

CLOTHS DRYER

Field of the Invention

5 The present invention relates to a cloths dryer such as a household cloths dryer, a household washing and drying machine having a washing function or the like.

Background of the Invention

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Fig. 5 shows a configuration of a conventional drum type washing and drying machine. Hereinafter, the configuration thereof will be described. As illustrated in Fig. 5, housing 1 has therein cylindrical water tub 3
15 elastically supported by a plurality of suspensions 2 for absorbing vibrations generated during a washing and a water-extracting operation. Rotatably installed in water tub 3 is horizontal shaft type cylindrical rotary drum 5 for accommodating therein objects to be dried (hereinafter,
20 referred to as "cloths"). Rotational shaft 6a is driven by motor 6 to rotate rotary drum 5.

An inner surface of rotary drum 5 is provided with a plurality of baffles (not shown) for agitating cloths, whereas a cylindrical wall of rotary drum 5 is provided with
25 a plurality of drum perforations 5a. Housing 1 has on its front surface opening 1a for loading/unloading cloths 4 and

door 7 for opening/closing opening 1a. Water tub 3 and rotary drum 5 have on front surfaces thereof openings 3a and 5b for loading/unloading cloths 4 as well, respectively. Opening 3a of water tub 3 is watertightly connected to opening 1a of housing 1 by bellows 8 made of rubber or the like. Further, water drain outlet 9 for draining washing water is provided on a bottom portion of water tub 3, and a leading end thereof communicates with the outside of the machine.

Blower 12 blows air to make it first pass through heater 13 to be heated by it to thereby generate a warm air stream that is to be flown into rotary drum 5 through air supply opening 14. The warm air for drying operation becomes humidified while passing through rotary drum 5 and the humid air water tub 3 and is dehumidified while passing through circulation duct 15. One end of circulation duct 15 is connected to air outlet 16 provided at a lower portion of water tub 3, whereas the other end thereof is connected to blower 12. Water supply valve 17 controls a water supply from water supply hose 18 connected to a tap or the like.

In the aforementioned configuration, a wash cycle is performed after door 7 is opened and then cloths and detergent are loaded into rotary drum 5. First of all, if water supply valve 17 supplies a specific amount of water into water tub 3 and rotary drum 5 by opening a water supply opening through which washing water is supplied, rotary drum

5 is driven to rotate by driving motor 6 which in turn rotates the cloths in forward and reverse directions to be cleaned. After a specific period of time, driving motor 6 is stopped and, also water drain valve 10 is opened. Accordingly, soiled water is drained from rotary drum 5 and water tub 3 to outside the machine via water drain hose 11. Next, water is supplied into water tub 3 and rotary drum 5 again to execute a rinsing operation. When the rinsing operation is completed, soiled water is drained by opening water drain valve 10 and, then, cloths 4 are water-extracted by centrifugal force generated by rotating rotary drum 5 with driving motor 6 at a high speed.

After the wash cycle is completed, a dry cycle is commenced. The following is a description of the drying operation. Air blown by blower 12 in a direction indicated by an arrow "a" is heated by heater 13 to form a warm air stream, while cloths 4 are agitated by rotating rotary drum 5 with driving motor 6 at a low speed. The warm air stream is flown into rotary drum 5 through air supply opening 14 and then absorbs moisture from cloths 4 therein. Next, the humid warm air passes through water tub 3 via drum perforations 5a of rotary drum 5 and then reaches circulation duct 15 via air outlet 16.

At this time, since a water supply opening for supplying cooling water is opened by water supply valve 17, the cooling water is injected into circulation duct 15.

Under this condition, when the warm air containing moisture from cloths 4 passes through circulation duct 15, it is cooled through a heat exchange with the cooling water therein. Accordingly, the moisture is condensed, and then
5 the dehumidified warm air returns to blower 12 as indicated by an arrow "b". Meanwhile, the cooling water and the condensed water are drained to outside the machine via water drain valve 10. Likewise, cloths 4 in rotary drum 5 can be dried by circulating warm air along a circulation path
10 including blower 12, heater 13, air supply opening 14, rotary drum 5, water tub 3, air outlet 16 and circulation duct 15.

The conventional configuration is energy-inefficient in that heat used for drying cloths 4 is discharged to
15 outside by a heat radiation from the cooling water of circulation duct 15 or from housing 1 without being reused.

In order to overcome such drawback, there has been suggested a clothes dryer having a heat pump in which a compressor for compressing a coolant, a heat radiator for
20 radiating heat from the compressed coolant, a pressure regulating valve for depressurizing the high-pressure coolant and a heat absorber for allowing the depressurized low-pressure coolant to absorb heat from an environment are connected by a conduit so that the coolant can circulate
25 therethrough (see, e.g., Japanese Patent Laid-open Publication No. H7-178289). In such configuration, since a

heat amount discharged to the outside can be collected, cloths can be dried in an energy-efficient way.

However, in comparison with the heater type cloths dryer and the washing and drying machine shown in Fig. 5, the cloths dryer and the washing and drying machine having a heat pump require a large number of components for the aforementioned heat pump in which the compressor, the heat radiator, the pressure regulating valve and the heat absorber are connected in a pipeline, e.g., a copper pipe or the like, an air duct for allowing air to flow in the heat absorber and the heat radiator or the like. In order to install such large number of components, it is required to enlarge an exterior dimension of the housing or compactly accommodate the components by efficiently using an empty space in the housing.

Summary of the Invention

It is, therefore, an object of the present invention to compactly accommodate a heat pump and an air duct structure in an unused empty space of a housing.

In accordance with the present invention, there is provided a cloths dryer including: a drying chamber for accommodating cloths therein; a heat pump in which a compressor for compressing a coolant, a heat radiator for radiating heat of the compressed coolant, a pressure

regulating valve for depressurizing the high-pressure coolant and a heat absorber for allowing the depressurized low-pressure coolant to absorb heat from an environment thereof are connected in a pipeline so that the coolant
5 circulates therethrough; and a heat exchange unit for allowing drying air from a blower to flow from the heat absorber to the heat radiator and then to the drying chamber, wherein the heat absorber has a first air inlet surface for introducing the drying air therethrough and a first air
10 outlet surface through which the air passing through the first air inlet surface is discharged to outside of the heat absorber, the heat radiator has a second air inlet surface for introducing the air from the heat absorber therethrough and a second air outlet surface through which the air
15 passing through the second air inlet surface is discharged to outside of the heat radiator, and the first air outlet surface of the heat absorber is facing the second air inlet surface of the heat radiator in the heat exchange unit at an acute angle therebetween, and wherein the drying air flows
20 from the first air inlet surface of the heat absorber to the first air outlet surface thereof, and from the second air inlet surface of the heat radiator to the second air outlet surface thereof and, then, the drying air out of the heat radiator substantially horizontally flows along a horizontal
25 air duct formed above the heat absorber and the heat radiator.

Accordingly, it is possible to scale down the heat exchange unit for accommodating the heat absorber and the heat radiator and further to achieve an overall compact size despite a large capacity of a water storage for collecting water condensed by a cooling process in the heat absorber.

Brief Description of the Drawings

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments, given in conjunction with the accompanying drawings, in which:

Fig. 1 shows a sectional view of a washing and drying machine in accordance with a preferred embodiment of the present invention;

Fig. 2 describes a rear view of the washing and drying machine;

Fig. 3 provides a schematic system diagram of the washing and drying machine;

Fig. 4 illustrates a sectional view of principal parts of a washing and drying machine in accordance with a second preferred embodiment of the present invention; and

Fig. 5 presents a sectional view of a conventional washing and drying machine.

Detailed Description of the Preferred Embodiment

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. Detailed explanations of parts identical or similar to those described in the prior art will be omitted, and the like reference numerals will be used therefor. Further, the present invention is not limited to those preferred embodiments.

10 (First preferred embodiment)

Fig. 1 shows a cross sectional view of a washing and drying machine in accordance with a first preferred embodiment of the present invention; Fig. 2 describes a rear view thereof; and Fig. 3 provides a schematic system diagram illustrating a configuration of a heat pump in accordance with the first preferred embodiment of the present invention and an air flow for drying operation.

As shown in Fig. 1, housing 1 has therein cylindrical water tub 3 elastically supported by a plurality of suspensions 2 for absorbing vibrations generated during a washing and a water-extracting operation. Cylindrical rotary drum 5 having a bottom portion for accommodating cloths 4 is rotatably installed in water tub 3 and driven to rotate by driving motor 6. Further, rotary drum 5 having a plurality of drum perforations 5a on its cylindrical peripheral wall serves as a washing chamber during a wash

cycle and as a drying chamber during a dry cycle. By inclining a direction of a rotational axis of rotary drum 5 at an angle of about 20 to 30 degrees from a horizontal direction, water tub 3 and rotary drum 5 in housing 1 are declined from their front surfaces toward their rear surfaces.

Housing 1 has on its front surface opening 1a for loading/unloading cloths 4 therethrough and door 7 for opening/closing opening 1a. Water tub 3 and rotary drum 5 have in front surfaces thereof openings 3a and 5b for loading/unloading cloths 4 therethrough, respectively. Opening 3a of water tub 3 is watertightly connected to opening 1a of housing 1 by bellows 8 formed of rubber or the like. Further, water drain outlet 9 for draining washing water is provided on a bottom portion of water tub 3, so that soiled washing water can be drained to outside the machine via water drain hose 11 connected to water drain valve 10.

Blower 12 forming a blower unit is installed between air outlet 16 provided at an upper portion of water tub 3 and air exhaust duct 20 communicating with air outlet 16. Accordingly, blower 12 can suck air in rotary drum 5 and water tub 3 through air outlet 16 and then send the sucked air in a direction indicated by an arrow "c". Further, as can be seen from the rear view of Fig. 2, air supply duct 21 provided on an outer surface of water tub 3 communicates

with air supply opening 14 of water tub 3.

Provided below a bottom of water tub 3 is heat exchange unit 31 for accommodating therein heat absorber 30 and heat radiator 32 forming a heat pump. Heat absorber 30
5 has first air inlet surface 30a for introducing a drying air therethrough and first air outlet surface 30b through which an air passing through first air inlet surface 30a is discharged to outside of heat absorber 30. Heat radiator 32 has second air inlet surface 32a for introducing the air
10 from heat absorber 30 therethrough and second air outlet surface 32b through which an air passing through second air inlet surface 32a is discharged to outside of heat radiator 32. Further, heat absorber 30 and heat radiator 32 are formed of fin and tube type heat exchangers for performing a
15 heat exchange operation between a coolant and air for drying operation in the heat pump. Herein, air outlet surface 30b faces air inlet surface 32a at an acute angle therebetween and, also, outward directions of normal lines of air outlet surface 30b and air inlet surface 32a are declined with
20 respect to a horizontal direction. Accordingly, a dropping of water condensed in heat absorber 30 is facilitated, and therefore the condensed water can be effectively collected in a water storage chamber 36 formed thereunder.

Heat exchange unit 31 is configured such that drying
25 air flows from the top of heat absorber 30 (first air inlet surface 30a) to the bottom thereof (first air outlet surface

30b) but flows from the bottom of heat radiator 32(second air inlet surface 32a) to the top thereof(second air outlet surface 32b), as indicated by arrows "d". The air passing through heat radiator 32 is elevated and then horizontally moves along horizontal air duct 31a formed above heat exchange unit 31. Next, the air flows along air supply duct 21 in a direction indicated by arrow "e" shown in Fig. 2 and then is introduced into water tub 3 through air supply opening 14.

10 An outlet of horizontal air duct 31a airtightly communicates with an inlet of air supply duct 21 by air supply hose 32 made of an extensible and contractible bellows shaped flexible material. Similarly, air outlet 16 and air exhaust duct 20 airtightly communicate with each other by air exhaust hose 34 made of an extensible and contractible bellows shaped flexible material. The purpose of such configuration is to prevent a vibration of water tub 3 supported by vibration absorbing suspensions 2 from being directly transferred to the heat pump accommodated in heat exchange unit 31 and at the same time form a path for allowing a watertight flow of fluid such as air or the like.

20 Installed in the middle of a path of air exhaust duct 20 is detachable lint filter 35 serving as a filtering unit for removing foreign substances included in air, lint filter 25 35 being formed of a synthetic fiber net or the like. With the use of lint filter 35, foreign substances are prevented

from intruding into the heat pump including blower 12, heat absorber 30 and heat radiator 32 or the like, so that a functional deterioration thereof can also be prevented.

5 Provided under heat absorber 30 in heat exchange unit
31 is water storage chamber 36 for collecting condensed
water produced by cooling air passing through heat absorber
30. Therefore, a capacity of water storage chamber 36 can
increase despite a scaling down of heat exchange unit 31.
Water drain pump 37 formed of a centrifugal pump is attached
10 to water storage chamber 36, and an outlet of water drain
pump 37 is connected to water drain hole 39 provided at an
upper rear portion of water tub 3 via pump drain pipe 38.
Accordingly, the condensed water collected in water storage
chamber 36 is introduced into water tub 3 and then
15 discharged to outside the machine via water drain outlet 9,
water drain valve 10 and water drain hose 11. Since water
drain hole 39 is provided at an upper portion of water tub 3,
even if the amount of water exceeding a specific level is
supplied into water tub 3, washing water does not flow
20 backward into water storage chamber 36. Further, since
washing water does not intrude into pump drain pipe 38,
contaminants in the washing water will not be attached to an
inner portion of the pipe, resulting in no poor drainage.

 A water storage capacity of water storage chamber 36
25 is configured to be greater than an inner capacity of pump
drain pipe 38. Accordingly, even though pump 37 stops after

completion of water drainage, it is possible to prevent a backward flow of water remaining in pump drain pipe 38 from causing an overflow of condensed water from water storage chamber 36.

5 As illustrated in Fig. 2, compressor 41 forming the heat pump is installed near heat exchange unit 31 side by side under horizontal air duct in housing 1. Compressor case 45 accommodates therein compressor 41.

10 As described above, heat absorber 30 and heat radiator 32 are installed in heat exchange unit 31 such that they face each other; water storage chamber 36 is formed in a space under heat absorber 30; horizontal air duct is horizontally provided above heat exchange unit 31; and compressor 41 is positioned near heat exchange unit 31 under
15 horizontal air duct. With such arrangement, those components can be compactly configured as a unit, thereby enabling to effectively accommodate such components in a space under a rear portion of housing 1.

20 Referring to Fig. 3, there is illustrated an air circulation. In the air circulation, drying air from blower 12 is blown into water tub 3 and rotary drum 5 through air supply duct 21 and air supply opening 14. Next, after passing through cloths 4 in rotary drum 5, the air is discharged through air outlet 16 and then passes through
25 heat absorber 30 and heat radiator 32 in heat exchange unit 31 via air exhaust duct 20. Thereafter, the air returns to

air supply duct 21.

Further, the heat pump includes: compressor 41; heat radiator 32 for radiating heat of the compressed coolant; pressure regulating valve 42 formed of a throttle valve, a capillary tube or the like for depressurizing the high-pressure coolant; heat absorber 30 for allowing the depressurized low-pressure coolant to absorb heat from an environment thereof; and pipeline 43 where the coolant circulates in the heat pump. The coolant circulates in a direction indicated by arrows 44, thereby establishing a heat pump cycle.

Furthermore, controller 48 having a microcomputer or the like controls operations of driving motor 6, water drain valve 10, blower 12, compressor 41 or the like, thereby controlling a series of cycles including washing, water-extraction and drying in sequence.

The following is an explanation of an operation of the washing and drying machine configured as described above. In a wash cycle, detergent is added into rotary drum 5 in a state where water drain valve 10 is closed and water is supplied into water tub 3 to a specific water level. Next, rotary drum 5 loaded with cloths 4 and water is driven to rotate by driving motor 6, thereby washing cloths 4.

Also in a rinse cycle following the wash cycle, water is supplied into water tub 3 similarly to as in the wash cycle and, then, rotary drum 5 is driven to rotate, thereby

rinsing cloths 4. In a water-extraction cycle, soiled water in water tub 3 is drained to outside the machine by opening water drain valve 10 and, then, rotary drum 5 accommodating therein cloths 4 is driven to rotate by driving motor 6 at a high speed, thereby performing a centrifugal water-extraction.

In a dry cycle, the coolant is compressed by operating compressor 41 of the heat pump and then passes through heat radiator 32, pressure regulating valve 42 and heat absorber 30 due to the compression pressure. Herein, heat radiator 32 radiates heat due to the compression of the coolant, whereas heat absorber 30 absorbs heat by using the low-pressure coolant depressurized by pressure regulating valve 42. At this time, if blower 12 is driven, warm air heated by the heat radiation of heat radiator 32 is blown through air supply duct 21 to be flown into water tub 3 and rotary drum 5 through water supply opening 14 and drum perforations 5a.

Rotary drum 5 is driven to rotate by driving motor 6, so that cloths 4 are tossed up and down. The warm air blown into rotary drum 5 becomes humidified by absorbing moisture while passing through cloths 4 being tossed up and down. The humid air is discharged from water tub 3 through air outlet 16 and then passes through lint filter 35 where foreign substances such as lint or the like are filtered out. Next, the humid air, after getting rid of foreign substances

such as lint or the like at lint filter 35, reaches heat exchange unit 31 via air exhaust duct 20. Thereafter, the humid warm air is dehumidified by losing sensible heat and latent heat while passing through heat absorber 30 to
5 thereby be separated into dry air and condensed water. The dry air becomes warmed while being reheated by heat radiator 32. Then, the warm air circulates to blower 12 again via air supply duct 21, air supply opening 14, rotary drum 5 and cloths 4.

10 The condensed water separated by heat absorber 30 is collected in water storage chamber 36 provided in a lower portion of the heat exchange unit 31. By regularly operating water drain pump 37, the collected water is supplied into water tub 3 via pump drain pipe 38 and then
15 discharged to outside the machine via water outlet 9, water drain valve 10 and water drain hose 11. In this case, the air from blower 12 repeats the aforementioned circulation, thereby increasing a pressure inside heat exchange unit 31, e.g., a pressure inside heat absorber 30, water storage
20 chamber 36 or the like. Accordingly, water drain pump 37 can more efficiently drain the condensed water from water storage chamber 36.

As described above, in case the heat pump is employed, heat that has been conventionally discharged to outside the
25 machine can be collected by heat absorber 30 and then radiated by heat radiator 32. Since such heat is reusable,

it is possible to shorten a drying time and use the energy more efficiently.

5 The first preferred embodiment provides a configuration in which the heat pump is installed at a washing and drying machine capable of automatically performing the wash cycle to the dry cycle. However, the same effects can be achieved by a configuration in which the heat pump is installed at a cloths dryer exclusively having a drying function only.

10 Moreover, in the first preferred embodiment, a discharging side of water drain pump 37 is connected to water drain hole 39 formed at an upper rear portion of water tub 3 via pump drain pipe 38. However, since it is merely an example of a simple drainage configuration, the
15 discharging side thereof is not necessarily connected to water drain hole 39 of water tub 5. For example, in case pump drain pipe 38 is connected to water outlet 9 or water drain valve 10 such that a part of pump drain pipe 38 is lifted above a maximum water level h (shown in Fig. 1) of
20 water tub 3, even if the amount of water exceeding a specific level is supplied into water tub 3, washing water does not flow backward into water storage chamber 36. However, in case, washing water intrudes into pump drain pipe 38 through water drain hole 9, impurities to be drained
25 may flow backward. To that end, a filter for preventing an intrusion of impurities can be provided together with a

backflow prevention valve or the like. Consequently, there is no need to connect pump drain pipe 38 to water tub 3 subject to a vibration or the like while in operation, resulting in a technically simple configuration.

5 (Second preferred embodiment)

Fig. 4 illustrates a cross sectional view of heat exchange unit 31 in accordance with a second preferred embodiment of the present invention. Detailed explanations of parts identical or similar to those described in the first preferred embodiment will be omitted, and the like reference numerals will be used therefor.

A plurality of detection electrodes 54 serving as a water volume detector for detecting a water volume in the water storage chamber 36 are attached inside water storage chamber 36 in accordance with the second preferred embodiment and also electrically connected to controller 48 by respective lead lines 55 watertightly connected thereto. Controller 48 monitors an electrical resistance between detection electrodes 54. If a water level in water storage chamber 36 increases, detection electrodes 54 become contacted with water so that the electrical resistance between detection electrodes 54 is changed. Accordingly, it is possible to detect a water storage condition.

In case the water level in water storage chamber 36 increases despite the driving of water drain pump 37, controller 48 determines that a breakdown of water drain

pump 37, a clog of pump drain pipe 38 or the like has taken place. In such case, a heat pumping operation, a heat exchanging operation and the like are suspended by stopping compressor 41 and blower 12, thereby preventing an overflow
5 of water in water storage 36.

As described above, the cloths dryer in accordance with the present invention can compactly accommodate therein a heat pump and an air duct configuration in a rear lower portion of a drying chamber, i.e., an unused empty space of
10 a housing, thereby enabling to achieve an energy-efficient household washing and drying machine or dryer.

While the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and
15 modification may be made without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. A cloths dryer comprising:
 - a drying chamber for accommodating cloths therein;
 - 5 a heat pump in which a compressor for compressing a coolant, a heat radiator for radiating heat of the compressed coolant, a pressure regulating valve for depressurizing the high-pressure coolant and a heat absorber for allowing the depressurized low-pressure coolant to
 - 10 absorb heat from an environment thereof are connected in a pipeline so that the coolant circulates therethrough; and
 - a heat exchange unit for allowing drying air from a blower to flow from the heat absorber to the heat radiator and then to the drying chamber,
 - 15 wherein the heat absorber has a first air inlet surface for introducing the drying air therethrough and a first air outlet surface through which the air passing through the first air inlet surface is discharged to outside of the heat absorber, the heat radiator has a second air
 - 20 inlet surface for introducing the air from the heat absorber therethrough and a second air outlet surface through which the air passing through the second air inlet surface is discharged to outside of the heat radiator, and the first air outlet surface of the heat absorber is facing the second
 - 25 air inlet surface of the heat radiator in the heat exchange unit at an acute angle therebetween, and wherein the drying

air flows from the first air inlet surface of the heat absorber to the first air outlet surface thereof, and from the second air inlet surface of the heat radiator to the second air outlet surface thereof and, then, the drying air
5 out of the heat radiator substantially horizontally flows along a horizontal air duct formed above the heat absorber and the heat radiator.

2. The cloths dryer of claim 1, wherein the compressor is
10 installed under the horizontal air duct formed above the heat exchange unit.

3. The cloths dryer of claim 1 or 2, wherein an outward direction of a normal line of the first air outlet surface
15 of the heat absorber is declined with respect to a horizontal direction.

4. The cloths dryer of any one of claims 1 to 3, further comprising: a water storage chamber for collecting condensed
20 water, the chamber being provided in the heat exchange unit formed under the heat absorber of the heat pump.

5. The cloths dryer of claim 4, further comprising:
a water tub for reserving washing water therein in a
25 wash cycle, the water tub including the drying chamber;
a pump drain pipe communicating with the water storage

chamber, for draining the condensed water collected in the water storage chamber; and

5 a water drain pump provided between ends of the pump drain pipe, for sucking the stored condensed water, wherein a part of the pump drain pipe is provided above a maximum water level of the water tub.

6. The cloths dryer of claim 5, wherein the water storage chamber is designed such that a water storage volume thereof
10 is greater than a water volume collected in a pump drain conduit connected to an outlet of the water drain pump.

7. The cloths dryer of any one of claims 4 to 6, wherein the blower for blowing the drying air is provided at an
15 upstream side of the heat absorber in an air duct for connecting the drying chamber and the heat exchange unit.

8. The cloths dryer of any one of claims 4 to 7, wherein the water storage chamber formed under the heat absorber has
20 therein a water volume detector for detecting a water volume in the water storage chamber.