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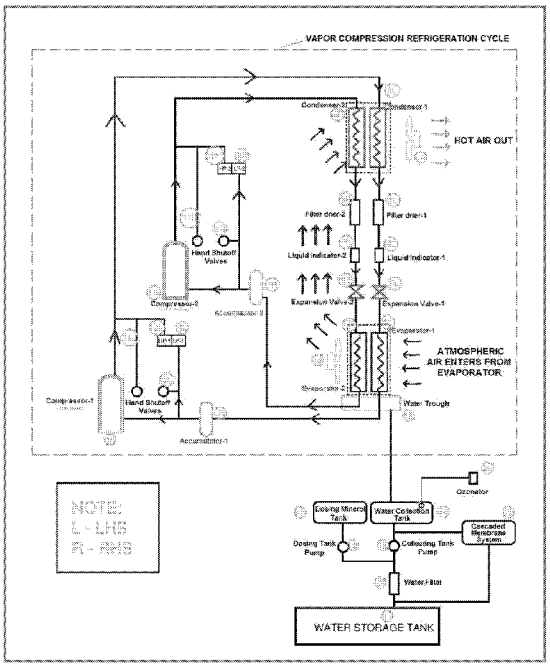

Figure 1

(57) Abstract: An integrated Atmospheric Water Generator(AWG) capable of selectively producing three different types of water (i)potable, (ii)alkaline an (iii)demineralised water of biomedical grade comprising a vapour compression refrigeration unit for condensation of atmospheric moisture involving a vapor condensation unit including forced suction of atmospheric moist air involving fan means ducted to evaporator; said evaporator maintained below dew point temperature by circulation of refrigerant; said moist air on contact with cold surface of evaporator looses heat and condenses into water droplets; collection tray/trough for collecting the thus generated water droplets and cooperatively integrated with membrane-based ultrafiltration, controlled essential chemical dosage and reverse osmosis(RO) membrane system, incorporated with an indigenous high flux polyetherurea membrane in single pass to obtain 2ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1ppm TDS., thereby to produce three different types of water, namely potable, alkaline and demineralised water of biomedical grade.

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TITLE: AN AUTOMATED ATMOSPHERIC WATER GENERATOR FOR PRODUCING HIGH QUALITY WATER FOR DRINKING AND BIOMEDICAL APPLICATIONS.

FIELD OF THE INVENTION

The present invention relates to an integrated and automated atmospheric water generator (AWG) involving newer design for achieving higher efficiency and more rapid water vapor condensation. Atmospheric water generator is integrated with membrane to produce potable water, alkaline water and demineralized water. The remineralization process disclosed in this invention is carried out by employing dosing of novel optimal mineral rich salt solution to achieve high quality potable water and alkaline water. The membrane process unveiled in this invention is carried out by employing indigenous high flux polyether sulfone ultrafiltration membrane for disinfection and turbidity removal of water. The present invention also discloses the production of demineralized water for use in variety of industrial and medical applications. The demineralization process disclosed in the innovation is achieved by using a polyetherurea reverse osmosis membrane to further process the output water from AWG.

BACKGROUND OF THE INVENTION

Water is one of the most essential resources for human life and ecosystem. The world's availability of fresh water resources accessible by human kind accounts to only 1% of the total water available on the earth. Moreover, the continuous depletion of ground water resources has created a major crisis for sustenance of life. In most parts of India, people travel miles to avail a few litres of fresh water and most of the border areas have no water source. The available water is also contaminated with industrial and agricultural pollutants. The only solution to overcome this problem is to depend on the seawater resource. Desalination of seawater is not a decentralized solution, since it involves installation of plant only near a sea shore. Moreover the transportation of water involves high logistic costs, whereas the concentrated brine from the plant creates ecological imbalance in the

sea. Each day about 850 billion liters of water evaporates from the sea into the atmosphere as water vapor. The harvesting of water vapor from atmosphere would be a realistic solution for solving the scarcity of water.

Reference may be given to patent 4,146,372, 27th March 1979, Wilhelm Groth and Peter Hussmann, wherein adsorbing agent, silica gel was used for recovering water from the atmosphere.

Reference may also be given to patent US 6,572,902 B2, 3rd June 2003, Robert M. Abramowitz and George Arnold, which discloses a process for production of alkaline water. Alkaline minerals were added to the purified water to obtain alkaline water having pH 9-10 and 22–240 ppm of total dissolved solids (TDS).

Reference is given to patent US 6,684,648 B2, 3rd February 2004, Abdul-Rahman Abdul-Kader M. Faqih, wherein a commercial indoor dehumidifier with moderate design changes related to condensation surface area has been used for condensing water vapor from the humid atmosphere to produce fresh water. An electronic sensor or a float is placed in a container for detecting the water level. The system automatically starts when the container is empty and turns off when the container is filled with water.

Reference may also be given to patent US 2013/0047655 A1, 28th February 2013, Keith White, which discloses a process to produce water for multi-zone applications from atmospheric water generator. Ozone gas at a specified rate is externally injected into the water to remove bacteria while the excess ozone present in the water is immediately purged from the purification circuit. The ozone treated water is passed through resins, adsorbents, UV or filter for further purification. The immediate purging of ozone gas helps in reducing the pressure build-up within the system and prevents ozone-resistant material from getting deteriorated.

Reference may be made to patent US 2018/0209123 A1, 26th July 2018, Majid Bahrami and Farshid Bagheri, wherein a hybrid atmospheric water generator comprising of preconditioning unit is designed to enhance the production rate of

water at a lower cost. The sorption bed comprising of a desiccant material within the preconditioning unit absorbs a large amount of moisture from air due to increase in relative humidity (RH).

Reference may also made to patent US 9,561,451 B2, 7th February 2017, Ronald M. Dorfman, wherein an atmospheric water generator is designed with network communication involving user authentication and control system for monitoring water production and collecting data.

Reference may also be made to patent US 2014/0138236A1, 22nd May, 2014, Keith White, which describes the use of turbine power for condensation of moisture from atmospheric air to produce water for building and zone applications.

Reference is given to patent US 2014/0083120 A1, 27th March 2014, Elizabeth Nowak and Guy Katz, wherein solar energy is used to raise the temperature of air in the condensing chamber while cooling of air is facilitated by the use of wind energy. The system may be used off the energy grid to produce potable water for large scale applications.

Reference may be given to patent US 2012/0073320 A1, 29th March 2012, Diego Castanon Seoane, wherein the invention discloses a heat exchanger with panels arranged in parallel along a central axis to condense water from atmosphere. The air flow around the evaporator is maintained sufficiently high which thereby creates a turbulence flow pattern of the air stream.

Reference may be made to patent US 8,118,912 B2, 21st February, 2012, Felix Rodriguez and Nizar K. Khanji, wherein the atmospheric water generator uses two separate air chambers, one for capturing moisture from the ambient air and another for converting the captured moisture from hygroscopic material into water.

Reference may be given to patent US 2013/0340458 A1, 26th December 2013, Mark Edward Shaw and Sean M. James, where the disclosed data centre water

generator runs on renewable energy to produce potable water. The heated air from data centre is directed towards the water generator thereby enabling greater amount of water condensation.

Reference may be made to patent US 005,669,221, 23rd September 1997, Terry L. LeBleu and Francis C. Forsberg, which discloses a portable water generator that employs filters for removing undesirable contaminants from air, with heating, cooling and automatic continuous UV sterilization system for producing potable water of high quality.

Reference may be made to patent US7043934B2,01-05-2000, is directed to a water making device that collects the moisture contained in the atmosphere and condenses it into high purity water. In one embodiment, moist air entering the water making/water cooling system flows across an air filter, then a precooler heat exchanger (where the air stream is cooled to or close to its dew point) and then a water extraction heat exchanger, where the air stream is cooled further and water is extracted.As claimed by the inventor herein that "2. Equipment for extraction of moisture from air as in claim 1, through a heat exchange process is facilitated using contact of ambient air with hot / cold refrigerant gas"

Reference may be given to patent US6776001B2,07-02-2000, relates to a method and an apparatus for providing enhanced indirect evaporative cooling of air, water, fuel, or other fluids while controlling the humidity. The design makes cooling down to the dew point possible without energy input other than the energy to produce the fluid flow needed.As claimed by the inventor that their product utilizes lesser electric power.

Reference may be made to patent application published as WO2016010486A1,16-07-2015,The membrane according to any one of the preceding claims, wherein the hydrophilic polymer is any one selected from the group comprising: polyvinyl alcohol, nafion polymer, polyamide, polyacrylic acid and cellulose acetate.

Reference may be made to patent US5306511A,18-03-1993, A highly concentrated alkaline solution is formed by combining potassium hydroxide

(KOH) with sodium hydroxide (NaOH) so that an alkaline drinking water may be formulated. One part of concentrated alkaline additive solution is diluted with several parts of distilled water in a one ounce mixture.As claimed by the inventor "additive salt for Alkaline water".

Reference may be made to non patent literature (National Center for Biotechnology Information, U.S. National Library of Medicine),09-07-1905, Polyethersulfone (PES), as shown in Figure1,1, is considered one of the well-known polymeric material to be used to make ultrafiltration (UF), microfiltration (MF), and gas separation membranes since it provides unique properties such as outstanding thermal, mechanical, hydrolytic strength in both hot and wet environments. As claimed by the inventor "novel high flux polyethersulfone based ultrafiltration membrane for clarification and disinfection of the output water".

The present invention relates design of atmospheric water generator offering a low cost solution within a single system, to meet three objectives, namely the extraction of atmospheric moisture for production of three different grades of water. The AWG uses efficient heat exchange system involving separate fans for condenser and evaporator for directing the cold exit air from the evaporator towards the condenser which thereby results in lower energy consumption as compared to the prior art.

The present AWG is a highly compact integrated unit that meets the quality requirements of waterfor both domestic and biomedical applications.

Its distinguishing feature is that it is single equipment which enables integration of AWG with membrane based ultrafiltration, controlled essential chemical dosage and reverse osmosis (RO) membrane to produce three different types of water, namely potable, alkaline and demineralised water of biomedical grade.

The lower cost, energy efficiency and simplicity of the equipment make it economical to install and maintain with user friendly features in comparison to the prior art. The automated control system within the AWG enables regular

monitoring of water usage and its quality with provision for trip off when relative humidity goes below 25%.

Drawbacks in existing state-of-art and measures taken by way of present invention to overcome the drawbacks:

Atmospheric water generators, which use vapor compression model, consume electric power. The conventional systems use a single fan for the evaporator and condenser, with a fixed CFM. This results in lower efficiency of condensation.

By utilizing separate fans for evaporator and condenser, and by having higher CFM fan for condenser, the condensation process of the refrigerant is enhanced resulting in lower power consumption.

The water extracted from atmosphere has very low dissolved solids, resulting in absence of essential minerals.

By having automated dosing of salt mixture at a predetermined level (using electronic control) with the water extracted from air, the water is made to potable standards on a consistent basis.

The medical grade water conventional system using ground water as source, involves various stages of filtration, before going through resin treatment.

By using atmospheric water as source water, the various pretreatment processes are avoided. The required quality can be achieved without using resins.

The advantage being reduced processes, lesser maintenance. Further since the water from air has very low TDS, reject water percentage is brought down sizably.

The present design is environmentally safe as it has an inbuilt automated provision for switching off when the relative humidity goes below 25%.

OBJECTS OF THE INVENTION

The main objective of the present invention is to produce three grades of water i.e. potable water, alkaline water and demineralized water using indigenous

atmospheric water generator integrated with the custom designed novel membrane filtration system.

Another objective of the present invention includes harvesting of atmospheric moisture with higher efficiency.

Yet another objective of the present invention relates to incorporate novel instrumentation features for optimum running of the atmospheric water generator with constant feed back to the company server on the performance of machine for continuous monitoring and quick troubleshooting, if necessary.

Another objective of the present invention is to produce potable and alkaline water by automated dosing of a concentrated solution containing essential minerals.

Yet another objective of the invention is to provide a water quality of less than 2 ppm of TDS for biochemical and biomedical applications.

A still further object of the present invention is to achieve the following advantages of AWG over alternative thermal or RO driven desalination plants, where seawater is converted to potable water:

a) AWG is a decentralized solution, involving no pipeline for distribution of water, also the maintenance cost and labor associated with the pipelines.

b) AWG has zero effluent water, unlike desalination plant which involve huge quantities of effluent.

c) AWG is environmentally friendly, unlike desalination plant where the high concentrated brine as effluent, goes back to sea to causing ecological contaminations.

d) AWG can work without the requirement of a raw water source like ground, sea or surface water.

SUMMARY OF THE INVENTION

The basic aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) capable of selectively producing three different types of water (i) potable, (ii) alkaline and (iii) demineralised water of biomedical grade comprising:

Vapor condensation unit including forced suction of atmospheric moist air involving fan means ducted to evaporator ;

Said evaporator maintained below dew point temperature by circulation of refrigerant ;

Said moist air on contact with cold surface of evaporator looses heat and condenses into water droplets ;

collection tray/trough for collecting the thus generated water droplets;

cooperatively integrated with membrane-based ultrafiltration, controlled essential chemical dosage and reverse osmosis (RO) membrane to produce three different types of water, namely potable, alkaline and demineralised water of biomedical grade.

A further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising:

(a) Independent fans for evaporator and condenser;

(b) Condenser fan having higher CFM (cubic feet per minute) when compared to evaporator fans.

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising condenser unit having operative supply of addition of exit cold air emanating from the evaporator with ambient air to reduces the outlet temperature of refrigerant from the condenser

and reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output.

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising
water from the collection trough operatively connected to storage tank;
operatively connected dosing tank for feeding mineral enriched solution including alkaline minerals.

Another aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising ultrafiltration spiral wound membrane module based on high flux polyethersulfone membrane to effectively clarify and disinfect potable water having desired total dissolved solids (TDS) and pH for domestic purpose.

Yet another aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) wherein water from the collection tank is passed through a series of pre filters inclusive of polypropylene spun cartridge, granular activated carbon and carbon block filter followed by thin film composite RO membrane system with high flux polyetherurea membrane material to produce demineralized water with a TDS of < 2 ppm, preferably including a second stage RO membrane is utilized followed by a mixed bed ion exchange resin columnto achieve a TDS level below 1 ppm.

A further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising automatic water level control unit adapted such that when the water level in the storage tank is low, a signal is generated to a respective pumpto switch-on automatically involving an inbuilt electronic control device and similarly, when the water level in the storage tank is full, a signal is generated to respective pumps to switch-off automatically.

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising automated dosing of mineral rich solution with atmospheric water condensate to attain potable water with TDS of 70-90 ppm and alkaline water with pH of 8.3 to 10alongwithhigh flux polyethersulfone ultrafiltration membrane modulefor efficient clarification and disinfection of the remineralized water.

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising dosing of alkaline minerals based on bicarbonates of sodium, calcium and magnesium.

A further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) 10 to 12 micron preferably 10 micron pleated air filters through which atmospheric air is sucked in before subjecting the same to vapor condensation.

Another aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising high flux polyethersulfone based ultrafiltration membrane having pore size in the range from 0.005 to 0.05 m enables 99.9% rejection of bacteria/virus with complete clarification and disinfection of the output water.

Yet another aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising demineralization unit including a pre-treatment system, two-staged cascaded membrane systems and an optional ion exchange system, the said pretreatment system including polypropylene spun cartridge and activated carbon filter to remove suspended solids, dissolved organic, colloidal matter, color and odour, a high flux PES ultrafiltration membrane effectively clarifying and disinfecting potable water, selective polyetherurea composite membranes with positive surface charge over membrane surface offers minimal problems pertaining to bio-fouling deposition

offering high water flux in the said two-staged cascaded membrane system, the output water adapted to pass through demineralization unit to produce DM water with conductivity in the range between 1.56 $mScm^{-1}$ and 3.12 $mScm^{-1}$.

A further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising a vapor compression refrigeration cycle comprising, a compressor that draws the refrigerant vapor from an evaporator and discharges high pressure and high temperature vapor into a condenser wherein the temperature of the refrigerant is reduced in the condenser by cold air from evaporator and ambient air is sucked in by a condenser fan, resulting in a saturated or sub-cooled liquid; an expansion valve through which said condensed liquid then flows where it experiences a pressure drop as a result of which temperature and pressure of the refrigerant further reduces before entering the evaporator, so that the refrigerant in the evaporator vaporises by taking heat from the ambient air entering the system caused due to the forced suction by a evaporator fan and exits as low temperature and low pressure vapour; an accumulator through which said vaporised refrigerant is then passes to collect any residual liquid refrigerant and enters the compressors as low pressure and low temperature vapor to restart the cycle.

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) comprising said fan near the evaporator takes the air from the ambient atmosphere and passes through a series of air filters (3) and then enters into the evaporator (6), where the air is cooled below its dew point and moisture in the air is converted into pure water which gets collected in the water trough (15), then flows into the collecting tank (16) by gravity where the water is subjected to ozone treatment in a predetermined frequency by an ozone generator (22).

A still further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) wherein pure water from collection tank is

pumped (18) and mixed with minerals dosed (19) from the dosing tank (17) and passed through a multi-stage filtration (20) to generate potable or alkaline water, whereas, the system generates demineralized water, when the water from the collection tank passes through a RO membrane system incorporated with an indigenous high flux polyetherurea membrane (23) in single pass to obtain 2 ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1 ppm TDS.

A further aspect of the present invention is directed to an integrated Atmospheric Water Generator (AWG) wherein control instrumentation provided for optimum running of the atmospheric water generator with constant feed back to a central server on the performance of the machine for continuous monitoring and quick troubleshooting.

Another aspect of the present invention is directed to a process for selectively producing any one or more of three different types of water (i) potable, (ii) alkaline and (iii) demineralised water of biomedical grade comprising:

subjecting atmospheric air to vapor condensation involving the system as described abovefor production of ultrapure water from ambient air using atmospheric water generator according to present invention comprises the steps of:

condensing of atmospheric moisture using said vapor compression system,involving forced suction of atmospheric moist air using a fan, ducted to the evaporator;

said moist air entering the system after passing through pleated polypropylene micro static air filter for removing suspended particles up to 12 microns;

bringing said moist air in contact with the cold surface of the evaporator coil, involving a separate fan, which is maintained below dew point temperature by circulation of the refrigerant wherebythe moist air on contact with cold surface of

the evaporator looses heat and condenses into water droplets on the surface of the coil;

said condensed water from the coil trickles down into a collection trough which is further treated by an ozone generator operated at predetermined frequency;

pumping said pure water from collection tank and mixing with minerals dosed from the dosing tank and passing through a multi-stage filtration (20) to generate potable water;

obtaining alkaline water involving dosing with essential alkaline mineral salts to achieve a pH of 8.3 to 10,

generating demineralized water, by passing the water from the collection tank through a RO membrane system incorporated with an indigenous high flux polyetherurea membrane in single pass to obtain 2 ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1 ppm TDS.

A further aspect of the present invention is directed to said process comprising addition of exit cold air emanating from the evaporator with ambient air to reduce the outlet temperature of refrigerant from the condenser and reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output.

A still further aspect of the present invention is directed to said process wherein when the water level in the storage tank is low, a signal is generated to a respective pump to switch-on automatically involving an inbuilt electronic control device and similarly, when the water level in the storage tank is full, a signal is generated to respective pumps to switch-off automatically.

A still further aspect of the present invention is directed to said process wherein said evaporator fan is operated at CFM rating of 230 to 260 cfm preferably 260cfm and the condenser fan operated with higher CFM rating of 540 cfm to 800 cfm preferably 800cfm, for desired water output of 1.0 LPH to 1.2 LPH, using atmospheric air of 70% RH at a temperature of 30°C.

The objects and advantages of the invention are described hereunder in details with reference to accompanying non limiting illustrative drawings and examples:

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. 1: shows the Process flow diagram of atmospheric water generator for production of potable, alkaline and demineralized water according to present invention.

FIG. 2: Illustrates the Sectional and Isometric Views of Atmospheric Water Generator apparatus/system according to present invention.

Fig. 3: Shows SEM Pictures of (a) Surface and (b) Cross-section of Polyethersulfone based ultrafiltration membrane.

FIG. 4: Representation of Instrumentation and Control Flow Diagram of the Atmospheric Water Generator system according to present invention.

FIG. 5: is the graph plot of Relative humidity vs. Dew point temperature for varying ambient air temperature.

FIG. 6: is the graph plot of Dew point temperature versus water production rate.

DETAILED DESCRIPTION OF THE INVENTION WITH REFERENCE TO THE ACCOMPANYING DRAWINGS

The present invention relates to an automated atmospheric water generator(AWG) and a low cost process for production of potable, alkaline and demineralized water using said indigenous atmospheric water generator. In an embodiment of the present invention, ambient air is sucked into atmospheric water generator after passing through 12 micron pleated air filters. The filtered air passes through cold surface of evaporative coils maintained below dew point temperature to facilitate condensation of water vapor. The exit cold air is added to ambient air to facilitate better condensation of refrigerant vapor in the condenser coil. The condensed water is collected in a tray to be filled into a storage tank where the water is ozone treated.

The present invention is thus directed to provide an automated atmospheric water generator (AWG) involving newer design for achieving higher efficiency and more rapid water vapor condensation for producing different grades of water i.e. potable water, alkaline water and demineralized water from atmospheric moisture.

The method for production of ultrapure water from ambient air using atmospheric water generator according to present invention comprises the following steps:

Atmospheric water generator works on the principle of condensation of atmospheric moisture using vapor compression system. The process for atmospheric moisture condensation involves forced suction of atmospheric moist air using a fan, ducted to the evaporator. The moist air enters the system after passing through pleated polypropylene micro static air filter for removing suspended particles up to 12 microns. Air then comes in contact with the cold surface of the evaporator coil which is maintained below dew point temperature by circulation of the refrigerant. The moist air on contact with cold surface of the evaporator looses heat and condenses into water droplets on the surface of the coil. The water from the coil trickles down into a collection trough which is further treated by an ozone generator operated at predetermined frequency.

To obtain potable water, the water from the trough is collected in a collection tank and pumped into the storage tank using a diaphragm pump. The mineral enriched solution from the dosing tank is pumped using dosing pump which is serially connected to diaphragm pump. The two separate pipelines are interconnected before entering the storage tank and mineralized (fortified) water is passed through a polypropylene spun cartridge followed by a granular activated carbon column to remove suspended solids, dissolved organic, colloidal matter, color and odour. An ultrafiltration spiral wound membrane module based on high flux polyethersulfone membrane is then employed to effectively clarify and disinfect potable water having desired total dissolved solids (TDS) and pH for domestic purpose.

According to a further aspect of the present invention, the method for production of alkaline water with pH of 8.5 to 10 by the atmospheric water generator is similar to potable water production except that the dosing tank is enriched with essential alkaline minerals.

The method for production of demineralized water by the atmospheric water generator includes following steps:

The atmospheric moisture is condensed and collected in the collection tank. The water from the collection tank is passed through a series of pre filters inclusive of polypropylene spun cartridge, granular activated carbon and carbon block filter followed by thin film composite RO membrane system with indigenous high flux polyetherurea membrane material to produce demineralized water with a TDS of < 2 ppm. To achieve a TDS level below 1 ppm, a second stage RO membrane is utilized followed by a mixed bed ion exchange resin column.

The system is provided with automatic water level control unit. When the water level in the storage tank is low, a signal is given to the respective pumps to switch-on automatically by using an inbuilt electronic control device. Similarly, when the water level in the storage tank is full, a signal is given to respective pumps to switch-off automatically.

The atmospheric water generator (AWG) system according to present invention having the following novel and advantageous features:

1. Design of low cost device based on extraction of atmospheric moisture for dispensing potable water, alkaline water and demineralized water, as per the requirement.
2. Equipment for extraction of moisture from air comprises a heat exchange process facilitated using contact of ambient air with hot / cold refrigerant gas.
3. The process design of atmospheric water generator unit includes ambient air filtration and increased water vapor condensation, utilizing lesser electric power with innovations including:

(a) Independent fans for evaporator and condenser.

(b) Condenser fan having higher CFM (cubic feet per minute) when compared to evaporator fans.

(c) Improved condenser efficiency by addition of exit cold air emanating from the evaporator with ambient air.

4. The process design for production of remineralized or potable water having a TDS of 60–100 ppm from the output of atmospheric water generator that involves dosing of essential mineral salts followed by treatment with novel high flux polyethersulfone based ultrafiltration membrane for clarification and disinfection of the output water.

5. The process design for production of alkaline water involves dosing with essential alkaline mineral salts to achieve a pH of 8.3 to 10.

6. A process of demineralization that includes the treatment of atmospheric water condensate with a thin film composite membrane system embedded with high flux polyetherurea membrane to obtain water having TDS of 2 ppm in a single RO stage and less than 1 ppm in a cascaded double stage RO followed by post treatment with mixed bed ion exchange resin column.

7. The atmospheric water generator further comprises equipments wherein:
   i. Condenser fan has higher CFM when compared to fan ducted to evaporator. This improves efficiency of the condensing unit in the atmospheric water generator unit, thus reducing the overall power consumption.
   ii. Utilization of the exit cold air from the evaporator duct along with ambient air reduces the outlet temperature of refrigerant from the condenser. This reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output.

8. The present design comprising the automated dosing of mineral rich solution with atmospheric water condensate to attain potable water with

TDS of 70-90 ppm and alkaline water with pH of 8.3 to 10. The novel high flux polyethersulfone ultrafiltration membrane module, employed in the process, further ensures efficient clarification and disinfection of the remineralized water.

9. The present design of AWG implements demineralization wherein the condensate water from atmospheric water generator is passed through a thin film composite RO system based on indigenously developed polyether urea membrane to achieve demineralized water of 2 ppm TDS level.
10. Conventional alkaline water generator involves various filtration units while the present design for production of alkaline water does not involve any complex processes, but dosing of alkaline minerals based on bicarbonates of sodium, calcium and magnesium.
11. Conventional demineralized water production units involve various filtration stages followed by cation and anion exchange resin columns. In the present AWG, the output water is passed through single of double stage RO followed by treatment with bed resin column to achieve a TDS less than 1 ppm which constitutes Type-2 water useful for niche biomedical and biochemical applications.
12. A process implemented by the present AWG system where the cost per Liter of remineralized water produced is INR 0.65 to 1.3 for a power tariff of Rs. 3/- Rs. 6/- per unit respectively (USD 0.01 to 0.02) for the present AWG machine operating at a capacity of 1000 Lit/day.

The system and method of the AWG are described hereunder in further details in relation to accompanying drawings:

Accompanying **FIG. 1** shows the process flow diagram of atmospheric water generator integrated with membrane process / chemical dosage for production of three different grades of water i.e. remineralized or potable water, demineralized water and alkaline water. In a typical vapor compression refrigeration cycle of atmospheric water generator, the compressor (1) draws the refrigerant vapor from

the evaporator and discharges high pressure and high temperature vapor into the condenser (2). The temperature of the refrigerant is reduced in the condenser (2) by cold air from evaporator and ambient air is sucked in by the condenser fan (14), resulting in a saturated or sub-cooled liquid. The liquid then flows through the expansion valve (5), where it experiences a pressure drop as a result of which temperature and pressure of the refrigerant further reduces before entering the evaporator (6). The refrigerant in the evaporator vaporises by taking heat from the ambient air entering the system caused due to the forced suction by the evaporator fan (12) and exits as low temperature and low pressure vapor. The vaporised refrigerant then passes through an accumulator (7) to collect any residual liquid refrigerant and enters the compressors (1) as low pressure and low temperature vapor to restart the cycle. The fan (12) near the evaporator takes the air from the ambient atmosphere and passes through a series of air filters (3) and then enters into the evaporator (6), where the air is cooled below its dew point and moisture in the air is converted into pure water which gets collected in the water trough (15), then flows into the collecting tank (16) by gravity where the water is subjected to ozone treatment in a predetermined frequency by an ozone generator (22). The pure water from collection tank is pumped (18) and mixed with minerals dosed (19) from the dosing tank (17) and passed through a multi-stage filtration (20) to generate potable or alkaline water, whereas, the system generates demineralized water, when the water from the collection tank passes through a RO membrane system incorporated with an indigenous high flux polyetherurea membrane (23) in single pass to obtain 2 ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1 ppm TDS.

The demineralization unit comprises of a pre-treatment system, two-staged cascaded membrane systems and an optional ion exchange system. The pretreatment system include of polypropylene spun cartridge and activated carbon filter to remove suspended solids, dissolved organic, colloidal matter, colour and odour, while the novel high flux PES ultrafiltration membrane effectively clarifies and disinfects the water to make it potable. Selective polyetherurea composite

membranes are used in the two-staged cascaded membrane system. The output water from the AWG is allowed to pass through demineralization unit to produce DM water with conductivity in the range between 1.56 $mScm^{-1}$ and 3.12 $mScm^{-1}$. Polyether urea membrane carries a positive surface charge. The skin layer of polyether urea is smooth when compared to polyamide membrane which thereby offers tminimal bio-fouling.

Accompanying **FIG. 2** illustrates sectional and isometric views of atmospheric water generator. The system is provided with two circuits of compressor, condenser, accumulator and evaporator to facilitate continuity of water extraction in the event of any failure in either of the circuit. The operation of the system is regulated by a control panel provided with embedded printed circuit board (PCB) to cut-off the unit when the pressure of the refrigerant goes below or above the desired level. The PCB switches off the system when the water level in the collection tank is nearing the brim. The PCB also receives signal from the relative humidity and temperature control unit provided in the system and switches off the system once the RH goes below the prefixed level. The system is also provided with high pressure and low pressure switches to turn-off when the refrigerant pressure goes below or above the acceptable level.

SEM studies were carried out to describe the structural and functional advantages of high flux polyethersulfone (PES) based ultrafiltration membrane described in the present invention. **Figure 3** illustrates the surface and cross-sectional images of the hydrophilized PES membrane. The surface image of PES membrane shows the distribution of pores of diameter falling in ultrafiltration range (Figure 3(a)), whereas the cross-sectional image show the formation of two layers, an upper active PES layer penetrating into a bottom layer made of macroporous non-woven polyester support (Figure 3(b)). The presence of aromatic benzene connected to sulphonyl groups and ether linkages in PES structure contributes to greater chemical stability as well as improved physical properties including mechanical strength. The hydrophilicity of PES membrane was increased by addition of an

organic acid (propionic acid) during preparation of polymer solution. Addition of propionic acid into polymer solution accelerates phase inversion process which thereby improves the overall flux of ultrafiltration membrane.

Accompanying **FIG. 4** represents the instrumentation and control flow diagram of atmospheric water generator system. Sensor systems allow the user and/or controller of the prototype to determine the operational parameters such as relative humidity, temperature, water level and TDS. Featuring powerful sensors and state-of-the-art functions, the multi-parameter monitoring makes it easy to get highly reliable water quality data, continuously throughout its operation. Atmospheric water generator systems involve user authentication, recording and tracking of water quality data and functioning of the machine. The generators may be placed in network communication with other such generators to exchange water availability information therewith, or may communicate with a central server element by way of LAN, Internet, cell tower, peer-to-peer mesh or satellite. A server element in network communication with the computer elements are configured to receive signal from one or more of the user profile data, water quality data and service data. Information is conveyed to the user regarding the water quality and the machine performance through a mobile app.

Experimental Trials:

The performance of the AWG system was evaluated and tested through a number of experimental trials and the results are presented by way of following examples:

Example 1

Experimental trials to study the effect of variation in '% relative humidity' for production of water from 'atmospheric water generator' are reported. As the relative humidity increases, the water output flow increases due to elevated levels of available moisture in the atmosphere.

S. No	Relative Humidity (%)	Water Output Flow (L/h)
1	30	13.5
2	35	16.2
3	40	18.3
4	50	23.4
5	55	24
6	60	25.5
7	65	25.8
8	78	27.6
9	82	33.6

Example 2

Experimental trials of producing remineralized water with respect to varying environmental conditions in a dayhave been performed. The remineralized water after essential salt dosing is examined for TDS and flux of ultrafiltration membrane. An essential salt solution of 1170 ppm TDS is stored in the mineral dosing tank and dosed continuously into the water outlet stream obtained from the storage tank. The TDS of salt dosed water is initially high as the water generation was less and as the time progressed the TDS and UF flux have become stable.

S.No.	Time (Hr:min)	Temp (°C)	Relative Humidity (%)	TDS (ppm)	UF Flux (L/m^2 hr) of filtered drinking water
1	13:00	34	41	84	51.5
2	13:30	35	41	79	53.2
3	14:00	35	41	81	54
4	14:30	34	42	79	54.1
5	15:00	36	39	79	55.8
6	15:30	35	38	79	56.0
7	16:00	35	38	80	57.5

8	16:30	35	38	76	59.1
9	17:00	35	38	79	59.0
10	17:30	35	37	79	60.0

Example 3

Experimental trials of producing alkaline water were performed using addition of alkaline salts with varying concentration. The effect on alkalinity of water with varying concentration of salt added to the water is studied. The alkalinity of water increases with increase in addition of alkaline salt mixture.

S. No.	Salt concentration (g/L)	pH of water
1	0.1	8.3
2	0.2	8.5
3	0.25	8.6

Example 4

Experimental trials on production of demineralized water from the condensate of atmospheric water generator unit were performed by integration of a thin film composite RO membrane unit based on indigenous polyether urea membrane to obtain demineralized water. At 2 bar applied feed pressure, the permeate water from thin film composite system contained a TDS of less than 1 ppm with 3.32 µS/cm conductivity. The output permeate flow was measured as 20.6 L/h.

Example 5

Fig. 5 shows a graph plotted between % relative humidity and dew point temperature for varying ambient air temperature (T). Atmospheric air contains certain amount of moisture. The maximum amount of moisture held by air depends on ambient air temperature. The dew point temperature is calculated for a given relative humidity and saturation air temperature. The moisture present in the

atmospheric air starts to condense out when the air temperature approaches the dew point. The refrigerant flowing inside the evaporator cools down the surrounding air temperature below its dew point resulting in formation of dew over the surface of evaporator coils. Increase in dew point temperature from 53 to 88 °F increases the water production rate from 20 to 65 L/h as depicted in **Fig. 6**.

Example 6

The following experimental trial data shows the improved operational efficiency of the present AWG system over the conventional one by selective use of independent fans for the condenser and evaporator with condenser fan higher CFM and utilization of the exit cold air from the evaporator duct along with ambient air reduces the outlet temperature of refrigerant from the condenser. This reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output:

Comparative data of trial done with two designs, first one,what is being used in conventional AWG- evaporator and condenser on the same line and using single fan at the exit of condenser; and

Second one is for innovation in Applicant's design involving evaporator and condenser having two different fans and both of them being placed separately and not on the same line. The condenser having higher CFM.

The trial conducted with same capacity compressor (5102 BTU) and same size evaporator (9"x9"- 2 row)and condenser (11"x 10" 4 row) .

When they are placed separately and uses different fans, evaporator fan (230 cfm) with condenser having higher capacity fan (540 cfm) in the innovative design, the conventional prior art design having the evaporator connected by a duct to the condenser and the condenser connected to the condenser fan (540 cfm).

After taking two readings:

It is observed that at RH of 69% and temperature 28 degree C the output of water was 1020 ml per hour in the prior art design of single fan and in the claimed new design of present invention, the output was 1200 ml per hour showing an increase efficiency by 18%. Current consumption was 3A in both the cases.

It was further observed that at RH of 70% and temperature 28 degree C the output of water was 900 ml per hour in the prior art design of single fan and the in the claimed design of present invention, the output was 1200 ml per hour showing an increase efficiency by 25%.Current consumption was 3A in both the cases.

However, when the condenser fan CFM was increased to 800 from 540,
Voltage being constant at 220 V, The amperage observed was 3.2 A for the design with 540 CFM fan at the condenser, and was 2.8 A for 800 CFM fan at the condenser, the reduction in amperage in the new design is 12.6%.

When exit cold air was allowed to mix with ambient air from the evaporator,
For the same ambient temperature of 28 degree C, the temperature of the condenser outlet was 34 degree C at the condenser outlet and 3 degree C at evaporator inlet; but when the exit cold air was not mixed with ambient air the temperature at the condenser outlet being 40 degree C and the evaporator inlet 7 degree C.

Thus it was observed that when cold air is mixed with ambient air, the drop in temperature at the condenser outlet and evaporator inlet is higher, resulting in higher heat exchange.

It is thus possible by way of the present invention to provide an atmospheric water generator (AWG) device for production of potable water, alkaline water and medical grade water. The production of potable water involves remineralisation with essential mineral rich salt mixture using an automated dosing technique. An

embodiment to attain alkaline grade potable water by alkaline rich mineral salt fortification is also described. The product water is further processed with integrated micro-filtration for removal of suspended solids followed by ozonation and ultraviolet (UV) sterilization for complete disinfection and ultrafiltration by high flux polyether sulfone membrane for removal of turbidity and colloidal silica. Alternatively, for production of ultrapure water for use in biotechnological, biochemical, medical and industrial applications, the atmospheric water generator is integrated with a novel thin film composite polyetherurea reverse osmosis membrane in single stage or multiple cascade stage configurations followed by resin treatment, depending upon the purity grade of water required.

We Claim:

1. An integrated Atmospheric Water Generator (AWG) capable of selectively producing three different types of water (i) potable, (ii) alkaline and (iii) demineralised water of biomedical grade comprising:

Vapor condensation unit including forced suction of atmospheric moist air involving fan means ducted to evaporator ;

Said evaporator maintained below dew point temperature by circulation of refrigerant ;

Said moist air on contact with cold surface of evaporator looses heat and condenses into water droplets ;

collection tray/trough for collecting the thus generated water droplets;

cooperatively integrated with membrane-based ultrafiltration, controlled essential chemical dosage and reverse osmosis (RO) membrane to produce three different types of water, namely potable, alkaline and demineralised water of biomedical grade.

2. An integrated Atmospheric Water Generator (AWG) as claimed in claim 1 comprising:

(c) Independent fans for evaporator and condenser;

(d) Condenser fan having higher CFM (cubic feet per minute) when compared to evaporator fans.

3. An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 or 2 comprising condenser unit having operative supply of addition of exit cold air emanating from the evaporator with ambient air to reduces the outlet temperature of refrigerant from the condenser and reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output.

4.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 3 comprising
water from the collection trough operatively connected to storage tank ;
operatively connected dosing tank for feeding mineral enriched solution including alkaline minerals.

5.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 4
comprising ultrafiltration spiral wound membrane module based on high flux polyethersulfone membrane to effectively clarify and disinfect potable water having desired total dissolved solids (TDS) and pH for domestic purpose.

6.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 4 wherein water from the collection tank is passed through a series of pre filters inclusive of polypropylene spun cartridge, granular activated carbon and carbon block filter followed by thin film composite RO membrane system with high flux polyetherurea membrane material to produce demineralized water with a TDS of < 2 ppm, preferably including a second stage RO membrane is utilized followed by a mixed bed ion exchange resin columnto achieve a TDS level below 1 ppm.

7.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 6 comprising automatic water level control unit adapted such that when the water level in the storage tank is low, a signal is generated to a respective pumpto switch-on automatically involving an inbuilt electronic control device and similarly, when the water level in the storage tank is full, a signal is generated to respective pumps to switch-off automatically.

8.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 7 comprising automated dosing of mineral rich solution with

atmospheric water condensate to attain potable water with TDS of 70-90 ppm and alkaline water with pH of 8.3 to 10alongwithhigh flux polyethersulfone ultrafiltration membrane modulefor efficient clarification and disinfection of the remineralized water.

9.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 8 comprising dosing of alkaline minerals based on bicarbonates of sodium, calcium and magnesium.

10.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 9 comprising 10 to 12 microns preferably 10 micron pleated air filters through which atmospheric air is sucked in before subjecting the same to vapor condensation.

11.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 10 comprising high flux polyethersulfone based ultrafiltration membrane having pore size in the range from 0.005 to 0.05 m enables 99.9% rejection of bacteria / virus with complete clarification and disinfection of the output water.

12.An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 11 comprising demineralization unit including a pre-treatment system, two-staged cascaded membrane systems and an optional ion exchange system, the said pretreatment system including polypropylene spun cartridge and activated carbon filter to remove suspended solids, dissolved organic, colloidal matter, color and odour, a high flux PES ultrafiltration membrane effectively clarifying and disinfecting potable water, selective polyetherurea composite membranes with positive surface chargeover membrane surface allows minimal problems pertaining to bio-fouling deposition by offering high water flux in said two-staged cascaded membrane system, the output water adapted to pass through demineralization unit to produce DM water with conductivity in the range

between 1.56 $mScm^{-1}$ and 3.12 $mScm^{-1}$. Polyether urea membrane carries a positive surface charge.

13. An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 12 comprising

a vapor compression refrigeration cycle comprising

a compressor that draws the refrigerant vapor from an evaporator and discharges high pressure and high temperature vapor into a condenser wherein the temperature of the refrigerant is reduced in the condenser by cold air from evaporator and ambient air is sucked in by a condenser fan, resulting in a saturated or sub-cooled liquid;

an expansion valve through which said condensed liquid then flows where it experiences a pressure drop as a result of which temperature and pressure of the refrigerant further reduces before entering the evaporator, so that the refrigerant in the evaporator vaporises by taking heat from the ambient air entering the system caused due to the forced suction by a evaporator fan and exits as low temperature and low pressure vapour;

an accumulator through which said vaporised refrigerant is then passes to collect any residual liquid refrigerant and enters the compressors as low pressure and low temperature vapor to restart the cycle.

14. An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 13 comprising

said fan near the evaporator takes the air from the ambient atmosphere and passes through a series of air filters and then enters into the evaporator, where the air is cooled below its dew point and moisture in the air is converted into pure water

which gets collected in the water trough, then flows into the collecting tank by gravity where the water is subjected to ozone treatment in a predetermined frequency by an ozone generator.

15. An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 14wherein

pure water from collection tank is pumped and mixed with minerals dosed from the dosing tank and passed through a multi-stage filtration to generate potable or alkaline water, whereas, the system generates demineralized water, when the water from the collection tank passes through a RO membrane system incorporated with an indigenous high flux polyetherurea membrane in single pass to obtain 2 ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1 ppm TDS.

16. An integrated Atmospheric Water Generator (AWG) as claimed in anyone of claims 1 to 15 wherein control instrumentation provided for optimum running of the atmospheric water generator with constant feed back to a central server on the performance of the machine for continuous monitoring and quick troubleshooting.

17. A process for selectively producing any one or more of three different types of water (i) potable, (ii) alkaline and (iii) demineralised water of biomedical grade comprising:

subjecting atmospheric air to vapor condensation involving the system as claimed in anyone of claims 1 to 16 for production of ultrapure water from ambient air using atmospheric water generator according to present invention comprises the steps of:

condensing of atmospheric moisture using said vapor compression system,involving forced suction of atmospheric moist air using a fan, ducted to the evaporator;

said moist air entering the system after passing through pleated polypropylene micro static air filter for removing suspended particles up to 12 microns;

bringing said moist air in contact with the cold surface of the evaporator coil, involving a separate fan, which is maintained below dew point temperature by circulation of the refrigerant whereby the moist air on contact with cold surface of the evaporator looses heat and condenses into water droplets on the surface of the coil;

said condensed water from the coil trickles down into a collection trough which is further treated by an ozone generator operated at predetermined frequency;

pumping said pure water from collection tank and mixing with minerals dosed from the dosing tank and passing through a multi-stage filtration to generate potable water;

obtaining alkaline water involving dosing with essential alkaline mineral salts to achieve a pH of 8.3 to 10,

generating demineralized water, by passing the water from the collection tank through a RO membrane system incorporated with an indigenous high flux polyetherurea membrane in single pass to obtain 2 ppm TDS or cascaded two-stage arrangement with resin to achieve water quality of less than 1 ppm TDS.

18. A process as claimed in claim 17 comprising addition of exit cold air emanating from the evaporator with ambient air to reduce the outlet temperature of refrigerant from the condenser and reduction in temperature creates increased heat exchange at the evaporator coil, resulting in higher condensation efficiency leading to increased water output.

19. A process as claimed in anyone of claims 17 or 18 wherein when the water level in the storage tank is low, a signal is generated to a respective pump to switch-on automatically involving an inbuilt electronic control device and

similarly, when the water level in the storage tank is full, a signal is generated to respective pumps to switch-off automatically.

20. A process as claimed in anyone of claims 17to 19 wherein said evaporator fan is operated at CFM rating of 230 to 260cfm preferably 260cfm and the condenser fan operated with higher CFM rating of 540 cfm to 800cfm preferably 800cfm, for desired water output of 1.0 LPH to 1.2 LPH, using atmospheric air of.70% RH at a temperature of 30°C.

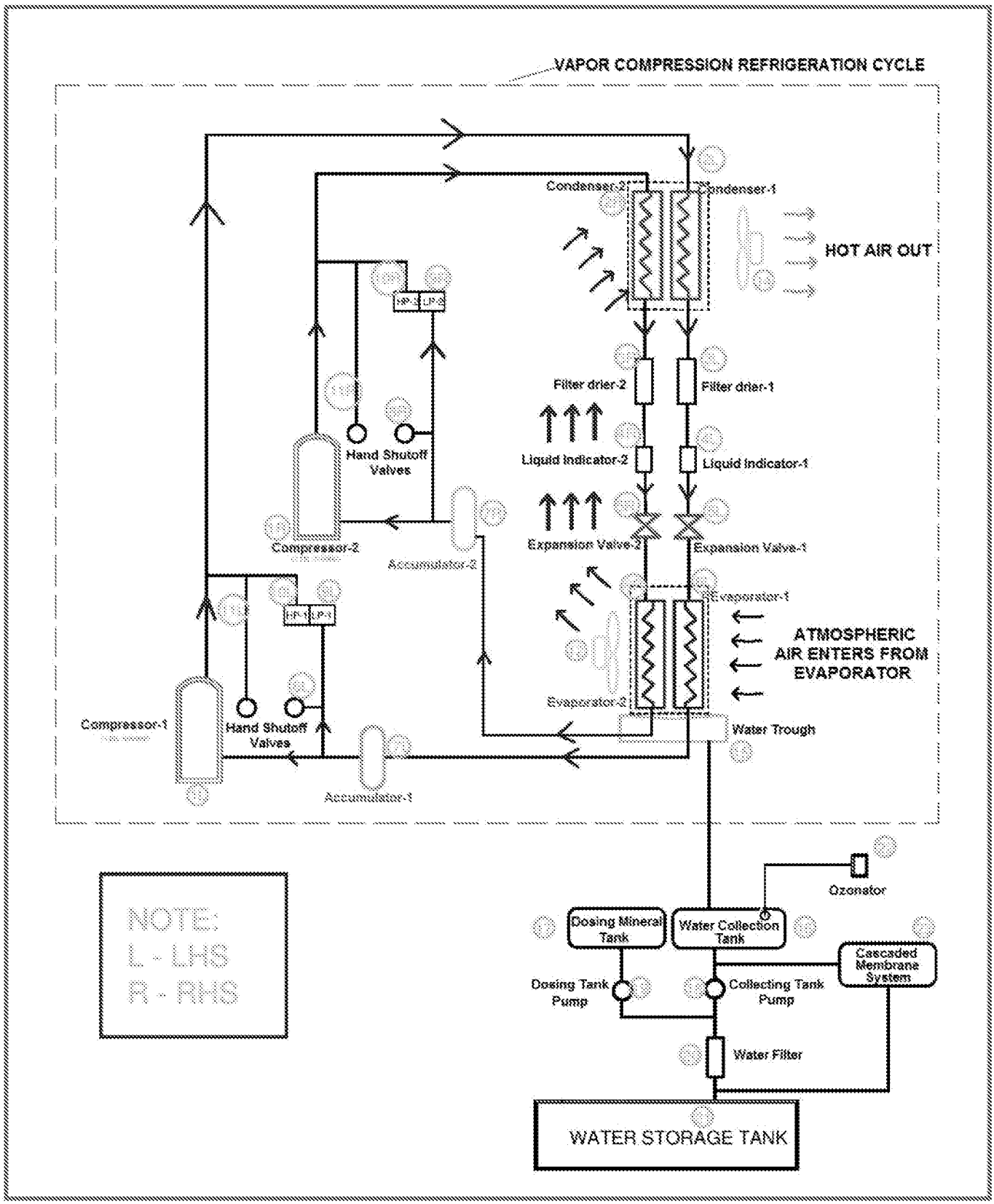
VAPOR COMPRESSION REFRIGERATION CYCLE
Condenser-2
Condenser-1
HOT AIR OUT
Filter drier-2
Filter drier-1
Liquid Indicator-2
Liquid Indicator-1
Expansion Valve-2
Expansion Valve-1
Evaporator-1
ATMOSPHERIC AIR ENTERS FROM EVAPORATOR
Evaporator-2
Water Trough
Hand Shutoff Valves
Compressor-2
Accumulator-2
Hand Shutoff Valves
Compressor-1
Accumulator-1
NOTE:
L - LHS
R - RHS
Ozonator
Dosing Mineral Tank
Water Collection Tank
Cascaded Membrane System
Dosing Tank Pump
Collecting Tank Pump
Water Filter
WATER STORAGE TANK

Figure 1

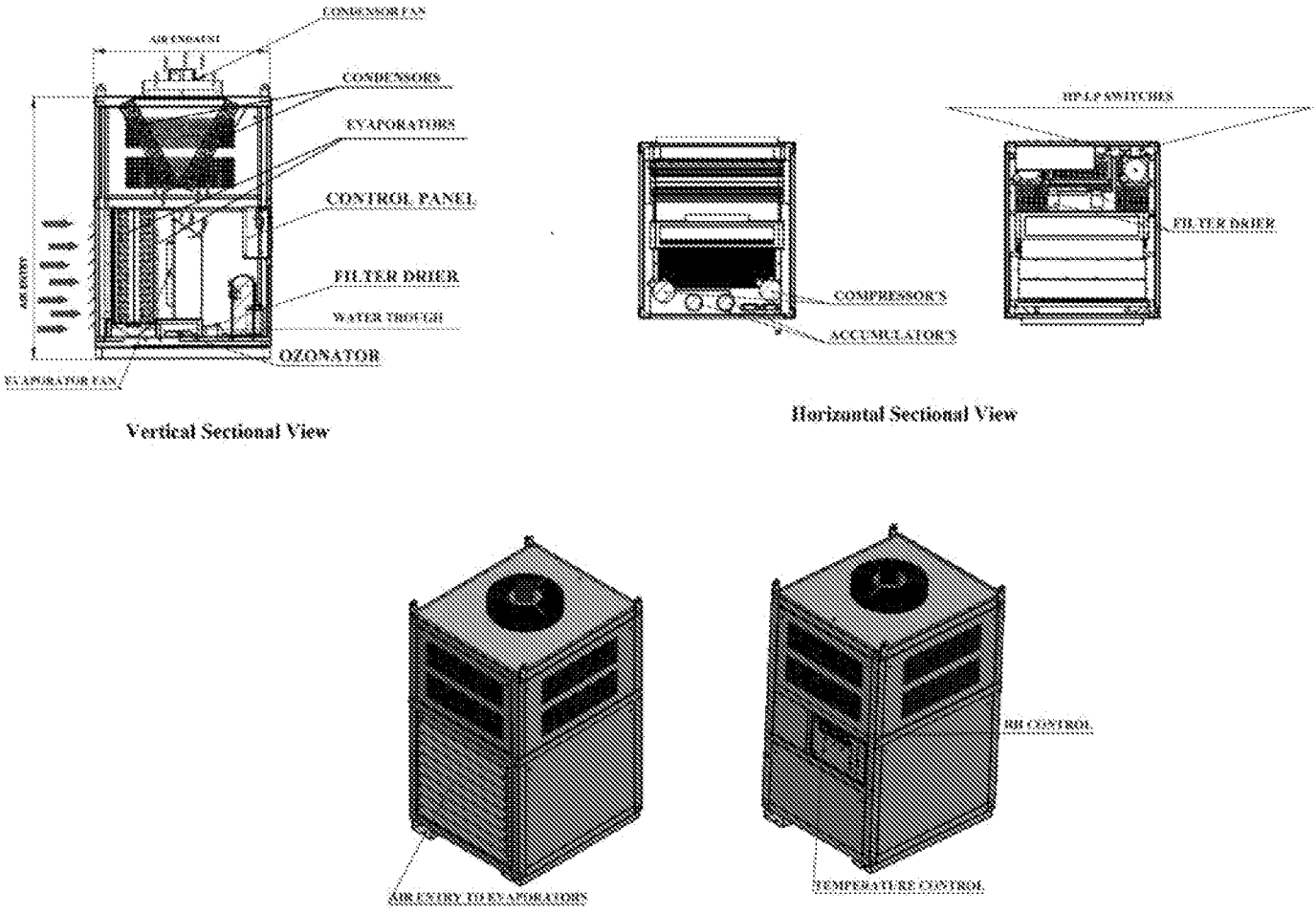

Figure 2

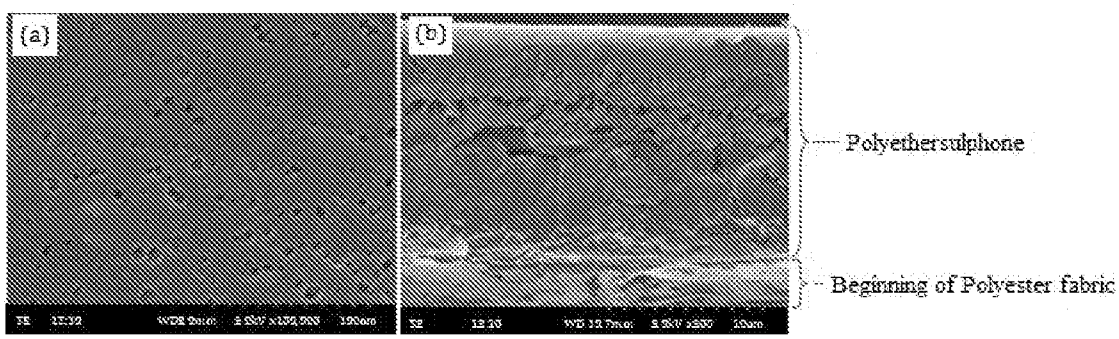

Figure 3

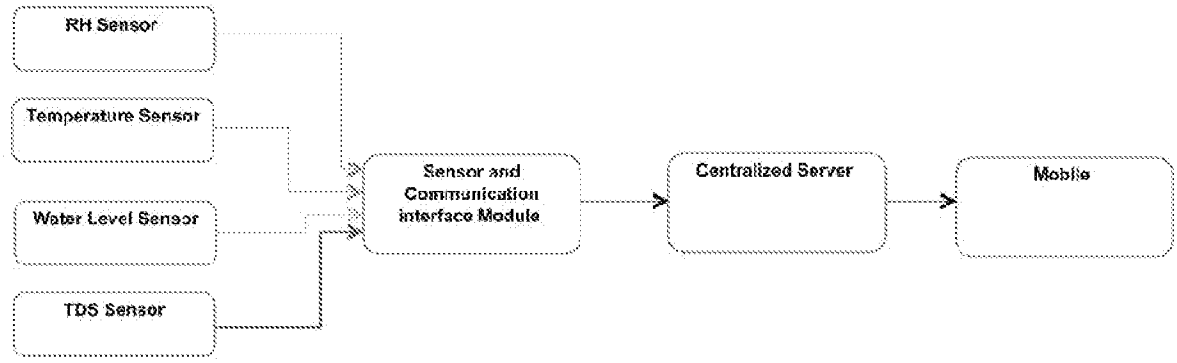

Figure 4

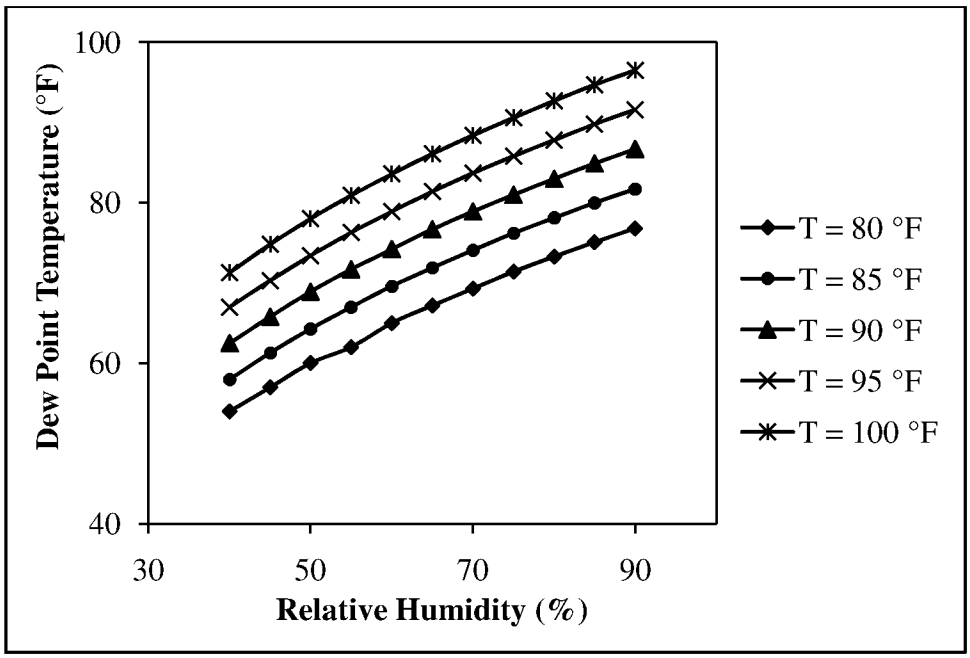

Figure 5

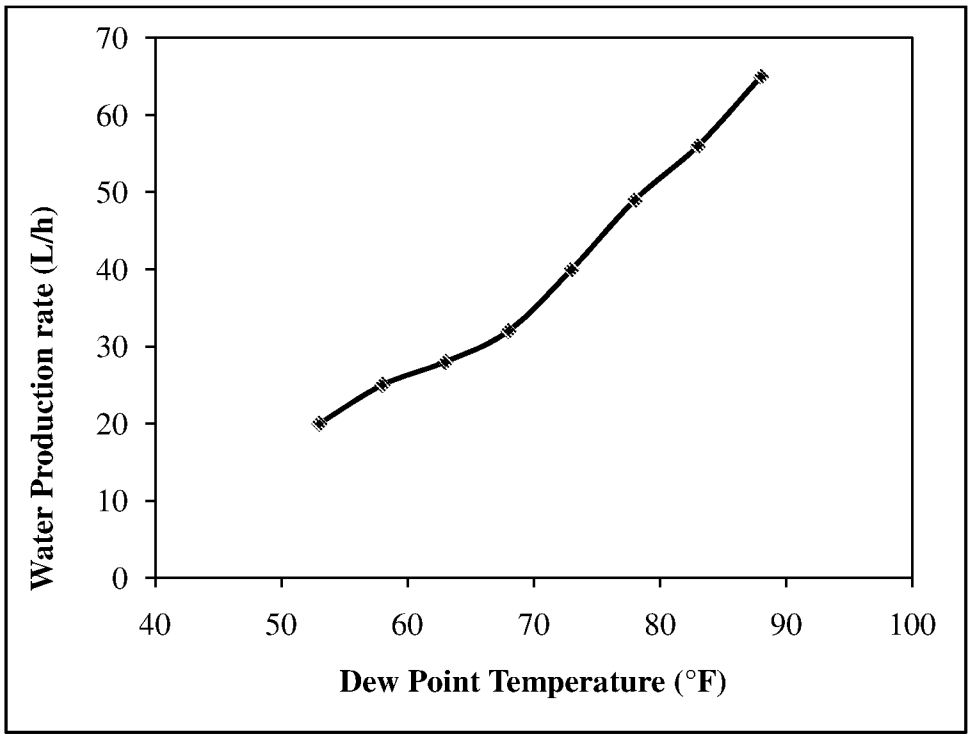
Water Production rate (L/h)
70
60
50
40
30
20
10
0
40
50
60
70
80
90
100
Dew Point Temperature (°F)

Figure 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2019/050829

A. CLASSIFICATION OF SUBJECT MATTER
E03B3/28,C02F1/28,C02F1/44,C02F1/78 Version=2020.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

CPC: E03B 3/28, Y02A 20/109, C02F 1/28, C02F 1/44, C02F 1/78

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

TotalPatent One, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IN 201817015828 A (LEAUDELAIR SA) 07 September 2018 (07.09.2018) Abstract, Page 13; last para, Page 14; 1st and 2nd para, Page 14; first para under section 5.2, Page 15; 4th-6th para, Page 16; 5th para, Page 17; last para, Page 18; 3rd and 4th para, Page 19; 8th & 9th para, Page 21; 1st para, 2nd para, last para, section 5.4	1, 4-6, 8-17
Y	Page 17; 6th para, Page 25; 6th para	7, 19
A	Page 13; last para, Page 14; 1st and 2nd para	2-3, 18, 20
A	EP2565336 A1 (HSU, Henry, et al.) 06 March 2013 (06.03.2013) Para [0071]	2, 20
Y	US6684648 B2 (FAKIEH RESEARCH & DEVELOPMENT CENTER) 03 February 2004 (03.02.2004) Column 18; line 1-9, Column 19; line 22-42, Column 20; line 34-41	7, 19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21-02-2020	21-02-2020
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Seetha Raman A Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2019/050829

Citation	Pub.Date	Family	Pub.Date
IN 201817015828 A	07-09-2018	AU 2016359441 A1	12-07-2018
		BR 112018009993 A2	06-11-2018
		EP 3408230 A1	05-12-2018
		FR 3044003 A1	26-05-2017
		WO 2017089988 A1	01-06-2017
		PH 12018501033 A1	28-01-2019
		SG 11201804224R A	28-06-2018
		US 2019127253 A1	02-05-2019
		ZA 201804215 B	24-04-2019
EP 2565336 A1	06-03-2013	WO 2011134426 A1	03-11-2011
		ES 2669843 T3	29-05-2018
		US 2013213865 A1	22-08-2013