operating in series or parallel with one another to meet a cooling load of a building having one or more chillers. Where multiple cooling towers are used, the cooling towers may configured to switch between different modes of operation, such as dry, wet, and adiabatic modes. Some cooling systems may include ice thermal storage systems or chilled water storage systems to charge or store cooling capacity when the cooling demand and/or energy rates are low and utilize the stored cooling capacity when the cooling demand and/or energy rates are high.

[0005] One issue with some of these prior cooling systems is that they operate their cooling towers according to fixed rules or programming so that when certain conditions are present, the cooling tower operates in a certain mode and/or the fan of the cooling tower is operated at a certain speed. Since these cooling systems operate according to fixed rules, they often are not operating efficiently and consume more energy and/or more water than is necessary.

[0006] Some cooling systems are known that utilize artificial intelligence to control the operation of the cooling system. However, these prior systems often overlook how components of the cooling system interact to affect the overall operation of the cooling system. Additionally, some of these cooling systems are configured to optimize energy consumption, but do not account for the consumption of water and chemicals that are used by the cooling tower of the system. Since these systems do not account for all inputs utilized by the cooling system, these systems may not be able to accurately optimize the cost of operating the cooling system.

SUMMARY OF INVENTION

[0006a] According to a first aspect of the present invention, there is provided a heat exchanger system comprising:

a cooling system comprising:

a heat generating apparatus configured to transfer heat to a process fluid;

a heat rejection apparatus configured to remove heat from the process fluid;

a sensor configured to detect a variable of the cooling system; and

processor circuitry operably coupled to the sensor and configured to provide the variable and a plurality of potential operating parameters of the cooling system to a machine

learning model representative of the cooling system to estimate at least one of energy consumption, water usage, and chemical usage of the cooling system for the potential operating parameters;

the processor circuitry configured to determine, based at least in part on the estimated at least one of energy consumption, water usage, and chemical consumption for the potential operating parameters, an optimal operating parameter of the cooling system to satisfy a target optimization criterion; and

the processor circuitry configured to cause the cooling system to utilize the optimal operating parameter.

[0006b] According to a second aspect of the present invention, there is provided a heat rejection apparatus for a cooling system, the heat rejection apparatus comprising:

a cooling tower comprising an evaporative heat exchanger operable to cool process fluid;

a sensor configured to detect a variable of the cooling tower;

a controller operably coupled to the cooling tower and the sensor, the controller configured to implement an optimal operating parameter for the cooling tower to satisfy a target optimization criterion;

the optimal operating parameter being determined at least in part by providing the variable and a plurality of potential operating parameters of the cooling tower to a machine learning model representative of the cooling tower to estimate power consumption and water usage for the potential operating parameters.

[0006c] According to a third aspect of the present invention, there is provided a method for operating a cooling system, the method comprising:

at a processor associated with a cooling system:

receiving a variable of the cooling system detected by a sensor of the cooling system;

providing the variable and a plurality of potential operating parameters of the cooling system to the machine learning model representative of the cooling system to estimate at least one of energy consumption, water usage, and chemical usage of the cooling system for the potential operating parameters;

determining, based at least in part on the estimated at least one of energy consumption, water usage, and chemical usage for the potential operating parameters, an optimal operating parameter of the cooling system to satisfy a target optimization criterion; and

effecting utilization of the optimal operating parameter by the cooling system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1A is a schematic view of a cooling system including a cooling subsystem having a cooling tower, pump, and a chiller, FIG. 1A further showing a cooling subsystem controller in communication with a master controller and a server computer;

[0008] FIG. 1B is a schematic view of an alternative cooling tower including an indirect heat exchanger having a series of serpentine tube runs;

[0009] FIG. 2 is a flow diagram of a method that includes determining one or more optimal set points of the cooling subsystem of FIG. 1 and an operating mode of the cooling