transformation are prove practice effect of the ultrasonic wave, cavitation effect is one of the unique characteristic effect observed in the certain liquids, which is further useful effect used in a nanoparticles production in which size of the particle can be reduced by the forces of cavitation. From the above study, it is observed that in the field of nanotechnology contribution of ultrasonic waves overcome the difficulties for the production of nanoparticles as compared to traditional methods.
The physical effect of ultrasonic is very common in a day today's experimental practices. This can be used in combination with the chemical effect known as sonochemistry. Another critical and interesting process of ultrasonic wave observed in the cavitation bubble formation which can be employs close to the phase boundary of two immiscible liquids the resultant shock wave can provide a very high-grade quality mixing. This phenomenon can be used in the food, cosmetic, textile and pharmaceutical. It is also useful in the petrochemical process industry. Recent study and observations on sonication have shown that the particles can be forced into vibrant collision, the result of it even though metallic fusion is possible. Ultrasonic plays an important role in chemical reactions which is known as sonochemistry which includes depolymerisation oxidation hydrolysis and sonification process, too.
An effective model based on pH controller must account for the non-linearity of the neutralization

process. A pH control is a challenging problem mainly because of the uncertainty involved in process modeling, which is very crucial for attainable control quality. In the food and biotechnological industries, pH control is necessary to assure product yield and quality. For wastewater treatment, the pH of effluent streams must be regulated to protect the aquatic and human welfare and to comply with limits imposed by legislation.

It is well - known that PID controllers are widely used to manipulate the pH value in the industrial process. In the present process for controlling the pH, acid and base flow is manipulated by PID controller. This requires the huge amount of continuous flow of acid and base solutions. This is very cost effective and time consumable in industrial practice. Taking into consideration above said critical problem we are proposing in this research work the new innovative idea to solve this problem in a beneficial way which is described as follows:

Ultrasound has evolved from an emerging technology, within the recent ten years and has developed into a fully commercial processing technology. High reliability and scalability, as well as low maintenance costs and high-energy efficiency, make the ultrasound-promising contender for established liquid processing equipment.

2. MATERIALS AND METHODS

Materials and methods used for this work are as follow

2.1. *Materials*

The chemicals, used in this work, are Potassium Carbonate and Sodium Carbonate. For the evaluation of basic idea of effect of ultrasonic waves on pH can be studied by laboratory scale prototype ultrasonic pH controller. The entire experimental methodology based on the principle of wave propagation of ultrasonic sound waves with respect to frequency. It is found that for a particular frequency range when ultrasonic waves penetrate through a particular solution its pH value change. This great dealing is further so useful in the industrial sector.

2.2. *Needs to control*

Most process plants generate a wastewater effluent that must be neutralized prior to discharge or reuse. Consequently, pH control is needed in just about every process plant, and yet a large percentage of pH loops perform poorly. Results are inferior product quality, environmental pollution, and material waste. With ever - increasing pressure to improve plant efficiency and tighter regulations in environmental protection effective and continuous pH control is highly desirable.

There are two major reasons for the need of control:

- To maintain the desired value of dynamic variables when disturbances occur.
- To respond to change in the desired value. The desired values are based on a thorough analysis of the plant operation and objectives.

The development of automatic control systems in the past 50 years has been equated in the importance to the industrial revolution in the 19^{th} century. It is required in agriculture, chemical industry, food processing wastewater treatment process etc. In the entire spectrum of industrial process the pH control problem is the most demanding. In order to cope with the chemistry of the process, exhaustive investigation of the characteristics of the material to determine the measurable ionic load (concentration of H^+ and OH^-) in pH process. It is important to know how much the pH of the treatable material varies and the frequency with which the load changes and respective curve nature of titration at various ion loading.

3. ORIENTATION OF THE RESEARCH WORK

The ultrasonic effect is employed in controlling and changing pH in petrochemical, electromechanical industries for getting yield product, quality control and changing the characterization. Changing and controlling of pH value is so critical problem mainly because of uncertainty in the processing system which is very crucial for maintain or getting control quality requirement. In this connection the designed model that acquires the essential feature of the process without being over loaded with parameters can be high level desirable. The process of effect of ultrasonic on pH value follow up the basic physical laws, approximation, constant parameter setting, natural behaviour of system, surrounding conditions, uncertain behaviour etc. to achieve the target for good optimal and desire change in pH for the particular solution. The ultrasonic pH system designed involves the normal design process physically as well as chemical consideration impact. It is also human real taste oriented decision have been introduced is another part of the system. This design process requires initial lot of efforts to carry out taste runs and monitor its observation based performance.

Number of laboratory experiment was carried out to change in pH with respect to ultrasonic penetration to understand its functionality, effectiveness and involvement of chemical and physical reactions, practical limitations. .

4. EXPERIMENTATION

Ultrasonic has become an important and widely accepted method for non invasive imaging of human body and thus offers greater potential for further

development in diagnostic medicine. Ultrasonic energy has the ability to propagate through soft biological tissues suffering only moderate attenuation in its passage. The propagation of an acoustical signal in biological media is characterized by variation in physical parameters which describe the state of the tissues.

High power ultrasound field leads to the generation of cavitation bubbles. During ultrasonic treatment, high frequency acoustic signals are used to initiate the cavitation process. The ultrasonic field applied leads to the breakdown of cohesive forces of the liquid molecules, resulting in the generation of cavitation bubbles However; the chemical effects of ultrasound originate from hot spots formed during the collapse of acoustic cavitation bubbles.

For instance, pH of effluent streams from wastewater plants must be maintained within stringent environmental limits. However, high performance and robust pH control is often difficult to achieve due to nonlinear and time-varying process characteristics. By taking the above facts into account the experimental setup has been designed this research work introduces innovative system of controlling the pH known as ultrasonic pH controller in which instead of acid base flow control using the ultrasonic treatment has been used for changing the ionic concentration that is change in the pH value. The major advantage of this system is ultrasonic wave generator is one time investment replaces the frequent acid or base solution in the flow control.

Proposed work deals with guided control of pH value, whereas controlling will be found very safe, easy than the current methods. The following paragraph explains the actual experimental procedure and experimental setup

Figures show the experimental set up designed and developed for the study of the effect of ultrasonic sound waves on pH. The basic set up is designed by considering the various things into account. Some of them to be mentioned are the ultrasonic generator, pH meter, industrial chemicals to be used, etc. As pH control has become a standard testing ground for process control strategies because of the nonlinear and non stationary behavior of acid-base-salt –water system. The control of pH is common in the chemical process as well as biotechnological industries. For this experimental work chemicals used are alkaline in nature and volumes of these chemicals are 500 ml.

Ultrasonic waves are penetrated through aqueous solution then pH values are measured with the help of pH meter. Variation in pH value before and after penetration of ultrasonic waves is shown in observation table.

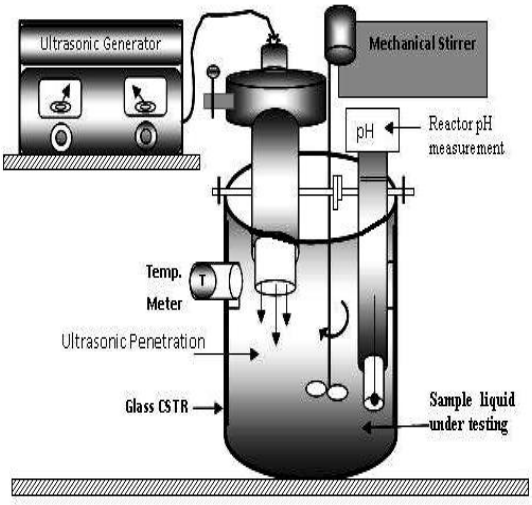


Fig 1 Design of the basic experimental setup

5. INSTRUMENTATION

Instrumentation includes glass material reactor fitted with ultrasonic generator and pH measurement system which is as shown in figure.

Alkaline chemicals like potassium carbonate and sodium carbonate are taken to carry out the experiment as shown in fig. (1). from this research work we are sure that neutralization process can be achieved by ultrasonic penetration which is vey suitable and economical than the traditional process. This research work basically compares traditional control with the ultrasonic control of pH.

6. OBSERVATION AND OBSERVATION TABLE

The comparison motives for further research work for greater industrial application. Penetration energy of ultrasonic gives the measure change in the pH value. This penetration is for time duration of 5 and 10 minutes. After penetration of ultrasonic waves change in pH value towards neutral is observed. This excellent result is definitely useful to control pH which is the basic need in the chemical industry. Thus it is concluded that this research work proves the developed prototype ultra sonopenitrator device is very useful than the traditional methods to control the pH value.

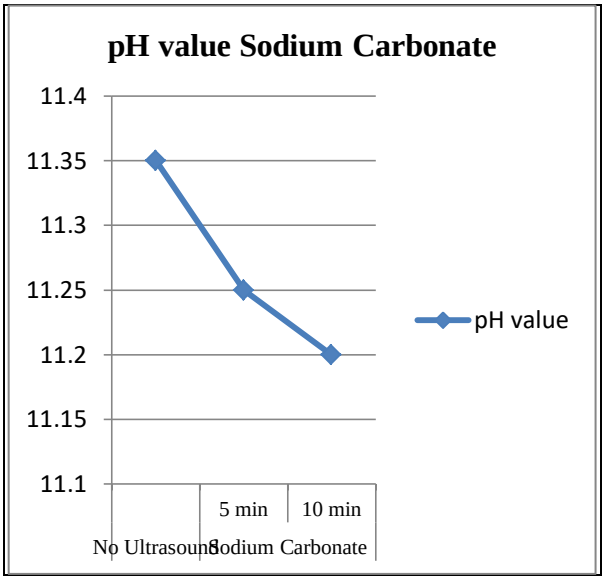
Here we consider alkaline solution i.e. sodium carbonate and potassium carbonate solution. As these solutions are alkaline solution its pH value is more than 7. Now in the experimental part when we find out pH values of these solutions before penetration of ultrasonic waves and after penetration of ultrasonic waves then change in pH values are observed in the observation table.

7. OBSERVATION TABLES

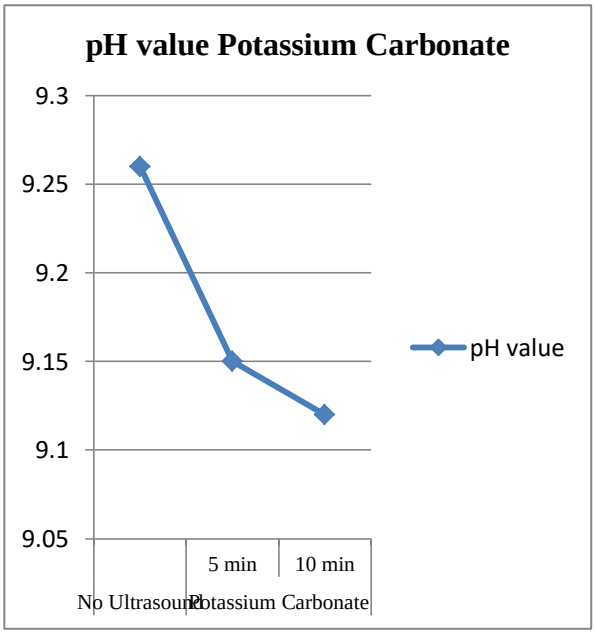
Table 1. pH Values of the solutions before and after penetration

Samples	pH Values	
Potassium Carbonate	No ultrasound	9.26
	5 minutes	9.15
	10 Minutes	9.12
Sodium Carbonate	No ultrasound	11.35
	5 minutes	11.25
	10 Minutes	11.20

Above observations show us change in pH value before and after penetration of ultrasonic waves in the aqueous solution. These values go near to the neutral values which are very much useful in the chemical industry.



Graph (1) pH value Vs Time for Sodium Carbonate



Graph (2) pH value Vs Time for Potassium Carbonate

From both the graphs it is clear that there is linear decrease in the PH of an electrolyte at concentration 0.1 N with respect to greater penetration of ultrasonic waves in the solution.

8. RESULTS AND DISCUSSION

The ultrasonic waves penetrated through the basic solutions i.e. Potassium Carbonate and Sodium Carbonate with the fixed frequency of 30 kHz. After 5 and 10 minutes readings are recorded from the time of penetration of ultrasonic waves as described in the observation table. Penetration of ultrasonic waves

alters pH value of basic solutions tending towards neutral value. In the present study, the parameter i.e. pH changes are observed before penetration of ultrasonic wave and after penetration. This research work basically compares traditional control with the ultrasonic control of pH, the comparison motives for further research work for greater industrial application. Penetration energy of ultrasonic gives the measure change in the pH value.

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