CLAIMS:

What we claim is:

1. A method for operating a cooling tower having a fan for cooling liquids used in an industrial process, comprising:

utilizing a direct-drive, variable speed permanent magnet motor to rotate the fan;

utilizing a plurality of variable speed pumps to pump the liquids from the cooling tower to the industrial process and then back to the cooling tower, wherein each variable speed pump comprises a permanent magnet motor and sensor devices for outputting pump status signals;

utilizing a variable process control system that comprises a plurality of programmable motor controllers, each of which providing power signals to a corresponding permanent magnet motor and outputting motor status signals that represent the speed and torque of each permanent magnet motor, the variable process control system further comprising a computer system in electronic communication with the programmable motor controllers and the pump status signals, wherein the computer system comprises a data storage resource for storing data representing operational characteristics of the permanent magnet motors and the programmable motor controllers, a fan speed curve, cooling tower design parameters, environmental stress,

fan aerodynamic properties including fan pitch, fan balance data, and fan vibration signatures;

measuring the flow rate of liquids flowing through the variable speed pumps;

processing the measured flow rate to determine the process demand;

measuring the plenum pressure; and

utilizing the computer system to process the determined process demand, the measured plenum pressure, the fan pitch and the rotational speed and torque of the fan to determine to determine mass airflow produced by the fan.

2. The method according to claim 1 wherein the step of utilizing the computer system to process the determined process demand further comprises determining if the mass airflow produced by the fan is sufficient to meet the determined process demand.

3. The method according to claim 2 further comprising the step of using a programmable motor controller to increase the speed of the permanent magnet motor that drives the fan in order to increase mass airflow if the current mass airflow is not sufficient to meet the determined process demand.

4. The method according to claim 2 wherein cooling tower includes a collection basin for

receiving liquids cooled by the fan and a condenser that is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, and wherein the method further comprising the steps of:

receiving a condenser temperature set-point;

utilizing the computer system to determine a collection basin temperature that is based on the received condenser temperature set-point; and

utilizing the programmable motor controllers to output motor control signals to all permanent magnet motors that will adjust the fan rotational speed and the flow of liquids through the variable speed pumps in order to maintain the actual collection basin temperature at a temperature that is substantially the same as the determined collection basin temperature.

5. The method according to claim 4 further comprising the step of continuously measuring the actual collection basin temperature.

6. The method according to claim 5 further comprising the step of utilizing the computer system to process the measured actual collection basin temperature.

7. The method according to claim 4 wherein the step of utilizing the computer system to determine a collection basin temperature comprises the step of calculating the collection basin

temperature.

8. The method according to claim 4 wherein the data storage device has stored therein historical process demand data and historical environmental stress data, the method further comprising the steps of:

utilizing the computer system to process the current process demand data and environmental stress data and the historical process demand data and environmental stress data with a Runge-Kutter algorithm to generate a fan speed curve that defines fan speed over a predetermined amount of time wherein variations in fan speed occur in relatively small increments over the predetermined amount of time; and

utilizing the programmable motor controllers to control the speed of the direct-drive variable speed permanent magnet motor in accordance with the generated fan speed curve.

9. The method according to claim 8 further comprising the step of utilizing the programmable motor controllers to control the speed of the permanent magnet motors of the variable speed pumps in accordance with the rotation speeds defined by the generated fan speed curve.

10. The method according to claim 8 wherein the predetermined amount of time is twenty four hours.

11. The method according to claim 8 wherein the fan speed curve is substantially similar to a sinewave.

12. The method according to claim 1 wherein the direct-drive, variable speed motor, permanent magnet motor comprises a housing having an interior, a stator and rotor within the interior and bearings within the interior, the method further comprising the steps of:

measuring the temperature of the motor housing;

determining if the measured temperature of the motor housing exceeds a motor housing temperature threshold; and

utilizing the computer system to generate an alert signal if the measured motor housing temperature exceeds the motor housing temperature threshold.

13. The method according to claim 12 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

14. The method according to claim 12 further comprising the steps of:

measuring the temperatures of the interior and the stator;

determining if the measured temperature of the stator exceeds a predetermined stator

temperature threshold;

determining if the measured temperature of the interior exceeds a predetermined interior temperature threshold;

utilizing the computer system to generate an alert signal if the measured interior temperature exceeds the interior threshold temperature or if the measure stator temperature exceeds the stator threshold temperature.

15. The method according to claim 14 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

16. The method according to claim 12 further comprising the steps of:

measuring the temperatures of the bearings;

determining if the measured temperature of the bearings exceeds a predetermined bearing temperature threshold;

utilizing the computer system to generate an alert signal if the measured bearing temperature exceeds the bearing threshold temperature.

17. The method according to claim 16 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

18. The method according to claim 12 further comprising the steps of:

measuring vibrations at the motor;

utilizing the computer system to process the measured vibrations and determine if the measured vibrations match any of the stored reference vibration signatures; and

generating an alert signal if the measured vibrations match any of the stored reference vibration signatures.

19. The method according to claim 18 wherein the step of utilizing the computer system to process the measured vibrations further comprises the step of processing the measured vibrations with a Fast Fourier Transform.

20. The method according to claim 18 wherein the step of measuring the vibrations at the motor comprise the step of measuring the vibrations at the motor housing.

21. The method according to claim 18 wherein the step of measuring the vibrations at the motor comprise the step of measuring the vibrations at the bearings.

22. The method according to claim 18 wherein the stored reference vibration signatures include predetermined vibration signatures that correspond to impending failure of the fan or the direct-drive, variable speed, permanent magnet motor, and wherein the method further comprises the steps of:

utilizing the computer system to determine if the measured vibrations match any of the predetermined vibration signatures; and

generating an alert signal if the measured vibrations match any of the predetermined vibration signatures.

23. The method according to claim 22 further comprising the step of generating a motor control signal to a programmable motor controller to cease providing power signals to the direct-drive variable speed, permanent magnet motor so as to allow the direct-drive variable speed, permanent magnet motor to coast to 0.0 RPM if it is determined that the measured vibrations match any of the predetermined vibration signatures.

24. The method according to claim 23 further comprising the step of holding the motor at 0.0 RPM.

25. The method according to claim 22 further comprising the step of generating a motor control signal to a programmable motor controller to ramp down the speed of the direct-drive variable speed, permanent magnet motor to 0.0 RPM in accordance with a predetermined

negative ramp rate.

26. The method according to claim 25 further comprising the step of holding the motor at 0.0 RPM.

27. The method according to claim 22 further comprising the steps:

determining if the measured vibration results from a resonant motor speed of the direct-drive variable speed permanent magnet motor if it has previously been determined that the measured vibration does not match any of the stored reference vibrations; and

programming the programmable motor controller which powers the direct-drive, variable speed permanent magnet motor to skip over the motor speed that is the same as the resonant speed.

28. The method according to claim 25 further comprising the step of storing in the data storage device the measured vibration that corresponds to the resonant motor speed.

29. A method for operating a fan in a cooling tower wherein the fan cools liquids used in an industrial process, the method comprising the steps of:

utilizing a direct-drive variable speed motor, permanent magnet motor to rotate the fan at a rotational speed;

utilizing a variable process control system comprising a programmable motor controller for providing power signals to the variable speed motor, permanent magnet motor, programmable motor controller having a data storage resource for storing a predetermined motor deceleration operation curve that decelerates the motor in accordance with a predetermined negative ramp rate; and

providing power signals to the direct-drive variable speed motor, permanent magnet motor that correspond to the predetermined motor deceleration operation curve to decrease the motor speed to 0.0 RPM.

30. The method according to claim 29 further comprising the step of holding the motor at 0.0 RPM:

31. The method according to claim 30 further comprising the step locking the motor shaft to prevent rotation thereof.

32. The method according to claim 29 wherein the cooling tower includes a collection basin for receiving liquids cooled by the fan and a condenser that is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, and wherein each programmable motor controller has a data storage resource for storing the predetermined motor deceleration operation curve having a predetermined negative ramp rate, and wherein the method further comprises the steps of:

utilizing a plurality of variable speed pumps to (i) pump the liquids from the collection basin to the condenser, (ii) pump liquids from the condenser to the industrial process, (iii) pump liquids from the industrial process back to the condenser, and (iv) pump liquids from the condenser to the cooling tower, each variable speed pump comprising a permanent magnet motor; and

providing power signals, in accordance with the predetermined motor deceleration operation curve, to the permanent magnet motors of the variable speed pumps so as to decrease the speed of the permanent magnet motors of the pumps to 0.0 RPM.

34. A method for de-icing a cooling tower having a fan that cools liquids in an industrial process, the method comprising the steps of:

utilizing a direct-drive variable speed permanent magnet motor to rotate the fan at a rotational speed;

utilizing a variable process control system that comprises a programmable motor controller for providing power signals to the direct-drive variable speed permanent magnet motor to effect either forward or reverse operation of the motor, the variable process control system further comprising a computer system in communication with the programmable motor controller, the computer system having a data storage resource for storing (i) cooling tower design parameters, and (ii) historical environmental

stress data corresponding to the geographical location of the cooling tower;

providing current environmental stress data to the computer system;

processing the current environmental stress data, the cooling tower design parameters and the historical environmental stress data to determining if a de-icing should be implemented; and

providing power signals to the direct-drive variable speed permanent magnet motor to effect reverse operation of the permanent magnet motor so as to effect reverse operation of the fan if the processing of the current environmental stress data, the cooling tower design parameters and the historical environmental stress data to determine that de-icing is to be implemented.

35. The method according to claim 34 further comprising the step of maintaining reverse rotation of the permanent magnet motor for a predetermined amount of time.

36. A method for operating a fan in a cooling tower comprising the steps of:

utilizing a direct-drive variable speed motor, permanent magnet motor to rotate the fan;

utilizing a variable process control system comprising a computer system and a programmable motor controller in electronic signal communication with the computer

system, wherein the programmable motor controller provides power signals to the variable speed motor, permanent magnet motor that accelerate or decelerate the rotational speed of the permanent magnet motor and wherein the programmable motor controller outputs signals for input to the computer system which represent the speed of the permanent magnet motor; and

utilizing the programmable motor controller to detect the rotational speed of the permanent magnet motor and whether the permanent magnet motor is operating in a forward or reverse direction.

37. The method according to claim 36 further comprising the steps of accelerating the motor rotational speed to a desired motor speed in within a first time duration if the detected motor rotational speed was 0.0 RPM.

38. The method according to claim 36 wherein if it is detected than the motor is rotating in reverse, then the method further comprises the steps of:

using a first rate of acceleration to cause deceleration of the motor rotational speed to 0.0 RPM; and

accelerating the motor rotational speed to a first determined rotational speed in a second time duration that is less than the first time duration.

39. The method according to claim 36 wherein if it is detected than the motor is rotating in the forward direction, then the method further comprises the step of using the first rate of acceleration to accelerate the motor rotational speed to the first determined rotational speed in a time duration that is less than the first time duration.

40. The method according to claim 39 wherein if it is detected that the motor rotational speed is greater than the first predetermined rotational speed, then method further comprises the step of using a first rate of deceleration to decelerate the motor rotational speed to the first predetermined rotational speed.

41. A variable process control system for a cooling tower having a fan that cools liquid used in an industrial process, the variable process control system comprising:

a variable speed permanent magnet motor having a rotatable shaft connected to the fan to rotate the fan;

a plurality of variable speed pumps to pump the liquids from the cooling tower to the industrial process and then back to the cooling tower, wherein each variable speed pump comprises a permanent magnet motor and sensor devices for providing pump status signals;

a plurality of programmable motor controllers, each of which providing power signals to a corresponding permanent magnet motor and outputting motor status signals that

represent the speed and torque of each permanent magnet motor;

sensor devices for measuring the flow rate of liquids flowing through the variable speed pumps and measuring plenum pressure;

a computer system in electronic communication with the programmable motor controllers and the pump status signals, the computer system includes a data storage resource for storing reference data representing operational characteristics of the permanent magnet motors and the programmable motor controllers, at least one fan speed curve, cooling tower design parameters, environmental stress, fan aerodynamic properties including fan pitch, fan balance data, and fan vibration signatures, wherein the computer system is programmed to process the measured flow rate to determine the process demand and then process determined process demand, the measured plenum pressure, the fan pitch and the rotational speed and torque of the fan to determine to determine mass airflow produced by the fan.

42. The variable process control system according to claim 1 wherein the computer system comprises:

a data acquisition and signal processing device; and

an industrial computer in communication with the data acquisition and signal processing device.

43. The variable process control system according to claim 41 wherein the computer system is programmed to determine if the mass airflow produced by the fan is sufficient to meet the determined process demand.

44. The variable process control system according to claim 42 wherein the computer system is programmed to automatically issue control signals to the programmable motor controller corresponding to the permanent magnet motor that drives the fan to increase the rotational speed of the fan if the current mass airflow is not sufficient to meet the determined process demand.

45. The variable process control system according to claim 41 wherein cooling tower includes a collection basin for receiving liquids cooled by the fan and wherein a condenser is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, the variable process control system further comprising:

means for providing a condenser temperature set-point to the computer system; and

wherein the computer system is further programmed to calculate a collection basin temperature that is based on the provided condenser temperature set-point and generate motor control signals for input to the programmable motor controllers to adjust the speed of the permanent magnet motors so as to adjust the fan rotational speed and the flow of liquids through the variable speed pumps in order to maintain

the actual collection basin temperature at a temperature that is substantially the same as the determined collection basin temperature.

46. The variable process control system according to claim 45 further comprising at least one temperature sensor in communication with the computer system for continuously measuring the actual collection basin temperature.

47. The variable process control system according to claim 46 wherein the computer system is further programmed to process the measured actual collection basin temperature.

48. The variable process control system according to claim 46 wherein computer system is programmed to calculate the collection basin temperature.

49. The variable process control system according to claim 41 wherein the data storage resource has stored therein historical process demand data and historical environmental stress data, the computer system being further programmed to:

process the current process demand data and environmental stress data and the historical process demand data and environmental stress data with a Runge-Kutter algorithm to generate a fan speed curve that defines fan speed over a predetermined amount of time wherein variations in fan speed occur in relatively small increments over the predetermined amount of time; and

generate control signals for the programmable motor controllers to control the speed of the direct-drive variable speed permanent magnet motor in accordance with the generated fan speed curve.

50. The variable process control system according to claim 49 wherein the computer system is further programmed to generate control signals to the programmable motor controllers to control the rotational speed of the permanent magnet motors of the variable speed pumps in accordance with the rotational speeds defined by the generated fan speed curve.

51. The variable process control system according to claim 41 wherein the direct-drive, variable speed motor, permanent magnet motor comprises a housing having an interior, a stator and rotor within the interior and bearings within the interior.

52. The variable process control system according to claim 51 further comprising at least one sensor for measuring the temperature of the motor housing, and wherein the computer system is programmed to determine if the measured temperature of the motor housing exceeds a motor housing temperature threshold, and generate an alert signal if the measured motor housing temperature exceeds the motor housing temperature threshold.

53. The variable process control system according to claim 52 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

54. The variable process control system according to claim 51 further comprising at least one sensor device for measuring the temperatures of the interior and the stator, and wherein the computer system is programmed to determine if the measured temperature of the stator exceeds a predetermined stator temperature threshold, determine if the measured temperature of the interior exceeds a predetermined interior temperature threshold and generate an alert signal if the measured interior temperature exceeds the interior threshold temperature or if the measure stator temperature exceeds the stator threshold temperature.

55. The variable process control system according to claim 54 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

56. The variable process control system according to claim 55 further comprising sensors for measuring the temperatures of the bearings, and wherein the computer system is programmed to determine if the measured temperature of the bearings exceeds a predetermined bearing temperature threshold, and generate an alert signal if the measured bearing temperature exceeds the bearing threshold temperature.

57. The variable process control system according to claim 56 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

58. The variable process control system according to claim 51 further comprising sensors for measuring vibrations at the motor, and wherein the computer system is programmed to process the measured vibrations and determine if the measured vibrations match any of the stored reference vibration signatures, and generate an alert signal if the measured vibrations match any of the stored reference vibration signatures.

59. The variable process control system according to claim 58 wherein the computer system is programmed to process the measured vibrations further comprises the step of processing the measured vibrations with a Fast Fourier Transform.

60. The variable process control system according to claim 58 wherein the sensors measure the vibrations at the motor housing.

61. The variable process control system according to claim 58 wherein the sensors measure vibrations at the bearings.

62. The variable process control system according to claim 58 wherein the stored reference vibration signatures include predetermined vibration signatures that correspond to impending failure of the fan or the direct-drive, variable speed, permanent magnet motor, and wherein the computer system is programmed to determine if the measured vibrations match any of the predetermined vibration signatures, and generate an alert signal if the measured vibrations match any of the predetermined vibration signatures.

63. A high torque, low speed permanent magnet motor, comprising:

a motor housing;

a stator within the housing;

a rotor within the housing;

a shaft connected to the rotor which rotates with the rotor; and

a bearing system comprising a pair of radial bearings that locate and support the shaft relative to the motor housing, the pair of radial bearings comprising a cylindrical roller bearing and a tapered roller output bearing.

64. The high torque, low speed permanent magnet motor according to claim 63 wherein the bearing system further comprises a spherical thrust bearing which provides only axial locating forces.

65. The high torque, low speed permanent magnet motor according to claim 63 wherein the shaft penetrates and extends from the motor housing, the high torque, low speed permanent magnet motor further comprising a sealing system to seal the area where the shaft penetrates the motor housing, the sealing system comprising:

a double radial lip seal; and

an Inpro™ seal mounted immediately outboard of the double radial lip seal.

66. The high torque, low speed permanent magnet motor according to claim 63 wherein the

motor housing has no more than four longitudinally extending channels in the peripheral portion of the motor housing for receiving mounting bolts.

67. The high torque, low speed permanent magnet motor according to claim 63 further comprising a quick-disconnect connector connected to the exterior of the motor housing, the quick-disconnect connector having signal connection section located within the interior of the motor housing.

68. The high torque, low speed permanent magnet motor according to claim 67 further comprising a plurality of temperature and vibration sensors wired to the signal connection section of the quick-disconnect connector.

embodiments, the fan lock mechanism can be activated by a motor (e.g. screw activated) or a pull-type locking solenoid. FIG. 22 shows the fan lock mechanism mounted on top of the motor 20 so it can engage the upper portion of motor shaft 24. FIG. 23 shows the fan lock mechanism mounted at the bottom of motor 20 so the fan lock mechanism can engage the lower, non-drive end 25 of motor shaft 24. This caliper-type fan-lock mechanism comprises housing or cover 1400 and a caliper assembly, indicated by reference numbers 1402 and 1404. This caliper-type fan-lock mechanism includes disc 1406, flexible shaft cover 1410 and shaft or threaded rod 1408 that is disposed within the flexible shaft cover 1410.

Referring to FIG. 25, there is shown a band-type fan-lock mechanism which can be used with motor 20. This band-type fan lock mechanism comprises housing or cover 1600, flexible shaft cover 1602 and a shaft or threaded rod 1604 that is disposed within the flexible shaft cover 1604. The band-type fan lock mechanism further includes fixed lock bands 1606 and 1610 and lock drum 1608. In an alternate embodiment, a cable is used in place of the shaft or threaded rod 1604. In alternate embodiments, the band-type fan lock mechanism can be activated by a motor (e.g. screw activated) or a pull-type locking solenoid. FIG. 25 shows the fan lock mechanism mounted on top of the motor 20 so it can engage the upper portion of motor shaft 24. FIG. 24 shows the fan lock mechanism mounted at the bottom of motor 20 so the fan lock mechanism can engage the lower, non-drive end 25 of motor shaft 24.

In another embodiment, the fan lock is configured as the fan lock described in U.S. Patent Application Publication No. 2006/0292004, the disclosure of which published application is hereby incorporated by reference.

De-Ice Mode

The variable process control system and motor 20 are also configured to implement a "De-Ice Mode" of operation wherein the fan is operated in reverse. Icing of the fans in a cooling tower may occur depending upon thermal demand (i.e. water from the industrial process and the

CLAIMS

1. A method for operating a cooling tower having a fan for cooling liquids used in an industrial process, comprising:

utilizing a direct-drive, variable speed, permanent magnet motor to rotate the fan;

utilizing a plurality of variable speed pumps to pump the liquids from the cooling tower to the industrial process and then back to the cooling tower, wherein each variable speed pump comprises a permanent magnet motor and sensor devices for outputting pump status signals;

utilizing a variable process control system that comprises a plurality of programmable motor controllers, each of which providing power signals to a corresponding permanent magnet motor and outputting motor status signals that represent the speed and torque of each permanent magnet motor, the variable process control system further comprising a computer system in electronic communication with the programmable motor controllers and the sensor devices, wherein the computer system comprises a data storage resource for storing data representing operational characteristics of the permanent magnet motors and the programmable motor controllers, a fan speed curve, cooling tower design parameters, environmental stress, fan aerodynamic properties including fan pitch, fan balance data, and fan vibration signatures;

measuring the flow rate of liquids flowing through the variable speed pumps;

processing the measured flow rate to determine the process demand;

measuring the plenum pressure; and

utilizing the computer system to process the determined process demand, the measured plenum pressure, the fan pitch and the rotational speed and torque of the fan to determine mass airflow produced by the fan.

2. The method according to claim 1 wherein the step of utilizing the computer system to process the determined process demand further comprises determining if the mass airflow produced by the fan is sufficient to meet the determined process demand.

3. The method according to claim 2 further comprising the step of using a programmable motor controller to increase the speed of the permanent magnet motor that drives the fan in order to increase mass airflow if the current mass airflow is not sufficient to meet the determined process demand.

4. The method according to claim 2 wherein cooling tower includes a collection basin for receiving liquids cooled by the fan and a condenser that is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, and wherein the method further comprises the steps of:

receiving a condenser temperature set-point;

utilizing the computer system to determine a collection basin temperature that is based on the received condenser temperature set-point; and

utilizing the programmable motor controllers to output motor control signals to all permanent magnet motors that will adjust the fan rotational speed and the flow of liquids through the variable speed pumps in order to maintain the actual collection basin temperature at a temperature that is substantially the same as the determined collection basin temperature.

5. The method according to claim 4 further comprising the step of continuously measuring the actual collection basin temperature.

6. The method according to claim 5 further comprising the step of utilizing the computer system to process the measured actual collection basin temperature.

7. The method according to claim 4 wherein the step of utilizing the computer system to determine a collection basin temperature comprises the step of calculating the collection basin temperature.

8. The method according to claim 4 wherein the data storage device has stored therein historical process demand data and historical environmental stress data, the method further comprising the steps of:

utilizing the computer system to process the current process demand data and environmental stress data and the historical process demand data and environmental stress data with a Runge-Kutter algorithm to generate a fan speed curve that defines fan speed over a predetermined amount of time wherein variations in fan speed occur in relatively small increments over the predetermined amount of time; and

utilizing the programmable motor controllers to control the speed of the direct-drive variable speed permanent magnet motor in accordance with the generated fan speed curve.

9. The method according to claim 8 further comprising the step of utilizing the programmable motor controllers to control the speed of the permanent magnet motors of the variable speed pumps in accordance with the rotation speeds defined by the generated fan speed curve.

10. The method according to claim 8 wherein the predetermined amount of time is twenty four hours.

11. The method according to claim 8 wherein the fan speed curve is substantially similar to a sinewave.

12. The method according to claim 1 wherein the direct-drive, variable speed, permanent magnet motor comprises a housing having an interior, a stator and rotor within the interior and

bearings within the interior, the method further comprising the steps of:

measuring the temperature of the motor housing;

determining if the measured temperature of the motor housing exceeds a motor housing temperature threshold; and

utilizing the computer system to generate an alert signal if the measured motor housing temperature exceeds the motor housing temperature threshold.

13. The method according to claim 12 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

14. The method according to claim 12 further comprising the steps of:

measuring the temperatures of the interior and the stator;

determining if the measured temperature of the stator exceeds a predetermined stator temperature threshold;

determining if the measured temperature of the interior exceeds a predetermined interior temperature threshold;

utilizing the computer system to generate an alert signal if the measured interior temperature exceeds the interior threshold temperature or if the measured stator temperature exceeds the stator threshold temperature.

15. The method according to claim 14 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

16. The method according to claim 12 further comprising the steps of:

measuring the temperatures of the bearings;

determining if the measured temperature of the bearings exceeds a predetermined bearing temperature threshold;

utilizing the computer system to generate an alert signal if the measured bearing temperature exceeds the bearing threshold temperature.

17. The method according to claim 16 further comprising the steps of routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

18. The method according to claim 12 further comprising the steps of:

measuring vibrations at the motor;

utilizing the computer system to process the measured vibrations and determine if the measured vibrations match any of the stored reference vibration signatures; and

generating an alert signal if the measured vibrations match any of the stored reference vibration signatures.

19. The method according to claim 18 wherein the step of utilizing the computer system to process the measured vibrations further comprises the step of processing the measured vibrations with a Fast Fourier Transform.

20. The method according to claim 18 wherein the step of measuring vibrations at the motor comprises the step of measuring the vibrations at the motor housing.

21. The method according to claim 18 wherein the step of measuring vibrations at the motor comprises the step of measuring the vibrations at the bearings.

22. The method according to claim 18 wherein the stored reference vibration signatures include predetermined vibration signatures that correspond to impending failure of the fan or the direct-drive, variable speed, permanent magnet motor, and wherein the method further comprises the steps of:

utilizing the computer system to determine if the measured vibrations match any of the

predetermined vibration signatures; and

generating an alert signal if the measured vibrations match any of the predetermined vibration signatures.

23. The method according to claim 22 further comprising the step of generating a motor control signal to a programmable motor controller to cease providing power signals to the direct-drive variable speed, permanent magnet motor so as to allow the direct-drive variable speed, permanent magnet motor to coast to 0.0 RPM if it is determined that the measured vibrations match any of the predetermined vibration signatures.

24. The method according to claim 23 further comprising the step of holding the motor at 0.0 RPM.

25. The method according to claim 22 further comprising the step of generating a motor control signal to a programmable motor controller to ramp down the speed of the direct-drive variable speed, permanent magnet motor to 0.0 RPM in accordance with a predetermined negative ramp rate.

26. The method according to claim 25 further comprising the step of holding the motor at 0.0 RPM.

27. The method according to claim 22 further comprising the steps:

determining if the measured vibration results from a resonant motor speed of the direct-drive variable speed permanent magnet motor if it has previously been determined that the measured vibration does not match any of the stored reference vibrations; and

programming the programmable motor controller which powers the direct-drive, variable speed permanent magnet motor to skip over the motor speed that is the same as the resonant speed.

28. The method according to claim 25 further comprising the step of storing in the data storage device the measured vibration that corresponds to the resonant motor speed.

29. A method for operating a fan in a cooling tower wherein the fan cools liquids used in an industrial process, the method comprising the steps of:

utilizing a direct-drive variable speed motor, permanent magnet motor to rotate the fan at a rotational speed;

utilizing a variable process control system comprising a programmable motor controller for providing power signals to the variable speed, permanent magnet motor, the programmable motor controller having a data storage resource for storing a predetermined motor deceleration operation curve that decelerates the motor in accordance with a predetermined negative ramp rate; and

providing power signals to the direct-drive variable speed motor, permanent magnet motor that correspond to the predetermined motor deceleration operation curve to decrease the motor speed to 0.0 RPM.

30. The method according to claim 29 further comprising the step of holding the motor at 0.0 RPM:

31. The method according to claim 30 further comprising the step locking the motor shaft to prevent rotation thereof.

32. The method according to claim 29 wherein the cooling tower comprises a collection basin for receiving liquids cooled by the fan and a condenser that is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, and wherein each programmable motor controller comprises a data storage resource for storing the predetermined motor deceleration operation curve having a predetermined negative ramp rate, and wherein the method further comprises the steps of:

utilizing a plurality of variable speed pumps to (i) pump the liquids from the collection basin to the condenser, (ii) pump liquids from the condenser to the industrial process, (iii) pump liquids from the industrial process back to the condenser, and (iv) pump liquids from the condenser to the cooling tower, each variable speed pump comprising a permanent magnet motor; and

providing power signals, in accordance with the predetermined motor deceleration operation curve, to the permanent magnet motors of the variable speed pumps so as to decrease the speed of the permanent magnet motors of the pumps to 0.0 RPM.

33. A direct drive system for rotating a fan in a cooling tower that is used to cool fluids used in a process, comprising:

a variable speed, permanent magnet motor comprising a motor casing, a stator, rotor and a rotatable shaft configured to be connected to a fan in a cooling tower, the motor further comprising a bearing system configured to (i) enable the permanent magnet motor to rotate the fan in a forward direction or a reverse direction, (ii) absorb the thrust loads resulting from the weight of the fan and the airflow produced by rotation of the fan, (iii) oppose the radial loads at the thrust end of the rotatable shaft and (iv) oppose the reverse thrust loads resulting from reverse rotation of the fan and yaw loads; and

a motor speed control device to generate electrical signals that control the rotational speed of the permanent magnet motor.

34. A method for de-icing a cooling tower having a fan that cools liquids in an industrial process, the method comprising the steps of:

utilizing a direct-drive variable speed permanent magnet motor to rotate the fan at a rotational speed;

utilizing a variable process control system that comprises a programmable motor controller for providing power signals to the direct-drive variable speed permanent magnet motor to effect either forward or reverse operation of the motor, the variable process control system further comprising a computer system in communication with the programmable motor controller, the computer system comprising a data storage resource for storing (i) cooling tower design parameters, and (ii) historical environmental stress data corresponding to the geographical location of the cooling tower;

providing current environmental stress data to the computer system;

processing the current environmental stress data, the cooling tower design parameters and the historical environmental stress data to determining if de-icing should be implemented; and

providing power signals to the direct-drive variable speed permanent magnet motor to effect reverse operation of the permanent magnet motor so as to effect reverse operation of the fan if the processing of the current environmental stress data, the cooling tower design parameters and the historical environmental stress data to determine that de-icing is to be implemented.

35. The method according to claim 34 further comprising the step of maintaining reverse rotation of the permanent magnet motor for a predetermined amount of time.

36. A method for operating a fan in a cooling tower comprising the steps of:

utilizing a direct-drive variable speed motor, permanent magnet motor to rotate the fan;

utilizing a variable process control system comprising a computer system and a programmable motor controller in electronic signal communication with the computer system, wherein the programmable motor controller provides power signals to the variable speed motor, permanent magnet motor that accelerate or decelerate the rotational speed of the permanent magnet motor and wherein the programmable motor controller outputs signals for input to the computer system which represent the speed of the permanent magnet motor; and

utilizing the programmable motor controller to detect the rotational speed of the permanent magnet motor and whether the permanent magnet motor is operating in a forward or reverse direction.

37. The method according to claim 36 further comprising the steps of accelerating the motor rotational speed to a desired motor speed within a first time duration if the detected motor rotational speed was 0.0 RPM.

38. The method according to claim 36 wherein if it is detected that the motor is rotating in reverse, then the method further comprises the steps of:

using a first rate of acceleration to cause deceleration of the motor rotational speed to 0.0 RPM; and

accelerating the motor rotational speed to a first determined rotational speed in a second time duration that is less than the first time duration.

39. The method according to claim 36 wherein if it is detected than the motor is rotating in the forward direction, then the method further comprises the step of using the first rate of acceleration to accelerate the motor rotational speed to the first determined rotational speed in a time duration that is less than the first time duration.

40. The method according to claim 39 wherein if it is detected that the motor rotational speed is greater than the first predetermined rotational speed, then method further comprises the step of using a first rate of deceleration to decelerate the motor rotational speed to the first predetermined rotational speed.

41. A variable process control system for a cooling tower having a fan that cools liquid used in an industrial process, the variable process control system comprising:

a variable speed permanent magnet motor having a rotatable shaft connected to the fan to

rotate the fan;

a plurality of variable speed pumps to pump the liquids from the cooling tower to the industrial process and then back to the cooling tower, wherein each variable speed pump comprises a permanent magnet motor and sensor devices for providing pump status signals;

a plurality of programmable motor controllers, each of which providing power signals to a corresponding permanent magnet motor and outputting motor status signals that represent the speed and torque of each permanent magnet motor;

sensor devices for measuring the flow rate of liquids flowing through the variable speed pumps and measuring plenum pressure;

a computer system in electronic communication with the programmable motor controllers and the pump status signals, the computer system includes a data storage resource for storing reference data representing operational characteristics of the permanent magnet motors and the programmable motor controllers, at least one fan speed curve, cooling tower design parameters, environmental stress, fan aerodynamic properties including fan pitch, fan balance data, and fan vibration signatures, wherein the computer system is programmed to process the measured flow rate to determine the process demand and then process determined process demand, the measured plenum pressure, the fan pitch and the rotational speed and torque of the fan to determine

mass airflow produced by the fan.

42. The variable process control system according to claim 41 wherein the computer system comprises:

a data acquisition and signal processing device; and

an industrial computer in communication with the data acquisition and signal processing device.

43. The variable process control system according to claim 41 wherein the computer system is programmed to determine if the mass airflow produced by the fan is sufficient to meet the determined process demand.

44. The variable process control system according to claim 42 wherein the computer system is programmed to automatically issue control signals to the programmable motor controller corresponding to the permanent magnet motor that drives the fan to increase the rotational speed of the fan if the current mass airflow is not sufficient to meet the determined process demand.

45. The variable process control system according to claim 41 wherein cooling tower includes a collection basin for receiving liquids cooled by the fan and wherein a condenser is in the flow of liquids from the collection basin to the industrial process and in the flow of liquids from the industrial process to the cooling tower, the variable process control system further

comprising:

means for providing a condenser temperature set-point to the computer system; and

wherein the computer system is further programmed to calculate a collection basin temperature that is based on the provided condenser temperature set-point and generate motor control signals for input to the programmable motor controllers to adjust the speed of the permanent magnet motors so as to adjust the fan rotational speed and the flow of liquids through the variable speed pumps in order to maintain the actual collection basin temperature at a temperature that is substantially the same as the determined collection basin temperature.

46. The variable process control system according to claim 45 further comprising at least one temperature sensor in communication with the computer system for continuously measuring the actual collection basin temperature.

47. The variable process control system according to claim 46 wherein the computer system is further programmed to process the measured actual collection basin temperature.

48. The variable process control system according to claim 46 wherein computer system is programmed to calculate the collection basin temperature.

49. The variable process control system according to claim 41 wherein the data storage resource has stored therein historical process demand data and historical environmental stress data, the computer system being further programmed to:

process the current process demand data and environmental stress data and the historical process demand data and environmental stress data with a Runge-Kutter algorithm to generate a fan speed curve that defines fan speed over a predetermined amount of time wherein variations in fan speed occur in relatively small increments over the predetermined amount of time; and

generate control signals for the programmable motor controllers to control the speed of the direct-drive variable speed permanent magnet motor in accordance with the generated fan speed curve.

50. The variable process control system according to claim 49 wherein the computer system is further programmed to generate control signals to the programmable motor controllers to control the rotational speed of the permanent magnet motors of the variable speed pumps in accordance with the rotational speeds defined by the generated fan speed curve.

51. The variable process control system according to claim 41 wherein the direct-drive, variable speed motor, permanent magnet motor comprises a housing having an interior, a stator and rotor within the interior and bearings within the interior.

52. The variable process control system according to claim 51 further comprising at least one sensor for measuring the temperature of the motor housing, and wherein the computer system is programmed to determine if the measured temperature of the motor housing exceeds a motor housing temperature threshold, and generate an alert signal if the measured motor housing temperature exceeds the motor housing temperature threshold.

53. The variable process control system according to claim 52 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

54. The variable process control system according to claim 51 further comprising at least one sensor device for measuring the temperatures of the interior and the stator, and wherein the computer system is programmed to determine if the measured temperature of the stator exceeds a predetermined stator temperature threshold, determine if the measured temperature of the interior exceeds a predetermined interior temperature threshold and generate an alert signal if the measured interior temperature exceeds the interior threshold temperature or if the measure stator temperature exceeds the stator threshold temperature.

55. The variable process control system according to claim 54 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

56. The variable process control system according to claim 55 further comprising sensors for measuring the temperatures of the bearings, and wherein the computer system is programmed to determine if the measured temperature of the bearings exceeds a predetermined bearing temperature threshold, and generate an alert signal if the measured bearing temperature exceeds the bearing threshold temperature.

57. The variable process control system according to claim 56 further comprising means for routing the alert signal to a plant distributed control system in order to alert the operators of the industrial process.

58. The variable process control system according to claim 51 further comprising sensors for measuring vibrations at the motor, and wherein the computer system is programmed to process the measured vibrations and determine if the measured vibrations match any of the stored reference vibration signatures, and generate an alert signal if the measured vibrations match any of the stored reference vibration signatures.

59. The variable process control system according to claim 58 wherein the computer system is programmed to process the measured vibrations further comprises the step of processing the measured vibrations with a Fast Fourier Transform.

60. The variable process control system according to claim 58 wherein the sensors measure the vibrations at the motor housing.

61. The variable process control system according to claim 58 wherein the sensors measure vibrations at the bearings.

62. The variable process control system according to claim 58 wherein the stored reference vibration signatures include predetermined vibration signatures that correspond to impending failure of the fan or the direct-drive, variable speed, permanent magnet motor and wherein the computer system is programmed to determine if the measured vibrations match any of the predetermined vibration signatures, and generate an alert signal if the measured vibrations match any of the predetermined vibration signatures.

63. A variable speed permanent magnet motor, comprising:

a motor housing;

a stator within the housing;

a rotor within the housing;

a shaft connected to the rotor which rotates with the rotor, the shaft penetrating and extending from the motor housing;

a sealing system to seal the area where the shaft penetrates the motor housing and comprises a double radial lip seal and a seal bearing isolator mounted immediately outboard of the double radial lip seal such that the seal bearing isolator is in tandem with the double radial seal ; and

a bearing system comprising bearings that locate and support the shaft relative to the motor housing, the bearings comprising a cylindrical roller bearing and a tapered roller output bearing.

64. The permanent magnet motor according to claim 63 wherein the bearing system further comprises a spherical thrust bearing which provides only axial locating forces.

65. The permanent magnet motor according to claim 63 wherein the motor housing has no more than four longitudinally extending channels in the peripheral portion of the motor housing for receiving mounting bolts.

66. The permanent magnet motor according to claim 63 further comprising a quick-disconnect connector connected to the exterior of the motor housing, the quick-disconnect connector having a signal connection section located within the interior of the motor housing.

67. The permanent magnet motor according to claim 66 further comprising a plurality of temperature and vibration sensors wired to the signal connection section of the quick-disconnect connector.

68. A drive system for rotating a fan in a cooling tower that is used to cool fluids used in a process, the drive system comprising a variable speed permanent magnet motor comprising a motor casing, a stator, a rotor and a rotatable shaft, the rotatable shaft being configured for connection to the fan, the variable speed permanent magnet motor further comprising a bearing system configured to enable the variable speed, permanent magnet motor to rotate the fan in a forward direction or a reverse direction and bear fan loads, and at least one vibration sensor to sense vibrations caused by rotation of the fan and output vibration sensor signals.

69. The drive system according to claim 68 further comprising a signal processor to process the vibration sensor signals to determine the cause of the vibrations.

70. The drive system according to claim 69 further comprising a data storage device to store historic trending data that includes known vibration signatures, the signal processor being configured to compare the vibration sensor signals to the stored known vibration signatures.

71. The drive system according to claim 68 further comprising a motor control device to generate electrical signals that control the rotational speed of the motor.

72. The drive system according to claim 68 wherein the variable speed permanent magnet motor further comprises at least one temperature sensor to sense the temperature of the stator and output temperature sensor signals.

73. The direct drive system according to claim 68 wherein the bearing system comprises a spherical roller thrust bearing to absorb the thrust loads resulting from the weight of the fan and the airflow produced by rotation of the fan.

74. The direct drive system according to claim 68 wherein the bearing system further comprises a cylindrical roller bearing to oppose the radial loads at the thrust end of the rotatable shaft.

75. The direct drive system according to claim 68 wherein the bearing system further comprises a tapered roller output bearing to oppose the reverse thrust loads resulting from reverse rotation of the fan and yaw loads.

76. A cooling tower system comprising:

a cooling tower structure;

a variable speed permanent magnet motor supported by the cooling tower structure, the variable speed permanent magnet motor comprising a motor casing, a stator, a rotor and a rotatable shaft, the permanent magnet motor further comprising a bearing system configured to bear fan loads and enable the permanent magnet motor to rotate the fan in a forward direction or a reverse direction;

a fan connected to the rotatable shaft;

at least one vibration sensor to sense vibrations produced by rotation of the fan and output vibration sensor signals; and

a signal processing system comprising a signal processor and a database having stored therein known vibration signatures, the signal processing system being configured to process the vibration sensor signals with signal processing algorithms and compare the processed vibration sensor signals with stored

known vibration signals in order to determine the cause of the sensed vibrations.

77. The cooling tower system according to claim 76 further comprising at least one temperature sensor to measure heat of the stator and output temperature sensor signals, wherein the signal processing system is configured to process the temperature sensor signals.

78. The cooling tower system according to claim 76 further comprising at least one air-flow sensor to measure air-flow produced by rotation of the fan and output air-flow sensor signals, wherein the signal processing system is configured to process the air-flow sensor signals.

79. The cooling tower system according to claim 76 further comprising a motor speed control device to provide electrical signals that control the rotational speed of the motor.

80. The cooling tower system according to claim 76 wherein the variable speed permanent magnet motor is positioned so that the rotatable shaft is vertically oriented.

81. The cooling tower system according to claim 76 wherein the cooling tower structure comprises:

a fan deck; and

a fan stack positioned on the fan deck, wherein the fan operates within the fan stack.

82. The cooling tower according to claim 76 wherein the cooling tower comprises:

a fan deck; and

a fan cylinder positioned on the fan deck, wherein the fan operates within the fan cylinder.

83. The cooling tower according to claim 76 wherein the cooling tower structure comprises:

fill material supported by the cooling tower structure; and

a basin for collecting cooled fluids.

84. The cooling tower according to claim 76 wherein the cooling tower further comprises a tube bundle supported by the cooling tower structure, wherein the tube bundle comprises a tube network through which fluids flow and a plurality of fins attached to the tube network, wherein the tube bundle is positioned so that air-flow produced by the rotation of the fan flows through the tube bundle.

85. A method of operating a cooling tower having a fan to cool fluids used in a process, comprising:

utilizing a direct-drive, variable speed motor to rotate the fan at a rotational speed, wherein the motor has a rotatable shaft that is connected to the fan;

continuously sensing vibrations produced by rotation of the fan; and

continuously processing the sensed vibrations with at least one signal processing algorithm and comparing the processed sensed vibrations to known vibration

signatures stored in a database to determine the cause of the vibrations.

86. The according to claim 85 further comprising the step of adjusting the rotational speed of the motor if the sensed vibrations substantially match a predetermined vibration signature.

87. A variable speed motor for rotating a fan in a wet-cooling tower or air-cooled heat exchanger, comprising:

a motor casing having an interior;

a stator within the interior;

a rotor within the interior ;

a rotatable shaft connected to the rotor and configured to be connected to the fan;

a bearing system configured to enable the variable speed motor to rotate the fan in a forward direction or a reverse direction and bear the fan loads;

at least one vibration sensor positioned within the interior of the casing;

at least one temperature sensor positioned within the interior of the casing; and

an internal wiring network within the interior of the casing and electrically connected to the at least one vibration sensor and the at least one temperature sensor.

88. The variable speed motor according to claim 87 further comprising a signal connector attached to the casing and electrically connected to the internal wiring network, wherein the signal connector is configured for electrical connection to wires that are external to the motor casing.

89. An industrial air-cooled heat exchanger for cooling fluids used in an industrial process, comprising:

a support structure;

a tube bundle supported by the support structure, the tube bundle being configured to receive fluids to be cooled;

a motor supported by the support structure, the motor comprising a motor casing, a stator and rotor located within the motor casing and a rotatable shaft;

a fan connected to the rotatable shaft of the motor such that rotation of the rotatable shaft causes rotation of the fan which causes an airflow that cools the fluid flowing through the tube bundle;

wherein the motor further comprises a bearing system that is configured to (i) support and locate the rotatable shaft with respect to the motor casing, (ii) enable the motor to rotate the fan in a forward direction or in a reverse direction, and (iii) bear the fan loads; and

wherein the support structure positions the tube bundle, the fan and the motor at a predetermined height above the ground.

90. The industrial air-cooled heat exchanger according to claim 89 further comprising a motor speed control device to control the rotational speed of the motor.

91. The industrial air-cooled heat exchanger according to claim 90 wherein the motor speed control device comprises a variable frequency drive device.

92. The industrial air-cooled heat exchanger according to claim 89 further comprising at least one vibration sensor to sense vibrations produced by rotation of the fan and output vibration sensor signals.

93. The industrial air-cooled heat exchanger according to claim 92 further comprising a signal processor to process the vibration sensor signals to determine the cause of the vibrations.

94. The industrial air-cooled heat exchanger according to claim 93 further comprising a data storage device to store historic trending data that includes known vibration signatures, the signal processor being configured to compare the vibration sensor signals to the stored known vibration signatures.

95. The industrial air-cooled heat exchanger according to claim 89 further comprising at least one temperature sensor to sense the heat of the stator and output temperature sensor signals.

96. The industrial air-cooled heat exchanger according to claim 89 further comprising a fan stack attached to the support structure, wherein the fan operates within the fan stack.

97. The industrial air-cooled heat exchanger according to claim 89 further comprising a fan cylinder attached to the support structure, wherein the fan operates within the fan cylinder.

98. The industrial air-cooled heat exchanger according to claim 89 wherein the bearing system comprises a spherical roller thrust bearing to absorb the thrust loads resulting from the

weight of the fan and the airflow produced by rotation of the fan.

99. The industrial air-cooled heat exchanger according to claim 89 wherein the bearing system further comprises a cylindrical roller bearing to oppose the radial loads at the thrust end of the rotatable shaft.

100. The industrial air-cooled heat exchanger according to claim 89 wherein the bearing system further comprises a tapered roller output bearing to oppose the reverse thrust loads resulting from reverse rotation of the fan and yaw loads.

101. The industrial air-cooled heat exchanger according to claim 89 wherein the motor is oriented such that the rotational shaft of the motor is vertically oriented.

102. An air-cooled heat exchanger for use in a petroleum refinery for cooling fluids used in a petroleum refining process wherein the air-cooled heat exchanger has a tube bundle for receiving the fluids, and a fan that causes an airflow that cools the fluid flowing through the tube bundle, wherein the improvement comprises:

a motor comprising a motor casing, stator, rotor and rotatable shaft connected to the fan, wherein the motor further comprises a bearing system that is configured to (i) support and locate the rotatable shaft with respect to the motor casing, (ii) enable the motor to rotate the fan in a forward direction or in a reverse direction, and (iii) bear the fan loads, the motor further comprising at least one vibration sensor to

sense vibrations produced by rotation of the fan and output vibration sensor signals; and

a motor speed control device to generate electrical signals that control the rotational speed of the motor; and

a signal processor to process the vibration sensor signals with predetermined algorithms and compare the processed vibration sensor signals with reference vibration signatures to determine the cause of the vibrations.

103. The air-cooled heat exchanger according to claim 102 further comprising a data storage device to store at least one reference vibration signature.

104. The air-cooled heat exchanger according to claim 102 wherein the motor comprises a permanent magnet motor.

105. The air-cooled heat exchanger according to claim 102 wherein the motor comprises a temperature sensor to measure the heat of the stator and output temperature sensor signals.

106. A wet-cooling tower for use in a petroleum refinery for cooling fluids used in a petroleum refining process wherein the wet-cooling tower comprises fill material, a collection basin and a fan, wherein the improvement comprises:

a motor comprising a motor casing, stator, rotor and rotatable shaft connected to the fan, wherein the motor further comprises a bearing system that is configured to (i)

support and locate the rotatable shaft with respect to the motor casing, (ii) enable the motor to rotate the fan in a forward direction or in a reverse direction, and (iii) bear the fan loads, the motor further comprising at least one vibration sensor to sense vibrations produced by rotation of the fan and output vibration sensor signals; and

a motor speed control device to generate electrical signals that control the rotational speed of the motor; and

a signal processor to process the vibration sensor signals with predetermined algorithms and compare the processed vibration sensor signals with reference vibration signatures to determine the cause of the vibrations.

107. The wet-cooling tower according to claim 106 further comprising a data storage device to store at least one reference vibration signature.

108. The wet-cooling tower according to claim 106 wherein the motor comprises a permanent magnet motor.

109. The wet-cooling tower according to claim 106 wherein the motor comprises a temperature sensor to measure the heat of the stator and output temperature sensor signals.

110. A heating, ventilation and/or air-conditioning (HVAC) system comprising:

a fan:

a motor comprising a motor casing, stator, rotor and rotatable shaft connected to the fan,

wherein the motor further comprises a bearing system that is configured to (i) support and locate the rotatable shaft with respect to the motor casing, (ii) enable the motor to rotate the fan in a forward direction or in a reverse direction, and (iii) bear the fan loads while the fan is rotating and stationary, the motor further comprising at least one vibration sensor to sense vibrations produced by rotation of the fan and output vibration sensor signals;

a motor speed control device to generate electrical signals that control the rotational speed of the motor; and

a signal processor to process the vibration sensor signals with predetermined algorithms and compare the processed vibration sensor signals with reference vibration signatures to determine the cause of the vibrations.

111. The heating, ventilation and/or air-conditioning (HVAC) system according to claim 110 further comprising a data storage device to store historic trending data that includes at least one reference vibration signatures.

112. The heating, ventilation and/or air-conditioning (HVAC) system according to claim 110 wherein the motor comprises a permanent magnet motor.

113. The heating, ventilation and/or air-conditioning (HVAC) system according to claim 110 wherein the motor includes a temperature sensor to measure the heat of the stator and output temperature sensor signals.