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(54) IRONING DEVICE WITH ENERGY RECUPERATION

(57) The invention relates to an ironing device for ironing laundry to be ironed, comprising:
- a heated ironing bed, preferably formed between at least one ironing roller and at least one trough;
- a supply conveyor bed for conveying the laundry to be ironed to the ironing bed;
- a discharge conveyor bed for conveying the laundry to be ironed away from the ironing bed;
- a preheater for preheating the laundry to be ironed on the supply conveyor bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed on the discharge conveyor bed; and
- a heat transfer device for transferring heat from the heat recovery device to the preheater.

The invention furthermore relates to a method for ironing laundry to be ironed and an energy-saving system for an ironing device.

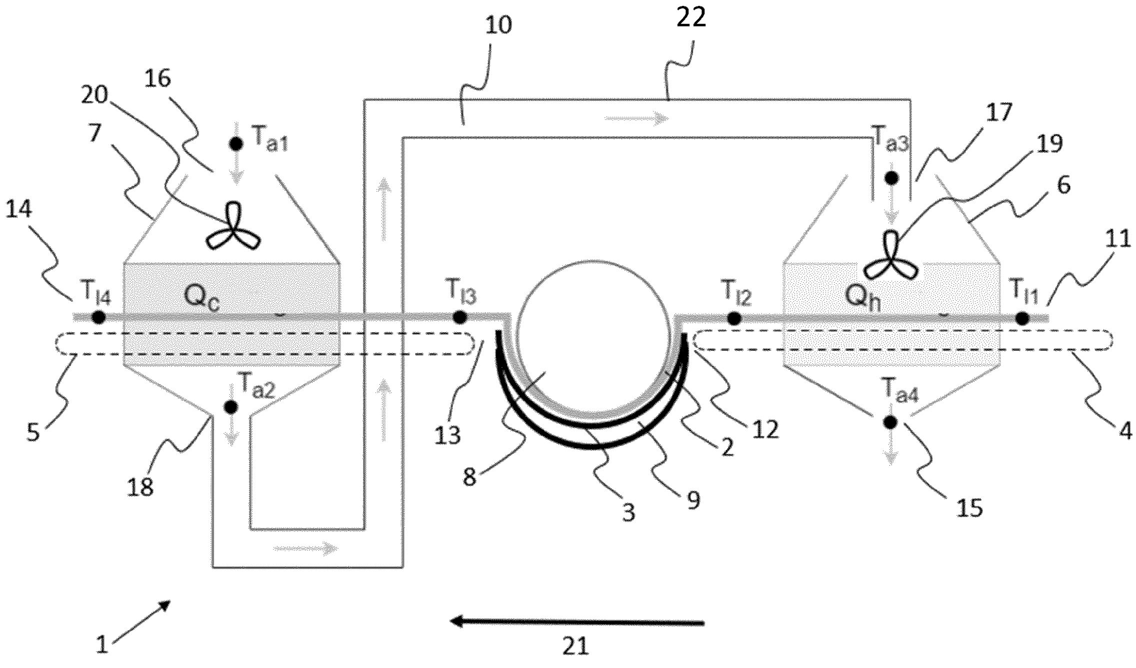


Fig. 1

Description

TECHNICAL FIELD

[0001] The invention relates to an ironing device for ironing laundry to be ironed. In particular, the invention relates to an industrial ironing device. The invention provides an energy-efficient ironing device, and/or provides a method for increasing the capacity of existing ironing devices.

TECHNOLOGICAL BACKGROUND OF THE INVENTION

[0002] Ironing devices and in particular industrial ironing devices for ironing laundry to be ironed use considerable amounts of energy and heat. In an ironing device, an ironing bed has to be kept at a sufficiently high temperature, and heat has to be transferred to the laundry to be ironed not only for the ironing itself, but also for evaporating water in the laundry to be ironed. In order to render the sector more environmentally friendly and to be able to reduce costs, there is a need to make ironing devices more energy efficient. There is a need to increase the capacity of both existing and new ironing devices. There is a need for ironing devices of greater capacity for a certain amount of consumed energy.

SUMMARY

[0003] In order to meet the above needs, the invention provides an ironing device for ironing laundry to be ironed, comprising:

- a heated ironing bed, preferably formed between at least one ironing roller and at least one trough;
- a supply conveyor bed for conveying the laundry to be ironed to the ironing bed;
- a discharge conveyor bed for conveying the laundry to be ironed away from the ironing bed;
- a preheater for preheating the laundry to be ironed on the supply conveyor bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed on the discharge conveyor bed; and
- a heat transfer device for transferring heat from the heat recovery device to the preheater.

[0004] In one embodiment, the heat recovery device accommodates an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the discharge conveyor bed.
[0005] In one embodiment, the preheater accommodates an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed.
[0006] In one embodiment, the heat transfer device comprises an air duct which supplies to the preheater at least some of the air stream or the gas stream over and/or through the laundry to be ironed from the heat recovery device.
[0007] The invention also provides an ironing device (1) for ironing laundry to be ironed (2), comprising:

- a heated ironing bed (3), preferably formed between at least one ironing roller (8) and at least one trough (9);
- a supply conveyor bed (4) for conveying the laundry to be ironed (2) to the ironing bed (3);
- a discharge conveyor bed (5) for conveying the laundry to be ironed (2) away from the ironing bed (3);
- a preheater (6) for preheating the laundry to be ironed (2) on the supply conveyor bed (4);
- a heat recovery device (7) for recovering heat emanating from the laundry to be ironed (2) on the discharge conveyor bed (5);
- a heat transfer device (22) for transferring heat (Q) from the heat recovery device (7) to the preheater (6);

  wherein the heat recovery device (7) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the discharge conveyor bed (5);
  wherein the preheater (6) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the supply conveyor bed (4); and
  wherein the heat transfer device (22) comprises an air duct configured for supplying to the preheater (6) at least some of the air stream or the gas stream (10) over and/or through the laundry to be ironed (2) from the heat recovery device (7).

[0008] In one embodiment, the heat recovery device comprises a ventilator which passes air or gas over and/or through the laundry to be ironed, preferably creating an air stream or gas stream in the process.
[0009] In one embodiment, the trough is heated, preferably heated by gas, electricity or steam.

[0010] In one embodiment, the supply conveyor bed and/or the discharge conveyor bed are permeable to air or gas.
[0011] In one embodiment, the temperature of the ironing bed is at least 120°C, preferably at least 130°C, preferably at least 140°C, preferably at least 150°C, preferably at least 160°C, preferably at least 165°C, preferably at least 170°C.
[0012] In one embodiment, a sealing is provided between the preheater and the supply conveyor bed.
[0013] In one embodiment, a sealing is provided between the heat recovery device and the discharge conveyor bed.
[0014] The invention provides a method for ironing laundry to be ironed, comprising the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b);

wherein the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a).
[0015] In one embodiment, preheating in step a) causes the temperature of the laundry to be ironed to rise by at least 3°C, preferably at least 5°C, preferably at least 7°C, preferably at least 10°C, preferably at least 13°C, preferably at least 15°C compared to room temperature.
[0016] In one embodiment, heat is recovered in step c) by a transfer of heat from the laundry to be ironed to an air stream or gas stream.
[0017] In one embodiment, the laundry to be ironed is preheated in step a) by a transfer of heat from an air stream or gas stream to the laundry to be ironed.
[0018] The invention also provides a method for ironing laundry to be ironed, comprising the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b), wherein heat is recovered by a transfer of heat from the laundry to be ironed to an air stream or gas stream;

wherein at least some of the air stream or the gas stream obtained in step c) is supplied during preheating in step a); and
wherein the laundry to be ironed is preheated in step a) by a transfer of heat from the supplied air stream or gas stream to the laundry to be ironed.

[0019] In one embodiment, the method for ironing laundry to be ironed comprises the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b), wherein heat is recovered by heat transfer from the laundry to be ironed to an air stream or gas stream;

wherein the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a);
wherein at least some of the air stream or the gas stream obtained in step c) is supplied during the preheating in step a); and
wherein the laundry to be ironed is preheated in step a) by heat transfer from the supplied air stream or gas stream to the laundry to be ironed.

[0020] The invention provides in an energy-saving system for an ironing device, wherein the ironing device comprises a heated ironing bed; wherein the energy-saving system comprises the following:

- a preheater, suitable for preheating laundry to be ironed before the laundry to be ironed enters the heated ironing bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed after the laundry to be ironed has left the heated ironing bed;
- a heat transfer device for transferring heat from the heat recovery device to the preheater.

[0021] The invention also provides an energy-saving system for an ironing device, wherein the ironing device comprises a heated ironing bed;
wherein the energy-saving system comprises the following:

- a preheater, suitable for preheating laundry to be ironed before the laundry to be ironed enters the heated ironing bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed after the laundry to be ironed has left the heated ironing bed;
- a heat transfer device for transferring heat from the heat recovery device to the preheater;

wherein the heat recovery device is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the discharge conveyor bed;
wherein the preheater is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed; and wherein the heat transfer device comprises an air duct configured for supplying to the preheater at least some of the air stream or the gas stream over and/or through the laundry to be ironed from the heat recovery device.

DESCRIPTION OF THE FIGURES

[0022]

Fig. 1 illustrates an outline sketch of an ironing device according to an embodiment of the invention.

Fig. 2 illustrates an outline sketch of an ironing device according to an embodiment of the invention.

Fig. 3 illustrates the effect of the linear density of the yarns (Tex) on T_{a1}, T_{a2}, T_{a3}, T_{a4}, T_{l1}, T_{l2}, T_{l3}, T_{l4}, Q_c and Q_h according to a model based on the embodiment illustrated in Fig. 1.

Fig. 4 illustrates the effect of the yarn density (TC) on T_{a1}, T_{a2}, T_{a3}, T_{a4}, T_{l1}, T_{l2}, T_{l3}, T_{l4}, Q_c and Q_h according to a model based on the embodiment illustrated in Fig. 1.

Fig. 5 illustrates the effect of the flow rate of the air stream on T_{a1}, T_{a2}, T_{a3}, T_{a4}, T_{l1}, T_{l2}, T_{l3}, T_{l4}, Q_c and Q_h according to a model based on the embodiment illustrated in Fig. 1.

DETAILED DESCRIPTION

[0023] As used below in this text, the singular forms "a", "an", "the" include both the singular and the plural, unless the context clearly indicates otherwise.

[0024] The terms "comprise", "comprises" as used below are synonymous with "including", "include" or "contain", "contains" and are inclusive or open and do not exclude additional unmentioned parts, elements or method steps. The terms "comprise", "comprises" include the term "contain".

[0025] The enumeration of numeric values by means of ranges of figures comprises all values and fractions in these ranges, as well as the cited end points.

[0026] The term "approximately" as used when referring to a measurable value, such as a parameter, an amount, a time period, and the like, is intended to include variations of +/- 10% or less, preferably +/-5% or less, more preferably +/-1% or less, and still more preferably +/-0.1% or less, of and from the specified value, in so far as the variations apply to the invention disclosed herein. It should be understood that the value to which the term "approximately" refers per se has also been disclosed.

[0027] All references cited in this description are hereby deemed to be incorporated in their entirety by way of reference.

[0028] Unless defined otherwise, all terms disclosed in the invention, including technical and scientific terms, have the meaning which a person skilled in the art usually gives them. For further guidance, definitions are included to further explain terms which are used in the description of the invention.

[0029] The invention provides an ironing device for ironing laundry to be ironed, comprising:

- a heated ironing bed, preferably formed between at least one ironing roller and at least one trough;
- a supply conveyor bed for conveying the laundry to be ironed to the ironing bed;
- a discharge conveyor bed for conveying the laundry to be ironed away from the ironing bed;
- a preheater for preheating the laundry to be ironed on the supply conveyor bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed on the discharge conveyor bed; and
- a heat transfer device for transferring heat from the heat recovery device to the preheater.

[0030] In the ironing bed, the laundry to be ironed has to be heated to a temperature above 100°C, typically above

120°C, preferably above 140°C, preferably above 160°C, such as 165°C. This temperature and the mechanical pressure exerted on the laundry to be ironed in the ironing bed ensure that creases in the laundry to be ironed disappear and that any water present in the laundry to be ironed evaporates. Because the ironing bed has to heat the laundry to be ironed and has to supply heat in order to evaporate the water, heat has to be provided in the ironing bed in order to keep the temperature of the ironing bed at the required level. The laundry to be ironed leaves the ironing bed at a temperature which is approximately equal to that of the ironing bed itself. The laundry to be ironed thus comprises a considerable amount of heat after it leaves the ironing bed. A part of this heat is extracted from the laundry to be ironed in the heat recovery device, as a result of which the laundry to be ironed cools down and the extracted heat is provided to the preheater by the heat transfer device and is used there to preheat the laundry to be ironed even before the laundry to be ironed enters the ironing bed. The result of this is that the ironing bed has to transfer less heat to the laundry to be ironed in order to reach the desired temperature and to evaporate the water. As a consequence thereof, the ironing roller is able to rotate more quickly, so that more laundry to be ironed can be processed per unit time. This results in efficient energy consumption and higher capacity. Another advantage of said ironing device is that less heat is dissipated to the environment, as a result of which the temperature in the space where the ironing device is installed is lowered. This may lead to a reduced need for ventilation or air-conditioning, which may result in additional energy savings.

[0031] The term "ironing device" as used herein refers to a device for ironing and/or supporting laundry to be ironed. Examples of ironing devices are ironing presses, roller iron steam presses and mangles, preferably a roller iron steam press. In one embodiment, the ironing device is an industrial ironing machine, preferably an industrial roller iron steam press.

[0032] The term "roller iron steam press" as used herein refers to an ironing machine which comprises at least one ironing roller. Preferably, a roller iron steam press comprises a trough and the ironing roller and trough form the ironing bed, between which the laundry to be ironed is passed. In one embodiment, the roller iron steam press comprises one, two or three ironing rollers.

[0033] In one embodiment, the trough may be pressed against the ironing roller via mechanical, hydraulic, pneumatic or electrical pressure. This makes it possible to achieve an optimum evaporation effect of the moisture in the laundry to be ironed. It also makes it possible to achieve an optimum ironing effect of the laundry to be ironed. It also makes it possible to achieve an optimum conveying effect of the laundry to be ironed between the ironing roller, which usually rotates, and the trough.

[0034] In one embodiment of the invention, the trough comprises several perforations distributed across the surface, or a part of the surface, of the trough. The perforations in the trough may form an arbitrary pattern. Preferably, the perforations in the trough form a regular pattern. More preferably, the perforations in the trough form a triangular, rectangular or diamond-shaped pattern across the surface, or a part of the surface, of the trough.

[0035] The term "ironing roller" includes the cylindrical ironing roller for an ironing device. In one embodiment, the ironing roller includes a sleeve.

[0036] In one embodiment, the ironing roller diameter is at least 200 mm, preferably at least 250 mm, preferably at least 300 mm, preferably at least 400 mm, preferably at least 500 mm, preferably at least 550 mm.

[0037] In one embodiment, the ironing roller diameter is at most 2000 mm, preferably at most 1600 mm, preferably at most 1300 mm, preferably at most 1200 mm, preferably at most 1000 mm, preferably at most 900 mm, preferably at most 800 mm.

[0038] In one embodiment, the ironing roller diameter is at least 200 mm to at most 2000 mm, preferably at least 200 mm to at most 1600 mm, preferably at least 200 mm to at most 1500 mm, preferably at least 250 mm to at most 1300 mm, preferably at least 300 mm to at most 1200 mm, preferably at least 400 mm to at most 1000 mm, preferably at least 500 mm to at most 900 mm, preferably at least 550 mm to at most 800 mm.

[0039] The term "laundry to be ironed" as used herein refers to any kind of fabric which can be introduced into an ironing device in order to be dried and/or ironed. Preferably, the laundry to be ironed has a minimum width of 1.0 m. Preferably, the laundry to be ironed has a maximum width of 3.3 m. Preferably, this laundry to be ironed comprises bed linen or table linen. The term "bed linen" comprises sheets, fitted sheets, undersheets, bedspreads, duvet covers and pillow covers. The term "table linen" comprises tablecloths and napkins. In one embodiment, the laundry to be ironed is flat material.

[0040] In one embodiment, the supply conveyor bed conveys the laundry to be ironed to the ironing bed, the laundry to be ironed is passed through the ironing bed by at least one rotating ironing roller, after which the laundry to be ironed is conveyed away by the discharge conveyor bed. In one embodiment, the supply conveyor bed and/or the discharge conveyor bed are formed by a conveyor belt or a conveyor chain.

[0041] In one embodiment, the heat recovery device accommodates an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the discharge conveyor bed. In one embodiment, the discharge conveyor bed runs through the heat recovery device.

[0042] In one embodiment, the heat recovery device is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the discharge conveyor bed.

[0043] In one embodiment, the preheater accommodates an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed. In one embodiment, the supply conveyor bed runs through the preheater.

[0044] In one embodiment, the preheater is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed.

[0045] In one embodiment, the heat transfer device comprises an air duct which supplies at least some of the air stream or the gas stream over and/or through the laundry to be ironed from the heat recovery device, to the preheater. In one embodiment, the heat transfer device is an air duct which connects the heat recovery device and the preheater to each other. In one embodiment, the transfer of heat from the heat recovery device to the preheater is achieved by means of an air stream or gas stream through the heat transfer device.

[0046] In one embodiment, the air stream or the gas stream in the heat transfer device has a flow rate corresponding to at least 0.5 m^3/kg laundry to be ironed (dry weight), preferably at least 1.0 m^3/kg laundry to be ironed (dry weight), preferably at least 2.5 m^3/kg laundry to be ironed (dry weight), preferably at least 3.0 m^3/kg laundry to be ironed (dry weight).

[0047] In one embodiment, the air stream or the gas stream in the heat transfer device has a flow rate corresponding to at most 10.0 m^3/kg laundry to be ironed (dry weight), preferably at most 7.0 m^3/kg laundry to be ironed (dry weight), preferably at most 5.0 m^3/kg laundry to be ironed (dry weight), preferably at most 4.0 m^3/kg laundry to be ironed (dry weight).

[0048] In one embodiment, the air stream or the gas stream in the heat transfer device has a flow rate corresponding to at least 0.5 to at most 10.0 m^3/kg laundry to be ironed (dry weight), preferably at least 1.0 to at most 7.0 m^3/kg laundry to be ironed (dry weight), preferably at least 2.5 to at most 5.0 m^3/kg laundry to be ironed (dry weight), preferably at least 3,0 to at most 4,0 m^3/kg laundry to be ironed (dry weight).

[0049] In one embodiment, the heat recovery device comprises a ventilator which passes air or gas over and/or through the laundry to be ironed. The air or gas which is passed over and/or through the laundry to be ironed will thus absorb heat emanating from the laundry to be ironed and will thus cause the temperature of the air or gas to rise.

[0050] In one embodiment, the ventilator in the heat recovery device is fitted on the other side of an air-permeable discharge conveyor bed, with respect to the heat transfer device, wherein the ventilator is configured to force air or gas through the air-permeable discharge conveyor bed.

[0051] In one embodiment, the heat recovery device comprises an air inlet, as a result of which gas or air can be drawn into the heat recovery device.

[0052] In one embodiment, the preheater comprises a ventilator which passes air or gas over and/or through the laundry to be ironed. Preferably, the air or gas emanates from the heat transfer device, preferably the air duct. Preferably, the air or gas emanates from the heat recovery device which is connected to the preheater via a heat transfer device. Due to the fact that the air or the gas from the heat transfer device or from the heat recovery device is hotter than the laundry to be ironed in the preheater, a transfer of heat takes place from the air or the gas to the laundry to be ironed, as a result of which the temperature of the laundry to be ironed rises.

[0053] In one embodiment, the preheater comprises an air outlet via which gas or air can be discharged from the preheater.

[0054] In one embodiment, the preheater comprises a preheater inlet via which air or gas enters the preheater. In one embodiment, the heat recovery device comprises a heat recovery outlet, via which air or gas leaves the heat recovery device. In one embodiment, the heat transfer device connects the heat recovery outlet to the preheater inlet.

[0055] In one embodiment, the invention provides an ironing device (1) for ironing laundry to be ironed (2), comprising:

- a heated ironing bed (3), preferably formed between at least one ironing roller (8) and at least one trough (9);
- a supply conveyor bed (4) for conveying the laundry to be ironed (2) to the ironing bed (3);
- a discharge conveyor bed (5) for conveying the laundry to be ironed (2) away from the ironing bed (3);
- a preheater (6) for preheating the laundry to be ironed (2) on the supply conveyor bed (4);
- a heat recovery device (7) for recovering heat emanating from the laundry to be ironed (2) on the discharge conveyor bed (5);
- a heat transfer device (22) for transferring heat (Q) from the heat recovery device (7) to the preheater (6);

  wherein the heat recovery device (7) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the discharge conveyor bed (5);
  wherein the preheater (6) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the supply conveyor bed (4); and
  wherein the heat transfer device (22) comprises an air duct, configured for supplying to the preheater (6) at least some of the air stream or the gas stream (10) over and/or through the laundry to be ironed (2) from the

heat recovery device (7).

[0056] In one embodiment, the heat transfer device comprises at least one ventilator which induces an air stream or gas stream from the heat recovery device to the preheater.

[0057] In one embodiment, the ironing bed is heated, preferably the heating of the ironing bed is effected by electricity, gas or steam, more preferably steam. Steam-heated ironing machines often require less maintenance. When the laundry to be ironed passes through the ironing bed, a transfer of heat will take place from the ironing bed to the laundry to be ironed. In one embodiment, some of the heat transferred from the ironing bed will be used for drying the laundry to be ironed.

[0058] In one embodiment, the trough is heated, preferably by gas or steam.

[0059] In one embodiment, the temperature of the ironing bed is at least 120°C, preferably at least 130°C, preferably at least 140°C, preferably at least 150°C, preferably at least 160°C, preferably at least 165°C, preferably at least 170°C.

[0060] In one embodiment, the supply conveyor bed and/or the discharge conveyor bed are air- or gas-permeable. This makes it possible for air or gas to be passed through the laundry to be ironed in the preheater or in the heat recovery device which makes efficient heat transfer between laundry to be ironed and air or gas possible.

[0061] In one embodiment, a sealing is provided between the preheater and the supply conveyor bed. Such a sealing preferably ensures that more of the gas or air heated in the heat recovery device is passed through or over the laundry to be ironed in the preheater, and that less heated gas or air is leaving the preheater before it has transferred its heat to the laundry to be ironed. In one embodiment, the sealing comprises glass fibre or Teflon.

[0062] In one embodiment, a sealing is provided between the heat recovery device and the discharge conveyor bed. This ensures that more air or gas which has been passed through or over the laundry to be ironed can be passed to the heat transfer device. In one embodiment, the sealing comprises glass fibre or Teflon.

[0063] In one embodiment, the ironing device comprises an ancillary heater which heats the air stream or the gas stream before it enters the heat recovery device. The ancillary heater may use residual heat to heat up the air stream or the gas stream, for example residual heat recovered from the chimney of a gas-fired ironing device. In one embodiment, the ancillary heater heats up the air stream by at least 2°C, at least 5°C, at least 7°C, at least 10°C, preferably compared to room temperature.

[0064] The invention provides a method for ironing laundry to be ironed, comprising the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b);

wherein the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a).

[0065] This method also ensures efficient use of energy, both with regard to the energy required for the ironing itself and the energy required to maintain the temperature in the space where ironing takes place.

[0066] In one embodiment, the preheating in step a) causes the temperature of the laundry to be ironed to rise by at least 3°C, preferably at least 5°C, preferably at least 7°C, preferably at least 10°C, preferably at least 13°C, preferably at least 15°C compared to room temperature, the room temperature preferably being 21°C.

[0067] In one embodiment, the heat recovery in step c) or in the heat recovery unit causes the temperature of the laundry to be ironed to drop by at least 3°C, preferably at least 5°C, preferably at least 7°C, preferably at least 10°C, preferably at least 13°C, preferably at least 15°C compared to the maximum temperature of the laundry to be ironed after leaving the ironing bed.

[0068] In one embodiment, the temperature of the laundry to be ironed after leaving the ironing bed, or after step b), is at least 120°C, preferably at least 130°C, preferably at least 140°C, preferably at least 150°C, preferably at least 160°C, preferably at least 165°C, preferably at least 170°C.

[0069] In one embodiment, the temperature of the laundry to be ironed after leaving the heat recovery unit, or after step c), is at most 160°C, preferably at most 150°C, preferably at most 140°C, preferably at most 130°C, preferably at most 120°C, preferably at most 110°C.

[0070] In one embodiment, heat is recovered in step c) by a transfer of heat from the laundry to be ironed to an air stream or gas stream.

[0071] In one embodiment, the laundry to be ironed is preheated in step a) by a transfer of heat from an air stream or gas stream to the laundry to be ironed.

[0072] In one embodiment, at least a part of the heated air stream generated in step c) is provided in step a).

[0073] In one embodiment, the invention provides a method for ironing laundry to be ironed, comprising the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b), in which heat is recovered by a transfer of heat from the laundry to be ironed to an air stream or gas stream;

wherein at least some of the air stream or the gas stream obtained in step c) is supplied during the preheating in step a); and

wherein the laundry to be ironed is preheated in step a) by a transfer of heat from the supplied air stream or gas stream to the laundry to be ironed.

[0074] In one embodiment, the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a).
[0075] The invention provides a method for ironing laundry to be ironed, comprising the following steps:
x) providing laundry to be ironed at a first temperature T_{l1};

a) preheating the laundry to be ironed, wherein the temperature of the laundry to be ironed rises from T_{l1} to a second temperature T_{l2} ;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed to a third temperature T_{l3};
c) recovering heat from the laundry to be ironed after step b), as a result of which the temperature of the laundry to be ironed drops to a fourth temperature T_{l4};

wherein the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a).
[0076] The invention provides a method for ironing laundry to be ironed, comprising the following steps:
x) providing laundry to be ironed at a first temperature T_{l1};

a) preheating the laundry to be ironed by passing an air stream or gas stream through or over the laundry to be ironed,

wherein the temperature of the laundry to be ironed rises from T_{l1} to a second temperature T_{l2}, and
wherein the temperature of the air stream or gas stream drops from T_{a3} to T_{a4};

b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed to a third temperature T_{l3};
c) recovering heat from the laundry to be ironed after step b) by passing an air stream or gas stream through or over the laundry to be ironed,

as a result of which the temperature of the laundry to be ironed drops to a fourth temperature T_{l4};, and
wherein the temperature of the air stream or gas stream rises from T_{a1} to T_{a2};

wherein the heat recovered in step c) is at least partly used for preheating the laundry to be ironed in step a).
[0077] In one embodiment, T_{l1} is equal to room temperature, preferably 21°C.
[0078] In one embodiment, T_{l2} is at least 3°C, preferably at least 5°C, preferably at least 7°C, preferably at least 10°C, preferably at least 13°C, preferably at least 15°C higher than T_{l1}.
[0079] In one embodiment, the method is carried out on an ironing device according to an embodiment described herein.
[0080] The invention provides an energy-saving system for an ironing device, wherein the ironing device comprises a heated ironing bed; wherein the energy-saving system comprises the following:

- a preheater, suitable for preheating laundry to be ironed before the laundry to be ironed enters the heated ironing bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed after the laundry to be ironed has left the heated ironing bed;
- a heat transfer device for transferring heat from the heat recovery device to the preheater.

[0081] In one embodiment, the invention provides an energy-saving system for an ironing device, wherein the ironing device comprises a heated ironing bed;
wherein the energy-saving system comprises the following:

- a preheater, suitable for preheating laundry to be ironed before the laundry to be ironed enters the heated ironing bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed after the laundry to be ironed has left the heated ironing bed;
- a heat transfer device for transferring heat from the heat recovery device to the preheater,

wherein the heat recovery device is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed , preferably the laundry to be ironed on the discharge conveyor bed,

wherein the preheater is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed, and

wherein the heat transfer device comprises an air duct, configured for supplying to the preheater at least some of the air stream or the gas stream over and/or through the laundry to be ironed from the heat recovery device.

[0082] Such an energy-saving system may be fitted to existing ironing devices, as a result of which the energy efficiency of the ironing device may increase. Fitting such an energy-saving system may also increase the capacity of the ironing device, since the ironing roller is able to rotate more quickly, as less heat is being extracted from the ironing roller, because the preheating stage already provides some of the heat for heating up the laundry to be ironed.

Examples

Example 1

[0083] **Fig. 1** shows an outline sketch of an ironing device according to an embodiment of the invention. The figure shows an ironing device (1), in which laundry to be ironed (2) is conveyed through the ironing device, along direction of travel (21). The laundry to be ironed (2) is taken to the ironing bed (3) via the supply conveyor bed (4), the ironing bed (3) being formed between an ironing roller (8) and a trough (9), preferably a heated trough. When the laundry to be ironed (2) passes through the ironing bed (3), the temperature of the laundry to be ironed (2) will increase considerably, preferably to a temperature T_{l3}. The laundry to be ironed (2) is conveyed away from the ironing bed (3) via the discharge conveyor bed (5).

[0084] The supply conveyor bed (4) conveys the laundry to be ironed (2) through the preheater (6); in the preheater an amount of heat (Q_h) is transferred from the air stream (10) to the laundry to be ironed (2), thus increasing the temperature of the laundry to be ironed (2) from T_{l1} - the temperature of the laundry to be ironed (2) before (11) the preheater (6) -, to T_{l2} - the temperature of the laundry to be ironed (2) after (12) the preheater (6) and before the ironing bed (3).

[0085] The discharge conveyor bed (5) conveys the laundry to be ironed (2) through the heat recovery device (7); in the heat recovery device (7) an amount of heat (Q_c) is transferred from the laundry to be ironed (2) to an air stream (10), thus decreasing the temperature of the laundry to be ironed (2) from T_{l3} - the temperature of the laundry to be ironed (2) after (13) the ironing bed (3) and before the heat recovery device (7) -, to T_{l4} - the temperature of the laundry to be ironed (2) after (12) the heat recovery device (7).

[0086] The heat recovery device (7) comprises an air inlet (16), as a result of which air of temperature T_{a1} is drawn in by a first ventilator (20). The ventilator (20) forces the drawn-in air through the laundry to be ironed (2) on the discharge conveyor bed (5), with the air stream (10) absorbing an amount of heat (Q_c) and the temperature of the air stream (10) rising to T_{a2}. The air stream (10) leaves the heat recovery device (7) via the heat recovery outlet (18) and is then passed to the preheater (6) via the heat transfer device (22) and the preheater inlet (17). The air stream (1) has a temperature T_{a3} at the preheater inlet (17) and is forced through the laundry to be ironed (2) on the supply conveyor bed (4) by a second ventilator (19), with an amount of heat (Q_h) being transferred from the air stream (10) to the laundry to be ironed (2). After this transfer of heat, the temperature of the air stream (10) will drop to T_{a4}. The air stream will subsequently leave the preheater (6) via air outlet (15).

[0087] The arrangement illustrated in Fig. 1 was used for a simulation, performed using Python 3.6, in which the air temperatures T_{a2}, T_{a3} and T_{a4} and the temperatures T_{l2} and T_{l4} of the cotton laundry to be ironed were calculated. In the simulation, it was assumed that the laundry to be ironed (2) is wet when it is introduced into the ironing device, the water in the laundry to be ironed was assumed to have evaporated after the laundry had passed through the ironing bed (3). In the simulation, it was assumed that there are no heat losses in the heat transfer device (22), as a result of which $T_{a2} = T_{a3}$. In the simulation, it was assumed that the temperature of the water in the laundry to be ironed and the temperature of the cotton of the laundry to be ironed are identical.

[0088] In the simulation following formulas were used to calculate the temperatures:

$$T_{a2} = T_{a1} + \frac{\dot{Q}_c}{\dot{m}_{air}\, C_{p,air}}$$

$$T_{a4} = T_{a3} - \frac{\dot{Q}_h}{\dot{m}_{air}\, C_{p,air}}$$

$$T_{l2} = T_{l1} + \frac{\dot{Q}_h}{\dot{m}_{cotton}\, C_{p,cotton} + \dot{m}_{water}\, C_{p,water}}$$

$$T_{l4} = T_{l3} - \frac{\dot{Q}_c}{\dot{m}_{cotton}\, C_{p,cotton}}$$

[0089] In the simulation, the cotton laundry to be ironed was regarded as a finned tubular heat exchanger, wherein the yarns in the length direction were deemed to be tubes with a diameter *d* and a length *l* of 3.3 m. The yarns in the transverse direction were deemed to be rectangular fins, with a square cross section of dy x dy, and a length of 0.6 m. The distance between the yarns was represented as *dp,* and is identical, both in the length direction and in the transverse direction. In addition, the laundry to be ironed is defined by the linear density of the yarns (*Tex*) and the yarn density (*TC*), being the number of yarns per square inch. In this case, the following relationships apply:

$$V_{yarn} = \frac{\pi \cdot d^2 \cdot l}{4} = \frac{Tex \cdot l}{\rho}$$

[0090] Here, V_{yarn} stands for the volume of the yarn, *d* for the diameter of the yarn, *l* for the length of the yarn and ρ for the density of the yarn. The percentage of air in the yarn was assumed to be between 40 and 45%. The density of the yarn was assumed to be 0.8 g/cm^3 for low-spun cotton yarn and assumed to be 0.9 g/cm^3 for medium-spun cotton yarn. As a result thereof, the diameter of the yarn may be calculated by means of the following equation:

$$d = 0.0357 \cdot \sqrt{\frac{Tex}{\rho}}$$

[0091] The ε- NTU method was used in order to calculate the heat transfer speed (Q):

$$Q = \varepsilon \cdot Q_{max}$$

$$Q_{max} = C_{min} \cdot (T_{hot,in} - T_{cold,in})$$

$$NTU = \frac{U \cdot A}{C_{min}}$$

[0092] Here, ε stands for the efficiency of the heat exchanger, Q_{max} stands for the heat transfer speed, C stands for the capacity ratio, which is the product of the specific heat capacity (*cp*) and the mass flow rate ($\dot{m}$), C_{min} stands for the minimum capacity ratio of the air and linen capacity ratio, *NTU* stands for the number of transfer units, A stands for the total surface of the heat exchanger, and *U* stands for the total thermal conduction, being the product of *ho* (the external convection coefficient) and ηo (the total external efficiency).

[0093] If Q is known, the temperatures T_{a2}, T_{a4}, T_{l2} *and* T_{l4} can be calculated as indicated above. To this end, use was made of the heat transfer correlation for rectangular fins from the VDI Wärmeatlas in order to calculate the external convection coefficient *ho.*

$$Nu_d = 0.2 \cdot Re_d \cdot \left(\frac{A}{A_{to}}\right)^{-0.15} \cdot Pr^{\frac{1}{3}}$$

$$A = A_f + A_t = N_f \cdot 2 \cdot \left(d_y \cdot W - N_t \cdot \frac{d_y^2}{4} \cdot \pi\right) + 2 \cdot d_y \cdot W \cdot N_f + \pi \cdot d_y \cdot (L - d_y \cdot N_f)$$

$$A_{to} = N_t \cdot \pi \cdot d_y \cdot L$$

$$h_o = \frac{Nu_d \cdot \lambda_{cotton}}{d_y}$$

[0094] Here, R_{ed} stands for the Reynolds number, A stands for the total external surface area of the heat exchanger, which is the sum of the fin surface area (A_f) and the free external surface area (A_t) of the tubes and A_{to} is the surface of the tubes without fins.

[0095] The total efficiency can be calculated using the following equations:

$$\eta_o = 1 - (1 - \eta_f) \cdot \frac{A_f}{A}$$

$$\eta_f = \frac{\tanh(X)}{X}$$

$$X = \frac{\varphi d_o}{2} \sqrt{\frac{2h_o}{\lambda_{cotton}\delta}}$$

$$\varphi = (\varphi' - 1) \cdot (1 + 0.35 \cdot \ln(\varphi'))$$

$$\varphi' = 1.28 \cdot \frac{b_f}{d_y} \cdot \sqrt{\frac{l_f}{b_f} - 0.2}$$

[0096] Here, $\lambda cotton$ stands for the thermal conductivity of the fins, δ stands for the thickness of the fins (which in this case is equal to the diameter of the yarn), with *bf* being equal to *dy* and *lf* being equal to the sum of *dy* and *dp*.

[0097] In the simulation, the following data were used as starting position:

T_{a1}	30°C
T_{l1}	21°C
T_{l3}	165°C
Mass flow of water in wet laundry to be ironed	200 kg/h
Mass flow of cotton in laundry to be ironed	420 kg/h

Table 1: Input data

Flow rate of air stream	1600 m^3/h

(continued)

Length of heat transfer area in preheater	3.3 m
Width of heat transfer area in preheater	0.6 m
Length of heat transfer area in heat recovery device	3.3 m
Width of heat transfer area in heat recovery device	0.6 m
$C_{p, cotton}$	1340 J/kgK
λ_{cotton}	0.02 W/mK
TC	150
Tex	15

[0098] Using the data from Table 1, the following results were obtained:

Table 2: Results of the simulation

T_{a2}	62.5°C
T_{a3}	62.5°C
T_{a4}	45.6°C
T_{l2}	41.5°C
T_{l4}	56.6°C
Q_c	16.9 kW
Q_h	8.0 kW

[0099] The simulation thus shows that it is possible to increase the temperature of the laundry to be ironed by 20.5°C before the laundry to be ironed enters the ironing bed. As a result thereof, the ironing roller can rotate at least 10% more quickly, which corresponds with an increase in capacity of at least 10%.

[0100] Using the same simulation, the effect of the linear density of the yarns (Tex) of the laundry to be ironed was calculated and this is illustrated in **Fig. 3.** This shows that, depending on the linear density of the yarns (from 5 Tex to 25 Tex), the preheater can increase the temperature of the laundry to be ironed by 34.0°C to 45.5°C.

[0101] **Fig. 4** illustrates the effect of the yarn density, using the simulation described herein. Fig. 4 shows that by keeping the yarn density between 50 to 250 yarns per square inch, the preheater can increase the temperature of the laundry to be ironed by 23.0°C to 50°C.

[0102] **Fig. 5** illustrates the effect of the flow rate of the air stream, using the simulation described herein. Fig. 5 shows that the temperature T_{l2} remains more or less constant between 40°C and 42°C in the tested interval.

<u>Example 2</u>

[0103] **Fig. 1** shows an outline sketch of an ironing device (1) according to an embodiment of the invention. The ironing device (1) from Fig. 2 differs from that in Fig. 1 in the positioning of the ventilators (19, 20). Ventilator (20) is situated on the opposite side of the laundry to be ironed (2) with respect to the air inlet (16). Ventilator (19) is situated on the same side of the laundry to be ironed (2) with respect to the air outlet (15).

Claims

1. Ironing device (1) for ironing laundry to be ironed (2), comprising:

- a heated ironing bed (3), preferably formed between at least one ironing roller (8) and at least one trough (9);
- a supply conveyor bed (4) for conveying the laundry to be ironed (2) to the ironing bed (3);
- a discharge conveyor bed (5) for conveying the laundry to be ironed (2) away from the ironing bed (3);
- a preheater (6) for preheating the laundry to be ironed (2) on the supply conveyor bed (4);

- a heat recovery device (7) for recovering heat emanating from the laundry to be ironed (2) on the discharge conveyor bed (5);
- a heat transfer device (22) for transferring heat (Q) from the heat recovery device (7) to the preheater (6);

wherein the heat recovery device (7) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the discharge conveyor bed (5);
wherein the preheater (6) is configured for accommodating an air stream or gas stream (10) over and/or through the laundry to be ironed (2), preferably the laundry to be ironed (2) on the supply conveyor bed (4); and
wherein the heat transfer device (22) comprises an air duct configured for supplying to the preheater (6) at least some of the air stream or the gas stream (10) over and/or through the laundry to be ironed (2) from the heat recovery device (7).

2. Ironing device according to Claim 1, wherein the heat recovery device (7) comprises a ventilator (20) which passes air or gas over and/or through the laundry to be ironed (2).

3. Ironing device according to Claim 1 or 2, wherein the trough (9) is heated, preferably by electricity, gas or steam.

4. Ironing device according to at least one of Claims 1 to 3, wherein the supply conveyor bed (4) and/or the discharge conveyor bed (5) are permeable to air or gas.

5. Ironing device according to at least one of Claims 1 to 4 wherein the temperature of the ironing bed (3) is at least 120°C, preferably at least 130°C, preferably at least 140°C, preferably at least 150°C, preferably at least 160°C, preferably at least 165°C.

6. Ironing device according to at least one of Claims 1 to 5, wherein a sealing is provided between the preheater (6) and the supply conveyor bed (4).

7. Ironing device according to at least one of Claims 1 to 6, wherein a sealing is provided between the heat recovery device (7) and the discharge conveyor bed (5).

8. Method for ironing laundry to be ironed, comprising the following steps:

a) preheating the laundry to be ironed;
b) passing the preheated laundry to be ironed through an ironing bed, preferably an ironing bed formed by at least one ironing roller and one trough, thus further heating the laundry to be ironed;
c) recovering heat from the laundry to be ironed after step b), wherein heat is recovered by a transfer of heat from the laundry to be ironed to an air stream or gas stream;

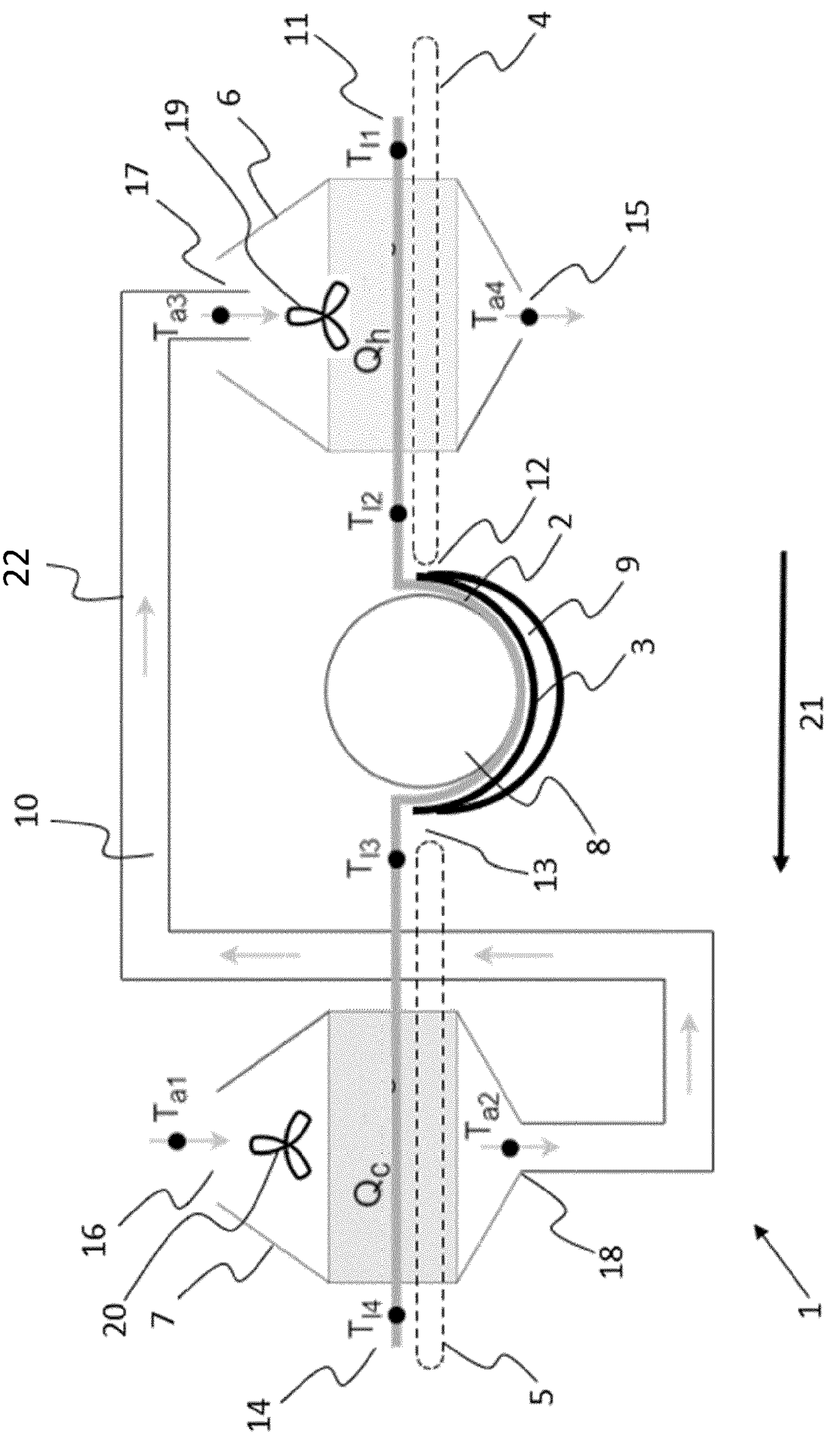
wherein at least some of the air stream or the gas stream obtained in step c) is supplied during the preheating in step a); and
wherein the laundry to be ironed is preheated in step a) by a transfer of heat from the supplied air stream or gas stream to the laundry to be ironed.

9. Method according to Claim 8, wherein the preheating in step a) causes the temperature of the laundry to be ironed to rise by at least 3°C, preferably at least 5°C, preferably at least 7°C, preferably at least 10°C, preferably at least 13°C, preferably at least 15°C compared to room temperature.

10. Energy-saving system for an ironing device, wherein the ironing device comprises a heated ironing bed;
wherein the energy-saving system comprises the following:

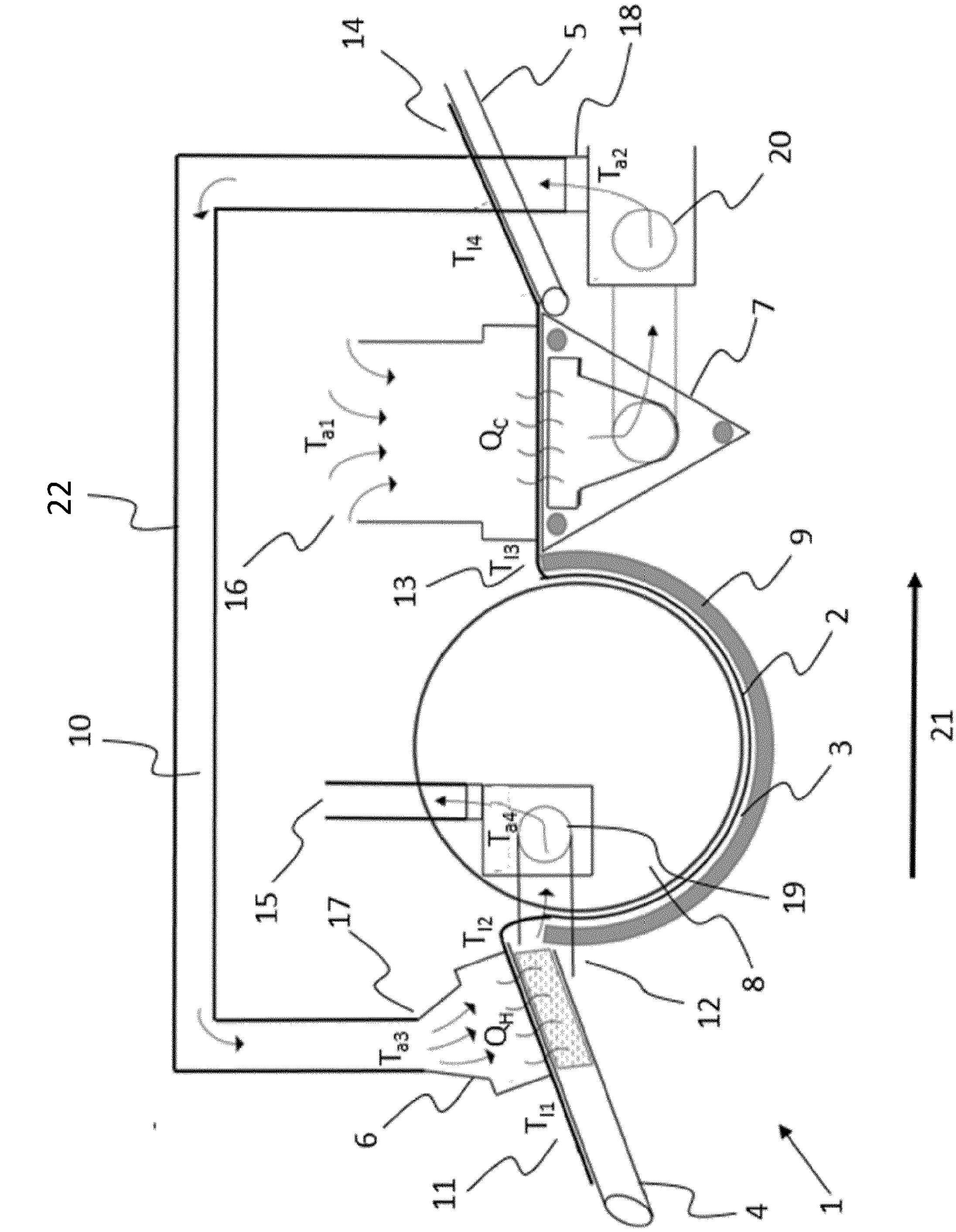
- a preheater, suitable for preheating laundry to be ironed before the laundry to be ironed enters the heated ironing bed;
- a heat recovery device for recovering heat emanating from the laundry to be ironed after the laundry to be ironed has left the heated ironing bed;
- a heat transfer device for transferring heat from the heat recovery device to the preheater;

wherein the heat recovery device is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the discharge conveyor bed;
wherein the preheater is configured for accommodating an air stream or gas stream over and/or through the laundry to be ironed, preferably the laundry to be ironed on the supply conveyor bed; and
wherein the heat transfer device comprises an air duct configured for supplying to the preheater at least some of the air stream or the gas stream over and/or through the laundry to be ironed from the heat recovery device.



22
10
17
19
6
11
4
T_{a3}
Q_h
T_{l1}
T_{a4}
15
T_{l2}
12
2
9
3
8
13
T_{l3}
21
T_{a1}
T_{a2}
Q_c
16
20
7
18
T_{l4}
14
5
1

Fig. 1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T_{a1}
T_{a2}
T_{a3}
T_{a4}
T_{l1}
T_{l2}
T_{l3}
T_{l4}
Q_C
Q_H

Fig. 2

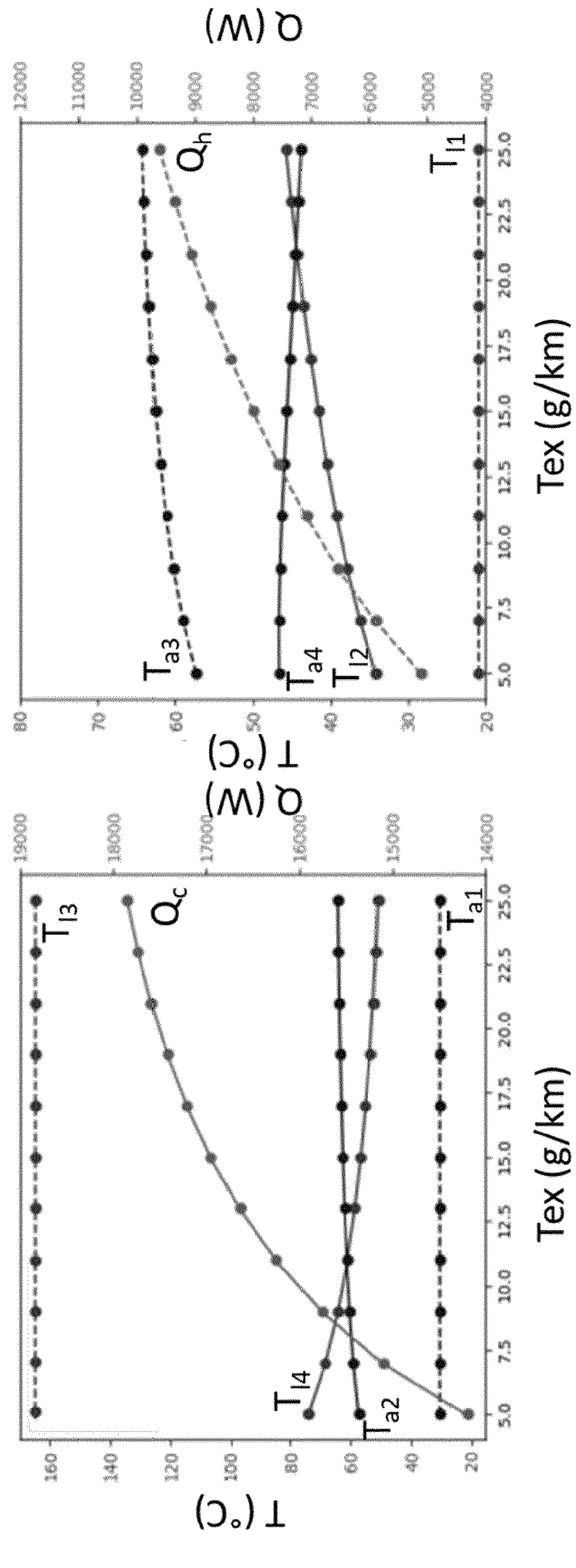


Fig. 3

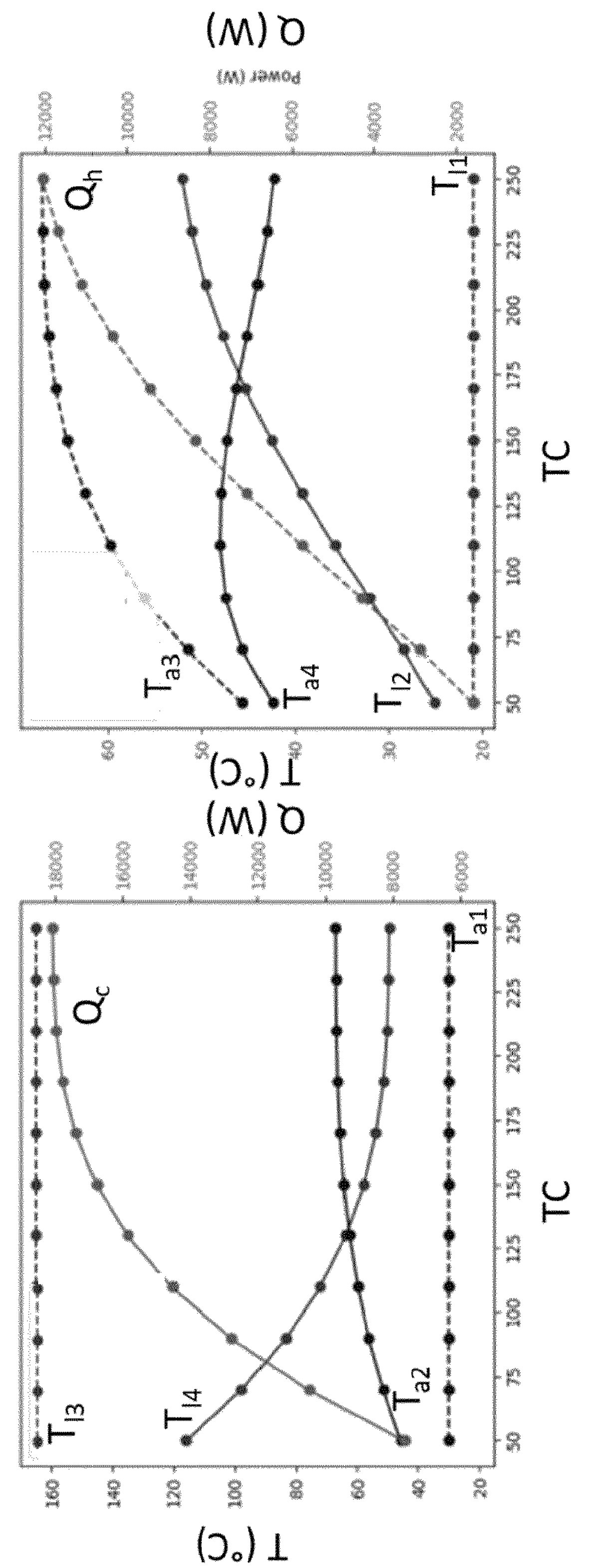
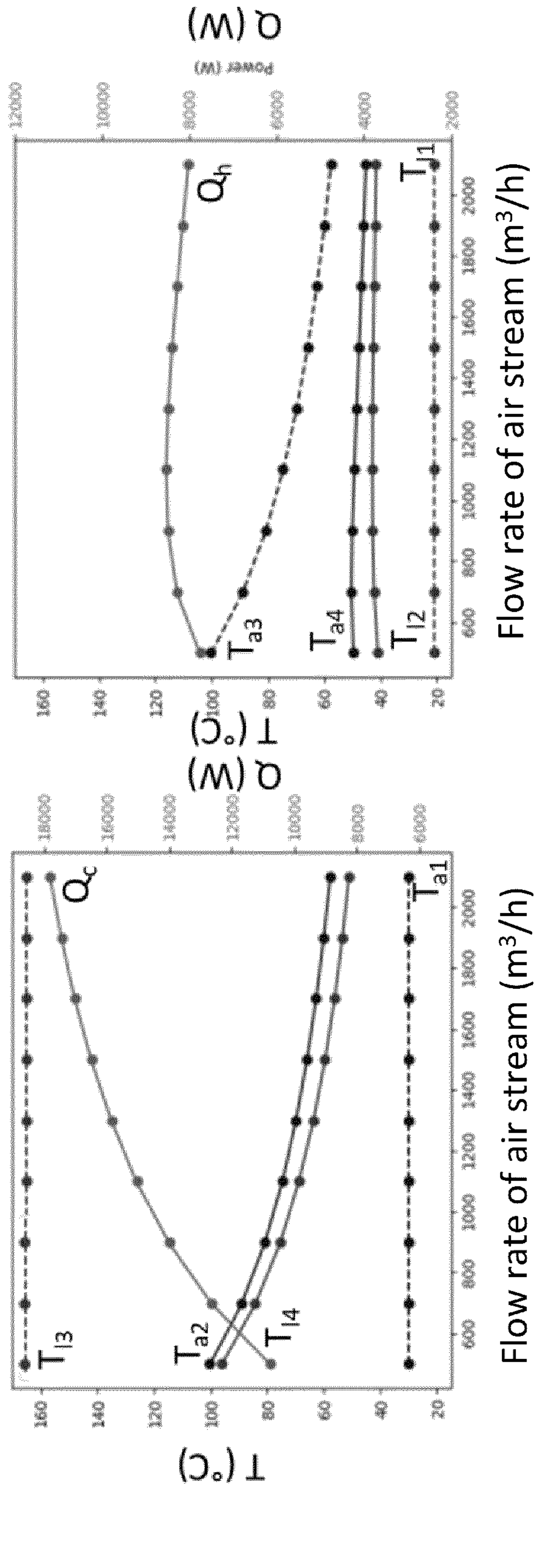


Fig. 4



Q (W)
Power (W)
T (°C)
Flow rate of air stream (m3/h)
Qh
Ta3
Ta4
Tl2
Tl1
Q (W)
T (°C)
Flow rate of air stream (m3/h)
Tl3
Ta2
Tl4
Qc
Ta1

Fig. 5