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(54) **WAREWASHER WITH HEAT RECOVERY SYSTEM**
GESCHIRRSPÜLMASCHINE MIT WÄRMERÜCKGEWINNUNGSSYSTEM
LAVE-VAISSELLE DOTÉ D'UN SYSTÈME DE RÉCUPÉRATION DE CHALEUR

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Description

TECHNICAL FIELD

[0001] This application relates generally to warewashers such as those used in commercial applications such as cafeterias and restaurants and, more particularly, to a heat recovery system that adapts to operating conditions of the warewasher. A warewash machine as defined in the preamble fo claim 1 is known from WO 2015/080928 A1.

BACKGROUND

[0002] Commercial warewashers commonly include a housing area which defines washing and rinsing zones for dishes, pots, pans and other wares. Heat recovery systems have been used to recover heat from the machine that would ordinarily be lost to the machine exhaust.

[0003] Waste heat recovery systems such as a heat pump or refrigeration system uses evaporator(s), compressor(s) and condenser(s) such that the operation involves thermal fluids (including refrigerant) for recovering waste energy and re-using captured energy at areas of interest. The systems require the thermal fluid to operate within a specified envelope to prevent system shut down from high or low pressure, hence, the need for effective controls.

[0004] It would be desirable to provide a heat recovery system that adapts to machine operating conditions in order to make more effective use of heat recovery. It would also be desirable to provide a heat recovery system that is able to more effectively maintain desired subcooled condition of refrigerant medium. It would also be desirable to support such heat recovery systems to enable operation continuously or semi-continuously at startup, at steady state or at the standby or idle mode while simultaneously recovering waste energy and tempering the waste hot stream to a predetermined temperature by the use of thermal fluid(s).

SUMMARY

[0005] In one aspect, a warewash machine for washing wares includes a chamber for receiving wares, the chamber having at least one wash zone. A waste heat recovery unit is arranged to transfer heat from exhaust air of the machine to incoming water traveling along a water flow path through the waste heat recovery unit to a booster heater of the machine. A refrigerant medium circuit includes at least a first condenser arranged to deliver refrigerant medium heat to the incoming water. A control arrangement monitors subcooled refrigerant medium condition and responsively modifies operation of one or more of: (i) speed of a compressor of the refrigerant medium circuit, (ii) speed of an exhaust fan the causes air flow across the waste heat recovery unit or (iii) speed of a pump that controls incoming water flow along the water flow path.

[0006] In a further aspect, a method is provided for adaptively controlling a warewash machine that includes a chamber for receiving wares, the chamber having at least one wash zone, a refrigerant medium circuit including at least one condenser through which the incoming water to the machine flows, and a waste heat recovery unit through which incoming water to the machine flows. The method involves: identifying an under-condensed condition of subcooled refrigerant medium in the refrigerant medium circuit or an over-condensed condition of subcooled refrigerant medium in the refrigeration medium circuit; and in response to identification of the under-condensed or over-condensed condition, varying at least one of (i) a speed of a compressor of the refrigerant medium circuit, (ii) a speed of an exhaust fan that causes air flow across the waste heat recovery unit or (iii) a speed of a pump that controls incoming water flow through the waste heat recovery unit and the condenser.

[0007] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a schematic side elevation of one embodiment of a warewasher; and

Fig. 2 is a schematic depiction of a refrigerant circuit and an incoming water flow path of the warewash machine.

DETAILED DESCRIPTION

[0009] Referring to Fig. 1, an exemplary conveyor-type warewash machine, generally designated 10, is shown. Warewash machine 10 includes a housing 11 that can receive racks 12 of soiled wares 14 from an input side 16. The wares are moved through tunnel-like chambers from the input side toward a blower dryer unit 18 at an opposite exit end 17 of the warewash system by a suitable conveyor mechanism 20. Either continuously or intermittently moving conveyor mechanisms or combinations thereof may be used, depending, for example, on the style, model and size of the warewash system 10. Flight-type conveyors in which racks are not used are also possible. In the illustrated example, the racks 12 of soiled wares 14 enter the warewash system 10 through a flexible curtain 22 into a pre-wash chamber or zone 24 where sprays of liquid from upper and lower pre-wash manifolds 26 and 28 above and below the racks, respectively, function to flush heavier soil from the wares. The liquid for this purpose comes from a tank 30 and is delivered to the manifolds via a pump 32 and supply conduit 34. A drain structure 36 provides a single location where liquid is pumped from the tank 30 using the pump 32. Via the same drain structure, liquid can also be drained from the tank and out of the machine via drain path 37, for example, for a tank cleaning operation.

[0010] The racks proceed to a next curtain 38 into a main wash chamber or zone 40, where the wares are subject to sprays of cleansing wash liquid (e.g., typically water with detergent) from upper and lower wash manifolds 42 and 44 with spray nozzles 47 and 49, respectively, these sprays being supplied through a supply conduit 46 by a pump 48, which draws from a main tank 50. A heater 58, such as an electrical immersion heater provided with suitable thermostatic controls (not shown), maintains the temperature of the cleansing liquid in the tank 50 at a suitable level. Not shown, but which may be included, is a device for adding a cleansing detergent to the liquid in tank 50. During normal operation, pumps 32 and 48 are continuously driven, usually by separate motors, once the warewash system 10 is started for a period of time.

[0011] The warewash system 10 may optionally include a power rinse (also known as post-wash) chamber or zone (not shown) that is substantially identical to main wash chamber 40. In such an instance, racks of wares proceed from the wash chamber 40 into the power rinse chamber, within which heated rinse water is sprayed onto the wares from upper and lower manifolds.

[0012] The racks 12 of wares 14 exit the main wash chamber 40 through a curtain 52 into a final rinse chamber or zone 54. The final rinse chamber 54 is provided with upper and lower spray heads 56, 57 that are supplied with a flow of fresh hot water via pipe 62 running from a hot water booster 70 under the control of a variable speed pump 114 (or alternatively any other suitable valve capable of automatic control). A rack detector 64 may be actuated when a rack 12 of wares 14 is positioned in the final rinse chamber 54 and through suitable electrical controls (e.g., the controller mentioned below), the detector causes actuation of pump 114 which delivers incoming water and causes hot rinse water to move from the booster 70 to the spray heads 56, 57. The water then drains from the wares and is directed into the tank 50 by gravity flow. The rinsed rack 12 of wares 14 then exits the final rinse chamber 54 through curtain 66, moving into dryer unit 18, before exiting the outlet end 17 of the machine.

[0013] An exhaust system 80 for pulling hot moist air from the machine (e.g., via operation of a blower 81) may be provided. As shown, a cold water input 72 line may run through a waste heat recovery unit 82 (e.g., a fin-and-tube heat exchanger through which the incoming water flows, though other variations are possible) to recover heat from the exhaust air flowing across and/or through the unit 82. The water line or flow path 72 then runs through one or more condensers 84 (e.g., in the form of a plate heat exchanger or shell-and-tube heat exchangers, though other variations are possible), before delivering the water to the booster 70 for final heating. A condenser 88 may be located in the wash tank and a condenser 90 may be located in the blower dryer unit 18. A second waste heat recovery unit 92 may also be provided.

[0014] Referring now to Fig. 2, the flow configuration for both incoming fresh cold water and for refrigerant are shown. Cold fresh water is first heated by the hot air passing through the waste heat recovery unit 82, then heated further by refrigerant when passing through condenser 84. The heated water then enters the booster 70 for final heating. The refrigerant medium circuit 100 includes an electronic thermal expansion valve 101, which leads to a waste heat recovery unit 92 to recover heat from warm waste air (e.g., the exhaust air flow) after some heat has already been removed from the exhaust air flow by unit 82. A compressor 102 compresses the refrigerant to produce superheated refrigerant, which then flows sequentially through the condensers 88, 90 and 84.

[0015] Generally, condenser 88 may take the form of coil submerged in the wash tank 50 to deliver refrigerant heat to the wash water, condenser 90 may take the form of a coil over which the drying air blows to deliver some refrigerant heat to the drying air and condenser 84, which may be a plate-type heat exchanger, delivers residual refrigerant heat to the incoming fresh water. The incoming water to the booster heater passes through both the waste heat recovery unit 82 and condenser 84. In the event of undesired conditions within the machine, adjustments can be made to compensate.

[0016] In this regard, one or more sensors 110 are provided to monitor the conditions of the subcooled refrigerant. The monitoring may be continuous, periodic or triggered by some event (e.g., identification of a rack at a certain location in the machine). By way of example, both a temperature sensor and a pressure sensor may be used to monitor the subcooled refrigerant medium downstream of the last condenser 84 and upstream of the thermal expansion valve 101. If the monitoring indicates that the condition of the subcooled refrigerant medium has departed from a set specification, then corrective action can be take.

[0017] For example, any of the following conditions within the machine could lead to the condition of the subcooled refrigerant medium falling below a desired condition operating range, meaning the refrigerant medium has not been condensed sufficiently: an increase in the incoming cold water temperature, a decrease in the incoming cold water rate, an increase in the incoming cold water temperature and a decrease in the incoming cold water rate, an increase in waste moist hot air rate, an increase in waste moist hot air temperature, both increase in the waste moist hot air rate and waste moist hot air temperature, a decrease in the load on the warewash machine with an increase in the waste moist hot air rate and/or waste moist hot air temperature, or an inability of one of the condenser(s) to absorb or transfer the intended heat, as well as any combination of the above. All of these conditions will cause a decrease in the amount of condensation of the refrigerant medium that takes place in the refrigerant medium circuit 100 and could eventually cause the below range condition of the subcooled refrigerant medium.

[0018] When a low or below range subcooled condition is identified, any or all of the following corrective actions could be initiated: controlling the compressor 102 to slow down while the electronic thermal expansion valve 101 automatically adjusts to maintain the necessary superheat to the compressor (e.g., based upon indications from a temperature sensor 115), decreasing the speed of exhaust fan 81 while monitoring air flow via meter 106 to maintain the necessary heat load across the waste heat recovery units 82 and 92 and to maintain the necessary superheat to the compressor 102, or increasing the speed of variable speed pump 114 that delivers the incoming cool fresh water. Any of these actions will increase the level of condensation that takes place and can be used to bring the condition of the subcooled refrigerant medium back up into the desired operating range.

[0019] As another example, any of the following conditions within the machine could lead to the condition of the subcooled refrigerant medium falling above a desired condition operating range, meaning the refrigerant medium has been overly condensed or subcooled: a decrease in the incoming cold water temperature, an increase in the incoming cold water rate, both decrease in the incoming cold water temperature and increase of incoming cold water rate, a decrease in waste moist hot air rate, a decrease in waste moist hot air temperature, a decrease in both the waste moist hot air rate and waste moist hot air temperature, an increase in the load on the warewash machine with a decrease in the waste moist hot air rate and/or waste moist hot air temperature. All of these conditions will cause an increase in the amount of condensation of the refrigerant medium that takes place in the refrigerant medium circuit 100 and could eventually cause the above range condition of the subcooled refrigerant medium.

[0020] When a high or above range or overly subcooled condition is identified, any or all of the following corrective actions can be initiated: controlling the compressor 102 to speed up while the electronic thermal expansion valve 101 adjusts to maintain the necessary superheat to the compressor, or increasing the speed of the exhaust fan 81 to maintain the necessary heat load across the waste heat recovery units 82 and 92 in order to maintain the necessary superheat to the compressor 102, or decreasing the speed of the variable speed pump 114 that delivers the incoming cool fresh water. Any of these actions will decrease the level of condensation that takes place and can be used to bring the condition of the subcooled refrigerant medium back down into the desired operating range.

[0021] Moreover, in a situation where the heat load required by one or more of the condensers is satisfied, the speed of both the compressor 102 and exhaust fan 81 may be decreased, relying upon the excess heat load to maintain the minimum heat required in the machine and also to prevent unnecessary steam escape from the loading and unloading ends of the machine. In a standby mode of the machine (e.g., when wares are not being moved through the machine for cleaning) the speed of the exhaust fan 81 may be decreased to conserve heat in the machine. The exhaust fan 81 is typically on when the compressor 102 is on to prevent low pressure, unless conditions are close to high pressure, in which case the fan 81 may be shutdown. The moist hot air temperature (as indicated by temperature sensor 108) and flowrate (as indicated by sensor 106) may be used to determine the fan speed to maintain a desired set temperature drop across the waste heat recovery units 82 and 92, thereby maintaining the needed superheat and exhaust conditions.

[0022] By way of example, the subcooled condition of the refrigerant medium may be a difference between the actual temperature indicated by the temperature sensor 110 less a condenser saturation temperature corresponding to the pressure indicated by pressure sensor 110. An exemplary acceptable subcooled condition operating range may be between 10°F and 15°F, though variations are possible. Above 15°F indicates the refrigerant medium has been overly condensed or subcooled, and below 10°F indicates that the refrigerant medium has not been condensed enough (e.g., gas may be present). The condenser saturation temperature may be determined by reading the pressure indicated by pressure sensor 110 and (i) using a refrigerant pressure/temperature chart or table (e.g., stored in controller memory) to convert the pressure reading to the condenser saturation temperature or (ii) using an equation fitted to a refrigerant medium pressure/temperature chart to convert the pressure reading to the condenser saturation temperature.

[0023] A controller 150 may be provided to effect initiation and control of any of the corrective actions mentioned above based upon indications from the temperature sensor and pressure sensor, as well as for controlling other functions and operations of the machine as discussed above. As used herein, the term controller is intended to broadly encompass any circuit (e.g., solid state, application specific integrated circuit (ASIC), an electronic circuit, a combinational logic circuit, a field programmable gate array (FPGA)), processor (e.g., shared, dedicated, or group - including hardware or software that executes code) or other component, or a combination of some or all of the above, that carries out the control functions of the machine or the control functions of any component thereof. The controller may include variable adjustment functionality that enables, for example, the acceptable subcooled condition operating range to be varied (e.g., via an operator interface associated with the controller 150 or via a restricted service/maintenance personnel interface).

[0024] Ensuring that the refrigerant medium remains in a desired operating range as indicated above can help system operation by (i) assuring that the refrigerant medium is fully condensed to assist efficient operation of the thermal expansion valve 101, and/or (ii) reducing or eliminating the presence of gas in the refrigerant medium at the upstream side of the thermal expansion valve as the presence of such gas will tend to restrict refrigerant medium flow hence starving the evaporator of refrigerant medium, and/or (ii) assuring that the refrigerant medium is not overcooled coming out of the condenser chain, as such overcooling will require more energy delivery to the refrigerant medium at the evaporator in order to raise the refrigerant medium to desired compressor suction conditions, and if the evaporator is unable to deliver sufficient energy the performance and/or life of the compressor may be adversely impacted.

[0025] The above machine provides an advantageous method of correcting undesired conditions of a refrigerant medium circuit in a warewash machine. In particular, the method involves: identifying an under-condensed condition of subcooled refrigerant medium in the refrigerant medium circuit or an over-condensed condition of subcooled refrigerant medium in the refrigeration medium circuit; and in response to identification of the under-condensed or over-condensed condition, varying at least one of (i) a speed of a compressor of the refrigerant medium circuit, (ii) a speed of an exhaust fan that causes air flow across the waste heat recovery unit or (iii) a speed of a pump that controls incoming water flow through the waste heat recovery unit and the condenser. In one implementation, the identifying step includes sensing a refrigerant medium temperature and a refrigerant medium pressure downstream of all condensers in the refrigerant medium circuit. In one example of such an implementation, the identifying step includes determining a difference between the sensed refrigerant medium temperature less a condenser saturation temperature corresponding to the sensed refrigerant medium pressure. If the under-condensed condition of subcooled refrigerant medium is identified, the varying step involves at least one of: (i) reducing the speed of the compressor, (ii) reducing the speed of the exhaust fan or (iii) increasing the speed of the pump. If the over-condensed condition of subcooled refrigerant medium is identified, the varying step involves at least one of: (i) increasing the speed of the compressor, (ii) increasing the speed of the exhaust fan or (iii) decreasing the speed of the pump. The method may also involve monitoring temperature and flow rate of exhaust air and responsively adjusting the speed of the exhaust fan to maintain a set temperature drop across the waste heat recovery unit.

[0026] It is to be clearly understood that the above description is intended by way of illustration and example only and is not intended to be taken by way of limitation, and that changes and modifications are possible. Accordingly, other embodiments are contemplated and modifications and changes could be made without departing from the scope of this application. For example, the term refrigerant commonly refers to known acceptable refrigerants, but other thermal fluids could be used in refrigerant type circuits. The term "refrigerant medium" is intended to encompass all such traditional refrigerants and other thermal fluids. Embodiments with varying numbers of waste heat recovery units and/or numbers of condensers are also contemplated.

Claims

1. A warewash machine (10) for washing wares (14), comprising:

- a chamber for receiving wares (14), the chamber having at least one wash zone (40);
- a waste heat recovery unit (82) arranged to transfer heat from exhaust air of the machine (10) to incoming water traveling along a water flow path through the waste heat recovery unit (82) to a booster heater (70) of the machine (10);
- a refrigerant medium circuit (100) including at least a first condenser (84) arranged to deliver refrigerant medium heat to the incoming water;

characterized by
a control arrangement for monitoring subcooled refrigerant medium condition and for responsively modifying operation of one or more of:

(i) speed of a compressor (102) of the refrigerant medium circuit (100),
(ii) speed of an exhaust fan (81) that causes air flow across the waste heat recovery unit (82) or
(iii) speed of a pump (114) that controls incoming water flow along the water flow path.

2. The machine (10) of claim 1, wherein the control arrangement includes a refrigerant medium temperature sensor (108, 110, 115) and a refrigerant medium pressure sensor (110) downstream of all condensers (84, 88, 90) in the refrigerant medium circuit (100).

3. The machine (10) of claim 2, wherein the control arrangement includes a controller (150) connected with the refrigerant medium temperature sensor (108, 110, 115) and the refrigerant medium pressure sensor (110), the controller (150) configured to determine a subcooled condition of the refrigerant medium and to responsively control at least one of: (i) the speed of the compressor (102), (ii) the speed of the exhaust fan (81) or (iii) the speed of the pump (114).

4. The machine (10) of claim 3, wherein the subcooled condition of the refrigerant medium is a difference between an actual temperature indicated by the refrigerant medium temperature sensor (108, 110, 115) less a condenser saturation temperature corresponding to a pressure indicated by the refrigerant medium pressure sensor (110).

5. The machine (10) of claim 4, wherein the controller (150) is configured to identify a predefined subcooled condition indicative of under-condensing of the refrigerant medium and to responsively effect at least one of: (i) a reduction in the speed of the compressor (102), (ii) a reduction in the speed of the exhaust fan (81) or (iii) an increase in the speed of the pump (114).

6. The machine (10) of claim 4, wherein the controller (150) is configured to identify a predefined subcooled condition indicative of over-condensing of the refrigerant medium and to responsively effect at least one of: (i) an increase in the speed of the compressor (102), (ii) an increase in the speed of the exhaust fan (81) or (iii) a decrease in the speed of the pump (114).

7. The machine (10) of one of the preceding claims, wherein the control arrangement is further configured to monitor temperature and flow rate of exhaust air and to responsively adjust the speed of the exhaust fan to maintain a set temperature drop across the waste heat recovery unit (82).

8. A method of adaptively controlling a warewash machine (10) that includes a chamber for receiving wares (14), the chamber having at least one wash zone (40), a refrigerant medium circuit (100) including at least one condenser (84) through which the incoming water to the machine (10) flows, and a waste heat recovery unit (82) through which incoming water to the machine (10) flows,
characterized by
identifying an under-condensed condition of subcooled refrigerant medium in the refrigerant medium circuit (100) or an over-condensed condition of subcooled refrigerant medium in the refrigeration medium circuit (100); and
in response to identification of the under-condensed or over-condensed condition, varying at least one of (i) a speed of a compressor (102) of the refrigerant medium circuit (100), (ii) a speed of an exhaust fan (81) that causes air flow across the waste heat recovery unit (82) or (iii) a speed of a pump (114) that controls incoming water flow through the waste heat recovery unit (82) and the condenser (84).

9. The method of claim 8, wherein the identifying step includes sensing a refrigerant medium temperature and a refrigerant medium pressure downstream of all condensers (84, 88, 90) in the refrigerant medium circuit (100).

10. The method of claim 9, wherein the identifying step includes determining a difference between the sensed refrigerant medium temperature less a condenser saturation temperature corresponding to the sensed refrigerant medium pressure.

11. The method of claim 10, wherein, if the under-condensed condition of subcooled refrigerant medium is identified, the varying step involves at least one of: (i) reducing the speed of the compressor (102), (ii) reducing the speed of the exhaust fan (81) or (iii) increasing the speed of the pump (114).

12. The method of claim 10, wherein, if the over-condensed condition of subcooled refrigerant medium is identified, the varying step involves at least one of: (i) increasing the speed of the compressor (102), (ii) increasing the speed of the exhaust fan (81) or (iii) decreasing the speed of the pump (114).

13. The method of one of claims 8 to 12, further including: monitoring temperature and flow rate of exhaust air and responsively adjusting the speed of the exhaust fan (81) to maintain a set temperature drop across the waste heat recovery unit (82).

Patentansprüche

1. Geschirrspülmaschine (10) zum Spülen von Geschirr (14), die Folgendes umfasst:

einen Raum zum Aufnehmen von Geschirr (14), wobei der Raum mindestens eine Spülzone (40) aufweist;
eine Abwärmerückgewinnungseinheit (82), die angeordnet ist, Wärme aus der Abluft der Maschine (10) auf einströmendes Wasser, das sich entlang eines Wasserströmungswegs durch die Abwärmerückgewinnungseinheit (82) bewegt, an eine Zusatzheizung (70) der Maschine (10) zu übertragen;
einen Kühlmittelkreislauf (100), der mindestens einen ersten Kondensator (84) aufweist, der angeordnet ist, dem einströmenden Wasser Kühlmittelwärme zuzuführen;
gekennzeichnet durch
eine Steuerungsanordnung zum Überwachen einer Unterkühlungsbedingung des Kühlmittels und zum darauf ansprechenden Modifizieren des Betriebs von einem oder mehreren aus Folgenden: (i) einer Drehzahl eines Kompressors (102) des Kühlmittelkreislaufs (100), (ii) einer Drehzahl eines Abluftgebläses (81), das einen Luftstrom über die Abwärmerückgewinnungs-

einheit (82) verursacht, oder (iii) einer Drehzahl einer Pumpe (114), die den einströmenden Wasserstrom entlang des Wasserströmungswegs steuert.

2. Maschine (10) nach Anspruch 1, wobei die Steuerungsanordnung einen Kühlmitteltemperatursensor (108, 110, 115) und einen Kühlmitteldrucksensor (110) stromabwärts von allen Kondensatoren (84, 88, 90) in dem Kühlmittelkreislauf (100) beinhaltet.

3. Maschine (10) nach Anspruch 2, wobei die Steuerungsanordnung eine Steuerung (150) beinhaltet, die mit dem Kühlmitteltemperatursensor (108, 110, 115) und dem Kühlmitteldrucksensor (110) verbunden ist, wobei die Steuerung (150) konfiguriert ist zum Bestimmen einer Unterkühlungsbedingung des Kühlmittels und zum darauf ansprechenden Steuern von mindestens einem aus Folgenden: (i) der Drehzahl des Kompressors (102), (ii) der Drehzahl des Abluftgebläses (81) oder (iii) der Drehzahl der Pumpe (114).

4. Maschine (10) nach Anspruch 3, wobei die Unterkühlungsbedingung des Kühlmittels eine Differenz zwischen einer tatsächlichen Temperatur, die von dem Kühlmitteltemperatursensor (108, 110, 115) angegeben wird, und einer Kondensatorsättigungstemperatur, die einem Druck entspricht, der von dem Kühlmitteldrucksensor (110) angegeben wird, ist.

5. Maschine (10) nach Anspruch 4, wobei die Steuerung (150) konfiguriert ist zum Identifizieren einer vordefinierten Unterkühlungsbedingung, die eine Unterverdichtung des Kühlmittels anzeigt, und zum darauf ansprechenden Bewirken von mindestens einem aus Folgenden: (i) einer Reduktion der Drehzahl des Kompressors (102), (ii) einer Reduktion der Drehzahl des Abluftgebläses (81) oder (iii) einer Zunahme der Drehzahl der Pumpe (114).

6. Maschine (10) nach Anspruch 4, wobei die Steuerung (150) konfiguriert ist zum Identifizieren einer vordefinierten Unterkühlungsbedingung, die eine Überverdichtung des Kühlmittels anzeigt und zum darauf ansprechenden Bewirken von mindestens einem aus: (i) einer Zunahme der Drehzahl des Kompressors (102), (ii) einer Zunahme der Drehzahl des Abluftgebläses (81) oder (iii) einer Abnahme der Drehzahl der Pumpe (114).

7. Maschine (10) nach einem der vorhergehenden Ansprüche, wobei die Steuerungsanordnung ferner konfiguriert ist zum Überwachen der Temperatur und der Strömungsrate der Abluft und zum darauf ansprechenden Anpassen der Drehzahl des Abluftgebläses, um einen eingestellten Temperaturabfall über die Abwärmerückgewinnungseinheit (82) aufrecht zu erhalten.

8. Verfahren zum adaptiven Steuern einer Geschirrspülmaschine (10), die Folgendes beinhaltet:

einen Raum zum Aufnehmen von Geschirr (14), wobei der Raum mindestens eine Spülzone (40) aufweist, einen Kühlmittelkreislauf (100), der mindestens einen Kondensator (84) beinhaltet, durch welchen einströmendes Wasser zur Maschine (10) strömt, und eine Abwärmerückgewinnungseinheit (82), durch welche einströmendes Wasser zur Maschine (10) strömt,
gekennzeichnet durch
Identifizieren einer Unterverdichtungsbedingung von unterkühltem Kühlmittel in dem Kühlmittelkreislauf (100) oder einer Überverdichtungsbedingung von unterkühltem Kühlmittel im Kühlmittelkreislauf (100);
und
in Reaktion auf die Identifikation der Unterverdichtungs- oder Überverdichtungsbedingung, Variieren von mindestens einem aus Folgenden (i) einer Drehzahl eines Kompressors (102) des Kühlmittelkreislaufs (100), (ii) einer Drehzahl eines Abluftgebläses (81), das einen Luftstrom über die Abwärmerückgewinnungseinheit (82) verursacht, oder (iii) einer Drehzahl einer Pumpe (114), die einen einströmenden Wasserstrom durch die Abwärmerückgewinnungseinheit (82) und den Kondensator (84) steuert.

9. Verfahren nach Anspruch 8, wobei der Identifizierungsschritt Erfassen einer Kühlmitteltemperatur und eines Kühlmitteldrucks stromabwärts von allen Kondensatoren (84, 88, 90) in dem Kühlmittelkreislauf (100) beinhaltet.

10. Verfahren nach Anspruch 9, wobei der Identifizierungsschritt Bestimmen einer Differenz zwischen der erfassten Kühlmitteltemperatur und einer Kondensatorsättigungstemperatur, die dem erfassten Kühlmitteldruck entspricht, beinhaltet.

11. Verfahren nach Anspruch 10, wobei, wenn die Unterverdichtungsbedingung von unterkühltem Kühlmittel identifiziert wird, der Variierungsschritt mindestens eins aus Folgenden beinhaltet: (i) Reduzieren der Drehzahl des Kompressors (102), (ii) Reduzieren der Drehzahl des Abluftgebläses (81) oder (iii) Erhöhen der Drehzahl der Pumpe (114).

12. Verfahren nach Anspruch 10,
wobei, wenn die Überverdichtungsbedingung von unterkühltem Kühlmittel identifiziert wird, der Variierungsschritt mindestens eins aus Folgenden beinhaltet: (i) Erhöhen der Drehzahl des Kompressors (102), (ii) Erhöhen der Drehzahl des Abluftgebläses (81) oder (iii) Verringern der Drehzahl der Pumpe (114).

13. Verfahren nach einem der Ansprüche 8 bis 12, das ferner beinhaltet:
Überwachen der Temperatur und der Strömungsrate der Abluft und darauf ansprechendes Anpassen der Drehzahl des Abluftgebläses (81), um einen eingestellten Temperaturabfall über die Abwärmerückgewinnungseinheit (82) aufrecht zu erhalten.

Revendications

1. Machine lave-vaisselle professionnelle (10) pour laver de la vaisselle (14), comprenant :

une chambre pour recevoir de la vaisselle (14), la chambre ayant au moins une zone de lavage (40) ;
une unité de récupération de chaleur perdue (82) agencée pour transférer de la chaleur provenant d'air d'évacuation de la machine (10) à de l'eau entrante se déplaçant le long d'un chemin d'écoulement d'eau à travers l'unité de récupération de chaleur perdue (82) jusqu'à un élément chauffant d'appoint (70) de la machine (10) ;
un circuit d'agent réfrigérant (100) incluant au moins un premier condenseur (84) agencé pour fournir de la chaleur d'agent réfrigérant à l'eau entrante ;
caractérisé par
un agencement de commande pour surveiller une condition sous-refroidie d'agent réfrigérant et pour, en réponse, modifier le fonctionnement d'une ou de plusieurs de : (i) vitesse d'un compresseur (102) du circuit d'agent réfrigérant (100), (ii) vitesse d'un ventilateur d'évacuation (81) qui entraîne un écoulement d'air à travers l'unité de récupération de chaleur perdue (82) ou (iii) vitesse d'une pompe (114) qui commande un écoulement d'eau entrante le long du chemin d'écoulement d'eau.

2. Machine (10) selon la revendication 1,
dans laquelle l'agencement de commande inclut un capteur de température d'agent réfrigérant (108, 110, 115) et un capteur de pression d'agent réfrigérant (110) en aval de tous les condenseurs (84, 88, 90) dans le circuit d'agent réfrigérant (100).

3. Machine (10) selon la revendication 2,
dans laquelle l'agencement de commande inclut une unité de commande (150) connectée au capteur de température d'agent réfrigérant (108, 110, 115) et au capteur de pression d'agent réfrigérant (110), l'unité de commande (150) étant configurée pour déterminer une condition sous-refroidie de l'agent réfrigérant et pour, en réponse, commander au moins une de : (i) la vitesse du compresseur (102), (ii) la vitesse du ventilateur d'évacuation (81) ou (iii) la vitesse de la pompe (114).

4. Machine (10) selon la revendication 3,
dans laquelle la condition sous-refroidie de l'agent réfrigérant est une différence entre une température réelle indiquée par le capteur de température d'agent réfrigérant (108, 110, 115) moins une température de saturation de condenseur correspondant à une pression indiquée par le capteur de pression d'agent réfrigérant (110).

5. Machine (10) selon la revendication 4,
dans laquelle l'unité de commande (150) est configurée pour identifier une condition sous-refroidie prédéfinie indicative de sous-condensation de l'agent réfrigérant et pour, en réponse, effectuer au moins une de : (i) une réduction de la vitesse de the compresseur (102), (ii) une réduction de la vitesse du ventilateur d'évacuation (81) ou (iii) une augmentation de la vitesse de la pompe (114).

6. Machine (10) selon la revendication 4,
dans laquelle l'unité de commande (150) est configurée pour identifier une condition sous-refroidie prédéfinie indicative de sur-condensation de l'agent réfrigérant et pour, en réponse, effectuer au moins une de : (i) une augmentation de la vitesse de the compresseur (102), (ii) une augmentation de la vitesse du ventilateur d'évacuation (81) ou (iii) une réduction de la vitesse de la pompe (114).

7. Machine (10) selon l'une des revendications précédentes,
dans laquelle l'agencement de commande est en outre configuré pour surveiller une température et un débit de l'air d'évacuation et pour, en réponse, ajuster la vitesse du ventilateur d'évacuation pour maintenir une chute de température déterminée à travers l'unité de récupération de chaleur perdue (82).

8. Procédé de commande adaptative d'une machine lave-vaisselle professionnelle (10) qui inclut une chambre pour recevoir de la vaisselle (14), la chambre ayant au moins une zone de lavage (40), un circuit d'agent réfrigérant (100) incluant au moins un condenseur (84), à travers lequel de l'eau entrante pour la machine (10) s'écoule, et une unité de récu-

pération de chaleur perdue (82), à travers laquelle de l'eau entrante pour la machine (10) s'écoule,
caractérisé par
l'identification d'une condition sous-condensée d'agent réfrigérant sous-refroidi dans le circuit d'agent réfrigérant (100) ou d'une condition sur-condensée d'agent réfrigérant sous-refroidi dans le circuit d'agent réfrigérant (100) ; et
en réponse à l'identification de la condition sous-condensée ou sur-condensée, la variation d'au moins une de (i) une vitesse d'un compresseur (102) du circuit d'agent réfrigérant (100), (ii) une vitesse d'un ventilateur d'évacuation (81) qui entraîne un écoulement d'air à travers l'unité de récupération de chaleur perdue (82) ou (iii) une vitesse d'une pompe (114) qui commande un écoulement d'eau entrante à travers l'unité de récupération de chaleur perdue (82) et le condenseur (84).

9. Procédé selon la revendication 8,
dans lequel l'étape de l'identification inclut la détection d'une température d'agent réfrigérant et d'une pression d'agent réfrigérant en aval de tous les condenseurs (84, 88, 90) dans le circuit d'agent réfrigérant (100).

10. Procédé selon la revendication 9,
dans lequel l'étape de l'identification inclut la détermination d'une différence entre la température d'agent réfrigérant détectée moins une température de saturation de condenseur correspondant à la pression d'agent réfrigérant détectée.

11. Procédé selon la revendication 10,
dans lequel, si la condition sous-condensée d'agent réfrigérant sous-refroidi est identifiée, l'étape de la variation implique au moins une de : (i) la réduction de la vitesse du compresseur (102), (ii) la réduction de la vitesse du ventilateur d'évacuation (81) ou (iii) l'augmentation de la vitesse de la pompe (114).

12. Procédé selon la revendication 10,
dans lequel, si la condition sur-condensée d'agent réfrigérant sous-refroidi est identifiée, l'étape de la variation implique au moins une de : (i) l'augmentation de la vitesse du compresseur (102), (ii) l'augmentation de la vitesse du ventilateur d'évacuation (81) ou (iii) la réduction de la vitesse de la pompe (114).

13. Procédé selon l'une des revendications 8 à 12, incluant en outre :
la surveillance d'une température et d'un débit d'air d'évacuation et, en réponse, l'ajustement de la vitesse du ventilateur d'évacuation (81) pour maintenir une chute de température déterminée à travers l'unité de récupération de chaleur perdue (82).

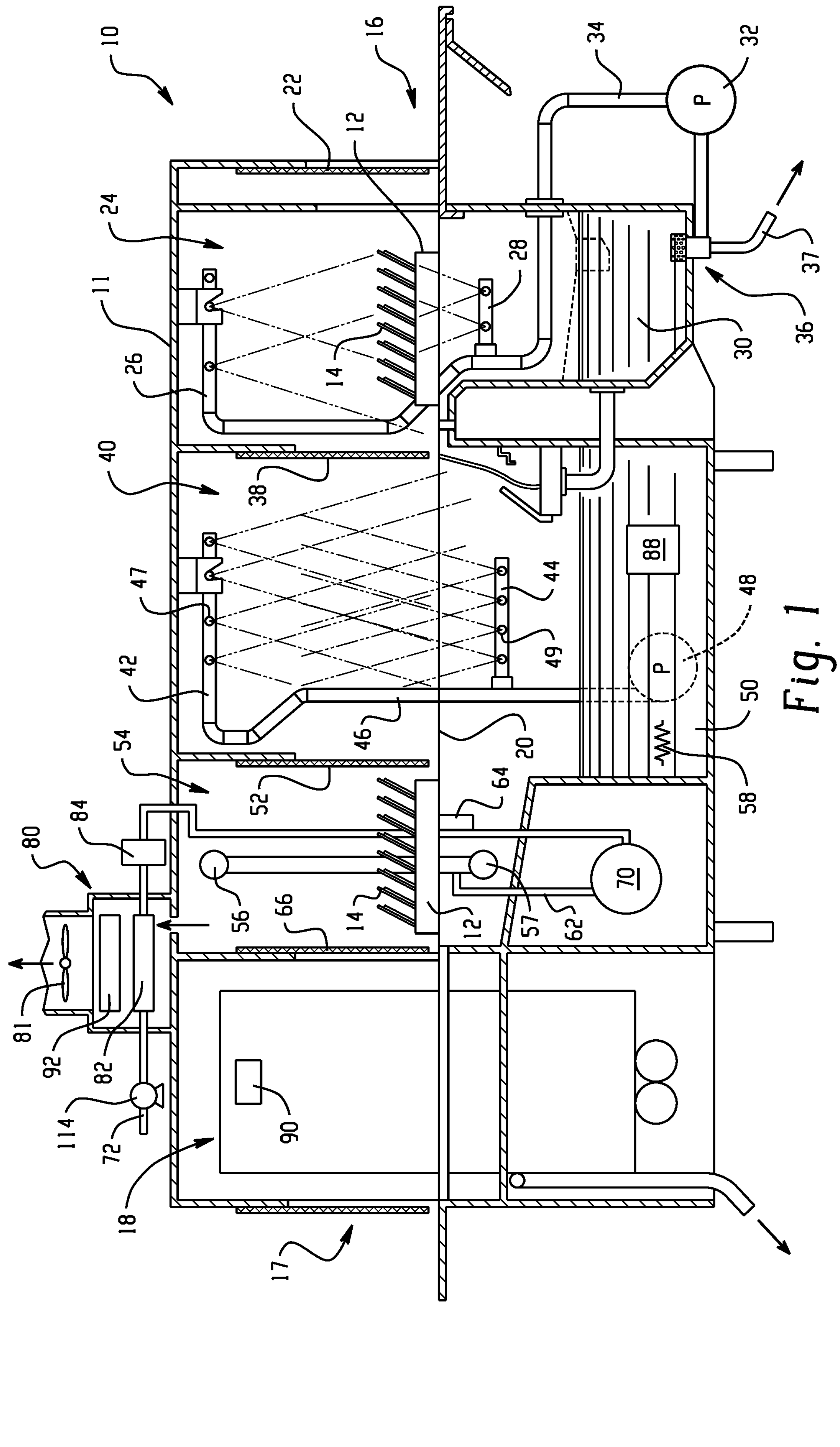
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Fig. 1

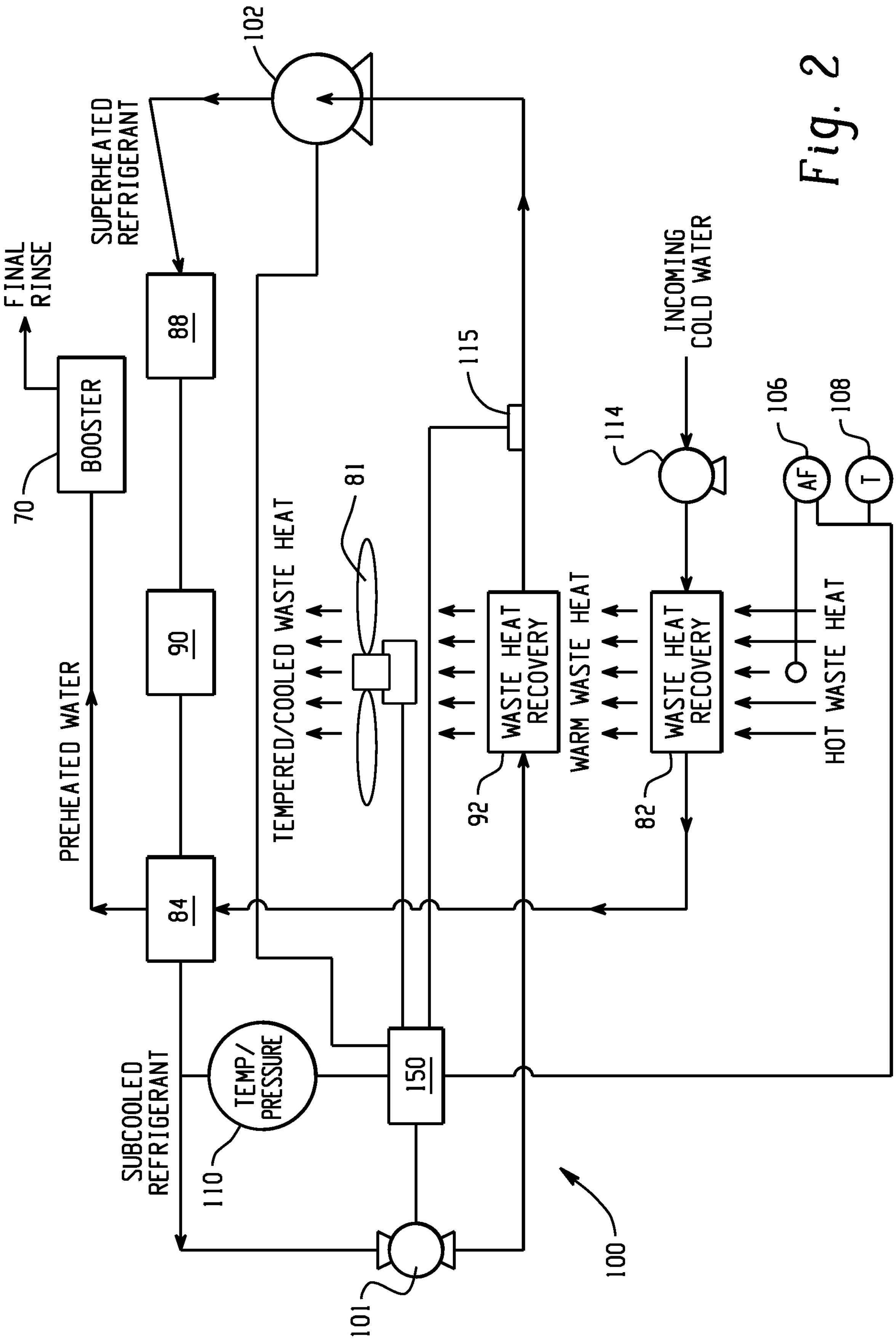
FINAL RINSE
BOOSTER
70
SUPERHEATED REFRIGERANT
88
90
84
102
PREHEATED WATER
TEMPERED/COOLED WASTE HEAT
81
115
WASTE HEAT RECOVERY
92
WARM WASTE HEAT
WASTE HEAT RECOVERY
82
INCOMING COLD WATER
114
106
AF
108
T
HOT WASTE HEAT
SUBCOOLED REFRIGERANT
TEMP/ PRESSURE
110
150
101
100

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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