The present invention has been made in light of the aforementioned problem, and embodimentsan object of the present invention seekis to provide an ultrasonic cleaning method and an ultrasonic cleaning apparatus by which a high particle removal rate is obtained in a stable manner.

Means for Solving the Problems

The inventors have earnestly studied a relationship between the dissolved gas concentration and the particle removal rate, and as a result, have obtained the following findings. Specifically, the inventors of the present invention have found that, by introducing a gas into a liquid having a certain range of dissolved gas concentration while irradiating the liquid with ultrasonic waves, the particle removal rate of the liquid can be increased, and the inventors of the present invention have arrived at the present invention.

An ultrasonic cleaning method according to an aspect of the present invention is an ultrasonic cleaning method for cleaning an object to be cleaned in a liquid in which a gas is dissolved, by irradiating the liquid with ultrasonic waves, and the method has the following steps. The liquid in which the gas is dissolved is prepared. Bubbles are generated in the liquid while the liquid is irradiated with the ultrasonic waves, and a state where the bubbles containing the gas dissolved in the liquid continue to be generated is realized. The object to be cleaned is cleaned in the state where the bubbles containing the gas continue to be generated.

In particular, the aspect of the present invention provides an ultrasonic cleaning method for cleaning an object to be cleaned in a liquid in which a first gas is dissolved, by

irradiating said liquid with ultrasonic waves, the method comprising the steps of: preparing said liquid in which said first gas is dissolved; introducing a second gas into said liquid while irradiating said liquid with the ultrasonic waves, and realizing a state where bubbles containing said first gas dissolved in said liquid continue to be generated triggered by dispersion, by the ultrasonic waves, of the bubbles generated by introducing said second gas into said liquid; and cleaning said object to be cleaned in the state where the bubbles containing said first gas continue to be generated and wherein the step of cleaning said object to be cleaned includes a step in which sonoluminescence occurs.

In the ultrasonic cleaning method according to the aspect of the present invention, the bubbles are generated in the liquid while the liquid is irradiated with the ultrasonic waves. Therefore, it is possible to realize the state where the bubbles containing

the gas dissolved in the liquid are more likely to be generated continuously. Since cleaning is done in this state, a high particle removal rate can be obtained in a stable manner.

~~Preferably, i~~In the ultrasonic cleaning method, the step of realizing a state where bubbles containing the gas continue to be generated is triggered by dispersion, by the ultrasonic waves, of the bubbles introduced into the liquid from outside. Since the bubbles are introduced from outside, the particle removal rate can be increased by a simplified method. In addition, since the bubbles are dispersed by the ultrasonic waves, bubbles serving as nuclei are more likely to be generated. Therefore, it is possible to realize the state where the bubbles are more likely to be generated continuously.

~~Preferably, i~~In the ultrasonic cleaning method, the step of cleaning the object to be cleaned includes a step in which sonoluminescence occurs. With this, a high particle removal rate is obtained in a more stable manner.

Preferably, in the ultrasonic cleaning method, the gas is nitrogen and a dissolved gas concentration in the liquid is 5 ppm or more and less than 11 ppm.

An ultrasonic cleaning apparatus according to an embodiment of the present invention is an ultrasonic cleaning apparatus for cleaning an object to be cleaned in a liquid in which a gas is dissolved, by irradiating the liquid with ultrasonic waves, the apparatus having: irradiation means for irradiating the liquid with the ultrasonic waves; a container for containing the liquid; and a mechanism for introducing a gas into the liquid. With the mechanism for introducing a gas into the liquid, it is possible to realize the state where the bubbles serving as nuclei are more likely to be generated in the liquid. As a result, the

Claims

1. An ultrasonic cleaning method for cleaning an object (W) to be cleaned in a liquid in which a first gas is dissolved, by irradiating said liquid with ultrasonic waves, the method comprising the steps of:
- preparing said liquid in which said first gas is dissolved;
- introducing a second gas (G) into said liquid while irradiating said liquid with the ultrasonic waves, and realizing a state where bubbles containing said first gas dissolved in said liquid continue to be generated; and
cleaning said object (W) to be cleaned in the state where the bubbles containing said first gas continue to be generated.

2. The ultrasonic cleaning method according to claim 1, wherein the step of realizing a state where bubbles containing said first gas continue to be generated is triggered by dispersion, by the ultrasonic waves, of the bubbles generated by introducing said second gas (G) into said liquid.

3. The ultrasonic cleaning method according to claim 1 or 2, wherein the step of cleaning said object to be cleaned includes a step in which sonoluminescence occurs.

4. The ultrasonic cleaning method according to any one of claims 1 to 3, wherein said gas is nitrogen and a dissolved gas concentration in said liquid is 5 ppm or more and less than 11 ppm.

5. An ultrasonic cleaning apparatus (100) for cleaning an object (W) to be cleaned in a liquid in which a gas is dissolved, by irradiating said liquid with ultrasonic waves, the apparatus comprising:
- irradiation means (30) for irradiating said liquid with the ultrasonic waves;

- a container (20) for containing said liquid; and
- a mechanism (4) for introducing a gas (G) into said liquid.

Claims

1. An ultrasonic cleaning method for cleaning an object to be cleaned in a liquid in which a first gas is dissolved, by irradiating said liquid with ultrasonic waves, the method comprising the steps of:
- preparing said liquid in which said first gas is dissolved;
- introducing a second gas into said liquid while irradiating said liquid with the ultrasonic waves, and realizing a state where bubbles containing said first gas dissolved in said liquid continue to be generated triggered by dispersion, by the ultrasonic waves, of the bubbles generated by introducing said second gas into said liquid; and
- cleaning said object to be cleaned in the state where the bubbles containing said first gas continue to be generated and wherein the step of cleaning said object to be cleaned includes a step in which sonoluminescence occurs.

2. The ultrasonic cleaning method according to claim 1 wherein said gas is nitrogen and a dissolved gas concentration in said liquid is 5 ppm or more and less than 11 ppm.