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EVAPORATIVE COOLER

[0001] The present patent application relates to an evaporative cooler. The application also relates methods for making, assembling, disassembling, installing, configuring, maintaining and using the evaporative cooler.

[0002] An evaporative cooler (also known as swamp cooler, desert cooler and wet air cooler) cools air through evaporation of water. The evaporative cooler differs from typical air conditioners, which use vapour-compression or absorption refrigeration cycles.

[0003] An evaporative cooler is normally less expensive to install and operate as no compressor is used. Power consumption of the evaporative cooler is limited to driving a fan and a water pump of the evaporative cooler, which normally has low current draw at its start-up. Water is used instead of ammonia or chlorofluorocarbon (CFC) which are toxic and difficult to replace. The evaporative cooler usually adopts a permeable membrane that acts as an effective air filter for removing a variety of contaminants in the air.

[0004] An evaporative cooler often requires constant supply of water to wet permeable or evaporative membranes of the evaporative cooler, which increases water demand, cost and labour to replenish a water tank of the evaporative cooler. The evaporative membranes must be cleaned or replaced on a regular basis to maintain cooling performance of the evaporative cooler. Wood wool pads are inexpensive but require replacement every few months. Higher-efficiency rigid evaporative membranes are expensive, although the rigid evaporative membranes may last for a number of years proportional to the water hardness. In areas with very hard water, the rigid evaporative membranes may only last for two years before mineral scale build-up on the evaporative membranes unacceptably degrades performance.

[0005] An evaporative cooler may become a place for mosquito breeding. Numerous authorities consider an improperly maintained cooler to be a threat to public health. Mould and bacteria may be dispersed into interior air from improperly maintained or

defective systems, causing Sick Building Syndrome and adverse effects for Asthma and allergy sufferers. Wood wool of dry cooler pads can catch fire even by small sparks.

[0006] Therefore, the present application aims to provide an evaporative cooler that may be able to improve performance, comfort, water use, maintenance and health impact on usage of the evaporative cooler.

[0007] The present invention aims to provide a new and useful evaporative cooler. The invention also aims to present new and useful methods of making, assembling, installing, repairing, upgrading, modifying, configuring and using the evaporative cooler. Essential features of the invention are provided by one or more independent claims, whilst advantageous features of the invention are presented by their dependent claims respectively.

[0008] According to a first aspect, the present application provides an evaporative cooler for lowering the ambient temperature. The evaporative cooler comprises an enclosure having a base, a contiguous wall circumscribing the base, a top lid covering the enclosure, at least one permeable medium enclosed within the enclosure being partially submerged in a fluid-tight chamber, a plurality of aperture (vents, bores) located along the enclosure (base, wall, top lid) for drawing and purging of a first fluid (air), a ventilator (motorized fan) within the enclosure for drawing the first fluid (air) from the exterior into the interior of the enclosure, and the fluid-tight chamber within the enclosure for holding a second fluid (water).

[0009] The enclosure can be weather-proof for protecting the internal parts from tampering by authorized personnel and external elements (dust, water, heat from the sun). The first fluid can be the ambient air (warm or cold) and the second fluid is the water. The permeable medium can be erected vertically or inclined at an angle (easier for the water to travel up at an inclination vs vertical, capillary action) within the enclosure with a one end (the width) of the permeable medium submerged in the water. The permeable medium can have a pre-determined dimension of length of not more than 300 millimeters and a width of not more than 150 millimeters providing a channel for the water to flow in opposition to gravity. (a narrower width provides a quicker water upward flow moistening the length (surface) of the permeable medium wall)

[0010] The permeable medium may be made of silicon carbite. The apertures, optionally on any part pf the surface of the enclosure, may be concentric circles and/or louvres and/or extension formed on the surface of the wall, the top lid and the base providing a first aperture for drawing of warm air and a second aperture for ejecting of a cold air. The ventilator (fan) may comprise a motor driving a fan blade provides a vacuum within the enclosure for drawing the warm air into the enclosure via the first aperture and the cold air ejected (discharge/purge) via the second aperture. The fluid tight chamber may be located at the bottom of the enclosure.

[0011] According to a second aspect, the present application provides a method of cooling the ambient air using the evaporative cooler. The method comprises a first step of immersing the one end of permeable medium in the water at the fluid-tight chamber; a second step of creating a vacuum within the enclosure using the ventilator; a third step of drawing the warm air via the first aperture from the exterior of the enclosure; a fourth step of passing the warm air through the moistened permeable medium; and a fifth step of ejecting the cold air through the second aperture (cold air sinks).

[0012] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of relevant inventions.

[0013] Fig. 1 illustrates a first embodiment of an evaporative cooler;
Fig. 2 illustrates a second embodiment of the evaporative cooler; and
Fig. 3 illustrates a third embodiment of the evaporative cooler.

[0014] Exemplary, non-limiting embodiments of the present application will now be described with references to the above-mentioned figures. Fig. 1 illustrates a first embodiment of an evaporative cooler 100. The evaporative cooler 100 comprises an enclosure 122 having a base 132, a contiguous wall circumscribing the base 132, a top lid 128 covering the enclosure 122. The top lid 128 having an air duct 124.

[0015] The evaporative cooler 100 also comprises at least one permeable medium 108 enclosed within the enclosure 122 with a one side being partially submerged in a fluid-tight chamber filled with water 116.

[0016] The evaporative cooler 100 also comprises a plurality of aperture 130 located around the surface of the enclosure 122. The aperture 130 can be along the wall and/or the top lid 128. The air duct 124 on the top lid 128 is also an aperture 130.

[0017] The evaporative cooler 100 also comprises a ventilator 102 within the enclosure 122. The ventilator 102 is driven by a ventilator motor 104 connected by a belt.

[0018] The fluid-tight chamber is within the enclosure 122 for holding the water 116 specifically at the bottom of the enclosure 122 in the first embodiment. The permeable medium 130 is partially submerged on the one end into the water. The other end of the permeable medium 130 is connected to a water distribution line 110. The water distribution line is connected to a water pump 106. The water pump 106 is located in the fluid-tight chamber at the base 132 which is powered by an electrical source normally from the electrical mains which is not shown. An overflow channel 112 is also located in the fluid-tight chamber with one end above the surface of the water 116 and the opposite end going through the base 132 of the enclosure 122. A ball float valve 114 is located above the surface of the water line attaching to the wall of the enclosure 122. The ball float valve 114 is then connected to a water valve 126 external to the enclosure 122 by a water hose.

[0019] Fig. 2 illustrates a second embodiment of the evaporative cooler 200. The evaporative cooler 200 having a heat exchanger 134 before the aperture 130. The heat exchanger 134 is electrically powered by the electrical main supply.

[0020] Fig. 3 illustrates a third embodiment of the evaporative cooler 300 as viewed from the longitudinal side. The evaporative cooler 300 of the third embodiment having a rectangular enclosure 122 with a front aperture 129 at a front side and a rear aperture 131 at a rear side. The front aperture 129 having a plurality of louvre 302 inclined at an angle. The rear aperture 131 having the ventilator 102 driven by a ventilator motor 104 (not shown) obtaining its electrical power 304 from the electrical mains. The ventilator

102 is a high suction pressurised fan. A water inlet is located at the front part of the enclosure 122. The overflow channel 112 is located at the bottom part along the front side of the enclosure 122.

[0021] Within the enclosure 122 are a plurality of permeable medium 108 erected vertically. The permeable medium 108 are supported by vertical grooves (not shown) that are formed on the interior sides along the wall of the enclosure 122. A first permeable medium 306, a second permeable medium 308 and a third permeable medium 310 are arranged vertically at regular spacing with the bottom ends partially submerged in the water 116. A top end of the third permeable medium 310 having a vertical wall 312. The second permeable membrane 308 and the third permeable membrane 310 having a labyrinth structure.

[0022] The permeable membranes 306,308,310 can be arranged vertically or horizontally. For both vertically or horizontally arrangement, the water 116 from the water inlet 314 is channeled on the permeable membranes 306,308,310 to moisten thereon.

[0023] The water inlet 314 is controlled by the ball float valve 114 located at the interior top part of the enclosure 122. The ball float floats on the surface of the water 116 at the interior bottom of the enclosure 122. The ball float cooperates with a rod which pivotally connects to the ball float valve 114. If the water level fell to a low level, the ball float valve 114 will be opened and water will flow into the enclosure 122, filling the fluid tight enclosure 122 at the bottom as well as moistening the permeable medium 306,308,310. The water level is determined by adjusting the length of the rod connected to the ball float. A longer rod implies a low water level whilst a short rod length implies a high water level. The water level is also directly related to the relative humidity of the warm air. If the air is moisture laden (relative humidity is high), then the water level can be lowered whilst a dry air means a higher water level is desired.

[0024] There are differences between the third embodiment 300 and the first 100 and the second embodiment 200. Firstly, the water is pumped from the bottom of the enclosure 122 to the top of the permeable medium 108 whilst in the third embodiment 300 water inlet 314 located at the top uses gravity to moisten the permeable mediums

306,308,310 saving energy. Secondly, the third embodiment 300 outflow cooled air 120 is ejected from the rear aperture 131 located at the side wall instead of at the top or bottom apertures 130.

[0025] The enclosure 122 provides protection of the internal parts of the evaporative cooler 100 preventing dust and water from entering as well as unauthorized access to the interior.

[0026] The enclosure 122 of the third embodiment 300 having vertical grooves on one or both longitudinal sides (lengths). The grooves provide support for the holding of the first permeable medium 306, the second permeable medium 308 and the third permeable medium 310. The vertical wall 312 provides a barrier so that the air flow is impeded from flowing above the third permeable medium 312 making the air moisture laden helping to cool the warm air. The second permeable membrane 308 and the third permeable membrane 310 having labyrinth structure provides a bigger surface area for the water 116 to moisten the permeable medium 308,310. The enlarged surface area provides the warm air (assuming dry warm air of about 50% relative humidity) to absorb the moisture thereon.

[0027] The top lid 128 provides access to the interior of the evaporative cooler 100. The top lid 128 having an air duct 124 provides a channel for the cool air out 120.

[0028] Alternatively, the air duct 124 can be located at the base 132 of the enclosure 122 which provides a channel for the cooled air to sink. However, the fluid-tight chamber at the base has to be modified. The centre of the base 132 having a through hole with an inner wall extending upwards from the hole forming a trough at the base 132. The hole can be concentric or other polygonal shapes. The height of the inner wall extends above the water level.

[0029] The permeable medium 108 provides a physical channel for the water 116 to travel upwards against the gravitational pull using the effect of capillary action. Capillary action occurs because of intermolecular forces between the water 116 and surrounding solid surfaces in this case is the permeable medium 108. The combination of surface tension (which is caused by cohesion within the water 116) and adhesive forces

between the water 116 and the permeable medium 108 wall act to propel the water 116. Hence, the one side of the permeable medium 108 is submerged in the fluid-tight chamber filled with water 116 so that the capillary action can be effected.

[0030] The permeable medium 108 is made of silicon carbite (SiC) which provides a uniform and quick absorption of water 116. Similar to a sponge, water is absorbed and moisten the whole permeable medium 108. The permeable material further provides filtration of the incoming air from the exterior of the enclosure 122 blocking impurities and pests. The permeable medium 108 can be erected upright or can be placed at an inclination into the water 116. The permeable medium 108 can be formed and shaped according to the required specifications and applications. The permeable medium 108 can be curved or twisted.

[0031] The aperture 130 provides opening for the warm air 118 into the enclosure 122 in particular along the wall. The aperture 130 also known as the air duct 124 provides a channel for the cool air out 120.

[0032] The ventilator 102 provides an accelerated drawing of the warm air 118 from the exterior into the interior of the enclosure 122. The ventilator 102 is driven by the ventilator motor 104 by a belt. Electrical power from the electrical mains is fed to the ventilator motor 104 rotates the motor which in turn engages the belt and turn the ventilator 102. The ventilator 102 can be made of a plurality of fan blade joined to a rotating point. The fan blade can be made of plastic or metal. The merits of using plastic is the water resistant property whilst metal provides reliability for long term outdoor use. The ventilator 104 having the fan blades rotate to create a vacuum within the enclosure 122 and hence the ambient air flows into the enclosure 122. The ventilator 104 can be positioned facing the air duct 124 forcing the warm air 118 to go through the permeable medium 108 and ejected through the air duct 124.

[0033] Alternatively, the ventilator 104 can be positioned behind the aperture 130 adjoining the wall of the enclosure 122. The warm air 118 is propelled into the enclosure 122 by the fan blades. The cooled air after passing through the moist permeable medium 108 is ejected through the air duct 124.

[0034] The fluid-tight chamber is located at the base 132 of the enclosure 122. The fluid-tight chamber provides a tank for holding of water 116. The water 116 is introduced into the fluid-tight chamber by the water valve 126 connected to the ball float valve. The water valve 126 is in a normally-opened position (tap is opened with water continuously flowing). The water inlet is controlled by the ball float valve 114 which shuts or open the said valve 114. The ball float valve 114 having a buoyancy ball attached to a one end of a swing arm and the other end connected to the said valve 114. When the water level is low, the buoyancy ball falls and the said valve 114 is open allowing water 116 to enter the fluid-tight chamber. If the water level is leveled with the ball float valve 114, the buoyancy ball rises and the said valve 114 is shut to discontinue the inflow of water 116.

[0035] The overflow channel 112 provides a channel for displacing excess water 116 in the fluid-tight chamber to the exterior of the enclosure 122. Alternatively, a conduit can be installed to channel the displaced water 116 back to the fluid-tight chamber to conserve the water 116.

[0036] The water pump 106 connected to an electrical source provides the channeling of the water 116 from the fluid-tight chamber at the base 132 to the opposite end of the permeable medium 108 near the top lid 128 via the water distribution line 110. The water 116 flowing in the water distribution line 110 moistens the permeable medium 108 at the opposite end to accelerate the moistening process. The water pump provides an additional method of moistening when the demand for a quicker temperature lowering is required. The water level inside the enclosure 122 provides control of the temperature of outflow cooled air.

[0037] The heat exchanger 134 provides the cooling of the incoming warm ambient air 118. The heat exchanger 134 comprising series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar

and temperatures greater than 260°C). The shell and tube heat exchangers are robust due to their shape.

[0038] In use, the evaporative cooler 100 provides two modes of operation, a direct evaporative cooling and an indirect evaporative cooling.

[0039] In the direct evaporative cooling, the ventilator 102 draws the warm air 118 through a moistened permeable medium 108 providing a large surface area for the evaporation of water 116 into the air. Water 116 is channeled to the permeable medium 108 either from the water distribution line 110 at the top or through the capillary action at the bottom of the permeable medium 108 or both ways. The permeable medium 108 is continually kept saturated with water 116. Any excess water that drips out from the bottom of the permeable medium 108 is collected in the fluid-tight chamber and recirculated to the top.

[0040] In the indirect evaporative cooling, a heat exchanger 134 is used to transfer the cool energy to the supply warm air 118 becoming the conditioned supply air.

[0041] The cooled moist air 120 from the direct evaporative cooling process never comes in direct contact with the conditioned supply air.

[0042] In the application, unless specified otherwise, the terms "comprises", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[0043] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0044] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and

should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0045] It will be apparent that various other modifications and adaptations of the application will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is intended that all such modifications and adaptations come within the scope of the appended claims.

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Reference Numeral

100	first embodiment, direct evaporative cooler
102	ventilator
104	ventilator motor
106	water pump
108	permeable medium
110	water distribution line
112	overflow channel
114	ball float valve
116	water
118	warm air in
120	cool air out
122	enclosure
124	air duct
126	water valve
128	top lid
129	front aperture
130	aperture
131	rear aperture
132	base
134	heat exchanger
200	second embodiment, indirect evaporative cooler
300	third embodiment of a direct evaporative cooler
302	louvre
304	electrical power
306	first permeable medium
308	second permeable medium
310	third permeable medium
312	vertical wall
314	water inlet

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Claims

1. An evaporative cooler comprising:
   - a receptacle for keeping an evaporative liquid;
   - a capillary material connected to the reservoir for drawing the evaporative liquid onto the capillary material; and
   - an air circulator for drawing ambient air onto the capillary material in order to cool down the ambient air.

2. The evaporative cooler of claim 1, wherein
the capillary material comprises at least one porous material either over a surface or over a volume.

3. The evaporative cooler of claim 2, wherein
the at least one porous material comprises silicon carbide.

4. The evaporative cooler of claim 2, wherein
the at least one porous material comprises a ceramic foam.

5. The evaporative cooler of claim 2, wherein
the at least one porous material comprises a sponge.

6. The evaporative cooler of any of the preceding claims, wherein
the capillary material comprises closely linked fibers for defining pockets of nanometers in-between the closely linked fibers.

7. The evaporative cooler of any of the preceding claims, wherein
the capillary material is coated with a light-emitting diode material or resistive heating material.

8. The evaporative cooler of any of the preceding claims, wherein
the capillary material is flexible, elastic, transparent, fire-resistant, degradable, washable or possessing a combination of any of these characteristics.

9. The evaporative cooler of any of the preceding claims further comprising a radiator of an air conditioner;
wherein the capillary material is attached or applied onto coils of the radiator.

10. The evaporative cooler of any of the preceding claims, wherein
the air circulator is formed by the capillary material as a duct (e.g. chimney vertically standing, sidewall with exposed surface or ceiling having bare surfaces, chute) for drawing ambient air along the duct (e.g. internally or externally).

11. The evaporative cooler of claim 10, wherein
the duct comprises multiple sticks, rods, plates or layers having gaps in-between themselves.

12. The evaporative cooler of any of the preceding claims, wherein
the capillary material comprises a structural surface (e.g. side wall surface, furniture surface) for cooling a room.

13. The evaporative cooler of any of the preceding claims, wherein
the capillary material comprises a permeable wall for permitting air passage between opposite sides of the permeable wall with negligible resistance or pressure drop.

14. The evaporative cooler of any of the preceding claims, wherein
the capillary material comprises a self-clean surface (e.g. superhydrophobic, superhydrophilic, photocatalytic).

15. The evaporative cooler of any of the preceding claims, wherein
the capillary material comprises labyrinth structure for guiding airflow over along an elongated path of the capillary material.

16. The evaporative cooler of any of the preceding claims, wherein
the receptacle is provided a bottom side, a top side or a lateral side of the capillary material.

17. The evaporative cooler of any of the preceding claims, wherein the receptacle comprises a liquid level regulator for controlling immersion depth of the capillary material at the receptacle.

18. The evaporative cooler of any of the preceding claims, wherein the capillary material comprises pores ranging from 10nm to 3.5mm, from 20nm to 1mm, from 100nm to 0.1mm, from 1µm to 50 µm or from any range between 10nm and 3.5mm.

19. An evaporative cooler substantially as hereinbefore described with reference to any one of the examples or embodiments and any one of the accompanying drawings.