(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 154 065 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.11.2001 Bulletin 2001/46

(51) Int Cl.^{7}: **D06F 58/20**

(21) Application number: **01104870.9**

(22) Date of filing: **28.02.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **09.05.2000 DE 10022613**

(71) Applicant: **Whirpool Corporation**
Benton Harbor, MI 49022 (US)

(72) Inventors:
- **Pöhler, Reinhold, c/o Whirlpool Europe s.r.l. 21025 Comerio (IT)**
- **Eck, Gismar, c/o Whirlpool Europe s.r.l. 21025 Comerio (IT)**

(74) Representative: **Guerci, Alessandro**
Whirlpool Europe S.r.l.
Patent Department
Viale G. Borghi 27
21025 Comerio (VA) (IT)

(54) Condensation clothes dryer with a heat pump and auxiliary resistance heater

(57) The invention concerns a condensation clothes dryer with a heat pump and a closed process air circuit that proceeds from a dryer drum and returns to it via an evaporator, blower and a condenser as well as an auxiliary resistance heater. The heat pump circuit for the cold-start, heating and operating phase is automatically adapted without program-controlled changes in the heat output and without overload protection as follows: The auxiliary resistance heater consists of one or more semiconductor resistors that heat the coolant for the condenser of the heat pump circuit.

EP 1 154 065 A2

Description

[0001] The invention concerns a condensation clothes dryer with a heat pump, and a closed process air circuit that proceeds from a clothes dryer drum and returns to it via an evaporator, a blower, a compressor and condenser as well as an auxiliary resistance heater.

[0002] Such a condensation clothes dryer is prior art in DE 31 13 471 A1. As shown in DE 26 53 322 C2, PTC resistors are used for auxiliary heating in clothes dryers. Since the resistance value of the PTC resistors increases more-or-less exponentially as the temperature increases, measures have to be taken to limit the starting current and prevent excessive heating during the heating phase. For this reason, the program circuitry of prior-art clothes dryers operate the PTC resistors in a series connection in a cold-start, and in parallel connection or partially parallel connection when heating. However, this requires extra program control and correspondingly powerful switching means. In addition, the heat must be adapted to the given operating conditions by means of expensive control and regulating devices, and there needs to be protection from overloads with potential fire danger due to faulty or failed control and regulating devices.

[0003] To maximise the effectiveness of such a condensation clothes dryer, the heat pump must be adapted to the various operating conditions such as the cold-start phase, heating phase and operating phase. The heat pump is designed to deal with changing operating parameters which requires a great deal of engineering.

[0004] The problem of the invention is to adapt a condensation clothes dryer of the initially-cited type to the different operating conditions solely by means of the auxiliary resistance heating system without additional engineering.

[0005] This problem is solved according to the invention by having the auxiliary resistance heating system consisting of one or more semiconductor resistors that heat the coolant for the condenser of the heat pump circuit.

[0006] Incorporating these semiconductor resistors into the heat pump circuit enables automatic adaptation to the various operating conditions with a corresponding self-regulating effect without risk of over heating solely by choosing the characteristics of the semiconductor resistors without switches, thermostats, etc.; the heat pump condenser is also heated more quickly in the heating phase.

[0007] As an auxiliary resistance heating system, the semiconductor resistors designed as PTC resistors provide full heat output during a cold-start. As the temperature rises, they reduce the heat output to the specified heating current due to their increasing resistance; as the temperature rises further, the heat output decreases toward zero which effectively prevents overheating.

[0008] In another possible adaptation, the PTC resistors are parallel-connected, series-connected or partially parallel-connected. This circuit design of the PTC resistors is used to attain a particular overall characteristic.

[0009] For the PTC resistors to function as start-up heaters and reduce cold-start current in the cold-start phase, one or more NTC resistors are series-connected in one embodiment to the parallel-connected, series-connected or partially parallel-connected PTC resistors.

[0010] The NTC resistors determine the starting current by means of their cold resistance, and the PTC resistors determine the heating current of the auxiliary resistance heating system with their hot resistance in the provided circuit.

[0011] The heat pump circuit is directly affected when the auxiliary resistance heating system is integrated in a flow heater that is connected between the compressor and condenser of the heat pump. When the PTC and NTC resistors thermally contact the condenser, they changed its parameters corresponding to the predominating operating conditions.

[0012] In one embodiment, the operating parameters of the heat pump circuit can be directly influenced automatically by the auxiliary resistance heating system by installing the auxiliary resistance heating system in a condenser bypass, or by mounting or installing the auxiliary resistance heater as a thermally-conducting, indirectly heating component at one or more locations on or in the condenser.

[0013] To allow the semiconductor resistors to be incorporated in the circuitry of the auxiliary resistance heater, the semiconductor resistors of the auxiliary resistance heater are preferably flat and are located between points of the resistance circuit designed as metal contact plates or metal cooling plates and are electrically connected to each other. The automatic adaptation of the auxiliary resistance heating system is provided as follows: At least one upstream NTC resistor and one downstream PTC resistor thermally contact each other via the metal contact plates or metal cooling plates.

[0014] The invention will be further explained with reference to the exemplary embodiment portrayed in the drawings. Shown are:

Fig. 1 a schematic illustration of the process air circuit in a condensation clothes dryer with a heat pump and auxiliary resistance heating system,

Fig. 2 the condenser of the heat pump with various combinations of auxiliary resistance heating, and

Fig. 3 a circuit diagram for a circuit of the PTC and NTC resistors of the auxiliary resistance heater.

[0015] In condensation clothes dryers, the clothes 12 to be dried are put into the dryer drum 1. The dryer drum

1 can rotate around an axis 2 to circulate the clothes 12. The closed process air circuit has a moist hot area 3, a demoisturised cooled area 2, and a hot dry area 6.

[0016] The process air is sucked out of the dryer drum 1 at an outlet, and it passes via the moist hot area 3 to the evaporator 11 of the heat pump. As the suction line 9 shows, the evaporator 11 is connected to the compressor 8. In another embodiment of the invention, a flow heater 14 with an installed auxiliary resistance heater W1 is connected in the pressure line 5 to the condenser 7 of the heat pump, as shown in Fig. 2. The condenser 7 is connected via line 4 with the throttle valve 13 to the evaporator 11. From the condenser 7, the process air returns via an inlet to the dryer drum 1, and the inlet is on the side of the drum opposite the outlet.

[0017] The process air is heated in the condenser 7 of the heat pump, and it absorbs steam as it passes through the dryer drum 1 that is removed from the process air when it cools in the evaporator 11 and is ejected as condensed water.

[0018] The heat pump absorbs energy from the evaporator 11 which it supplies to the condenser 7 along with a condensation heat of the condensed moisture from the laundry as well as part of its own heat loss.

[0019] To optimise the operation of such a condensation clothes dryer, the heat pump circuit must be adapted to various operating conditions such as the cold-start phase, heating phase and operating phase. It has proven to be advantageous to shorten the cold-start phase and heating phase.

[0020] An auxiliary resistance heating system can be advantageously used when it is constructed with semiconductor resistors. When PTC resistors are used as the semiconductor resistors, resistance increases as the temperature increases so that, when a maximum threshold temperature is attained, the heat output tends toward zero. This can be attained in a particularly advantageous manner when the maximum PTC temperature is slightly below the operating temperature of the heat pump so that it only acts as an auxiliary resistance heater in the heating phase of the heat pump.

[0021] It is particularly advantageous when the PTC resistors are integrated in the condenser for startup heating. The auxiliary resistance heater therefore does not require its own air-side heat-releasing surfaces or fastening system; the heat pump condenser is directly heated as well as the coolant supplied to the condenser since they are in direct thermal contact with the PTC resistors.

[0022] As shown in Fig. 2, the PTC resistors of the auxiliary resistance heater W3 integrated with the heat pump can thermally contact the condenser 7 at different sites. The PTC resistors can also be in a bypass to the condenser 7 as the auxiliary resistance heater W2 shows. The auxiliary resistance heater W1 can also be a component of a flow heater 14 between the compressor 8 and condenser 7 in the heat pump circuit.

[0023] If the start current is to be limited in the cold-start phase, then the PTC resistors that are parallel-connected, series-connected or partially parallel-connected can be series-connected upstream to the NTC resistors NTC1 and NTC2 as shown in the circuit diagram in Fig. 3. Each NTC resistor NTC1 and NTC2 can be parallel-connected downstream to two PTC resistors PTC1 and PTC2, or PTC3 and PTC4. The circuit is fed with alternating current L, N. As shown by the points in the circuit identified as KK, K1, K1', K2, the electrical connections required by the circuit can be realised with preferably plate-shaped contact bodies or cooling bodies that are electrically connected to the plate-shaped PTC and NTC resistors. The cooling bodies K1 and K1' can also be a single cooling body so that the two NTC resistors NTC 1 and NTC 2 are parallel-connected. The particular selection of the NTC and PTC resistors and their connection depends on the desired overall characteristic of the auxiliary resistance heater W1, W2 or W3 for adapting to the operating conditions of the cold-start phase, heating phase and operating phase. The various characteristics of the NTC and PTC resistors with their different resistance characteristics are also to be taken into account as variation parameters.

[0024] A special adaptation control, e.g. with program-controlled changes in the auxiliary resistance heater circuit can be dispensed with as well as a safety circuit to prevent overheating since the heating current is automatically prevented from exceeding the operating current by the overall characteristic of the auxiliary resistance heater.

Claims

1. A condensation clothes dryer with a heat pump and a closed process air circuit that proceeds from a dryer drum and returns to it via an evaporator, blower and a condenser as well as an auxiliary resistance heater,
   characterised in that
   the auxiliary resistance heater (W1, W2, W3) consists of one or more semiconductor resistors (PTC1, PTC2, PTC3, PTC4) that heat the coolant for the condenser (7) of the heat pump circuit.

2. A condensation clothes dryer according to claim 1,
   characterised in that
   the semiconductor resistors are PTC resistors (PTC1 - PTC4).

3. A condensation clothes dryer according to claims 1 or 2,
   characterised in that
   the PTC resistors (PTC1, PTC2, PTC3, PTC4) are parallel-connected, series-connected, or partially parallel-connected.

4. A condensation clothes dryer according to claim 3,

characterised in that
the parallel-connected, series-connected or partially parallel-connected PTC resistors are series-connected to one or more NTC resistors (NTC1,NTC2).

5. A condensation clothes dryer according to claim 4,
characterised in that
the NTC resistors (NTC1,NTC2) limit the starting current with their cold resistance, and the parallel-connected, series-connected or partially parallel-connected PTC resistors (PTC1 - PTC4) determine the maximum current of the auxiliary resistance heater (W1, W2, W3) with their hot resistance.

6. A condensation clothes dryer according to one of claims 1-5,
characterised in that
the auxiliary resistance heater (W1) is installed in a flow heater (14) between the compressor (8) and the condenser (7).

7. A condensation clothes dryer according to one of claims 1 - 5,
characterised in that
the auxiliary resistance heater (W2) is installed in a bypass (15) of the condenser (7).

8. A condensation clothes dryer according to one of claims 1 - 5,
characterised in that
the auxiliary resistance heater (W3) is a thermally conductive, indirectly heating component mounted or installed on or in one or more locations of the condenser (7).

9. A condensation clothes dryer according to one of claims 1-8,
characterised in that
the maximum temperature of the PTC resistors (PTC1 - PTC4) of the auxiliary resistance heater is only slightly below the operating temperature of the heat pump.

10. A condensation clothes dryer according to one of claims 1 - 9,
characterised in that
the semiconductor resistors of the auxiliary resistance heater (W1, W2, W4) are designed as electrically connected plates and are between points (KK1, K1, K1', K2) of the resistance circuit designed as metal contact plates or metal cooling plates.

11. A condensation clothes dryer according to claims 4 and 10,
characterised in that
at least one upstream NTC resistor and one downstream PTC resistor thermally contact each other via the metal contact plates or metal cooling plates.

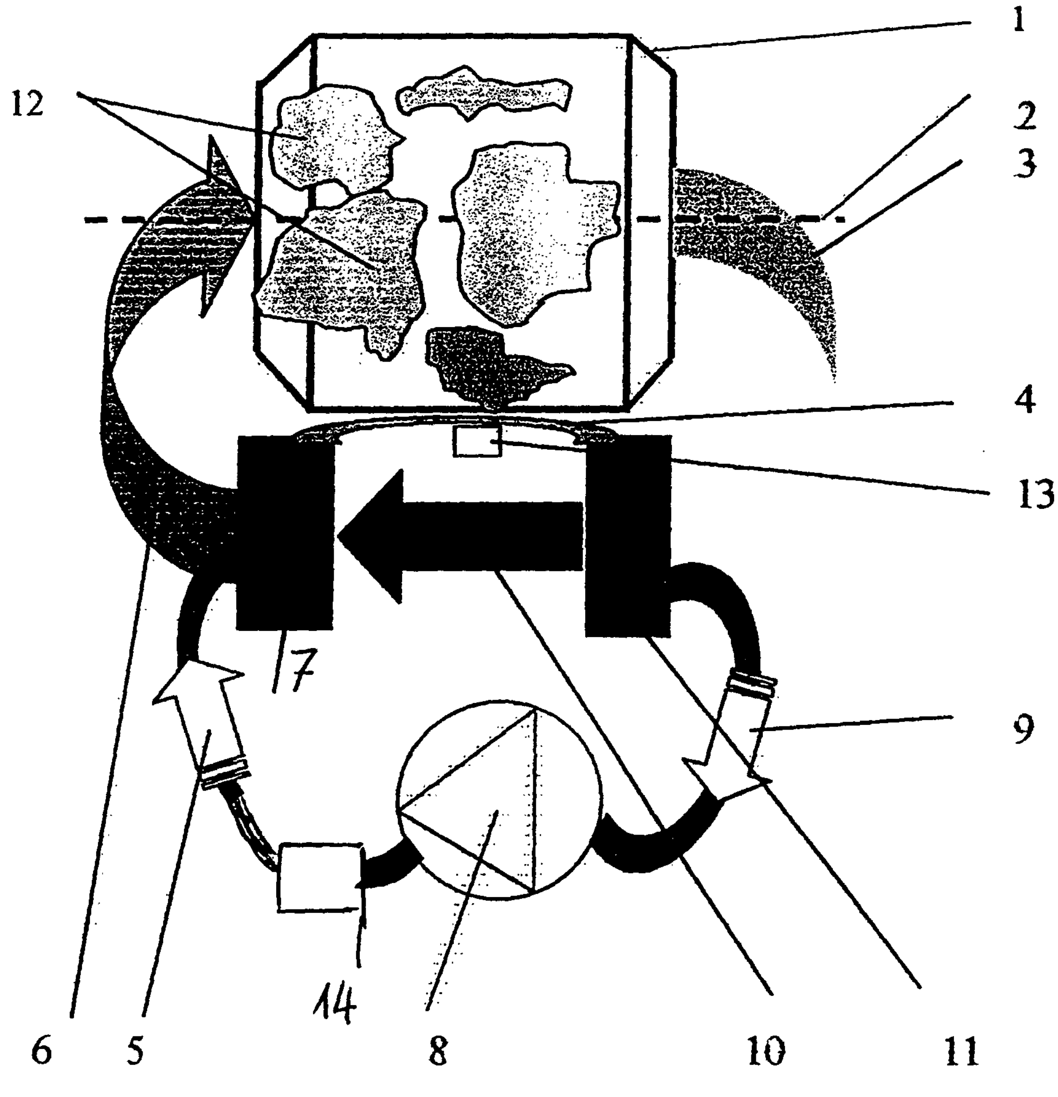

Fig. 1

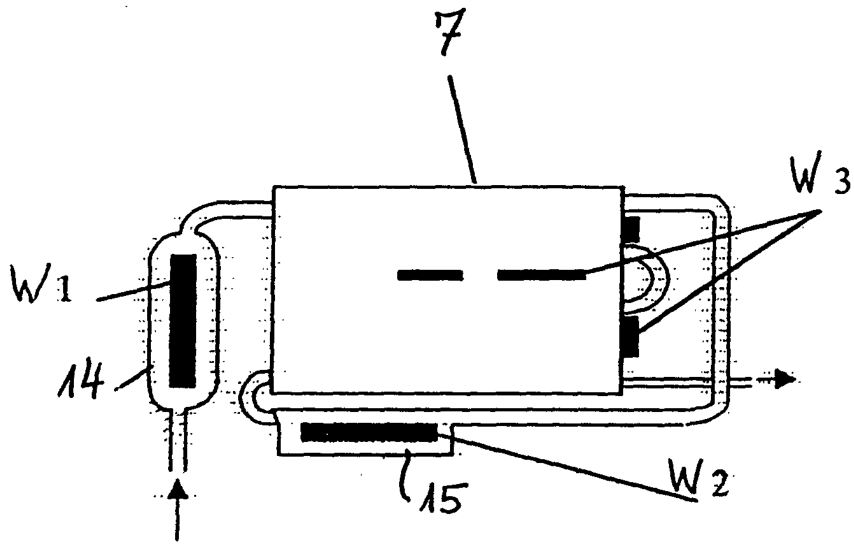

Fig.2

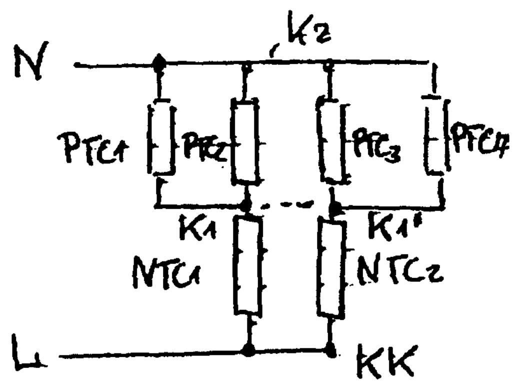

Fig. 3