Hydrogen or using pressurized dissolution where a gas is forcibly dissolved into liquid using a compressor, ultrasonic or impulse waves to create cavitation and formation of hydrogen bubbles. However due to low solubility of Hydrogen in water these arrangements are often complex and the Hydrogen does not stay dissolved in water for long periods (ie hours).

[0005] There is thus a need to provide a simple apparatus for generating ultrafine molecular hydrogen that stays dissolved in water for many hours or at least provide a useful alternative to existing apparatus.

SUMMARY

[0006] According to a first aspect, there is provided an apparatus configured to generate water comprising nano bubbles of molecular hydrogen comprising:

an input connector which in use is connected to a water source;

a valve for controlling a flow of water into the apparatus via the input connector;

a venturi gas-liquid mixer downstream of the valve and configured to receive a flow of pressurised water when the valve is open and a flow of Hydrogen gas from a hydrogen gas source, wherein the gas water mixer apparatus generates a mixed hydrogen gas/water output stream;

a nano bubble generating apparatus which receives the mixed hydrogen gas/water stream connected to the output of the venturi mixer and generates Hydrogen nano bubbles using a cavitation mechanism, wherein the nano bubble generating apparatus produces an output hydrogen water steam comprising Hydrogen nano bubbles with diameters of less than 200nm at an output concentration of between 0.8 and 1.2ppm wherein the concentration remains with 85% of the output concentration for at least 12 hours.

[0007] In one form, the concentration remains within 85% of the output concentration for at least 15 hours, and/or within 63% of the output concentration for at least 18 hours, and/or within 50% of the output concentration for at least 20 hours, and/or within 37% of the output concentration for at least 24 hours.

[0008] In one form, the apparatus further comprises a pump connected between the valve and the venturi gas-liquid mixer to pressurise the output water to at least one bar. In one form the pump pressurises the output water to be between one and three bar. In one form the pump has a rating of less than 100W.

[0009] In one form, the venturi gas-liquid mixer generates a mixed hydrogen gas/water output stream with a speed of between 0.5-1.5m/s and a flow rate of between 1.5-2.5L/min.

[0010] In one form, the hydrogen gas source is a gas bottle containing Hydrogen gas and a regulator.

nano bubble generating apparatus (4). In one embodiment, the output hydrogen gas/ water jet has a (high) speed of around 0.5-1.5 m/s, and a (low) flow rate of 1.5-2.5 L/min.

[0026] The nano bubble generating apparatus spins the input hydrogen gas/water through the apparatus and uses cavitation to dissolve the Hydrogen as nano bubbles in the water, generates an output stream of water containing ultrafine nano bubbles of molecular hydrogen at output (b). The apparatus can be used to generate hydrogen water at normal (one) atmospheric pressure and room temperature (25 degree Celsius) in which molecular hydrogen (H_2) has a concentration of up to 1.2ppm and stays dissolved for long periods of time.

[0027] In one embodiment, the nano bubble generating apparatus 4 is an embodiment of an apparatus as described in WO2014204399 titled AN APPARATUS FOR GENERATING NANOBUBBLES. This apparatus 4 comprises a tubular member 20 containing a longitudinal shaft having a cylindrical body 16, and first 12 and second end 14 portions formed as conical-shaped guides. The conical-shaped guide streamlines fluid flow from the venturi guide at the input 22 and to a fluid dispensing fitting at the output 24. The cylindrical body includes air-foil shaped projecting members 19 which protrude radially from the longitudinal shaft formed from a plurality of discs 17. The air-foil shaped projecting members are arranged in a predetermined manner on the outer circumferential surface of the disc member such that the projecting members do not overlap each other, leaving a slight gap in between each projecting member. The tubular member is formed as a cylindrical housing 21 which connects to an end piece 23. The diameter of the shaft and projecting members is slightly less than the inner diameter of the tubular member 20 to keep the fluid flow within the tubular member 20 in close contact with the airfoil-shaped projecting members 19. Figure 2A is a cross sectional view of an embodiment of the nano bubble generating apparatus 4 and Figure 2B is a perspective view of the cylindrical body 16 with the air-foil shaped projecting members 19 housed within the tubular member 20, having 22mm diameter by 180mm in length.

[0028] When the mixed hydrogen gas and water flows through the fluid supply inlet 22 of the tubular member 20 (eg from the Venturi mixer 3) it is guided by the conical-shaped guide 12 proximal to the inlet of the longitudinal shaft 22 and fed into the airfoil-shaped projecting members 19 of the body 16. When the fluid flow passes through the flow passage between two airfoil-shaped projecting members 19, the fluid converges and experiences a Venturi effect in that the velocity of the fluid flow increases as it passes through the airfoil-shaped projecting members 19. As fluid flow leaves the flow passage, it encounters a divergent flow from another airfoil-shaped projecting member 19 in its path which splits the fluid flow through the subsequent flow passages. The repeated convergent and divergent flow of fluid through the multiple flow passages causes velocity and pressure fluctuation and accelerates the formation of vortexes known as the Coanda effect. This causes the cavitation of nano bubbles of

Hydrogen gas from the fierce whirl created from the fluid flow through the multiple flow passages. The fluid flow swirls through the flow passages and is guided by the conical shaped guide 14 at the outlet 24 of the tubular member. The fluid flow that exits the tubular member 20 will contain numerous nano bubbles.

[0029] When the nano bubble generating apparatus 4 is combined with components described previously, highly concentrated ultrafine bubbles of molecular hydrogen can be dissolved in room temperature water at concentrations of up to 1.2ppm. Further the ultrafine hydrogen bubbles stay dissolved in the hydrogen water for long periods of time. An embodiment of the apparatus was used to generate a sample of hydrogen bubble water which was left exposed at room temperature, and the concentration of Hydrogen was repeatedly measured over a 32 hour period. Table 1 below is a plot of the measured concentration as a function of time, and Figure 3 is a plot of the concentration 30 of molecular Hydrogen (H_2) as a function of time in minutes.

CLAIMS

1. An apparatus configured to generate water comprising nano bubbles of molecular hydrogen comprising:

an input connector which in use is connected to a water source;

a valve for controlling a flow of water into the apparatus via the input connector;

a venturi gas-liquid mixer downstream of the valve and configured to receive a flow of pressurised water when the valve is open and a flow of Hydrogen gas from a hydrogen gas source, wherein the gas water mixer apparatus generates a mixed hydrogen gas/water output stream;

a nano bubble generating apparatus which receives the mixed hydrogen gas/water stream connected to the output of the venturi mixer and comprises a longitudinal shaft comprising a first end portion and a second end portion each formed as conical-shaped guides, and a plurality of radially projecting air-foil shaped projecting members, and the longitudinal shaft is housed within a cylindrical housing, and generates Hydrogen nano bubbles due to cavitation as the hydrogen gas/water stream flows through multiple flow passages created by the plurality of radially projecting air-foil shaped projecting members,

wherein the nano bubble generating apparatus produces an output hydrogen water steam comprising Hydrogen nano bubbles with diameters of less than 200nm at an output concentration of between 0.8 and 1.2ppm wherein the concentration remains within 85% of the output concentration for at least 12 hours.

2. The apparatus as claimed in claim 1, wherein the concentration remains within 85% of the output concentration for at least 15 hours.

3. The apparatus as claimed in claim 1 or 2, wherein the concentration remains within 63% of the output concentration for at least 18 hours.

4. The apparatus as claimed in claim 1, 2, or 3, wherein the concentration remains within 50% of the output concentration for at least 20 hours.

5. The apparatus as claimed in claim 1, 2, 3, or 4, wherein the concentration remains within 37% of the output concentration for at least 24 hours.

6. The apparatus as claimed in any preceding claim, further comprising a pump connected between the valve and the venturi gas-liquid mixer to pressurise the output water to at least one bar.

7. The apparatus as claimed in claim 6, wherein the pump pressurise the output water to be between one and three bar.

8. The apparatus as claimed in claim 6 or 7, wherein the pump has a rating of less than 100W.

9. The apparatus as claimed in any preceding claim, wherein the venturi gas-liquid mixer generates a mixed hydrogen gas/water output stream with a speed of between 0.5-1.5m/s and a flow rate of between 1.5-2.5L/min.

10. The apparatus as claimed in any preceding claim, where the hydrogen gas source is a gas bottle containing Hydrogen gas and a regulator.

11. The apparatus as claimed in claim 10, wherein the apparatus further comprises a housing and the gas bottle, pump if present, venturi gas-liquid mixer and nano bubble generating apparatus are contained in the housing, and the housing has dimensions of 400mm x 450mm x 200mm or less.

12. The apparatus as claimed in claim 10, wherein the apparatus further comprises a housing and the pump if present, venturi gas-liquid mixer and nano bubble generating apparatus are contained in the housing, and the gas bottle is external to the housing and supplies regulated hydrogen gas to the apparatus via a regulated connection.

13. The apparatus as claimed in any one of claims 1 to 9, where the hydrogen gas source is a hydrogen gas generating apparatus comprising an electrolysis based device with a reservoir and pump which generates and supplies hydrogen gas.

14. The apparatus as claimed in any preceding claim, further comprising a temperature control apparatus located prior to the venturi gas-liquid mixer to reduce or increase the temperature of the water provided to the venturi gas-liquid mixer.

15. The apparatus as claimed in any preceding claim, wherein the plurality of radially projecting air-foil shaped projecting members are arranged in a predetermined manner on the outer circumferential surface of the longitudinal shaft such that there is a slight gap between adjacent projecting members to create the multiple flow paths.

16. The apparatus as claimed in claim 15, wherein a diameter of the longitudinal shaft and projecting members is slightly less than an inner diameter of the housing.

17. A method for generating water comprising nano bubbles of molecular hydrogen comprising:
receiving an input flow of water with a pressure of at least one bar;
receiving an input flow of Hydrogen gas;

mixing the input flow of water with the input flow of Hydrogen gas in a venturi gas-liquid mixer to generates a mixed hydrogen gas/water output stream;

generating Hydrogen nano bubbles using a cavitation mechanism in a nano bubble generating apparatus which receives the mixed hydrogen gas/water stream and comprises a longitudinal shaft comprising a first end portion and a second end portion each formed as conical-shaped guides, and a plurality of radially projecting air-foil shaped projecting members, and the longitudinal shaft is housed within a cylindrical housing, and generates Hydrogen nano bubbles due to cavitation as the hydrogen gas/water stream flows through multiple flow passages created by the plurality of radially projecting air-foil shaped projecting members, and which produces an output hydrogen water steam comprising Hydrogen nano bubbles with diameters of less than 200nm at an output concentration of between 0.8 and 1.2ppm wherein the concentration remains within 85% of the output concentration for at least 12 hours.

18. The method as claimed in claim 17, wherein the concentration remains within 85% of the output concentration for at least 15 hours.

19. The method as claimed in claim 17 or 18, wherein the concentration remains within 63% of the output concentration for at least 18 hours.

20. The method as claimed in claim 17, 18, or 19, wherein the concentration remains within 50% of the output concentration for at least 20 hours.

21. The method as claimed in claim 17, 18, 19 or 20, wherein the concentration remains within 37% of the output concentration for at least 24 hours.

22. The method as claimed in any one of claims 17 to 21, wherein input water has a pressure of between one and three bar and is provided by a pump connected to a water supply.

23. The method as claimed in any one of claims 17 to 22, wherein the venturi gas-liquid mixer generates a mixed hydrogen gas/water output stream with a speed of between 0.5-1.5m/s and a flow rate of between 1.5-2.5L/min.

24. The method as claimed in any one of claims 17 to 23, wherein the plurality of radially projecting air-foil shaped projecting members are arranged in a predetermined manner on the outer circumferential surface of the longitudinal shaft such that there is a slight gap between adjacent projecting members to create the multiple flow paths.

25. The apparatus as claimed in claim 24, wherein a diameter of the projecting members is slightly less than the inner diameter of the housing.