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Measuring impurity of water by ultrasound and water treatment

Abstract

The aim of this paper is to demonstrate the idea of a system to measure the quality of water and treat water. The impurities of water can be divided into two parts, solvable and insolvable generally. The devices of measuring the impurity solvable and insolvable using different characteristics of acoustic wave, propagating velocity in water and reflection of ultrasound, will be introduced respectively in this paper. Also the device of treating water by pulsed discharge as the feedback of the system will be illustrated.

1. Introduction

1.1 Measuring impurity of water by ultrasound

1.1.1 Propagation of ultrasound in the water

Space filled with the substance, which extends the acoustic wave is called the acoustic field. The acoustic field is characterized by alternating sound pressure at each point and the intensity of the propagating wave.

$$P = \rho c V m, \tag{1}$$

$$I = W/St, \tag{2}$$

Where ρc – acoustic impedance (c – speed, ρ – density),
Vm – vibration velocity (velocity movement of the particles around the equilibrium position),
S – area through which the ultrasonic wave passes
t – time,
W – radiation power

1.1.2 Ultrasonic attenuation

Attenuation is defined as the total loss of ultrasonic energy that passes through a medium. Absorption, scattering, reflection and refraction are phenomena that contribute all to that loss [2].

$$A(z) = A_0 e^{-az}, \tag{3}$$

where A is the attenuated amplitude of the ultrasonic beam, A0 is the initial amplitude of the beam at distance 0, z is the distance (thickness of the sample) and α is the amplitude attenuation coefficient. The accepted value of the amplitude attenuation coefficient of ultrasound in pure water is 0.002 dB/cm/MHz.

1.1.3 Reflection of ultrasound

In order to determine the reflection coefficient R, which determines the proportion of the wave is being reflected, the acoustic impedance is needed and is define as

$$Z = \rho c \tag{4}$$

where c is the speed of sound and ρ is the density of the medium.

For fluids only, the sound reflection coefficient is defined in terms of the incidence angle and the characteristic impedance of the two media as

$$R = \frac{\frac{z2}{z1} - \sqrt{1 - [n-1]\tan^2\theta 1}}{\frac{z2}{z1} + \sqrt{1 - [n-1]\tan^2\theta 1}}, \tag{5}$$

where $n = (\frac{c2}{c1})^2$.

1.2 Treating water by pulsed streamer discharge

1.2.1 What is electrical discharge

An electrical discharge is the passage of electrical current through a material which normally does not conduct electricity. When a sufficiently high potential difference is applied between two electrodes placed in a dielectric medium, the latter will break down into positive ions and electrons giving rise to a discharge.

1.2.2 Pulsed discharge technique

Wastewater treatment using electrical discharge plasma generating by the pulsed power technology in water has been developed to improve that issue as an advanced water treatment technique [4]. In gas phase, this reaction was occurred during discharge [6]

$$O + O2 + M \rightarrow O3 + M \quad (6)$$

In water these active species were generated during discharge via reactions (7), (8) and (9). Because air was use as carrier gas O and e could reach the water and promote chemical reactions.

$$O\cdot + H2O \rightarrow \cdot OH + \cdot OH \quad (7)$$

$$e\cdot - + H2O \rightarrow \cdot OH + \cdot H + e\cdot - \quad (8)$$

$$OH + \cdot OH \rightarrow H2O2 \quad (9)$$

2. Overview of the system of measuring and treating water

The system consisting of link of measuring insolvable impurities, measuring solvable impurities and treating water as feedback is illustrated as fig. 2.1.

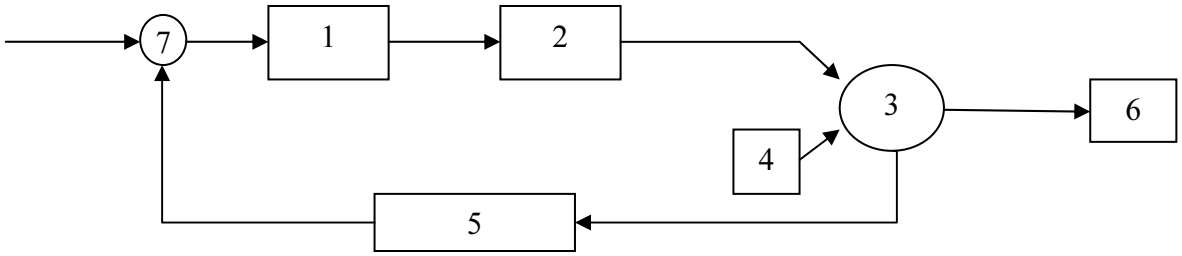

Fig. 2.1. The system of measuring and treating water.
Where 1 – the device measuring insolvable impurities; 2 – the device measuring solvable impurities; 3 – comparer; 4 – pure water; 5 – water treatment; 6 – water tank; 7 – buffer

3. Method

3.1 The device for measuring the insolvable impurities in water

The focusing method is shown as fig. 3.1. The next step shown as fig. 3.2 is the statistical processing of the data. To obtain a tomographic image.

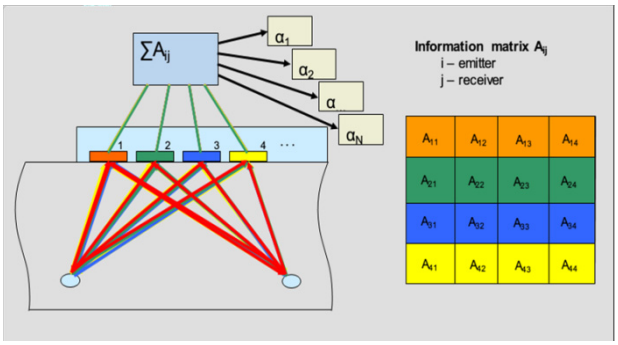

Fig. 3.1. The focusing method

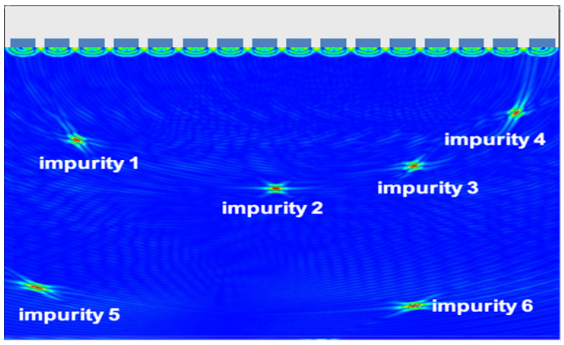

Fig. 3.2. The tomographic image

3.2 The device for measuring the solvable impurities of water

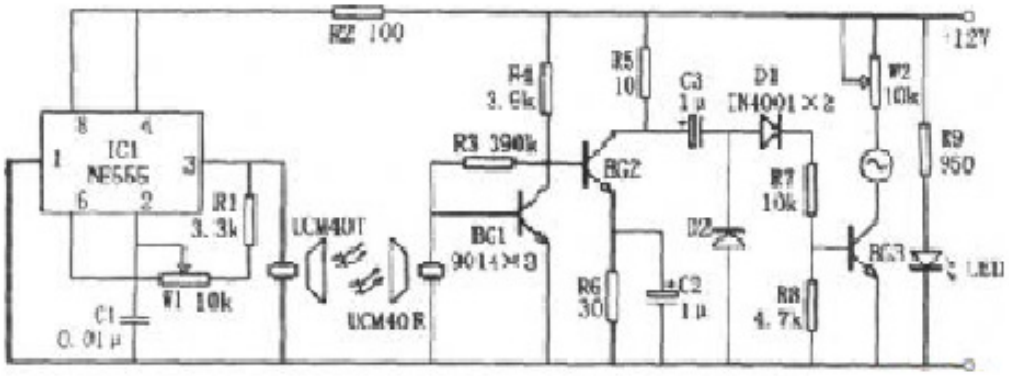

Fig. 3.3. the ultrasonic liquid level indicator circuit

4. Conclusion

Nowadays water pollution has become more and more serious. People have strong desire to using clean water. The water treatment system I designed can be easily built and placed. The system using the characteristics of ultrasound to test the impurities of water and the technique of pulsed discharge to teat water. The finally produced water would be very clean and tasty.

References

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