MODULAR COOLING TOWER

A modular cooling tower that serves to cool down cooling water or condense coolant. The modular cooling tower has a greatly reduced height, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow, ensures excellent heat exchange performance by preventing the recirculation of exhaust air, makes it easy to inspect and repair components inside the modular cooling tower, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.
FIG. 5
FIG. 6
Modular Cooling Towers
prior art

FIG. 16
prior art

FIG. 17
MODULAR COOLING TOWER
CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority from Korean Patent Application Number 10-2009-0025148 filed on 03, 24, 2009, the entire contents of which application is incorporated herein for all purposes by this reference.

BACKGROUND OF THE INVENTION

The present invention relates to a cooling tower, which serves to cool down cooling water or condense coolant, and more particularly, to a modular cooling tower, which has a greatly reduced height, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow, ensures excellent heat exchange performance by preventing the recirculation of exhaust air, makes it easy to inspect and repair components inside the modular cooling tower, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

In general, a refrigerator or an industrial heat exchanger operating in an air conditioning system or a freezing-cooling system produces waste heat, which has to be removed. For this purpose, this waste heat has to be exhausted to the air using a cooling medium.

Methods of cooling a cooling tower are divided into air cooling, which performs sensible heat cooling by forced-draft of air from the atmosphere colder than the fluid to be cooled, and evaporative cooling, which performs cooling using evaporative latent heat by bringing air into contact with cooling water. Cooling towers using evaporative cooling (hereinafter, referred to as “evaporative cooling towers”) are widely used since they can perform cooling more effectively than any other kind of cooling system and are economical.

Typical evaporative cooling towers are divided into a counter-flow cooling tower, which circulates air vertically upward and cooling water vertically downward, and a cross-flow cooling tower, which circulates air horizontally and cooling water vertically downward. In addition, methods of circulating cooling water are generally divided into an open circuit type, in which evaporative heat exchange occurs due to mutual contact while cooling water and air circulate through an open heat exchanger unit (e.g., fillers), and a closed circuit type, in which evaporative heat exchange occurs due to the contact of cooling water and air on the outer surface of an enclosed cooling coil in which cooling fluid (e.g., cooling water or coolant) circulates. Recently, a hybrid circuit type cooling tower, which combines the open heat exchanger unit with the closed heat exchanger unit to realize the benefits of improved heat exchange performance, decreased water pipe noise, and reduced use of water, has been developed, and demand for it is increasing.

In addition, ventilation systems are divided into a suction ventilation system and a forced-draft ventilation system. The suction ventilation system is installed in an exhaust port of the cooling tower to absorb hot air, which has been heated by heat exchange through a heat exchanger unit (e.g., fillers or a heat transfer tube). The forced-draft ventilation system is configured such that it can communicate with a supply port of the cooling tower and exhausts hot air, which has been heated by heat exchange, by forcibly blowing ambient air toward the heat exchanger unit.

In addition, an outdoor cooling tower has a vertical casing structure with an exhaust port arranged in the uppermost portion. In contrast, an indoor cooling tower has a horizontal casing structure with an exhaust port arranged in the uppermost portion, a supply port arranged in the side portion, and a fan unit arranged outside a casing.

In general, the cooling tower having a vertical casing is typically transported to a construction site in a disassembled state and is reassembled in the site since it is too high to be transported in the assembled state. Further, considering the structure of the cooling tower, it is impossible to install the cooling tower having a vertical casing in the multi-stage structure or on the ceiling of a building.

In addition, the cooling tower having a horizontal casing is easily transported due to the relatively low height thereof. However, it is impossible to install the cooling tower having a horizontal casing in the multi-stage structure or on the ceiling of a building.

In the forced-draft ventilation system, both the cooling tower having a vertical casing and the cooling tower having a horizontal casing generally use the entire upper opening of the casing as the exhaust port. Thus, the rate of ejecting exhaust gas is lowered and a hot stream of exhaust gas is blown again into the supply port depending on the direction and pressure of the wind in the atmosphere, thereby degrading the performance of the cooling towers.

In addition, when saturated humid air (RH 100%) is exhausted to the outside from the cooling tower after evaporative heat exchange, it mixes with the ambient air having a lower temperature so that moisture in the saturated humid air condenses, thereby creating a plume. The visibility of the plume tends to rise as the ambient temperature decreases.

Since the plume is a group of pure vapor, it is neither a source of pollution to the air nor harmful to the human. However, the plume may be misconceived as a source of pollution or fire if judged by vision since it looks similar to smoke. Since the plume is regarded as degrading aesthetic appearance of the surroundings, carrying legionella, obstructing the view, and the like, it causes public complaints. In winter, if atmospheric pressure is low, the plume may not actively rise so that condensed moisture is present not only around the cooling tower but also outside the surroundings, thereby freezing the ground and the surface of a facility. This is an undesirable side effect.

In order to reduce the plume, which causes the above-described problems, a known approach discloses a dry heat exchanger unit that is installed outside. Accordingly to this approach, the upper portion of the exhaust port of the cooling tower or the portion of the casing, which faces the exhaust area, is opened, and the dry heat exchanger unit uses hot cooling water as a heat source.

However, since the outside-mounted dry heat exchanger unit is exposed to air pollution materials, snow, and rain drops, it is vulnerable to corrosion and pollution. This, as a result, deteriorates the efficiency of heat exchange of the dry heat exchanger unit.

The above-described cooling tower having a horizontal casing to which the present invention relates is dis-

[0018] Below, a description will be given of conventional arts with reference to the accompanying drawings.

[0019] FIG. 16 is a cross-sectional view of a conventional indoor cooling tower (hereinafter, referred to as Conventional Art 1).

[0020] As disclosed in the detailed description and illustrated in the figure of Conventional Art 1, an indoor cooling tower 300 with a low silhouette was intended to provide “an indoor cooling tower that does not influence to indoor air in the area where the cooling tower is installed, reduces the space where the cooling tower is installed, maintains the performance of the cooling tower, reduces the pollution and loss of cooling water, and prevents indoor environmental pollution.”

[0021] In addition, as the technical features for realizing these objectives, the cooling tower 300 includes a casing 311, a blower fan 330, fillers (or fill sheets) 345, a heat exchanger unit 340, a cooling water spray unit 350, an eliminator 373, and a sump 375. The casing 311 has one supply port 313, through which air is introduced, and a pair of exhaust ports 315, through which air is exhausted. The casing 311 also defines a heat exchange area therein. The blower fan 330 blows air, introduced through the supply port 313, to be exhausted through the exhaust port 315. The fillers 345 allow air, introduced through the supply port 313, to pass through and cooling water to flow downward through. The heat exchanger unit 340 encloses the fillers 345. The spray unit 340 supplies hot cooling water to the filler 345. The eliminator 373 collects drops of water, scattering toward the exhaust port 315, into the cooling tower 300. The sump 374 collects and discharges cooling water, cooled down through the fillers 345.

[0022] In addition, the casing 311 has a cylindrical shape that surrounds the heat exchange area. The supply port 312, through which air is supplied into the casing 311, is formed in the sidewall of the casing 311, and the pair of exhaust ports 315, through which cooled air is exhausted to the outside, is formed in the upper portion of the casing 311.

[0023] A supply duct 317 is connected to the casing 311 such that a flow of air, which is introduced into the casing 311, flows along the supply duct 317.

[0024] Here, a supply duct connector 319, which is provided between the supply port 313 and the supply duct 317, flexibly connects the supply duct 317 to the supply port 313.

[0025] In addition, an exhaust duct 321 is arranged in front of each of the exhaust ports 315 so as to guide a flow of air, which is exhausted from the casing 311. The exhaust duct 321 is connected to the exhaust port 315 via a flexible exhaust duct connector 323.

[0026] The blower fan 330 includes a pair of fan bodies 331, which houses an impeller (not shown) therein, a drive motor 335, which generates a driving force to drive the impeller, a power transmission, which connects the driver motor 335 to the impeller, thereby transmitting the driving force from the drive motor 335 to the impeller. The power transmission includes pulleys 333 and 337 and a drive belt 339.

[0027] The impeller has a centrifugal structure, and the bodies 331 are supported on the interior of the casing 311 under the exhaust ports 315. The fan pulley 333 is mounted on one end of one impeller and is coupled with the drive belt 339. The fan pulley 333 is arranged on the exterior of the casing 311.

[0028] The cooling water spray unit 350 is arranged above the fillers 345 so as to supply hot cooling water toward the fillers 345. The cooling water spray unit 350 includes an inlet pipe 351, which is arranged above the fillers 345 and through which hot cooling water is introduced, a plurality of distribution pipes 353, which diverges from the inlet pipe 351 so as to distribute hot cooling water toward the fillers 345, and a plurality of spray nozzles 355, which is arranged on each of the distribution pipes 353 so as to forcibly spraying hot cooling water toward the fillers 345.

[0029] In addition, a supply louvre 371 is arranged between the fillers 345 and the supply port 313 to facilitate the flow of air, introduced through the supply port 313, to the fillers 345.

[0030] These features provide the indoor cooling tower that can reduce the space where the cooling tower is installed, do not influence to indoor air in the area where the cooling tower is installed, and prevent loss in cooling water as well as indoor environmental pollution.

[0031] However, the cooling tower of Conventional Art 1 provides a suction blower that exhausts saturated humid air, which has undergone heat exchange, by coming into direct contact with the saturated humid air. High specific gravity of the saturated humid air may increase the load of the blower or cause the blades to corrode. In addition, it is difficult to mount the cooling tower on the ceiling of a building. Since the cooling tower is designed to be installed indoors, it does not provide a good aesthetic appearance if installed outdoors. Furthermore, it is difficult to construct the cooling tower in a vertical position.

[0032] Below, FIG. 17 is a side elevation view schematically showing a conventional cooling tower having a low silhouette (hereinafter, referred to as Conventional Art 2).

[0033] As disclosed in the detailed description and illustrated in the figure of Conventional Art 2, a cooling tower 400 with a low silhouette was intended to provide “a counter-flow cooling tower with a relatively smaller vertical height” and “an improved counter-flow cooling tower with a trapezoidal configuration in order to reduce the vertical height of the cooling tower.”

[0034] In addition, as the technical features for realizing these objectives, the forced-draft counter-flow cooling tower 400 includes a centrifugal fan 494, a sump 414 to receive water sprayed from a water distribution network that includes trapezoidal fill sheets 458, a water main pipe 438, water distribution pipes 440, and spray nozzles 442. The water is sprayed from the sump 414 through a water discharge conduit 448. A plurality of mist eliminator baffles 450 is positioned above a heat transfer medium 410 and may be conveniently supported above the water distribution pipes 440.

[0035] The fill sheets 458 are aligned with a flow of incoming air that is introduced through a transition duct 496, propelled by the fan 494. It has been found that the horizontal distribution of air from such a centrifugal fan 494 is improved if the fan shaft 498 is slightly elevated and the air from the fan 494 is discharged toward the gradually flared transition duct 496, which expands to approximately match the dimensions of the inlet side 428 of a plenum 436. Another advantage of aligning the surfaces of the fill sheets 460 with the forceful air streams from the centrifugal fan 494 is that the lower edges of
the fill sheets 460 have a reduced tendency to flutter, thereby facilitating the air flow between the sheets.

[0036] According to these features, the cooling tower with low silhouette having a trapezoidal configuration can reduce the height to be smaller than those of conventional cooling towers, increase capacity, and greatly reduce the amount of energy consumed in driving a water pump by reducing the height of the cooling tower.

[0037] However, Conventional Art 2 has the following problems: Since the fill sheets are manufactured in the trapezoidal configuration, a great portion of the sheets are wasted in the manufacturing. Since the entire portion of the upper opening of the casing is used as the exhaust port, hot exhaust air may be blown back into the exhaust port depending on the direction and pressure of the wind in the atmosphere, thereby degrading the performance of the cooling tower. Inspection and repair are difficult due to the limited interior space. In addition, the cooling tower gives a bad outlook when mounted outdoors. Furthermore, it is difficult to mount the cooling on the ceiling of a building or in a multi-stage structure.

[0038] The information disclosed in this Background of the Invention section is only for the enhancement of understanding of the background of the invention and should not be taken as an acknowledgment or any form of suggestion that this information forms a prior art that would already be known to a person skilled in the art.

**BRIEF SUMMARY OF THE INVENTION**

[0039] Various aspects of the present invention provide a modular cooling tower, which has a greatly reduced height, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into and out of a heat exchanger unit without a bypass flow, ensures excellent heat exchange performance by preventing the recirculation of exhaust air, makes it easy to inspect and repair components inside the modular cooling tower, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

[0040] In an aspect of the present invention, the modular cooling tower may include a casing having a supply port and an exhaust port, the casing defining a heat exchange area therein; a heat exchanger unit arranged in the heat exchange area, wherein the heat exchanger unit allows cooling water and air to circulate therein, thereby exchanging heat with each other; a spray unit arranged above the heat exchanger unit, wherein the spray unit sprays cooling water; a blower fan unit for blowing air toward the heat exchanger unit and exhausting saturated humid air, which has undergone heat exchange, through the exhaust port; an eliminator for collecting drops of water scattering toward the exhaust port; a sump for collecting cooling water dropping through the heat exchanger unit, the sump having a cooling water outlet port; a frame assembly arranged along six inner surfaces of the casing to support the casing, wherein the casing has a horizontal box-like shape having six sides including a front plate, a rear plate, an upper plate, a bottom plate, a pair of side plates, the supply port is formed through the rear plate or the bottom plate of the casing, and the exhaust port is formed through the front plate of the casing; a ventilation partition unit arranged between the heat exchanger unit and the supply port to form the supply area such that cooling water and air efficiently circulate without a roundabout flow, wherein the ventilation partition unit includes a spray area-partitioning section, which partitions a portion of the spray unit, a supply area-partitioning section, which faces the heat exchanger unit, an upper partitioning section formed between the spray area-partitioning section and the supply area-partitioning section, and a ventilation opening formed in the supply area-partitioning section; a suction area formed between the ventilation partition unit and the supply port; an exhaust area formed between the heat exchanger unit and the exhaust port; a lower mounting assembly including a plurality of members, wherein the lower mounting assembly is arranged in the suction area or the exhaust area in close contact with the underside of the casing, and is fixed to the bottom plate by fixing bolts extending through the upper frame opposite the bottom plate; and an upper mounting assembly including a plurality of members, wherein the upper mounting assembly is fixed to the upper plate by fixing bolts extending through the upper frame opposite the upper plate.

[0041] Here, the casing may be made of iron or steel. Alternatively, the casing can also be made of Fiberglass Reinforced Plastic (FRP).

[0042] The casing including the supply port, the suction area, the supply area, the heat exchange area, the exhaust area, and the exhaust port may be constructed in a horizontal position, with the blower fan unit arranged in the suction area. Alternatively, the casing including the supply port, the suction area, the supply area, the heat exchange area, the exhaust area, and the exhaust port may be constructed in a horizontal position, with the blower fan unit arranged in the exhaust area.

[0043] A graphic film or a graphic plate, on which a picture or the like is printed, may be attached to the outer surface of some or all of the front and rear plates, the upper and bottom plates, and the two side plates of the casing.

[0044] An adhesive layer, which can be directly attached to the casing, may be formed on the rear surface of the graphic film and the graphic plate. Alternatively, the graphic plate may be attached to the casing by screw-fastening.

[0045] In addition, each of the front, rear, upper, and bottom plates of the casing may have a flange that extends outward so that they can be coupled with each other.

[0046] The modular cooling tower may also include an inspection unit, which is designed for the inspection or repair of the spray unit. The inspection unit may include an inspection hole and a detachable cover that opens and closes the inspection hole.

[0047] The inspection unit may include a detachable panel, which is fixed by bolts, or a door, which can be opened and closed by a hinge and a locker handle.

[0048] The modular cooling tower may also include one or more drains in the bottom plate that faces the supply area or the exhaust area.

[0049] The modular cooling tower may also include carriage ports respectively in the side plates of the casing, so that the heat exchanger unit and the blower fan unit can be separately carried in and out through the carriage ports, and detachable carriage port covers. Alternatively, the front and rear plates of the casing can have a detachable structure so that the heat exchanger unit and the blower fan unit can be easily carried in and out.
The upper portion of the exhaust port may be located adjacent to the upper plate and the lower portion of the supply port may be located adjacent to the bottom plate in order to effectively circulate air.

The modular cooling tower may also include at least one supply guide member and at least one shutter member in the supply port, the supply port extending through the rear plate of the casing. The supply guide member may include a plurality of guide blades, a supply guide member frame with the guide blades mounted thereon, and a plurality of hinges, wherein each of the hinges has one piece fixed to a side portion of the supply guide member frame and the other piece fixed to a portion of the casing adjacent to the supply port. The shutter member may fix the supply guide member while opening and closing the supply port. The shutter member may include a fixing bolt, fixed to the reinforcement frame, a fixing clamp holding the fixing bolt, and a fixing nut fixing the fixing clamp. Alternatively, the supply guide member frame with the guide blades mounted thereon may be detachably fixed to the portion of the casing adjacent to the supply port.

In addition, the supply guide member may be housed outside the frame of a supply-side muffler.

The guide blade may be an adjustable angle guide blade. Alternatively, the guide blade may be a fixed angle guide blade, with the angle fixed at the optimum guide angle.

The guide blade may be an adjustable angle guide blade. Alternatively, the exhaust guide blade may be a fixed angle guide blade, with the angle fixed at the optimum guide angle.

In addition, the exhaust guide blade may extend outward at an upward inclination in order to efficiently draw off exhaust gas upward.

The heat exchanger unit may be one selected from the group consisting of an open heat exchanger unit constructed with fillers, a closed heat exchanger unit, and a combination heat exchanger unit. The open heat exchanger unit may include the closed heat exchanger unit may include a wet-dry heat transfer tube; a fluid inlet head coupled to one end of the wet-dry heat transfer tube, the fluid inlet head having a fluid inlet port; a cooling fluid outlet header coupled to the other end of the wet-dry heat transfer tube, the cooling fluid outlet header having a cooling fluid outlet port; and a heat transfer tube support member supporting the wet-dry heat transfer tube. In the combination heat exchanger unit, an open type and a closed type are combined to each other to cool hot cooling water, which is introduced and sprayed through a spray pump from the supply.

The open heat exchanger unit may have a side shape selected from the group consisting of rectangle, square, and parallelogram.

Here, the open heat exchanger unit having a parallelogram side shape can circulate air more efficiently than the other heat exchanger units having different shapes.

In addition, the heat exchanger unit may be divided into two parts or more so that it can be separately carried into and out of the casing.

In addition, the open heat exchanger unit may include film-type fillers or splash-type fillers.

In addition, the open heat exchanger unit may also include a louver on the side portion of the heat exchanger unit, which faces the ventilation partition unit. The louver may guide a flow of supply air and collect scattering drops of cooling water.

The eliminator may be integrated to the open heat exchanger unit, which is constructed with film-type fillers. Alternatively, the eliminator may be provided as a separate eliminator.

A separate eliminator may be applied to each of the open heat exchanger unit constructed with splash-type fillers and the closed heat exchanger unit.

The eliminator may be integrated to the open heat exchanger unit constructed with film-type fillers. Alternatively, the eliminator may be provided as a separate eliminator.

The sump may include an overflow outlet, which discharges cooling water when the level of the cooling water exceeds the operating level of the sump, a drain, a supplemental water-supplying means, a strainer, which prevents impurities from entering a cooling water outlet port, a connector of a freezing prevention heater, and the like.

In addition, close contact sections on the opposite sidewalls of sump may be sealed watertight to the opposite side plates of the casing and so that cooling water, flowing along the inner surface of the opposite side plates of the casing, can be collected to the sump.

The modular cooling tower may also include a dry heat exchanger unit in the exhaust area as a plume-reducing means that can reduce the amount of plume by heat-saturated humid air, which is exhausted toward the exhaust port. The
The modular cooling tower may also include a spray partition member, which closes one side of the upper portion of the heat exchanger unit, thereby forming a spray area.

[0082] The modular cooling tower may also include a spray partition member, which closes one side of the underside of the upper plate of pressure-type spray unit and one side of the upper portion of the heat exchanger, thereby forming a spray area.

[0083] The blower fan unit may be one selected form the group consisting of a centrifugal blower fan unit, a plenum-type blower fan unit, and an axial flow blower fan unit. The centrifugal blower fan unit may include a fan housing having a fan exhaust port with a flange coupled to a ventilation opening, a fan support supporting the fan housing, centrifugal blades arranged inside the fan housing, a drive motor, pulleys respectively coupled to the centrifugal fan blades and to the drive motor, a drive belt, and a base supporting the fan support and the drive motor. The plenum-type blower fan unit may include a fan housing having a fan exhaust port with a flange coupled to the ventilation opening, centrifugal fan blades arranged inside the fan housing, and a drive motor driving the centrifugal fan blades. The axial flow blower fan unit may include a fan housing having an exhaust port with a flange coupled to a ventilation opening, a fan support supporting the fan housing, axial flow fan blades arranged inside the fan housing, a drive motor driving the fan blades, a base supporting the fan support and the drive motor, and vibration-proof members mounted between the fan support and the base and between the drive motor and the base.

[0084] Here, the centrifugal blower fan unit, the plenum-type blower fan unit, and the axial flow blower fan unit can be in the form of direct drive type or a belt drive type.

[0085] The modular cooling tower may also include a flexible vibration-proof coupling member between the ventilation opening and a flange, wherein the flexible vibration-proof coupling member prevents vibration of the blower fan unit from being transferred.

[0086] In addition, the blower fan unit may be arranged in the suction area.

[0087] The frame assembly may have a box-like configuration including an upper frame, a lower frame, and a pair of side frames, which are in close contact with the inner sides of the casing. Alternatively, the frame assembly may include a front frame, a rear frame, and a pair of side frames.

[0088] Here, the frames may be assembled together by bolt fastening.

[0089] In addition to the upper, lower, and side frames, the frame assembly may also include one or more horizontal reinforcement frames and one or more vertical reinforcement frames, which support the horizontal and vertical positions of the upper, lower, and side frames.

[0090] Here, bolt holes may be formed in corresponding portions of the casing and the frame assembly such that the casing and the frame assembly can be fixed to each other by
bolt fastening. Alternatively, the casing and the frame assembly can be fixed to each other by other fixing members such as a tap bolt.

[0091] The ventilation partition unit may include a spray area-partitioning section, which partitions a portion of the spray unit, a supply area-partitioning section, which faces the heat exchanger unit, and an upper partitioning section formed between the spray area-partitioning section and the supply area-partitioning section. Alternatively, the ventilation partition unit may have different structures or shapes as long as they partition the spray unit and the supply area in the same manner.

[0092] Here, the upper partitioning section may be inclined downward toward the heat exchanger unit in order to prevent cooling water, which flows along a surface of the spray area-partitioning section, from circulating into the exhaust area-partitioning section. Alternatively, the upper partitioning section may have a vertical water tank on the lower end of the spray area-partitioning section in order to realize the same function.

[0093] In the ventilation partition unit, the upper end of the spray area-partitioning section may be fixed to the upper plate of the casing, the lower end of the supply area-partitioning section may be fixed to the inner portion of the sump, and both the spray area-partitioning section and the supply area-partitioning section may be fixed to both the side plates of the casing. However, the fixing positions are not intended to be limiting.

[0094] The lower mounting assembly may be in close contact with the underside of the casing and be fixed by fixing bolts, which extend through both the bottom plate and the lower frame opposite the bottom plate. The lower mounting assembly may include upper and lower close contact sections each having a plurality of mounting holes through which the fixing bolts extend; side sections having a plurality of beam-fastening holes; two or more mounting sections, each of which is perpendicularly coupled to the horizontal center between the upper close contact section and the lower close contact section and is supported by a reinforcement plate having a plurality of beam-fastening holes; and a plurality of fixing beams fixing the two or more mounting sections together.

[0095] Here, the fixing beams, which fix the two or more mounting sections to each other, may be coupled by welding. Alternatively, fastening plates having bolt-fastening holes may also be arranged on both ends of the fixing beams such that the fixing beams can be coupled by bolt fastening.

[0096] The upper mounting assembly may be in close contact with the upper surface of the casing and be fixed by fixing bolts, which extend through both the upper plate and the upper frame opposite the upper plate. The upper mounting assembly may include upper and lower close contact sections each having a plurality of mounting holes, through which the fixing bolts extend; side sections having a plurality of beam-fastening holes; two or more mounting sections, each of which is perpendicularly coupled to the horizontal center between the upper close contact section and the lower close contact section, the mounting sections supported by a reinforcement plate having a plurality of beam-fastening holes; and a plurality of fixing beams fixing the three mounting sections together.

[0097] Here, the fixing beams, which fix the two or more mounting sections to each other, may be coupled by welding. Alternatively, fastening plates having bolt-fastening holes may also be provided on both ends of the fixing beams such that the fixing beams can be coupled by bolt fastening.

[0098] In addition, the body of the mounting assembly may be made of a C-shaped section steel or a J-shaped section steel.

[0099] The upper mounting assembly and the lower mounting assembly may be arranged, in a transverse direction, on the ends of the upper and bottom plates adjacent to the exhaust port, the central portions of the upper and bottom plates, and the ends of the upper plate and the lower plate adjacent to the supply port. Each of the upper and lower mounting assemblies may also include a fixing beam that fixes the sections of the mounting assembly in the horizontal direction.

[0100] If the area where the modular cooling tower is installed is limited, two of the modular cooling towers, which have the lower mounting assembly and the upper mounting assembly, may be vertically mounted in a multi-stage structure by fastening the lower mounting assembly and the upper mounting assembly together.

[0101] When the modular cooling towers are installed in a multi-stage structure, intermediate column members may also be provided between the lower mounting assembly and the upper mounting assembly in order to facilitate access to the inspection unit, which is designed for the inspection or repair of the supply space or the spray unit. Each of the intermediate column members may include a coupling plate having a plurality of bolt holes in the upper and lower ends.

[0102] When the modular cooling tower has to be installed on the ceiling of a building such as a machine room, the height of which is relatively higher than others, the modular cooling tower may be installed on the ceiling using the lower or upper mounting assembly as a fixing part.

[0103] The modular cooling tower may also include a base beam arranged on the lower close contact section of the lower mounting section, which serves as a fixing part. The base beam has a fastening hole to which a hanger is engaged.

[0104] The modular cooling tower may also include a vibration-proof member between the lower close contact section of the lower mounting assembly and the base beam.

[0105] The hanger may be formed as a rod with threads on both ends. Alternatively, the hanger may be made of a piece of section steel, with both ends thereof connected with fastening plates having fastening holes.

[0106] In addition, one or more anchors may be embedded into the portions of the ceiling to which the upper end of the hanger is coupled.

[0107] The modular cooling tower may also include, as means for guiding a flow of supply air and a flow of exhaust via ducts, a duct-connected supply guide member coupled to the supply port and a duct-connected exhaust guide member coupled to the exhaust port.

[0108] The modular cooling tower may also include a supply-side muffler coupled to the supply port and an exhaust-side muffler coupled to the exhaust port. The supply-side muffler includes a muffler housing and sound-absorbing materials. The exhaust-side muffler includes a muffler housing and sound-absorbing materials.

[0109] Here, the supply guide member may be detachably mounted on one end of the muffler housing of the supply-side muffler. The exhaust guide member may be detachably mounted on one end of the muffler housing of the exhaust-side muffler.
The modular cooling tower may also include vibration-proof members arranged between the fan support and the base, between the lower mounting assembly and the foundation, or between the lower mounting assembly and the upper mounting assembly.

The modular cooling tower may also include a plurality of cover wall support beams and fastening plates, respectively connected to both ends of each of the cover wall support beams, such that the cover wall, as a means for covering the modular cooling tower, can be simply installed without additional constructions. Each of the fastening plates has bolt-fastening holes such that the cover wall support beams are fastened at one end to the side portions of the lower mounting assembly and the upper assembly and the reinforcement plates at the other end to the cover wall beam screwing into the fastening-holes.

The modular cooling tower may also include a platform, as a means for utilizing an upper space of the modular cooling tower, on the upper mounting assembly. The platform includes a base plate, a horizontal beam fixing the base plate; a column member, a fastening plate having a plurality of bolt holes therein, the fastening plate formed on the lower portion of the column member, protective hand rails arranged along the edges of the base plate, and stairs.

The modular cooling tower may also include a plurality of solar power generators on the platform, wherein the power generators supply electric power to all or parts of lights around the cooling tower, a drive motor, a controller of the cooling tower.

As a means for improving the aesthetic appearance of the modular cooling tower so that it harmonizes with the surroundings, the modular cooling tower may include covering members mounted on the lower mounting assembly and the upper mounting assembly. The covering members face the side plates and the upper plate of the casing.

The modular cooling tower may also include covering members mounted on the lower mounting assembly and the upper mounting assembly so as to face the front plate and the rear plate. The covering members have a supply opening and an exhaust opening.

The modular cooling tower may also include fixing beams connecting the lower mounting assembly and the upper mounting assembly to the covering members in order to ensure a space that facilitates the fastening of the fixing bolts. Fastening plates having bolt-fastening holes are connected to both ends of the fixing beams.

Here, each of the covering members may be formed as a lightweight panel that is selected from the group consisting of a graphic panel, on which an advertisement is printed, a construction panel for harmonization with surrounding buildings, and a forming panel.

The modular cooling tower may also include a billboard installed on the upper mounting assembly.

The modular cooling tower may also include a pulpit on the upper mounting assembly. The pulpit is used to install a control panel of the cooling tower or a water treatment unit.

According to exemplary embodiments of the present invention as set forth above, the modular cooling tower has a greatly reduced height, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow, ensures excellent heat exchange performance by preventing the recirculation of exhaust air, makes it easy to inspect and repair components inside the modular cooling tower, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

The methods and apparatuses of the present invention have other features and advantages which will be apparent from, or are set forth in greater detail in, the accompanying drawings, which are incorporated herein, and in the following Detailed Description of the Invention, which together serve to explain certain principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a first exemplary embodiment of the invention;

FIG. 2 is a schematic side cross-sectional view of the modular cooling tower shown in FIG. 1;

FIG. 3 is a schematic view showing the configuration of the exhaust port and the supply port shown in FIG. 1;

FIG. 4 is a schematic view showing the arrangement of the exhaust port and the supply port shown in FIG. 1;

FIG. 5 is an enlargement of the mounting assembly shown in FIG. 1;

FIG. 6 is a schematic longitudinal cross-sectional view showing a multi-stage structure of the modular cooling towers shown in FIG. 1, on which a platform is mounted;

FIG. 7 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a second exemplary embodiment of the invention;

FIG. 8 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a third exemplary embodiment of the invention;

FIG. 9 is a schematic longitudinal cross-sectional view showing a multi-stage structure of the modular cooling towers shown in FIG. 8;

FIG. 10 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a fourth exemplary embodiment of the invention;

FIG. 11 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a fifth exemplary embodiment of the invention;

FIG. 12 is a schematic longitudinal cross-sectional view showing the modular cooling tower shown in FIG. 11, on which a roof unit is mounted;

FIG. 13 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a sixth exemplary embodiment of the invention;

FIG. 14 is a partially cutaway side elevation view schematically showing the modular cooling tower shown in FIG. 13, on which covering members are mounted;

FIG. 15 is a partially cutaway side elevation view schematically showing a multi-stage structure of the modular cooling towers shown in FIG. 13, on which covering members are mounted;

FIG. 16 is a side elevation view schematically showing a conventional indoor cooling tower; and
Fig. 17 is a side elevational view schematically showing a conventional cooling tower having a low silhouette.

DetaiLed Description of the Invention

Reference will now be made in detail to various embodiments of the present invention(s), examples of which are illustrated in the accompanying drawings and described below. While the invention(s) will be described in conjunction with exemplary embodiments, it will be understood that the present description is not intended to limit the invention(s) to those exemplary embodiments. On the contrary, the invention(s) is/are intended to cover not only the exemplary embodiments, but also various alternatives, modifications, equivalents and other embodiments that may be included within the spirit and scope of the invention as defined by the appended claims. In the following description of the present invention, detailed descriptions of known functions and components incorporated herein will be omitted when they may make the subject matter of the present invention unclear.

Throughout this disclosure, the same reference numerals and signs are used throughout the different drawings to designate the same or similar components, which will be described one time with respect to a certain exemplary embodiment. In the other exemplary embodiments, however, a description will be given of different features.

Fig. 1 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a first exemplary embodiment of the invention. Fig. 2 is a schematic side cross-sectional view of the modular cooling tower shown in Fig. 1. Fig. 3 is a schematic view showing the configuration of the exhaust port and the supply port shown in Fig. 1. Fig. 4 is a schematic view showing the arrangement of the exhaust port and the supply port shown in Fig. 1. Fig. 5 is an enlargement of the mounting assembly shown in Fig. 1, and Fig. 6 is a schematic longitudinal cross-sectional view showing the multi-stage structure of the modular cooling towers shown in Fig. 1, on which a platform is mounted. As shown in these figures, the first exemplary embodiment of the invention provides an open modular cooling tower 1.

The modular cooling tower 1 includes a casing 10, a supply port 17a, an exhaust port 18, an open heat exchanger unit 70a, a water spray unit 80a, spray partition members 27a, a centrifugal fan unit 90a, an eliminator 78, a sump 100, a frame assembly 30, a ventilation partition unit 20, a flexible vibration-proof coupling member 98, lower mounting assembly 130a, and upper mounting assembly 130b. The casing 10 has defined therein a heat exchange area composed of a supply area 24 and an exhaust area 25, and has a box-like shape having six sides including a front plate 11, a rear plate 12, an upper plate 15, a bottom plate 16, and a pair of side plates 13 and 14. The supply port 17a is formed through the rear plate 12, which faces the supply area 24. The exhaust port 18 is formed through the front plate 11, which faces the exhaust area 25. The heat exchanger unit 70a, in which cooling water and air circulate to exchange heat with each other, is arranged in the heat exchange area and is composed of fillers (or fill sheets). The spray unit 80a, having a plurality of spray tips 84 therein, is arranged above the open heat exchanger unit 70a to spray cooling water. The spray partition members 27a close the area between one side of the lower portion of the spray unit 80a and one side of the upper portion of the heat exchanger unit 70a, thereby forming a spray area. The centrifugal fan unit 90a is arranged inside the suction area 23 to blow air toward the heat exchanger unit 70a and exhaust saturated humid air, which has undergone heat exchange, through the exhaust port 18. The centrifugal fan unit 90a includes a fan housing 92a having a fan exhaust part 93 with a flange (no reference numeral assigned) coupled to a ventilation opening 21, a fan support 94 supporting the fan housing 92a, centrifugal blades 91a arranged inside the fan housing 92a, a drive motor 95, pulleys (no reference numerals designated) respectively coupled to the centrifugal fan blades 91a and to the drive motor 95, a drive belt (no reference numeral assigned), a base 96 supporting the fan support 94 and the drive motor 95, and a plurality of vibration-proof members 97 arranged between the fan support 94 and the base 96 and between the drive motor 95 and the base 96. The eliminator 78 is arranged adjacent to the exhaust side of the heat exchanger unit 70a to collect drops of water that are splashed toward the exhaust port 18. The sump 100 is configured to collect cooling water dropping through the heat exchanger unit 70a, with a cooling water outlet port 101 formed in a portion of the sump 100. The frame assembly 30 is arranged along the six inner surfaces of the casing 10 to support the casing 10. The frame assembly 30 includes an upper frame 33, a lower frame 34, a pair of side frames 31 and 32, one or more horizontal reinforcement frames 35, and one or more vertical reinforcement frames (not shown), the horizontal and vertical reinforcement frames supporting the horizontal and vertical positions of the respective frames 31, 32, 33, and 34. The ventilation partition unit 20 is arranged between the heat exchanger unit 70a and the supply port 17a to partition the supply area 24 and the suction area 23 such that cooling water and air can efficiently circulate without a roundabout flow. The ventilation partition unit 20 includes a spray area-partitioning section (no reference numeral assigned), which closes the area between the other side of the lower portion of a spray tank 83 and the other side of the upper portion of the heat exchanger unit 70a; a supply area-partitioning section (no reference numeral assigned), which partitions the supply area; an upper partitioning section (no reference numeral assigned), which is arranged between the spray area-partitioning section and the supply area-partitioning section and is inclined downward toward the heat exchanger unit 70a; and the ventilation opening 21 formed in the supply area-partitioning section. The flexible vibration-proof coupling member 98 connects the ventilation opening 21 with the flange, thereby preventing the vibration of the centrifugal fan unit 90a from being transmitted, and has coupling flanges (no reference numerals assigned) on both ends thereof. The lower mounting assembly 130a is in close contact with the underside of the casing 10 and is fixed to the bottom plate 16 by fixing bolts (no reference numerals assigned) extending through the lower frame 34 opposite the bottom plate 16. The lower mounting assembly 130a includes upper and lower contact sections (no reference numerals assigned), each having a plurality of mounting holes 134a and 134b through which the fixing bolts extend; side sections (no reference numerals assigned) having a plurality of beam-fastening holes 135a with which a first support beam 137 is fixed; three mounting sections 131a, 131b, and 131c, each of which is perpendicularly coupled to the horizontal center between the upper close contact section and the lower close contact section and is supported by a reinforcement plate 132 having a plurality of beam-fastening holes 135b; and fixing beams 133 fixing the three mounting sections 131a, 131b, and 131c together. The upper mounting assembly 130b is in close contact with the upper surface of the
casing 10 and is fixed by fixing bolts (no reference numerals assigned) extending through both the upper plate 15 and the upper frame 33 opposite the upper plate 15. The upper mounting assembly 130b includes upper and lower close contact sections (no reference numerals assigned) each having a plurality of mounting holes 134a and 134b, through which the fixing bolts extend; side sections (no reference numerals assigned) having a plurality of beam-fastening holes 135a to which the first support beam 137 is fixed; third mounting sections 131a, 131b, and 131c, each of which is perpendicularly coupled to the horizontal center between the upper close contact section and the lower close contact section and is supported by a reinforcement plate 132 having a plurality of beam-fastening holes 135b; and fixing beams 133 fixing the three mounting sections 131a, 131b, and 131c together.

On the upper plate 15, which faces the water spray unit 80a, there is provided an inspection unit 29, which includes an inspection hole (not shown) and a detachable cover (not shown), which is fixed by bolt-fastening so as to open/close the inspection hole.

The lower mounting assembly 130a is coupled to opposite edges and the central portion of the bottom plate 16.

The upper mounting assembly 130b is coupled to opposite edges and the central portion of the upper plate 15.

In addition, the first support beam 137 fixes the sections of the lower mounting assembly 130a, which are coupled to the opposite edges and the central portion of the bottom plate 16.

In addition, a pair of supply guide members 40a is provided inside the supply port 17a. Each of the guide members 40a includes a plurality of guide blades 42, a supply guide member frame 41a on which the guide blades 42 are mounted, and a plurality of hinges 43, each of the hinges 43 having one piece fixed to a side of the supply guide member frame 41a and the other piece fixed to the rear plate 12 of the casing adjacent to the supply port 17a.

Shutoff members 60 are also provided to fix a pair of the supply guide assemblies 40a and regulate the opening/closing of the supply port 17a. Each of the shutoff members 60 includes a fixing bolt 62 fixed to the reinforcement frame (not shown), a fixing clamp 61 holding the fixing bolt 62, and a fixing nut 63 fixing the fixing clamp 61.

In addition, a pair of exhaust guide members 50a is provided inside the exhaust port 18. Each of the exhaust guide members 50a includes a plurality of guide blades 52, an exhaust guide frame 51a on which the guide blades 52 are mounted, and a plurality of hinges 53, each of the hinges 53 having one piece fixed to a side of the exhaust guide frame 51a and the other piece fixed to the front plate 11 of the casing adjacent to the exhaust port 18.

Further, a shutoff member 60 is also provided to fix the pair of exhaust guide members 50a and regulate the opening/closing of the exhaust port 18. The shutoff member 60 includes a fixing bolt 62 fixed to the reinforcement frame 35, a fixing clamp 61 received in the fixing bolt 62, and a fixing nut 63 fixing the fixing clamp 61.

Here, the guide blades can be adjustable guide blades, which have an adjustable guide angle, or fixed guide blades, which have a guide angle fixed at the most suitable angle.

In addition, a cooling water guide port 82 is formed through and is coupled to one sidewall of the spray tank 83. The cooling water guide port 82 has a flange (no reference numeral assigned) on one end and a guide port (no reference numeral assigned) on the other end, which guides the supply of cooling water into the spray tank 83.

Further, a cooling water inlet pipe 81 is coupled to the cooling water guide port 82, extending through the front plate 11, and has flanges (no reference numeral assigned) on both ends thereof.

In addition, flanges (no reference numeral assigned) are provided on the upper end of the spray area-partitioning section in close contact with the upper plate 11 and on both ends of the supply area-partitioning section, which is in close contact with the two side plates 13 and 14, the upper partitioning section, and the supply area-partitioning section.

Further, a plurality of fixing bolt holes (no reference numeral assigned) is formed in the lower end of the supply area-partitioning section, which is in close contact with the sidewall of the sump 100.

The ventilation partition unit 20 is installed using the two side plates 13 and 13 and the sidewall of the sump 100 as fixing portions.

Below, a description will be given of an example of a facility in which a plurality of such modular cooling towers 1a is installed in a multi-stage structure using the lower mounting assembly 130a and the upper mounting assembly 130b as fixing portions.

As shown in FIG. 6, two modular cooling towers 1a, on each of which the lower mounting assembly 130a and the upper mounting assembly 130b are mounted, are installed in a multi-stage structure.

In the installation of this multi-stage structure, first, the lower mounting assembly 130a mounted on one of the modular cooling towers 1a is fastened to anchor bolts (no reference numeral assigned) embedded in a concrete foundation.

The lower mounting assembly 130a of one modular cooling tower 1a and the upper mounting assembly 130b of the other modular cooling tower 1a are brought into close contact with each other and are fastened to each other using fixing bolts.

In addition, a cover wall 200 is installed as a means for covering the multi-stage structure of the modular cooling towers 1a so that they cannot be seen from outside. Specifically, the cover wall 200 is installed using a plurality of cover wall support beams 210. Each of cover wall support beams 210 has fastening plates (no reference numeral assigned) connected to both ends thereof, the fastening plates having bolt-fastening holes (no reference numeral assigned). One side of the cover wall support beam 210 is fastened to the side portions of the lower mounting assembly 130a and the upper mounting assembly 130b and to the reinforcement plate 132 by bolt-screwing into the beam-fastening holes 135a and 135b, and the other side of the cover wall support beam 210 is fastened to the cover wall 200.

Next, a platform 250, which serves as a means for utilizing the upper space of the upper mounting assembly 130b mounted on the other modular cooling tower 1a, is fastened to the upper mounting assembly 130b using fixing bolts. The platform 250 includes a base plate 251, a horizontal beam 252 fixing the base plate 251, a column member 254, a fastening plate 253 having a plurality of bolt holes therein, the fastening plate 253 formed on the lower portion of the column member 254, protective hand rails 255 arranged along the edges of the base plate 251, and stairs 256.

Afterwards, a plurality of solar power generators 260 is installed on the platform 250, which supply part or all
of the electric power for lights around the modular cooling towers, the drive motors, control units of the modular cooling towers, and the like.

According to the first exemplary embodiment of the invention as set forth above, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, makes it easy to inspect and repair components inside the modular cooling tower due to the supply guide member, the exhaust guide member, and the inspection unit, which can be opened, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

FIG. 7 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a second exemplary embodiment of the invention. As shown in FIG. 7, the open modular cooling tower 1e according to the second exemplary embodiment of the invention differs from the above-described first exemplary embodiment, in that the open heat exchanger unit 70a has a parallelogram shape when viewed from the side and also includes a lower 79 in one end thereof, which faces the supply port 23.

A supply-side muffler 140, which includes a muffler housing 141 and sound-absorbing materials 142, is provided in the supply port 17a. The muffler housing 141 is coupled to the supply port 17a, and has a hinge 143 in one side thereof, fixed to the rear plate 12 of the casing, and a supply guide member 40b in the other side thereof, on which shutoff members 60 are mounted. In addition, the sound-absorbing materials 142 are arranged inside the muffler housing 141.

In addition, an exhaust-side muffler 150, which includes a muffler housing 151 and sound-absorbing materials 152, is also provided in the exhaust port 18. The muffler housing 151 is coupled to the exhaust port 18, and has a hinge 153 in one side thereof, fixed to the front plate 11 of the casing, and an exhaust guide member 50b in the other side thereof, on which shutoff members 60 are mounted. The sound-absorbing materials 152 are arranged inside the muffler housing 151.

According to the second exemplary embodiment of the invention, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, reduces noises of the cooling tower, makes it easy to inspect and repair components inside the modular cooling tower due to the supply-side muffler, the exhaust-side muffler, and the inspection unit, which can be opened, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

FIG. 8 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a third exemplary embodiment of the invention, and FIG. 9 is a schematic longitudinal cross-sectional view showing a multi-stage structure of the modular cooling towers shown in FIG. 8. As shown in these figures, the open modular cooling tower 1d according to the third exemplary embodiment of the invention differs from the above-described exemplary embodiments, in that the supply port 17b is formed through the bottom plate 16 of the casing, which faces the suction area 23, and a supply guide member 40c is mounted to the supply port 17b by the fastening of fixing bolts (no reference numerals assigned). The supply guide member 40c includes a bird prevention lattice 45, which prevents birds from entering the port, and a supply guide member frame 41a, on which the bird prevention lattice 45. The supply guide member frame 41a has flange (no reference numeral assigned) on one side thereof.

Here, the above-described shutoff members 60 and the supply guide member 40c can be mounted on the supply port 17b.

A pressure-type water spray unit 80b is provided above the open heat exchanger unit 70a. The pressure-type water spray unit 80b includes a main pipe 86 and distribution pipes 87, through which cooling water flows, and a plurality of spray nozzles 88 respectively coupled to each of the distribution pipes 87, the spray nozzles 88 spraying cooling water toward the heat exchanger unit.

Below, a description will be given of an example of a facility in which a plurality of such modular cooling towers 1d is installed in a multi-stage structure using the lower mounting assembly 130a and the upper mounting assembly 130b as fixing portions.

The two modular cooling towers 1d, on each of which the lower mounting assembly 130a and the upper mounting assembly 130b are mounted, are installed in a multi-stage structure, and include intermediate column members 136 between the lower mounting assembly 130a and the upper mounting assembly 130b and between the lower mounting assembly 130a and the foundation as a means for ensuring a space, through which a supply space and an inspection unit can be accessed. Each of the intermediate column members 136 includes coupling plates (no reference numerals assigned), which have a plurality of bolt holes in the upper and lower ends.

As a means for enhancing the supporting of the modular cooling towers 1d having the multi-stage structure, wall support beams 210 are also installed to support the lower mounting assembly 130a, the upper mounting assembly 130b, and walls of a building.

According to the third exemplary embodiment of the invention, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, makes it easy to inspect and
repair components inside the modular cooling tower due to the supply guide member, the exhaust guide member, and the inspection unit, which can be opened, reduces the area on which the cooling tower is installed by supplying air through the lower area, makes the upper space of the modular cooling tower to be used, is easily installed in a multi-stage structure on the roof of a building, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

[0176] FIG. 10 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a fourth exemplary embodiment of the invention. As shown in the figure, the modular cooling tower if according to the fourth exemplary embodiment of the invention differs from the above-described embodiments, in that an open heat exchanger and a closed heat exchanger are combined to each other to form a dry heat exchanger unit. Specifically, a closed heat exchanger unit 70b is provided in the heat exchange area. The closed heat exchanger unit 70b includes a wet-dry heat transfer tube 71; a fluid inlet head 72, which is coupled to one end of the wet-dry heat transfer tube 71 and has a fluid inlet port 73; a cooling fluid outlet header 74 coupled to the other end of the wet-dry heat transfer tube 71, the cooling fluid outlet header 74 having a cooling fluid outlet port 75; and heat transfer tube support members 77 supporting the wet-dry heat transfer tubes 71.

[0177] A pressure-type water spray unit 80b is provided above and spaced from the closed heat exchanger unit 70b.

[0178] An open heat exchanger unit 70a is also arranged between below the pressure-type water spray unit 80b and above the closed heat exchanger unit 70b. The open heat exchanger unit 70a serves to cool hot cooling water, which is sprayed after being introduced from the sump 100 through a spray pump 120.

[0179] Also provided is a plurality of plenum-type fan units 90b. Each of the fan units 90b includes a fan housing 92b having a fan exhaust port 93 with a flange (no reference numeral assigned) coupled to the ventilation opening 21, centrifugal fan blades 91b arranged inside the fan housing 92b, and a drive motor 95 driving the centrifugal fan blades 91b.

[0180] In the exhaust area 25, also provided is a dry heat exchanger unit 110. The dry heat exchanger unit 110 includes a dry heat transfer tube 111 having a plurality of heat transfer fins 115, a heat transfer tube housing (no reference numeral assigned) enclosing the heat transfer tube 111, the heat transfer tube housing having a flange coupled to the casing, a hot fluid inlet header 112 coupled to one end of the dry heat transfer tube 118, the hot fluid inlet header 112 having a hot fluid inlet port (no reference numeral assigned), and a hot fluid outlet header 114 coupled to the other end of the dry heat transfer tube 118, the hot fluid outlet header 114 having a hot fluid outlet port (no reference numeral assigned). A hot fluid connecting tube 116 is also arranged between the hot fluid outlet port of the hot fluid outlet header 114 and the fluid inlet port 73.

[0181] In addition, a cooling water outlet pipe 102 is arranged between the cooling water outlet port 101 of the sump 100 and a spray main pipe 86, and a spray pump 120, which supplies cooling water to the spray main pipe 86, is mounted on the cooling water outlet pipe 102.

[0182] Also provided are vibration-proof members 139 on the lower connecting section (no reference numeral assigned) of the lower mounting assembly 130a.

[0184] In addition, an inspection door (no reference numeral assigned) is also arranged in the side plate of the casing that faces the exhaust area 25.

[0185] According to the fourth exemplary embodiment of the invention, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, improves heat exchange performance by combining the open heat exchanger unit and the closed heat exchanger unit, reduces the amount of plume, makes it easy to inspect and repair components inside the modular cooling tower due to the supply guide member, the exhaust guide member, the inspection unit, and the inspection door, which can be opened, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

[0186] FIG. 11 is a longitudinal cross-sectional view schematically showing a modular cooling tower according to a fifth exemplary embodiment of the invention, and FIG. 12 is a schematic longitudinal cross-sectional view showing the modular cooling tower shown in FIG. 11, on which a roof unit is mounted. As shown in these figures, the modular cooling tower 1g according to the fourth exemplary embodiment of the invention includes an open heat exchanger 70a and a closed heat exchanger 70b, which are combined to each other to form a dry heat exchanger unit. In the modular cooling tower 1g of this exemplary embodiment, unlike the above-described embodiments, a duct-connected supply guide member 40d is coupled to the rear plate 12 of the casing, in which the supply port 17a is provided. The duct-connected supply guide member 40d is in the form of a frame having coupling flanges on both sides.

[0187] In addition, a duct-connected exhaust guide member 50e is coupled to the front plate 11, in which the exhaust port 18 is provided. The duct-connected exhaust guide member 50e is in the form of a frame having coupling flanges on both sides.

[0188] In addition, an inspection door (no reference numeral assigned) is also arranged in the side plate 13 or 14 of the casing that faces the suction area 23.

[0189] Vibration-proof members 139 are fastened to the lower connecting section of the lower mounting assembly 130a, base beams 180 having a fastening hole (no reference numeral assigned) are mounted under the vibration-proof members 139, and hangers 187 having threads on opposite ends are engaged into the fastening holes of the base beams 180.

[0190] Each of the hangers 187 has the lower portion fastened to the respective base beam 180 and the upper portion fastened to an anchor 183 embedded in the ceiling 230 such that the modular cooling tower 1g is mounted on the ceiling 230.

[0191] According to the fifth exemplary embodiment of the invention, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents dam-
age and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, improves heat exchange performance by combining the open heat exchanger unit and the closed heat exchanger unit, reduces the amount of plume, makes it easy to inspect and repair components inside the modular cooling tower due to the supply guide member, the exhaust guide member, the inspection unit, and the inspection door, which can be opened, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

[0192] FIG. 13 is a longitudinal cross-sectional view schematically showing a modular cooling tower 1h according to a sixth exemplary embodiment of the invention, FIG. 14 is a partially cutaway side elevational view schematically showing the modular cooling tower 1h shown in FIG. 13, on which covering members are mounted, and FIG. 15 is a partially cutaway side elevational view schematically showing a multi-stage structure of the modular cooling towers 1h shown in FIG. 13, on which covering members are mounted. As shown in these figures, the modular cooling tower 1h according to the fourth exemplary embodiment of the invention includes an open heat exchanger 70a and a closed heat exchanger 70b, which are combined to each other to form a dry heat exchanger unit. Unlike the above-described embodiments, in the modular cooling tower 1h of this exemplary embodiment, a fan unit 90c includes a fan housing 92c having an exhaust port 93 with a flange (no reference numeral assigned) coupled to a ventilation opening 21, a fan support 94 supporting the fan housing 92c, a drive motor 95 driving the fan blades 91c, a base 96 supporting the fan support 94 and the drive motor 95, and vibration-proof members 97 mounted between the fan support 94 and the base 96 and between the drive motor 95 and the base 96.

[0193] Although the fan unit 90c is illustrated as being a direct drive type, it can be a belt drive type.

[0194] The modular cooling tower also includes covering members 270 mounted on the lower mounting assembly 130a and the upper mounting assembly 130b. The covering members 270 serve as a means for improving the aesthetic appearance of the modular cooling tower so that it harmonizes with the surroundings. The covering members 270 are fixed by fixing members 271 so that they face the side plates 13 and 14 and the upper plate 15 of the casing.

[0195] In addition, covering members 270 each having a supply opening (not shown) and an exhaust opening (not shown) can also be mounted on the lower mounting assembly 130a and the upper mounting assembly 130b. The covering members 270 face the front plate 11 and the rear plate 12.

[0196] In addition, the aesthetic appearance of the modular cooling tower so that it harmonizes with the surroundings, the modular cooling tower also includes a plant-growing tray 275 on the upper mounting assembly 130b. Small trees, flowers and plants, grass can be grown in the plant-growing tray. The plant-growing tray 275 has a drain in the bottom.

[0197] In addition, a billboard is installed on the upper mounting assembly, located uppermost of the multi-stage structure of the modular cooling towers 1h.

[0198] In addition, a pulpit can be provided on the upper mounting assembly 130b. The pulpit is used to install a control panel of the cooling tower or a water treatment unit.

[0199] According to the sixth exemplary embodiment of the invention, the modular cooling tower greatly reduces the height using the horizontal box-like casing structure, is easily transported and installed as a finished product, prevents damage and has an improved aesthetic appearance because components are installed inside a casing, efficiently circulates cooling water and air into a heat exchanger unit without a bypass flow using the ventilation partition unit, ensures excellent heat exchange performance by preventing the recirculation of exhaust air due to the supply port and the exhaust port spaced apart from each other, improves heat exchange performance by combining the open heat exchanger unit and the closed heat exchanger unit, improves the aesthetic appearance of the modular cooling tower using the covering members so that the cooling tower harmonizes with the surroundings, makes it easy to inspect and repair components inside the modular cooling tower due to the supply guide member, the exhaust guide member, the inspection unit, and the inspection door, which can be opened, is easily installed in a multi-stage structure on the roof of a building, makes the upper space of the modular cooling tower to be used, and makes it easy to install a cover wall and covering members that cover the modular cooling tower.

[0200] The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for the purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teachings. The exemplary embodiments were chosen and described in order to explain certain principles of the invention and their practical application, to thereby enable others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

What is claimed is:
1. A modular cooling tower comprising:
   a casing having a supply port and an exhaust port, the casing defining a heat exchange area wherein:
   wherein the heat exchanger unit allows cooling water and air to circulate therein, thereby exchanging heat with each other;
   a spray unit arranged above the heat exchanger unit, wherein the spray unit sprays cooling water;
   a blower fan unit for blowing air toward the heat exchanger unit and exhausting saturated humid air, which has undergone heat exchange, through the exhaust port;
   an eliminator for collecting drops of water scattering toward the exhaust port;
   a sump for collecting cooling water dropping through the heat exchanger unit, the sump having a cooling water outlet port;
   a frame assembly arranged along six inner surfaces of the casing to support the casing, wherein the casing has a horizontal box-like shape having six sides including a
front plate, a rear plate, an upper plate, a bottom plate, a pair of side plates, the supply port is formed through the rear plate or the bottom plate of the casing, and the exhaust port is formed through the front plate of the casing;
a ventilation partition unit arranged between the heat exchanger unit and the supply port to form the supply area such that cooling water and air efficiently circulate without a roundabout flow, wherein the ventilation partition unit includes a spray area-partitioning section, which partitions a portion of the spray unit, a supply area-partitioning section, which faces the heat exchanger unit, an upper partitioning section formed between the spray area-partitioning section and the supply area-partitioning section, and a ventilation opening formed in the supply area-partitioning section;
a suction area formed between the ventilation partition unit and the supply port;
an exhaust area formed between the heat exchanger unit and the exhaust port;
a lower mounting assembly including a plurality of members, wherein the lower mounting assembly is arranged in the suction area or the exhaust area in close contact with an underside of the casing; and
an upper mounting assembly including a plurality of members, wherein the upper mounting assembly is arranged in close contact with an upper portion of the casing.

2. The modular cooling tower according to claim 1, wherein the casing includes a graphic film or a graphic plate attached to an outer surface thereof.

3. The modular cooling tower according to claim 1, further comprising at least one supply guide member and at least one shutoff member in the supply port, the supply port extending through the rear plate of the casing, wherein the supply guide member includes a plurality of guide blades, a supply guide member frame on which the guide blades are mounted, and a plurality of hinges, wherein each of the hinges has one piece fixed to a side portion of the supply guide member frame and the other piece fixed to a portion of the casing adjacent to the supply port, and wherein the shutoff member opens and closes the supply port.

4. The modular cooling tower according to claim 1, further comprising at least one supply guide member and at least one shutoff member in the supply port, the supply port extending through the bottom plate of the casing, wherein the supply guide member includes a bird prevention lattice, which prevents birds from entering the supply port, a supply guide member frame on which the bird prevention lattice is mounted, and a plurality of hinges, wherein each of the hinges has one piece fixed to a side portion of the supply guide member frame and the other piece fixed to a portion of the casing adjacent to the supply port, and wherein the shutoff member opens and closes the supply port.

5. The modular cooling tower according to claim 1, further comprising at least one exhaust guide member and at least one shutoff member in the exhaust port, wherein the exhaust guide member includes a plurality of exhaust guide blades, a exhaust guide member frame on which the exhaust guide blades are mounted, and a plurality of hinges, wherein each of the hinges has one piece fixed to a side portion of the exhaust guide member frame and the other piece fixed to a portion of the casing adjacent to the exhaust port, and wherein the shutoff member opens and closes the exhaust port.

6. The modular cooling tower according to claim 1, wherein the heat exchanger unit comprises one selected from the group consisting of an open heat exchanger unit, a closed heat exchanger unit, and a combination heat exchanger unit in which an open type and a closed type are combined to each other.

7. The modular cooling tower according to claim 6, wherein the open heat exchanger unit has a side shape selected from the group consisting of rectangle, square, and parallelogram.

8. The modular cooling tower according to claim 1, further comprising a louver on a side portion of the heat exchanger unit, which faces the ventilation partition unit, wherein the louver guides a flow of supply air and collects scattering drops of cooling water.

9. The modular cooling tower according to claim 1, further comprising a dry heat exchanger unit in the exhaust area, wherein the dry heat exchanger heats saturated humid air, exhausted toward the exhaust port, thereby reducing plume, and includes a dry heat transfer tube having a plurality of heat transfer fins, a hot fluid inlet header coupled to one end of the dry heat transfer tube, the hot fluid inlet header having a hot fluid inlet port, a hot fluid outlet header coupled to the other end of the dry heat transfer tube, the hot fluid outlet header having a hot fluid outlet port.

10. The modular cooling tower according to claim 1, wherein the heat exchanger unit comprises a gravity-type spray unit or a pressure-type spray unit.

11. The modular cooling tower according to claim 1, wherein the blower fan unit comprises one selected from the group consisting of a centrifugal fan unit, a plenum-type fan unit, and an axial-flow fan unit.

12. The modular cooling tower according to claim 1, further comprising a flexible vibration-proof coupling member between the ventilation opening and a flange, wherein the flexible vibration-proof coupling member prevents vibration of the blower fan unit from being transferred.

13. The modular cooling tower according to claim 1, wherein the upper partitioning section is inclined downward toward the heat exchanger unit in order to prevent cooling water, which flows along a surface of the spray area-partitioning section, from circulating into the exhaust area-partitioning section.

14. The modular cooling tower according to claim 1, wherein, in the ventilation partition unit, an upper end of the spray area-partitioning section is fixed to the upper plate of the casing, a lower end of the supply area-partitioning section is fixed to an inner portion of the sump, and both the spray area-partitioning section and the supply area-partitioning section are fixed to the side plates of the casing.

15. The modular cooling tower according to claim 1, further comprising a plurality of cover wall support beams on the lower mounting assembly and the upper mounting assembly, wherein the cover wall support beams fix a cover wall, which covers the cooling tower, and form a fastening plate having bolt-fastening holes in both ends.

16. The modular cooling tower according to claim 1, wherein the lower mounting assembly and the upper mounting assembly include:
   upper and lower close contact sections, each of which has a plurality of mounting holes, through which fixing bolts extend;
two or more mounting sections with a side section having a plurality of beam-fastening holes;
a reinforcement plate vertically coupled to a horizontal central portion of the mounting section, the reinforcement plate having a plurality of beam-fastening holes; and
fixing beams fixing the two or more mounting sections such that the mounting sections are in parallel to each other.

17. The modular cooling tower according to claim 1, comprising two of the modular cooling towers vertically mounted in a multi-stage structure by fastening the lower mounting assembly and the upper mounting assembly.

18. The modular cooling tower according to claim 1, wherein the modular cooling tower is mounted on a ceiling of a building using the lower mounting assembly or the upper mounting assembly as fixing sections.

19. The modular cooling tower according to claim 1, further comprising a first duct-connected guide member on the supply port and a second duct-connected guide member on the exhaust member.

20. The modular cooling tower according to claim 1, further comprising a first muffler on the supply port and a second muffler on the exhaust member.

21. The modular cooling tower according to claim 1, further comprising a vibration-proof member on at least one of the blower fan unit and the lower mounting assembly.

22. The modular cooling tower according to claim 1, further comprising a platform coupled to an upper portion of the upper mounting assembly, wherein the platform includes a base plate, a horizontal beam fixing the base plate, a column member with a fastener plate formed on a lower portion thereof, the fastener plate having a plurality of bolt holes, a hand rail arranged along outer edges of the base plate, and a stair.

23. The modular cooling tower according to claim 22, further comprising a plurality of solar power generators on the platform, wherein the solar power generators supply electric power to lights around the cooling tower, a drive motor, a controller of the cooling tower.

24. The modular cooling tower according to claim 1, further comprising covering members mounted on the lower mounting assembly and the upper mounting assembly, the covering members facing the side plates of the casing and the upper plate of the casing.

25. The modular cooling tower according to claim 24, wherein the covering member comprises one selected from the group consisting of a graphic panel, a construction panel, and a forming panel.

26. The modular cooling tower according to claim 1, further comprising covering members mounted on the lower mounting assembly and the upper mounting assembly so as to face the front plate and the rear plate, the covering members having a supply opening and an exhaust opening.

27. The modular cooling tower according to claim 25, wherein the covering member comprises one selected from the group consisting of a graphic panel, a construction panel, and a forming panel.

28. The modular cooling tower according to claim 1, further comprising one selected from the group consisting of a plant-growing tray, a billboard, and a pulpit, on the upper mounting assembly, wherein the pulpit used to install a control panel of the cooling tower or a water treatment unit.

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