COOLING TOWER CONTROL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent App. No. 63/023,467, filed May 12, 2020, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to cooling towers and, more specifically, to control systems for cooling towers.

BACKGROUND

[0003] Cooling towers often distribute evaporative liquid, such as water, onto an evaporative heat exchanger of the cooling tower. Cooling tower operation typically involves the use of a water treatment specialist to design and implement a water treatment system of the cooling tower. The water treatment system typically requires multiple chemicals to control biological growth, corrosion, scaling, and fouling as well as water use minimization. This can be costly, time consuming, and burdensome for smaller facilities with little to no on-site maintenance staff, especially in areas with challenging water treatment requirements such as large urban areas. In addition, when any of the water quality parameters exceed a specified tolerance level or the measuring sensors are faulty, even when an alarm is sent, the cooling tower can be left running with potentially high microbial content and/or with corrosive water which can damage the cooling tower or environment.

SUMMARY

[0003a] According to a first aspect of the claimed invention, there is provided a cooling tower system comprising:

a cooling tower comprising:

an evaporative heat exchanger, the cooling tower operable to distribute an evaporative liquid onto the evaporative heat exchanger;

a sensor configured to detect a parameter of the evaporative liquid; and

an evaporative liquid treatment system;

a controller operably coupled to the cooling tower, the controller having a normal operating mode wherein the controller operates the evaporative liquid treatment system to treat the evaporative liquid upon a determination of inadequate evaporative liquid quality based at least in part on the parameter of the evaporative liquid; and

the controller having a failsafe operating mode wherein the controller changes operation of the cooling tower upon a determination that the operation of the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

[0003b] According to a second aspect of the claimed invention, there is provided a cooling tower comprising:

an evaporative heat exchanger configured to receive a process fluid;

a fan assembly operable to cause airflow relative to the evaporative heat exchanger;

an evaporative liquid distribution system including at least one outlet to distribute evaporative liquid onto the evaporative heat exchanger and a sump to collect evaporative liquid from the evaporative heat exchanger;

an evaporative liquid treatment system of the evaporative liquid distribution system;

an evaporative liquid sensor of the evaporative liquid distribution system configured to detect an evaporative liquid parameter;

a controller operably coupled to the fan assembly and the evaporative liquid distribution system, the controller configured to:

operate the evaporative liquid treatment system upon a determination of inadequate evaporative liquid quality based at least in part on the evaporative liquid parameter; and

change operation of the evaporative liquid distribution system to facilitate safe operation of the cooling tower upon a determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

[0004] There is disclosed a cooling tower system is provided that includes a cooling tower and a controller operably coupled to the cooling tower. The cooling tower includes an evaporative heat exchanger and the cooling tower is operable

to distribute an evaporative liquid onto the evaporative heat exchanger. The cooling tower includes a sensor, which is configured to detect a parameter of the evaporative liquid, and an evaporative liquid treatment system.

[0005] In one example, the cooling tower is an open circuit direct evaporative cooling tower and the evaporative heat exchanger includes fill. The evaporative liquid comprises process fluid the cooling tower receives from a building or industrial process. The process fluid may be water or a water mixture (e.g., water and glycol). In another example, the cooling tower is a closed circuit indirect evaporative cooling tower and the evaporative heat exchanger includes an indirect evaporative heat exchanger, comprising serpentine tubes, plates, and/or fins, which receives a process fluid. The evaporative liquid of the closed circuit indirect evaporative cooling tower may be water, as one example. The cooling tower distributes the water onto the indirect evaporative heat exchanger.

[0006] The controller has a normal operating mode wherein the controller operates the evaporative liquid treatment system to treat the evaporative liquid upon a determination of inadequate evaporative liquid quality based at least in part on the parameter of the evaporative liquid. The controller further includes a failsafe operating mode wherein the controller changes operation of the cooling tower upon a determination that the operation of the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality. In this manner, the cooling tower system may continue to operate in a safe manner despite the inadequate evaporative liquid quality until the system is serviced. The controller, in the failsafe operating mode, operates the cooling tower to satisfy a requested cooling load while operating in a safe manner. If the cooling tower is unable to satisfy the requested cooling load, the controller in the failsafe operating mode operates the cooling tower to provide the maximum cooling capacity possible while still operating in the safe manner.

[0007] In one example, the cooling tower is operable in a plurality of modes including a wet mode and a dry mode. The controller, in the normal operating mode,

permits operation of the cooling tower in the wet mode and the dry mode. The controller, in the failsafe operating mode, refrains from operating the cooling tower in the wet mode. The cooling tower may thereby continue to operate in the dry mode to remove heat from the process fluid until the cooling tower is serviced and able to operate safely in the wet mode.

[0008] In some examples the cooling tower is operable in a dry mode or an adiabatic mode. For example, the cooling tower may have an indirect heat exchanger including coils that receive a process fluid and an adiabatic cooler including adiabatic pads and a water distribution system. The water distribution system distributes water onto the adiabatic pads to pre-cool air upstream of the coils. In the failsafe operating mode, the controller refrains from operating the cooling tower in the adiabatic mode but may operate the cooling tower in the dry mode.

[0009] Another example of the cooling tower is operable in a dry mode, an adiabatic mode, or a wet mode. The controller, in the failsafe operating mode, refrains from operating the cooling tower in the wet mode and the adiabatic mode. The controller, however, may operate the cooling tower in the dry mode.

[0010] There is disclosed a cooling tower is provided that includes an evaporative heat exchanger configured to receive a process fluid and a fan assembly operable to cause airflow relative to the evaporative heat exchanger. The cooling tower further includes an evaporative liquid distribution system including at least one outlet to distribute evaporative liquid onto the evaporative heat exchanger, a sump to collect evaporative liquid from the evaporative heat exchanger, and an evaporative liquid treatment system of the evaporative liquid distribution system. The evaporative liquid treatment system may include, for example, a water makeup supply and a UV light assembly operable to treat makeup water. In one example, the UV light assembly is mounted in a heat exchange section of the cooling tower or in an evaporative liquid side loop. As another example, the evaporative liquid treatment

Claims

What is claimed is:

1. A cooling tower system comprising:

a cooling tower comprising:

an evaporative heat exchanger, the cooling tower operable to distribute an evaporative liquid onto the evaporative heat exchanger;

a sensor configured to detect a parameter of the evaporative liquid; and

an evaporative liquid treatment system;

a controller operably coupled to the cooling tower, the controller having a normal operating mode wherein the controller operates the evaporative liquid treatment system to treat the evaporative liquid upon a determination of inadequate evaporative liquid quality based at least in part on the parameter of the evaporative liquid; and

the controller having a failsafe operating mode wherein the controller changes operation of the cooling tower upon a determination that the operation of the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

2. The cooling tower system of claim 1 wherein the controller, in the normal operating mode, is capable of operating the cooling tower in a plurality of modes of including a wet mode wherein the cooling tower distributes the evaporative liquid onto the evaporative heat exchanger and a dry mode wherein the cooling tower limits distribution of the evaporative liquid onto the evaporative heat exchanger; and

wherein the controller, in the failsafe operating mode, refrains from operating the cooling tower in the wet mode.

3. The cooling tower system of claim 2 wherein the plurality of modes of operation include an adiabatic mode; and

wherein the controller, in the failsafe operating mode, refrains from operating the cooling tower in the wet mode and the adiabatic mode.

4. The cooling tower system of claim 2 wherein the cooling tower includes at least one operating parameter sensor configured to detect an operating parameter of the cooling tower;

the controller is configured to receive a process fluid temperature request and determine whether to operate the cooling tower in the wet mode to satisfy the process fluid temperature request based at least in part on the process fluid temperature request and the operating parameter; and

wherein the controller, in the failsafe operating mode, refrains from operating the cooling tower in the wet mode despite the controller determining operation of the cooling tower in the wet mode is appropriate to satisfy the process fluid temperature request.

5. The cooling tower system of claim 1 wherein the evaporative liquid treatment system is operable to purge and flush the cooling tower; and

wherein the controller, in the normal operating mode, is configured to periodically cause the evaporative liquid treatment system to purge and flush the cooling tower.

6. The cooling tower system of claim 5 wherein the controller, in the failsafe operating mode, is configured to change the operation of the cooling tower including causing the evaporative treatment system to purge and flush the cooling tower more frequently than with the controller in the normal operating mode.

7. The cooling tower system of claim 1 wherein the controller, in the normal operating mode, is configured to operate the evaporative liquid treatment system including at least one of: opening a makeup liquid supply valve, opening a bleed off valve, running a purge and flush cycle, and adding a treatment chemical to the evaporative liquid; and

wherein the controller, in the failsafe operating mode, is configured to change operation of the cooling tower including at least one of turning off a spray pump, reducing a speed of a fan of the cooling tower, running a purge and flush cycle, and adding a treatment chemical to the evaporative liquid.

8. The cooling tower system of claim 1 wherein the sensor includes at least one of a conductivity sensor, a biofilm sensor, and a pH sensor;

wherein the parameter includes at least one of a conductivity parameter, a biofilm parameter, and a pH parameter; and

wherein the controller, in the failsafe operating mode, is configured to bypass consideration of the at least one of the conductivity parameter, biofilm parameter, and pH parameter.

9. The cooling tower system of claim 1 wherein the controller generates a remedial action signal upon the controller operating the liquid treatment system; and

the determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality is based at least in part upon the number of remedial action signals exceeding a predetermined number of remedial action signals.

10. The cooling tower system of claim 1 wherein the determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative

liquid quality is based at least in part on the parameter of the evaporative liquid being outside of an acceptable range for longer than a predetermined period of time.

11. The cooling tower system of claim 1 wherein the determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality is based at least in part upon the controller operating the evaporative liquid treatment system a predetermined number of times within a predetermined time period.

12. The cooling tower system of claim 1 wherein the determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality is based at least in part upon the parameter of the evaporative liquid after the operation of the evaporative liquid treatment system.

13. The cooling tower system of claim 12 wherein the determination of inadequate evaporative liquid quality is based at least in part upon the parameter of the evaporative liquid exceeding a first threshold; and

wherein the determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality is based at least upon the parameter of the evaporative liquid after the operation of the evaporative liquid treatment system exceeding a second threshold different than the first threshold.

14. The cooling tower system of claim 1 wherein the controller is configured to compare the parameter of the evaporative liquid before and after operation of the evaporative liquid treatment system; and

wherein the controller is configured to determine the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality based

at least in part upon the comparison of the parameter of the evaporative liquid before and after operation of the evaporative liquid treatment system.

15. The cooling tower system of claim 1 wherein the cooling tower includes a component comprising at least one of a pump, a motor, and a valve;

wherein the controller is configured to detect a failure of the component; and

wherein the controller is configured to determine the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality based at least in part upon the failure of the component.

16. The cooling tower system of claim 1 wherein the sensor includes at least one of:

a temperature sensor;

a conductivity sensor;

a bioactive material sensor;

a biofilm sensor;

a pH level sensor;

a plume sensor;

a drift sensor;

a total dissolved solids sensor;

a chlorine sensor; and

a flow rate sensor;

wherein the parameter of the evaporative liquid includes at least one of:

temperature;

water conductivity;

bioactive material;

biofilm;

pH level;

plume;

drift;

total dissolved solids;

chlorine concentration; and

flow rate.

17. The cooling tower system of claim 1 further comprising at least one operating parameter sensor configured to detect an operating parameter including at least one of:

ambient temperature;

sump fluid level;

spray pump operation;

sump sweeper pump operation;

side stream UV pump operation;

UV lamp intensity on make-up; and

wherein the determination of inadequate evaporative liquid quality is based at least in part on the evaporative liquid parameter and the operating parameter.

18. The cooling tower system of claim 1 wherein the evaporative liquid treatment system comprises a microbiological control system.

19. The cooling tower system of claim 1 wherein the evaporative liquid treatment system comprises an ultraviolet light system.

20. The cooling tower system of claim 1 wherein the controller includes communication circuitry, the controller configured to cause the communication circuitry to communicate a notification to a remote computing device upon the determination that the operation of the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

21. The cooling tower system of claim 20 wherein the controller remains in the failsafe operating mode until the controller receives a response to the notification.

22. The cooling tower system of claim 1 wherein the evaporative heat exchanger includes a working fluid inlet and a working fluid outlet; and

wherein the cooling tower comprises:

a fan configured to generate airflow relative to the evaporative heat exchanger;

an evaporative liquid distribution system configured to distribute the evaporative liquid onto the evaporative heat exchanger; and

a sump to collect evaporative liquid from the evaporative liquid heat exchanger.

23. The cooling tower system of claim 1 wherein the cooling tower is an open circuit direct evaporative cooling tower; and

wherein the evaporative heat exchanger includes fill.

24. The cooling tower system of claim 1 wherein the cooling tower includes a fan and the sensor includes a drift sensor;

wherein the parameter includes a drift parameter;

and

wherein the controller, in the failsafe operating mode, changes operation of the cooling tower including at least one of:

decreasing a maximum allowable speed of the fan; and

turning off the fan.

25. The cooling tower system of claim 1 wherein the cooling tower includes a plume abatement system and the sensor includes a plume sensor;

wherein the parameter includes a drift parameter; and

wherein the controller, in the failsafe operating mode, changes operation of the cooling tower including at least one of:

turning off the cooling tower; and

operating the plume abatement system.

26. The cooling tower system of claim 1 wherein the controller, in the failsafe operating mode, operates the cooling tower at a preset minimum cooling capacity.

27. A cooling tower comprising:

an evaporative heat exchanger configured to receive a process fluid;

a fan assembly operable to cause airflow relative to the evaporative heat exchanger;

an evaporative liquid distribution system including at least one outlet to distribute evaporative liquid onto the evaporative heat exchanger and a sump to collect evaporative liquid from the evaporative heat exchanger;

an evaporative liquid treatment system of the evaporative liquid distribution system;

an evaporative liquid sensor of the evaporative liquid distribution system configured to detect an evaporative liquid parameter;

a controller operably coupled to the fan assembly and the evaporative liquid distribution system, the controller configured to:

operate the evaporative liquid treatment system upon a determination of inadequate evaporative liquid quality based at least in part on the evaporative liquid parameter; and

change operation of the evaporative liquid distribution system to facilitate safe operation of the cooling tower upon a determination that the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

28. The cooling tower of claim 27 wherein the controller is configured to operate the cooling tower in a wet mode wherein the controller causes the evaporative liquid distribution system to distribute the evaporative liquid onto the evaporative heat exchanger and a dry mode wherein the controller limits the evaporative liquid distribution from distributing the evaporative liquid onto the evaporative heat exchanger; and

wherein the controller is configured to change the operation of the evaporative liquid distribution system including refraining from operating the cooling tower in the wet mode upon the determination that evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

29. The cooling tower of claim 27 wherein the controller is configured to operate the cooling tower in a dry mode, a wet mode, and an adiabatic mode; and

wherein the controller is configured to change the operation of the evaporative liquid distribution system including the controller refraining from operating the cooling tower in the wet mode and the adiabatic mode upon the determination that evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality.

30. The cooling tower of claim 27 wherein the evaporative liquid treatment system is operable to purge the evaporative liquid and provide new evaporative liquid; and

wherein the controller is configured to operate the evaporative liquid treatment system including purging the evaporative liquid and providing the new evaporative liquid upon the determination of inadequate evaporative liquid quality.

31. The cooling tower of claim 27 wherein the controller is configured to cause the evaporative liquid treatment system to periodically purge the evaporative liquid and provide new evaporative liquid; and

wherein the controller is configured to change operation of the evaporative liquid distribution system including increasing the frequency of the evaporative liquid distribution system purging the evaporative liquid and providing new evaporative liquid.

32. The cooling tower of claim 27 the controller is configured to operate the evaporative liquid treatment system including at least one of: opening a makeup liquid supply valve, opening a bleed off valve, running a purge and flush cycle, and adding a treatment chemical to the evaporative liquid; and

wherein the controller is configured to change operation of the evaporative liquid distribution system including at least one of turning off a spray pump, adjusting operation of the fan assembly, running a purge and flush cycle, and adding a treatment chemical to the evaporative liquid.

33. The cooling tower of claim 27 wherein the sensor includes at least one of a conductivity sensor, a biofilm sensor, and a pH sensor;

wherein the parameter includes at least one of a conductivity parameter, a biofilm parameter, and a pH parameter; and

wherein the controller is configured to bypass consideration of the at least one of the conductivity parameter, biofilm parameter, and pH parameter after the controller changes operation of the evaporative liquid distribution system.

34. The cooling tower of claim 27 wherein the determination that the evaporative liquid treatment system is unable to address the inadequate evaporative liquid quality is based at least in part upon the controller operating the evaporative liquid treatment system a predetermined number of times within a predetermined time period.

35. The cooling tower of claim 27 wherein the determination that the evaporative liquid treatment system is unable to address the inadequate evaporative liquid quality is based at least in part on the parameter of the evaporative liquid being beyond a threshold for longer than a predetermined period of time.

36. The cooling tower of claim 27 wherein the sensor is operable to detect the evaporative liquid parameter after the controller operates the evaporative liquid treatment system; and

wherein the determination that the evaporative liquid treatment system is unable to address the inadequate evaporative liquid quality is based at least in part on the evaporative liquid parameter after the controller operates the evaporative liquid treatment system.

37. The cooling tower of claim 27 wherein the controller is configured to detect a failure of at least one component of the evaporative liquid distribution system; and

wherein the determination that the evaporative liquid distribution system is unable to address the inadequate liquid quality is based at least in part upon the failure of the at least one component of the evaporative liquid distribution system.

38. The cooling tower of claim 27 wherein the evaporative liquid distribution system includes a spray pump; and

wherein the controller is configured to change operation of the evaporative liquid distribution system including keeping the spray pump turned off.

39. The cooling tower of claim 27 wherein the controller includes communication circuitry;

wherein the controller is configured to cause the communication circuitry to communicate a notification to a remote computing device upon the determination that

the evaporative liquid treatment system is unable to remedy the inadequate evaporative liquid quality; and

wherein the controller maintains the change to the evaporative liquid distribution system until the controller receives a response to the notification.

40. The cooling tower of claim 27 wherein the evaporative liquid treatment system: comprises:

a circulation circuit;

a pump operable to direct evaporative liquid about the circulation circuit; and

an ultraviolet light treatment system configured to treat evaporative liquid of the circulation system.

41. The cooling tower of claim 27 wherein the evaporative liquid treatment system comprises:

a makeup liquid supply; and

an ultraviolet light treatment system configured to treat makeup liquid provided by the makeup liquid supply.

42. The cooling tower of claim 27 wherein the evaporative liquid treatment system comprises a chemical treatment system configured to add a chemical treatment to the evaporative liquid.

43. The cooling tower of claim 27 wherein the parameter of the evaporative liquid includes at least one of:

temperature;

conductivity;

bioactive material;

biofilm;

pH level;

plume; and

drift.

44. The cooling tower of claim 27 further comprising at least one operating parameter sensor configured to detect an operating parameter including at least one of:

ambient temperature;

sump fluid level;

spray pump operation;

sump sweeper pump;

side stream UV pump operation;

UV lamp intensity on make-up; and

wherein the determination of inadequate evaporative liquid quality is based at least in part on the evaporative liquid parameter and the operating parameter.

45. The cooling tower of claim 27 further comprising a collector to collect at least a portion of the evaporative liquid from the evaporative heat exchanger and direct the evaporative liquid toward the sump; and

wherein the fan assembly is below the collector.

46. The cooling tower of claim 27 further comprising an outer structure;

wherein the indirect heat exchanger is in the outer structure;

wherein the outer structure has a footprint; and

wherein the sump is smaller than half the footprint of the outer structure.