AIR COOLER FOR CIRCULATING FLUIDS

Homer E. Fordyce, Kansas City, Mo., assignor to The Marley Company, Kansas City, Mo., a corporation of Delaware

Filed Feb. 12, 1968, Ser. No. 704,755

U.S. Cl. 165—122

7 Claims

ABSTRACT OF THE DISCLOSURE

A cross flow cooling tower has an upright coil comprising a plurality of rows of nearly horizontally extending finned tubes, the rows being arranged in a shingled configuration with each tube extending around the axis of the coil from the inside to the outside thereof.

In mechanical or natural draft crossflow air coolers it has been the practice to employ a coil comprising a number of rows of fluid-conveying tubes in which the fluid flows in heat exchange relationship to ambient air. The tubes of each row or bundle are commonly of the finned tube type and may extend either vertically or horizontally, depending upon the particular coil configuration. Although cooling towers of this general design have proven satisfactory in numerous industrial applications, problems do arise with respect to uniform exposure of each row of tubes to the air medium, control of the capacity of the cooler under varying climatic and load conditions, maintenance of the fluid-conveying tube rows, elimination of drain traps in horizontal tube coils, and prevention of corrosion of the fins of the tubes in vertical tube coils.

It is, therefore, the primary object of this invention to provide a coil as aforesaid of the multiple row type having a shingled configuration which permits uniform exposure of each row of tubes thereof to the external medium and which further provides ready access to each row for maintenance purposes without interference from adjacent rows.

Another important object of the instant invention is to provide a coil as aforesaid of the multiple row type having a shingled configuration which permits uniform exposure of each row of tubes thereof to the external medium and which further provides ready access to each row for maintenance purposes without interference from adjacent rows.

Still another important object of the invention is to provide such a coil in which each row thereof may be rapidly drained either for control purposes to deactivate a particular row or rows or in the event that shutdown of the system is required during operation under cold ambient air conditions where freezing of the fluid in the tubes could occur.

Yet another important object is to provide a coil as aforesaid which is capable of utilizing nearly horizontally disposed tubes having sufficient inclination to permit the required drainage thereof, whereas the fins of the maintenance may be disposed in nearly vertical planes to reduce corroboration problems which could otherwise occur due to settling of airborne corrosive particles on the surfaces of the fins.

In the drawings:
FIGURE 1 is a diagrammatic side view of a crossflow air cooler showing the casing and stack structure broken away and revealing one of the tube rows of the coil in side elevation;
FIG. 2 is a diagrammatic, top plan view of the cooler shown in FIG. 1, portions of the stack and casing being broken away to reveal the storage basin and the coil therebelow;
FIGS. 3 and 4 are flow diagrams illustrating applications of the cooler of the instant invention;
FIG. 5 is an enlarged, detail view showing several finned tubes terminating at a header; and
FIG. 6 is a cross-sectional view taken along line 6—6 of FIG. 5.

An air cooler broadly denoted 10 comprising a mechanical and natural draft hyperbolic crossflow cooling tower is shown in detail in FIGS. 1 and 2, the illustration thereof being simplified in certain respects for purposes of clarity. The cooler 10 is provided with framing 12 which supports a stack 14 and a casing 16 that merges with stack 14 and extends outwardly and downwardly therefrom in protecting relationship to an upright heat exchanger coil 18. The coil 18 is of the multiple row type comprising a vertical stack or bundle of nearly horizontally extending finned tubes. One of the rows 20 of coil 18 is shown in side elevation in FIG. 1, five other rows 22, 24, 26, 28 and 30 being broken away and revealed in cross section. As is clear in FIG. 2, row 18 extends 180° around the vertical axis of coil 18 from the inside of the coil to the outside thereof, the other rows 22-30 extending in like manner but being staggered with respect to one another to provide coil 18 with a "shingled" configuration.

It will be appreciated from a study of FIG. 2 that the coil 18 illustrated herein is formed from a total of twelve rows of finned tubes, six such rows having been described above and the remaining six being shown at 32, 34, 36, 38, 40 and 42. The inner and outer ends of the row 20 communicate with the upright inlet or supply header 44 and an upright outlet or return header 46 respectively. The other rows of tubes are likewise arranged with respect to their headers, the outlet header 48 of row 20 being shown in FIG. 2, together with the outlet headers 50, 52, 54, 56 and 58 of rows 24, 26, 28, 30 and 32 respectively. The inlet headers for rows 32, 34, 36, 38, 40 and 42 may be seen at 60, 62, 64, 66, 68 and 70 respectively.

It is important to note that the various vertically extending rows are radially spaced from one another and that the inlet and outlet headers of the rows are angularly spaced from one another at 30° intervals about the axis of coil 18. The axis of the composite coil 18 is coaxial with the vertical axis of stack 14, the latter having a fan 72 therein which is arranged with a vertical axis of rotation 74 common to both of the aforementioned axes.

Again referring to FIG. 2, it may be noted that each 30° segment of each of the rows between an adjacent pair of inlet or outlet headers is accurate with the row segments in each 30° angular span of the coil being disposed in parallelism. However each 30° section of the coil has a different center with respect to the accurate row segments therein, the arrangement being such that the tubes of each row extend from the inside to the outside of the coil and terminate at inlet and outlet headers that are diametrically opposed with respect to the axis of the composite coil represented at 74. This, in conjunction with the 30° staggering of the inlet and outlet ends of the tube rows, produces the shingled effect referred to above. In this respect, it should be understood that the 180° tube lengths disclosed herein are purely exemplary, the teachings of the instant invention being equally applicable to tubes of other lengths including a full 360° or greater.

The inlet ends of the tubes of coil 18 are higher than the outlet ends thereof as is clear in FIG. 1 where it may be seen that the tubes extend nearly horizontally but are somewhat inclined. The inclination provides rapid drainage and yet permits the use of a nearly vertical fin, as will be discussed hereinafter. The inlet headers are fed from a manifold 76 which circumscribes coil 18 adjacent the base thereof, one of the inlet header pipes 78 being
illustrated in FIG. 2 communicating manifold 76 with inlet header 64. One of the outlet header pipes 80 is illustrated connected to header manifold 76 with a storage basin 82 beneath stack 14. The other inlet headers are similarly connected by header pipes to manifold 76, and the other outlet headers are similarly connected by header pipes to basin 82, such additional pipes being omitted from FIG. 2 for purposes of clarity.

In the wider example, some of the finned tubes are illustrated in FIGS. 5 and 6, the outlet header 46 being selected for illustration. Three finned tubes 84 are shown in their ends communicating with header 46, each tube 84 being provided with a multitude of fin elements 86 formed as a continuous spiral. Since the tubes 84 are nearly horizontal and the fin elements 86 are relatively tightly spiralled, each element 86 is disposed in a generally vertical plane. Therefore, any airborne corrosive particles which may settle within tower 10 are less likely to accumulate on fin elements 86 and cause corrosion thereof than if the fin elements were horizontally disposed. As will become clear herein, the finned shingled coil configuration of the instant invention permits rapid drainage of the tubes although the same are only somewhat inclined; therefore, the advantage of nearly horizontal tubes from the corrosion standpoint may be realized without impairing the drainage capability of the coil.

FIGURES 3 and 4 illustrate exemplary applications of the cooler of the instant invention. In FIG. 3, a boiler 88 is shown for supplying steam to a turbine 90 in which, in turn, drives a load such as an electric generator 92. The turbine 90 exhausts into a direct contact condenser 94, the outlet thereof being communicated with manifold 76 via a conduit 96. A pump 98 supplies boiler 88 with water taken from conduit 96. The operating water level of condenser 94 is illustrated at 100.

The pumping circuit through the cooling tower 10 comprises pumps 102 having a horizontal water line 104 communicating with basin 82 and an outlet line 106 communicating with condenser 94. The circuit then extends along conduit 96 to the manifold 76, the supply path to the row 36 of coil 18 being through header pipe 78 and inlet header 64. The return is via an outlet header 108 and a header pipe 110 to the basin 82. The other rows of coil 18 are similarly disposed in the pumping circuit by their respective inlet and outlet headers, it being understood that the illustration of coil 18 appearing in both FIGS. 3 and 4 is entirely diagramatic in nature with no attempt being made in FIGS. 3 and 4 to show the actual spacing between the inlet and outlet headers 64 and 108. A shutoff valve 112 is located adjacent the bottom of inlet header 64, and a flow control valve 114 is disposed in outlet header pipe 110. The other inlet and outlet headers are likewise provided with shutoff and flow control valves. Therefore, in operation, it may be seen that the rows of coil 18 may be selectively activated, depending upon load requirements and the temperature of the ambient air which flows in crossflow relationship to the tubes of coil 18 either by natural draft or forcibly by the action of fan 72. The simplified control arrangement of the instant invention is particularly advantageous in applications where the temperature of the ambient air is subject to extreme day-to-day or seasonal variations.

By virtue of the shingled configuration of coil 18, it is evident that each row of the coil is equally exposed to the warmest and coolest temperature of the ambient air as it travels in a generally inward direction from the outside of the tower to the base of stack 14, and thence outwardly through the top of stack 14. This produces uniform predictable chimney effects at any stage of capacity reduction while maintaining symmetrical heat distribution continuously around the tower.

The shingled coil also causes the airflow path to be more tortuous than if the shingled configuration were not employed, resulting in greater residence time for the ambient heat exchange medium. Therefore, an increase in the efficiency of the structure is realized. Furthermore, inspection of the coil 18 may be facilitated by walking between the various rows, and maintenance thereof is greatly facilitated since adjacent rows do not interfere with each other.

Another distinct advantage of the instant invention is in the wider cooling range achieved by the shingled coil. The shingled configuration increases the capacity of the coil over equivalent concentric coil arrangements, but minimum capacity operation is not impaired since, with one row active and five rows inactive on the six-row coil illustrated, the tower performs at less than 1/3 of its capacity at constant flow conditions. This disproportionate ratio of capacity reduction is due to the fact that the finned coil air-side pressure drop is based on a six-row bundle while the total transfer for the composite coil at full capacity is based on a one-row coil. It should be understood that, as just used, the term "six-row" refers to the number of rows crossed by the ambient air as it passes through the coil. Thus, in the coil 18 chosen for illustration herein, operation at one-row capacity as discussed would require that two of the actual tube rows covering 360° be active, such as rows 20 and 32.

A system similar to FIG. 3 is illustrated in FIG. 4 and comprises a boiler 116 which delivers steam to a turbine 118, the latter exhausting into a shell and tube type condenser 120 to which a cool water inlet line 122 and a warm water outlet line 124 are connected. Condensate is returned from condenser 120 to boiler 116 by a pump 126. A pump 128 is in the circuit through coil 18 and is provided with a suction line 130 communicating with basin 82, the outlet thereof in communication with line 122. The outlet line 124 from condenser 120 extends to the manifold 76 and the supply return circuit through the one described above for FIG. 3.

It may be noted in both FIGS. 3 and 4 and that a pair of vent tubes 132 communicate with inlet header 64 at approximately the top and bottom thereof, it being understood that the other inlet headers of coil 18 are likewise vented to atmosphere at the top of tower 10 above the level of coil 18. Thus, when it is desired to drain a particular row such drainage occurs rapidly by merely closing the appropriate shutoff valve 112 and permitting the fluid contents of the row to discharge into basin 82.

Alternatively, a plurality of circumferentially located manifolds may be provided to gather alternate rows together into separate pump systems. In this arrangement, filling or draining of alternate rows can occur by staging pumps on and off. For example, it may be desired to gather a five-row coil (five rows crossed by the flowing air) into three separate pump systems with the first pump handling three rows in parallel, and the other two pump systems handling one row each. By staging pumps in response to controls which sense fluid temperatures, the coil thus operates with any number of rows from one to five, depending on heat load and ambient temperature conditions.

Furthermore, system capacity may also be reduced for light load or cold weather conditions by locating by butterfly valves intermediate the tops and bottoms of the uprow headers. With these valves in the "off" position prior to pump start-up, the upper portions of the rows can be left without water. The lower portions then operate with decreased effective heat transfer surface and with decreased chiller off-set, the latter being due to the cold air bypass above the active coil areas.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is: 1. In a heat exchanger: a coil having a plurality of radially spaced rows of elongated tubes presenting a central upright space therein, said tubes being adapted to convey a
5 fluid flowing therein for heat exchange with the ambient atmosphere, the outer, circumferentially extending face of the coil being open to said atmosphere,
structure associated with said coil for restricting flow of air from the surrounding atmosphere to substantially a horizontal path through the coil from the open face thereof to said central space in crossflow relationship to the fluid flowing in said tubes and for effecting substantially vertical discharge of the air from said space
the tubes of each row extending at least partially around the axis of the coil with each tube having an inner end at the inside of the coil and an outer end at the outside of the coil, the horizontal spacing between adjacent rows being sufficient to permit a workman to walk therebetween and
the inner and the outer ends of the tubes of each row being angularly spaced from the inner and the outer ends respectively of the tubes of the other of said rows, whereby to provide the coil with a shingled configuration; and
supply and return conduit means for said fluid communicating with said ends of the tubes.
2. The invention of claim 1, the angular spacing between the inner ends of the tubes of adjacent rows being substantially equal, and the angular spacing between the outer ends of the tubes of adjacent rows being substantially equal, whereby each row is equally exposed to the warmest and coolest temperature of the medium.
3. The invention of claim 1, said conduit means coupling said rows in parallel fluid-conveying relationship to one another,
4. The invention of claim 3, said coil being upright,
each of said tubes extending generally horizontally but having its longitudinal axis inclined to a degree to permit efficient drainage of said fluid therefrom.
5. The invention of claim 4, each of said tubes being finned and having a multitude of generally vertically disposed fin elements extending radially outwardly therefrom.
6. The invention of claim 4, each of said tubes having the ends thereof disposed at different vertical elevations, whereby one of said ends thereof is higher than the other, said conduit means including a plurality of inlet headers each communicating with the one ends of the tubes of a corresponding row, and a plurality of outlet headers each communicating with the other, lower ends of the tubes of a corresponding row.
7. The invention of claim 6, each of said inlet headers having means venting the same to atmosphere, whereby the tubes may be drained by gravity.

References Cited
UNITED STATES PATENTS
3,130,780 4/1964 Winship ............... 165—163
3,077,226 2/1963 Matheny ............... 165—125

ROBERT A. O'LEARY, Primary Examiner
C. SUKALO, Assistant Examiner

U.S. Cl. X.R.

165—184, 175