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(71) Applicant: **Electrolux Appliances Aktiebolag**
105 45 Stockholm (SE)

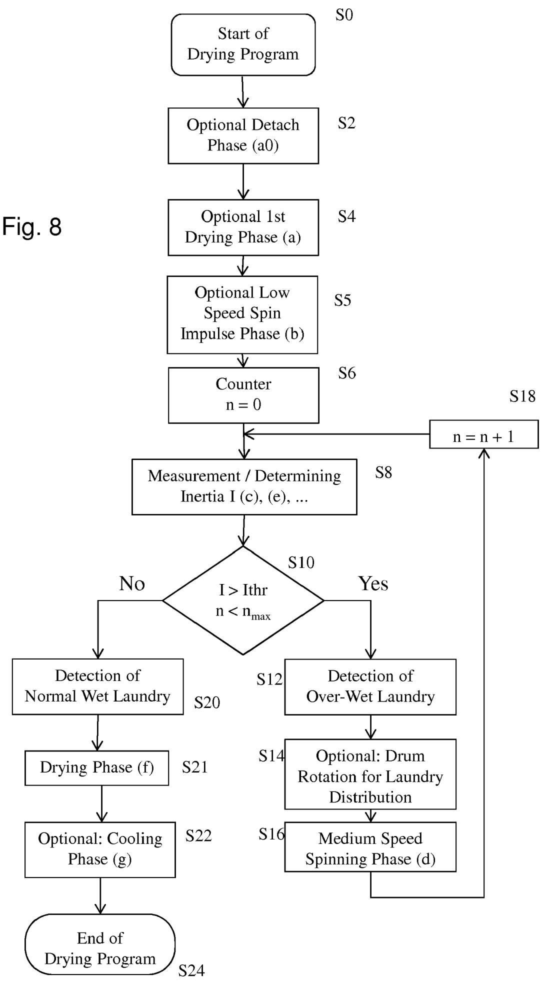
(72) Inventors:
- **BONDI, Martino**
  33080 Porcia (PN) (IT)
- **DRIUSSI, Paolo**
  33080 Porcia (PN) (IT)
- **GIROTTO, Terenzio**
  33080 Porcia (PN) (IT)

(74) Representative: **Electrolux Group Patents**
AB Electrolux
Group Patents
105 45 Stockholm (SE)

(54) DRYING METHOD IN A WASHER-DRYER

(57) The invention relates to a method for drying laundry to be implemented in a washing and drying apparatus. The washing and drying apparatus (2) comprises: a tub (30), a drum (36) arranged within the tub (30) and being adapted to receive laundry (40) for treatment within the drum, a washing arrangement adapted to wash the laundry received in the drum (36), a drying arrangement comprising a drying air heater (20, H) and a drying air fan (26, B), and a load detector (46, 60) for detecting a load signal indicative of the load received in the drum (36). The washing and drying apparatus is adapted to dry the laundry received in the drum (36) and the drying method comprises the steps of: Starting (S30) a drying program; detecting (d, S8) the load signal (I); evaluating (S10) the detected load signal (I); in dependency of the load evaluation, executing (S16) a spin cycle (d) or not executing a spin cycle; and drying (f, S22) the laundry (40) received in the drum (36) in a drying cycle.

Fig. 8



EP 3 109 356 A1

Description

[0001] The invention relates to a method for drying laundry to be implemented in a washing and drying apparatus.

[0002] A washer-dryer providing washing function and drying function is known from DE 10 2006 056 419 A1. The washer-dryer can be used for drying laundry only. In case it is detected that drying-only function is selected, dehydration by rotating the drum with 1000 rpm is executed before starting a drying phase in which the laundry is dried by drying air.

[0003] It is an object of the invention to provide a drying method for a washing and drying apparatus in which the drying efficiency for drying laundry is improved.

[0004] The invention is defined in claim 1. Particular embodiments are set out in the dependent claims.

[0005] In the drying programs of the washer dryers (washing and drying apparatus (machines)) a contribution to the water extraction could be given by a high speed spin performed at the beginning of the cycle. Fig 5 shows an example for such initial high speed spin phase w which have been tested in Applicant's laboratory for improving the drying program. The spin speed is at about 1350 rpm (compare R5 in Figs. 10, 11) and useful to reduce the initial humidity of the laundry load, but it's even more useful in the case where a user wants to dry a very wet (over-wet) laundry load. The high initial humidity (for example with humidity over 70%) could be due to washing by hand and then placing the wet laundry in the washer dryer for drying only or it could be due to an automatic wash program with no final spin or with very low speed final spin or due to a selected user option suppressing a final or high speed spin at the end of the wash program.

[0006] Unfortunately, the high speed spin performed at the beginning of the drying cycle could have also some disadvantages:

- Some types of laundry loads could remain attached to the drum after the high speed spin and so the drying performances could decrease dramatically (and also the uniformity). For this reason after the spin usually a detach phase x is provided (Fig. 5).
- If the apparatus temperature is high (for example if the user executes two consecutive drying programs), execution of the high speed spin phase w may be excluded to avoid high mechanical stress to the washing group structure.
- The laundry load could be excessively creased by a high speed spin w.

[0007] As a result of such findings the problem resulted to provide an efficient drying program specifically for unusually wet laundry while avoiding these disadvantages, while when the laundry is normal-wet the drying efficiency is not deteriorated (energy optimized).

[0008] According to the invention a method is provided for drying laundry. The method is to be implemented in a washing and drying apparatus which comprises:

- A tub.
- A drum arranged within the tub and being adapted to receive laundry for treatment within the drum.
- A washing arrangement adapted to wash the laundry received in the drum. The washing arrangement comprises components of the washing and drying apparatus that enable the apparatus to wash the laundry in the drum. The components include for example water supplying and dosing elements, wash agent supplying and dosing elements, and/or wash liquid draining elements for draining the wash liquid to the outside of the apparatus.
- A drying arrangement comprising a drying air heater and a drying air fan, wherein the drying apparatus is adapted to dry the laundry received in the drum. The drying arrangement comprises the components of the apparatus that enable drying of the laundry stored in the drum. The components may partially be shared with the washing arrangement and include for example a heater for heating drying air, a condenser for condensing water from the drying air (if the apparatus is not implementing a vented dryer that exhausts the drying air to the outside of the apparatus), a blower for conveying or circulating the drying air, and an air channel for guiding the drying air into and from the drum.
- A load detector for detecting a load signal indicative of the load received in the drum. The load detector is adapted to detect the load within the drum which is represented by the dry weight of the laundry and the weight of the water amount bound by the laundry. At the beginning of the drying cycle laundry the laundry should be wet, however the laundry may have different degrees of humidity (in the following reference is made to normal-wet (normal starting humidity) and over-wet (high starting humidity)). Load detection by the load detector may be based on one of a variety of load detection principles or a combination of such load detection principles, which are provided for example by: a weight sensor, an estimation of load via one or more drum motor parameters, water soaking of the laundry during a washing cycle. More principles or more details of the principles are disclosed below, in particular in the detailed embodiment section. Preferably the load signal is detected using an inertia sensor (e.g. inertia of drum motor during drum speed acceleration and/or deceleration) or is detected using a weight sensor detecting the weight of the drum or the tub.

[0009] The drying method comprises the steps of: starting a drying program; detecting the load signal provided by the load detector; evaluating the detected load signal; in dependency of the load evaluation, executing a spin cycle or not executing a spin cycle; and drying the laundry received in the drum in a drying cycle.

[0010] The detecting of the load signal is for measuring/estimating the signal which indicates the load within the drum which in turn is depending on the laundry load (dry weight) and the water content. The ’detection’ is not to be understood that the result is a load signal that delivers the physically true load value of the load in the drum, but is including the understanding that the detection is an ’estimate’ for the load which is convenient in most operation cases to optimize the drying efficiency. For example in case of load detection via the inertia signal or value, the signal is representative of the load and further may be influenced by the current mass distribution within the drum (e.g. imbalance effects).

[0011] According to the method, the load evaluation results in applying an (additional) spin cycle or not. If the load evaluation indicates that the laundry is over-wet, the spin cycle is provided which provides a mechanical dehydration (by centrifugal force). As compared to the drying by drying air and up to a certain low laundry humidity, the ’drying’ using dehydration spinning consumes much less energy. On the other hand, if the laundry is in a state of low humidity (normal-wet) the drying by drying air is more efficient as compared to spinning which would require excessive spinning speeds (laundry damage, apparatus wearing, extreme motor power) for removing the residual water amount from the laundry. Thus the drying cycle is started with the step (direct drying or preceding spin cycle) adequate to the actual need of the laundry. The background is that during the spin cycle (with the heater on or off) the water is removed by centrifugal force. At this time the laundry forms a ring and the drying air can not efficiently dry the laundry. At the other hand, driving the drum at low drum rotation speeds (preferably tumbling speed as used in drying cycle) and providing drying air improves uniform drying of the laundry.

[0012] For example, if the detection of the load signal and its evaluation results e.g. in the conclusion that the load (signal) is lower than a predetermined (first) load threshold, the spin cycle is not performed and the apparatus starts drying the laundry, e.g. by activating an drying air heater element and by activating a drying air blower. Preferably the load detection, the evaluation of the load signal and the execution or non-execution of the spin cycle is performed immediately after the drying program start. Thus preferably the step of evaluating the detected load signal is or comprises comparing the detected load signal with a threshold value and wherein, when the detected load signal is above the threshold value, the spin cycle is executed. As mentioned, the load signal is ’indicative’ of the laundry load and its water content.

[0013] In an embodiment, during at least a period of the spin cycle, the drum is rotated with a drum rotation speed in the range of 300 to 700 rpm or with a speed profile having a maximum speed in the range of 300 to 700 rpm. This ’first’ drum rotation or spin speed is lower than the maximum possible spin speed of the apparatus. The first (maximum) spin speed in the spin cycle is lower than a high spin speed which is normally used at the end of a washing cycle for dehydrating the laundry. The ’high’ spin speed available at the apparatus is at least 800 rpm, 900 rpm, 1000 rpm or 1100 rpm. The first spin speed (herein also called ’medium’ spin speed) ensures that laundry can be easily detached from the drum wall during the drying cycle following to the spin cycle.

[0014] Preferably, during the period of the spin cycle, during the period of the load detection or during the periods of load detection and spin cycle the heater and the drying air fan are activated as follows: the heater is OFF and the drying air fan is OFF, or the heater is OFF and the drying air fan is at least partially ON, or the heater is at least partially ON and the drying air fan is OFF, or the heater is at least partially ON and the drying air fan is at least partially ON. The activation state ’OFF’ means that the heater and/or drying air fan are switched OFF all the time period. On the other hand, the activation state ’ON’ includes that the heater and/or drying air fan are ON all the time period or are partially ON during this time period. The above activation state where the heater is ON and the fan is OFF is provided for example when a slight air circulation is provided by the rotation of the drum.

[0015] In an embodiment the washing and drying apparatus comprises at least one temperature sensor adapted to detect a temperature at the drying arrangement, at the washing arrangement or at the drying and washing arrangement. The method may further comprise the steps of: detecting and evaluating the temperature, and in dependency of the evaluated temperature and in dependency of the load evaluation: not executing the spin cycle, or deactivating the drying air heater during the spin cycle. In this embodiment the spin cycle is executed only if the detected temperature is below a temperature threshold; for example to avoid a drum spin with a hot tub which could increase the wearing of the apparatus and for avoiding tub material damage.

[0016] Preferably after the spin cycle, the method further comprises the step of: repeating the steps of detecting the load signal, evaluating the detected load signal and executing the spin cycle until the detected load signal is lower than a predetermined second load threshold and/or a counter has reached a predetermined number of repetitions or a time limit is expired. The second threshold for the load signal may be the same threshold as used at the first time of the load evaluation or it may be a different (e.g. a smaller or higher) threshold value. The counter counts the number times which the steps (loop including the spinning cycle) are repeated and monitoring the count and interrupting the loop prevents being captured in the loop if the spin cycle can not reduce the load signal. In this case in (each of) the previous steps of detecting/evaluating the (laundry) load signal it was determined that the load is above the threshold such that the spin cycle is executed repeatedly. The spin cycle which is executed the second time (or the further times) may provide spinning at a second or further spinning speeds or profiles which may be different from the spin speed/speed profile as used during the first spin cycle. Preferably the spin speeds used are increased each time the spin cycle is repeated. Alternative to using different speeds/profiles, the spin speed or profile may be the same spin speeds/profiles as the one of the first spin cycle. Under the situation that the laundry is over-wet, the laundry should loose water and the load signal should be lower in the following step of determining the load signal.

[0017] In an embodiment, after the spin cycle, a laundry detach cycle is executed. In the detach cycle preferably the drum is alternatively rotated clockwise and counterclockwise or in counter rotation compared to the rotation direction used during the spin cycle. The laundry detach cycle may be performed when the drying program has already started or as part of drying. Preferably the speed for detaching the laundry is lower than the speed at which the laundry adheres to the inner drum mantle during a full rotation and/or is lower than or equal to a speed where the laundry starts to tumble during a full rotation. The detach cycle is preferably executed after each spin cycle, if there are more than one spin cycles (e.g. above loop). Preferably during the detach cycle the heater is ON and the fan is ON or the heater is OFF and the fan is ON or OFF.

[0018] Preferably a time period of predetermined duration is provided between the step of starting the drying program and before detecting the load signal (e.g. before detecting the load signal the first time). Preferably providing/non-providing and/or the predetermined duration are dependent on user selection inputted via an input selector of the washing and drying apparatus and/or is dependent on laundry type (cotton, synthetics, mixed laundry ...). Preferably during the time period after program start and before detecting the load signal the drying air heater is ON and the drying air fan is ON. Preferably switching ON the drying air heater and drying air fan is dependent on user selection inputted via an input selector of the washing and drying apparatus and/or is dependent on laundry type (cotton, synthetics, mixed laundry ...).

[0019] In an embodiment, during or prior to the step of detecting the load signal, the drum is rotated at a second rotation speed or is accelerated up to a speed, which is lower than the first rotation speed and which is equal or greater than the minimum speed required to keep the laundry adhering to the inner surface of the drum during full rotations. The second drum rotation speed preferably is equal or lower than the first drum speed and/or equal or greater to the minimum speed required to keep laundry attached to the inner surface of the drum. Preferably the second rotation speed is in the range of 100 to 700 rpm or 200 to 600 rpm, more preferably in the range of 300 to 500 rpm, more preferably in the range of 350 to 480 rpm. Such so called 'spin impulse' is preceding the detection of the load signal (e.g. the measure/estimation of laundry inertia/weight). By this spin impulse the laundry is distributed along the drum mantle inner wall reducing the risk of imbalance and also prepares the laundry to attach to the drum wall before the spin cycle is executed.

[0020] In an embodiment the method provides the ability to check whether there was a preceding washing program (which is preceding the drying program to be started or already being started) and to check whether in this washing program a final dehydration spinning (e.g. after the last rinse) was made or not and to adapt the drying program execution in response thereto. Therefore the method preferably further comprises the steps of:

- Detecting whether the drying program to be executed is part of a washing and drying program and assessing whether during the washing program an after-rinse spinning cycle normally executed subsequent to the last laundry rinsing cycle has been skipped.
- When the after-rinse spinning cycle was skipped, then executing during the drying program the spin cycle at a first drum speed and then detecting the load signal. This means that if the apparatus has the information from the control unit that the previous final spinning was skipped (or a low spinning speed was used therein), the drying program provides a spin cycle before the first time detecting and evaluating the load signal, which might then result in the decision that (a further) spinning cycle is executed (e.g. in case of the load signal being above a threshold).
- When the after-rinse spinning cycle was not skipped, then during the drying program the step of detecting the load signal (of claim 1) before the spin cycle is executed or not.

[0021] Alternatively, when the after-rinse spinning cycle has not been skipped and the detected load signal is below the predetermined value, then continue with drying cycle.

[0022] The meaning of the 'last spinning cycle being skipped' (of the washing program) may include that the final spinning was executed at low spinning speed (e.g. below 700, 600, 500, or 400 rpm or is below R2). The 'skipping' during the washing program may also be the result of a user selection (for example completely skipping the final dehydration spin) or the result of the control unit detecting a fault or of a restriction that prevents applying high speed in the final spinning. For example in case of heavy imbalances.

[0023] In an embodiment, if it was determined that the after-rinse spinning cycle was not skipped, then before the step of detecting the load signal (of claim 1) is executed, the drum is rotated at a second speed and thereafter the load signal is detected. However it is noted that in general (independent of skipping the final spinning or not) and before each detection of the load signal, the drum may be rotated at the second speed (in a peak-shaped speed profile with the second speed as maximum or with the second speed for a predefined period of time). Preferably the second speed is between 100 and 700 rpm, further preferably between 300 and 500 rpm or is R2. Preferably the second speed is equal to or greater than the minimum speed required to keep the laundry adhering to the inner surface of the drum during full rotations. The purpose of rotating at the second speed before load signal detection is that the laundry is more evenly distributed thereby in the drum and is pre-attached to the drum wall for avoiding or reducing imbalance.

[0024] In an embodiment the operation parameters of the first drum spinning rotation and/or the parameter of spinning with the second speed are based on one or more of the following:

- a laundry treatment program or laundry treatment options set by a user via an input selector of the washing and drying apparatus;
- a laundry type as set by a user or as estimated by the washing and drying apparatus;
- the duration of the laundry treatment program set by a user or as estimated by the washing and drying apparatus; and
- in case that the drying program is part of a washing and drying program, an estimation of the water content in the laundry at the beginning of a drying cycle based on the laundry weight difference between the dry laundry weight at the beginning of a drying and washing program and the laundry wet weight at the end of the washing part of the washing and drying program.

[0025] The drum operation parameters are e.g. rotation speed and/or rotation duration. The first drum spinning rotation is the rotation speed or the maximum rotation speed of a speed profile used during the spinning cycle. The estimation of the (dry) laundry weight is made as mentioned above and/or below. E.g. it is evaluated or estimated from motor torque or direct laundry weight measurement. Preferably an algorithm is provided for estimating the laundry type, i.e. laundry composition (Cotton, Synthetic, Mix etc.). For example by monitoring the water level (i.e. laundry water absorption) reached within the tub compared to water amount supplied to the tub during the initial cycle of a washing step.

[0026] Preferably the drying arrangement comprises a drying air condensation device, and wherein the method comprises: When the drying air heater is activated, activating the drying air condensation device, and/or when the drying air heater is deactivated, at least temporary deactivating the drying air condensation device. For example a drying air condensation device may be provided by a water spray condenser driven by a water valve (preferably using tap water as cooling means).

[0027] Preferably the drying arrangement comprises a or the drying air condensation device, and the method comprises: Deactivating the drying air heater while the drying air condensation device is activated, and/or activating the drying air heater while the drying air condensation device is deactivated. If for example a quick temperature increase should be achieved, the (electrical or resistivity) heater is activated and the drying air condensation device is deactivated. Preferably, if a quick temperature drop is intended, the drying air condensation device is ON and the drying air heater is OFF. This may prevent overheating when the heater is controlled with a drying air temperature hysteresis.

[0028] In an embodiment, after the drying cycle, a laundry cooling cycle is provided by: Deactivating the drying air heater while the drying air fan is at least partially activated and while the drum is rotated in clockwise direction, in counter clockwise direction or in clockwise and counter-clockwise direction for cooling down the laundry. Preferably the cooling phase is provided after a (final) drying phase and before the (apparatus) end of the drying program (drying cycle).

[0029] Preferably the cooling phase for laundry cooling cycle is skipped in dependency of at least one of:

- A user selection input via an input selector of the washing and drying apparatus. Preferably the user selection input is an option that can be selected by the user for modifying a program which e.g. is selected by the user via a program selector.
- The laundry type as input by a user or as estimated by the washing and drying apparatus.
- The duration of the laundry treatment program set by a user or estimated by the washing and drying apparatus. The duration is for example estimated based on the inertia/weight measure.

[0030] In the detailed embodiment the term 'cycle' as used in the claims is denoted as 'phases'. In case of referring to Ri (i= 1 to 6) reference is made to the below and Fig. 12.

[0031] Reference is made in detail to preferred embodiments of the invention, examples of which are illustrated in the accompanying figures, which show:

Fig. 1 an exemplary outer appearance of a laundry treatment apparatus, which is a washer-dryer in the depicted example,

Fig. 2 a schematic representation of the arrangement of components of the laundry treatment apparatus of Fig. 1 having a heat pump system,

Fig. 3 a schematic block diagram of components of the treatment apparatus of Fig. 1,

Fig. 4 a diagram depicting the experimentally detected relation between the inertia measured at the drum drive motor and different types of laundry with different humidity values,

Fig. 5 the time diagram of drum rotation in a testing drying cycle using the high speed approach,

Fig. 6 a first example for drum rotation speed over time of a drying cycle starting with wet laundry,

Fig. 7 an example for drum rotation speed over time in a drying cycle when starting with laundry having a "normal" degree of humidity,

Fig. 8 an example for a flow diagram for a drying cycle with detecting the inertia indicative of the degree of humidity of the laundry,

Fig. 9 a diagram showing the relation between the inertia and different types and humidity degrees of laundry similar to Fig. 4 and including low laundry load or volumes,

Fig. 10 an example for drum rotation speed over time when washing and drying cotton laundry,

Fig. 11 another example for drum rotation speed over time when washing and drying synthetic laundry, and

Fig. 12 a table indicating preferred speeds or speed ranges for the drying and/or washing program.

[0032] Fig. 1 shows a washer dryer 2 which is an example for a laundry treatment apparatus. Preferably the washer dryer is a tumbling washing dryer where the laundry tumbles when the drum 36 is rotating at low speed. For that purpose the drum rotation axis is horizontal or inclined relative to the horizontal (without being vertically oriented). The washer dryer 2 described in detail is a heat pump system washer dryer. However the invention is also and preferably applicable in an electrically heated washer dryer - see also below - and except the way and arrangement for cooling/heating the drying air the following is fully applicable for any washer dryer.

[0033] Referring to Figs. 1 and 2, the washer dryer 2 has a cabinet 12 or housing defining the outer appearance. The laundry 40 is loaded through a loading opening 4 which is a loading passage between the front side of the front wall of the cabinet 12 and a front opening of a tub 30 and drum 36 receiving the laundry. A gasket is provided, which is sealing the opening at the front wall and the front opening of the tub 22.

[0034] The front side of the loading opening/passage 4 is closed by a loading door 6 or porthole which has a handle 7 for opening and closing the door. At the front side of the washer dryer 2 a display and input panel 8 is provided having input elements for inputting program selections and/or program options by the user. The panel 8 further has indicators for indicating the selected programs/options and/or the status of a running program. Via a program selector 10 the basic drying and/or washing programs can be selected by the user. A detergent drawer is arranged at the side of the panel 8 for receiving liquid and/or solid detergents and other treatment agents by manual filling respective compartments by the user. Optionally additional compartments or openings may be provided for receiving treatment agents for a drying and/or dry-cleaning process.

[0035] Fig. 2 schematically shows an exemplary arrangement of components in the interior of the cabinet 12 of the washer dryer 2 in side view. In this embodiment the drying function of the washer dryer is provided by a heat pump system 14 that has a refrigerant loop 16 for circulating the refrigerant as indicated by flow RF using refrigerant lines between the components of system 14. In the refrigerant loop 16 serially arranged are a first heat exchanger 18 (here an evaporator) for cooling the drying air and condensing the water taken from the laundry 40, a compressor 22 circulating the refrigerant, a second heat exchanger (condenser) 20 for heating the drying air, and an expansion device 24 for expanding the compressed refrigerant into the first heat exchanger 18.

[0036] In the exemplary washer dryer 2 the components of the heat pump system 6 (as an example for drying air cooling/heating system) are arranged above the tub 36, but in other embodiments the drying air cooling/heating components may be arranged or may be partially arranged below and/or laterally of the tub.

[0037] During the drying cycle, drying air is circulated within a drying air loop, wherein the drying air A is conveyed by a blower 26 arranged in a drying air channel 28 in which also the first and second heat exchangers 18, 20 are arranged. The drying air loop is formed by the drying air channel 28 and the tub 30, wherein the drying air channel guides the drying air exhausted from the tub through: an outlet 32, an optional fluff filter 42, the first heat exchanger 18, the second heat exchanger 20, and back through a drying air inlet 34 into the tub 30. Within the tub 30 the rotatable drum 36 is arranged as a laundry chamber receiving the laundry 40. The laundry is loaded/unloaded through drum and tub openings (indicated by 4) covered by the loading door 6 to be opened and closed by a user.

[0038] The drum 36 is driven by a drum motor 38 which is powered and controlled by a drum motor inverter 58 (which in turn is controlled by a control unit 46). At a sump within the tub 30 or in fluid connection with the tub a heater 44 is arranged for heating the washing liquid used for washing the laundry 40. In thermal contact with the heater 44 a heater temperature sensor 56 may be arranged.

[0039] The water supply arrangement (including the detergent flushing arrangement for the detergent drawer) as well as the water draining arrangement and optionally the washing water circulation system of the apparatus 2 are not shown or described in further detail.

[0040] Fig. 3 shows a schematic block diagram of components of the washer dryer which provide signals to and/or signals from the control unit 46 controlling the operation of the apparatus 2.

[0041] The control unit 46 is connected to a memory 48 (like RAM and/or ROM), which is designed to permanently store (e. g. EPROM) data for example for different user selectable programs and program cycles as well as apparatus operation parameters (e.g. thresholds, look-up tables) to be used during program runs and which depend on the selected program and/or user selected operation options. Finally memory for temporarily storing data during a program run is provided in the memory 48.

[0042] Via the input and display panel 8 the user can select the washing and/or drying program to be used for treating the laundry and options for the washing and/or drying program. For example via the input panel 8 the user can select the options cupboard-dry, damp-dry or ironing-dry as the final laundry humidity for a drying cycle to be executed. Also panel 8 indicates different information to the user. For example the program state, the start or interrupt of the program, the time-to-end of the running cycle, the selected options or the like.

[0043] The control unit 46 receives signals or values for processing and controlling the apparatus from:

- An optional ambient temperature sensor 54 that may be integrated in or located at the control unit 46 to detect the ambient temperature.
- A refrigerant temperature sensor (not shown) that is arranged at the refrigerant loop, for example at the condenser outlet or the compressor outlet, or a sensor located at the capillary 24 between the condenser 20 and evaporator 18 to detect the temperature of the refrigerant.
- A compressor temperature sensor (not shown) that indicates the operation temperature of the compressor 22, for example the compressor motor temperature.
- An outlet temperature sensor 52 that is arranged at the outlet 32 of the tub 30 for detecting the temperature of the drying air at this position.
- An inlet temperature sensor 50 that is arranged at the inlet 34 to detect the inlet temperature of the drying air at that position.
- The heater temperature sensor 56 for detecting the temperature of the heater 44, which may also be indicative of the ambient temperature, if the apparatus is freshly started without prior operation for a longer non-operation period.
- One or more signals from a sensor unit 60 of the drum motor inverter 58, which are indicative of one or more of the following: the motor torque, the inertia of the drum indicative of the load, the power consumed by the motor 38, the motor current, the motor or inverter temperature, the phase shift, the magnetic flux, the driving voltage, and the rotation speed.

[0044] In this example the compressor motor 22 is powered by a compressor inverter 64 to which a compressor inverter sensor unit 62 is associated, wherein the sensor unit 62 may be integrated in or at the compressor inverter 60. The compressor inverter sensor unit 62 sends a temperature signal related to the compressor motor and/or inverter 60 to the control unit 46.

[0045] As mentioned above, the washer dryer, instead of having a heat pump system as shown, may have an electrical (resistivity or radiator) heater as the second heat exchanger 20 (electrical heater instead of the refrigerant condenser). In such an embodiment preferably the first heat exchanger 18 (instead of the evaporator) for cooling the drying air after having passed the drum and laundry therein is a cooling surface cooled by water available in the washer dryer. And/or in the heat exchanger 18 the drying air is cooled and dehumidified by droplet or spray contact with the cooling water and/or the drying air is cooled and dehumidified by an air/air heat exchanger using ambient air for cooling the drying air. In such an embodiment, the drying air heating and/or the drying air cooling can be switched on or off with much shorter reaction times (follow-up time) and/or can be activated/deactivated in much shorter periods than in a heat pump system where temperature equilibration and compressor waiting times renders such system slow.

[0046] Fig. 5 - as already mentioned above - shows a drying test in the washer dryer 2 in which over-wet laundry was dried in a drying cycle (washing cycle not shown in Fig. 5) and in which a high speed spin speed has been used in phase w. At time 200 sec the drying cycle starts with a first drying phase v, in which the drum is slowly rotated for distributing the laundry within the drum. Preferably, during the first drying phase v the blower 26 and the electrical heater (or the heat pump system) are on for heating the drying air. The high spin speed phase w is following the first drying phase v during which the drum is rotated at a high rotation speed R5 (here about 1350 rpm). Thereby water is extracted from the laundry, specifically when the laundry was over-wet. Due to the high spin speed the laundry adheres to the inner drum mantel of the drum. For detaching the laundry from the drum a detach phase x is following the high spin speed phase w. After the detach phase x a second drying phase y is executed during which the laundry is dried until been dry.

[0047] As can be seen from the power signal over time, the heater is switched on during the first drying phase v and the second drying phase y while it is switched off during the high speed spin phase w and the detach phase x. Power consumption is high during the high spin speed phase w due to the power consumption of the motor 38.

[0048] From such test drying with different starting laundry humidities, it was found that laundry may not be efficiently detached from the drum mantel in the detach phase x. This renders the drying efficiency during the second drying phase y very inefficient. Further it was found that such laundry adhering to the drum wall (unsuccessful detaching) is more likely the wetter the laundry is at the start of the drying cycle. Also the risk of adhering laundry is increasing with increasing dry weight or volume of the laundry. Summarizing, the risk of adhering laundry is rising with increasing laundry dry weight and with increasing water amount bound by the laundry. The inertia is a good criterion or indicator for the load in the drum and the distribution of laundry within the drum. The inertia can be detected/estimated via drum motor parameters as these are responsive to the drum load (including a fixed inertia value for the drum) and are depending on the laundry dry weight and the water bound therein.

[0049] The inertia I is calculated by the control unit 46 receiving the signals of rotation speed over time and torque as detected (or pre-calculated) by the drum motor inverter 58 and the inverter sensor unit 60 therein. The inertia I may be calculated from the following equation

$$\tau = I \cdot d\omega/dt$$

wherein is the angular speed and τ is the torque [$kg \cdot m^2/s^2$].

[0050] The control unit 46 and/or the inverter sensor unit 60 can calculate the inertia I using the torque and rotation speed, wherein the torque is derived from one or more of the following signals detected in the inverter sensor unit 60: a motor current, the power, the phase shift, the magnetic flux, the driving voltage (all in time dependency and/or as a temporal ingredient). Determination of the inertia is known in detail from EP 2 107 151 A1 to which full reference is made relating to implementing an exemplary torque measurement and determining the inertia I.

[0051] Other sub-routines or steps of detecting the load signal (laundry load + water content) and which may be used here include determining/estimating the load by:

- Determining from one or more of the following drum motor parameters optionally including the time dependencies and/or gradients of these parameters: motor current, magnetic flux, motor power, torque, inertia (as above but in combination with one of the other parameters), or powering voltage.
- Weight determination in a preceding washing cycle.
- Determining from a weight sensor, for example a weight sensor that determines the weight of the tub at a suspension point.

[0052] Continuing with the example of load signal detection/evaluation using inertia: Fig. 4 shows the dependency of the inertia in dependency of different types of laundry and of the degree of humidity of such laundry. The inertia threshold Ithr is shown and some experimental measuring points. The tests for determining the inertia-criterion for the laundry being normal wet or over-wet have been made with laundry as used according to the IEC standard with a 4 kg load (weight of the dry laundry) and with 4 kg sponge material (also dry sponge weight). The humidity ranges of the starting humidity at which the inertias have been determined are indicated at the bottom of the diagram. Therein the range of 42 to 45 % of 4 kg IEC corresponds to a "normal" starting humidity and 52 % starting humidity corresponds to a "normal" wet starting humidity for 4 kg sponge material. The humidity range of 70 % or higher is an over-wet starting humidity.

[0053] For the points above the threshold Ithr it was found that laundry causing such inertia is over-wet. In the state of the over-wet starting humidity the drying efficiency normally is dramatically reduced, as the wet laundry tangles during drum rotation and forms lumps with a low surface area, such that the drying air can contact only the outer surfaces of the lumps. Further, the lumps fall down during the tumbling as an aggregate further reducing the drying efficiency. Therefore, laundry causing an inertia above the threshold has to be treated by a pre-spin at the beginning or in the initial phase of the drying cycle (see below).

[0054] The diagram of Fig. 4 shows that the inertia is a good criterion for deciding whether the laundry is over-wet and a dedicated treatment before or in the initial phase of the drying should be provided to improve the drying result and/or to reduce the drying time/energy. Independent of the laundry type (IEC or sponge as extremely different laundry types), the over-wet state can be determined. In an embodiment, it can be provided that the inertia threshold Ithr is depending on the laundry type as inputted by the user at the panel 8 and/or as determined by the apparatus 2 for example during previous washing phase or by using dynamic inertia and/or torque measurements.

[0055] The diagrams of Figs. 6 and 7 show drying cycles (not including washing cycles) from the start and the rotation speed in rpm of the drum is shown over time. The inertia threshold Ithr (in arbitrary units) is shown and is used for determining, whether the laundry is over-wet (Fig. 6) and a specific drying cycle including a spin phase d is to be implemented, or whether the laundry is normal-wet (Fig. 7) and the drying cycle can be executed without spin phase d. If there is no need for a spin phase, it is assumed that the laundry has a humidity as if spun (final spinning - phase n) at the end of a washing cycle before or it is assumed that the user loaded laundry which humidity is low enough for a "normal" drying cycle.

[0056] Fig. 6 shows a first drying phase a at the start of the drying cycle during which the drum is rotated at tumbling speed (between 50 and 80 rpm or at R6 of Figs. 10-12) which is interrupted by drum stop periods for enhancing laundry redistribution. Drum rotation may be alternate in clockwise and counterclockwise direction. During the first drying phase a, the heater 20 and/or blower 26 may be ON at least temporarily. Phase a is followed by a low speed impulse phase b during which a fast speed up-ramp up to a third rotation speed R3 and a down-ramp to lower rotation speed (e.g. R4) is executed. Preferably the speed profile is such that drum rotation at the third rotation speed R3 is only for a short time period. Thus a speed ramp peak with a low maximum drum speed R3 is provided during which the laundry does not tend to permanently adhere to the drum mantel (i.e. if the drum would be stopped now, the laundry detaches from the laundry wall at the top positions of the drum). The fourth rotation speed R4 is preferably such that the laundry is still adhering to the drum wall by centrifugal force so that the following inertia detection phase starts with adhering laundry. The spin peak ("low speed impulse") provides a more even distribution of the laundry along the drum mantel, which in turn improves the detection of the inertia by reduction of error sources in the inertia measurement and evaluation/estimation. Actually, it was observed that laundry imbalance by uneven distribution of laundry in the drum may render the inertia determination more unreliable und such imbalance is removed with the low speed impulses in phase b.

[0057] After phase b, in phase c the inertia is determined which is repeated here four times corresponding to the four sawtooth-like speed ramps between rotation speeds R4 and T. By the dotted horizontal lines the respective speeds are indicated. T is the maximum speed during inertia measurement and R4 is the starting speed - both are above the threshold speed at which the laundry is hold at the drum wall due to centrifugal force.

[0058] In the example of Fig. 6 the inertia I is determined each time a speed ramp R4 - T - R4 is performed and the inertias are summed up (here four times) to have as a result the total inertia I1. Of course instead of summing up, an average over all the inertias detected during each of the speed ramps can be made. The summed up inertia I1 is compared to the inertia threshold Ithr (which here of course is the four-fold of the simple inertia threshold). As the summed up inertia I1 is higher than the inertia threshold Ithr, the spin cycle proceeds with a medium speed spinning phase d, in which the rotation speed is increased first to a low spinning speed R2, then reduced to the rotation speed (for example R4) and thereafter the rotation speed is again increased to R2 and from there to R1 which is about 650 rpm. Thereafter, the rotation speed is reduced again to R4.

[0059] In phase c it was determined that the laundry is over-wet (I1 > Ithr) and thus, dehydration using medium spinning speed R1 is provided in phase d. As can be seen by the (single) inertia peaks (R4-T-R4), the inertia is detected before increasing to medium spin speeds R2 and R1 to detect whether there is any imbalance that may harm the drum and tub mechanics. By spinning with the low or medium spin speed R2, R1 it is avoided that the laundry significantly/permanently attaches to the drum mantel which would prevent or slow down detachment of the laundry in the following (second) drying phase f.

[0060] In phase e, the inertia measurement is repeated which is the same as in phase c. As indicated by 12, the added-up inertia 12 is lower than the inertia threshold Ithr, which means that there is no longer an over-wet state of the the laundry and the second drying phase f can follow to phase e.

[0061] If in phase e it would have been detected that the inertia 12 is higher than the threshold Ithr, the medium spin phase as in phase d can be repeated following by a third phase (like c and e) of determining the inertia I. See loop in the flow diagram of Fig. 8 with the repetition of steps S8 to S18.

[0062] Fig. 7 shows the rotation speed RPM of the drum over time for a drying cycle having essentially the same phases a, c and f as in Fig. 6. The phase b' of the low speed impulse is slightly modified as compared to phase b of Fig. 6. In this case, during the inertia detection Ib preceding the low speed impulse to R3 and which is denoted as Ib, it was evaluated that the inertia Ib is low and thus the time period at which the drum rotation speed is held at the third rotation speed R3 is extended. This can be seen from the plateau at the tip of the medium speed pulse. In phase c of Fig. 7 the total inertia I1 is determined again by four times executing the speed ramps R4-T-R4 and summing up the respectively determined inertias. As in this case it was evaluated that the summed-up inertia I1 is lower than the threshold Ithr, the procedure immediately proceeds with the second drying phase f.

[0063] Fig. 8 shows a flow diagram of a drying cycle according to the invention. The small letters in brackets refer to the different phases as shown in and described for Figs. 6, 7, 10 and 11. The drying starts at step S0 where the drying cycle is initialized by setting the variables for the drying cycle. In the optional step S2 a detach phase a0 is performed (compare Fig. 10) and is preferably executed when a combined washing and drying program is running and the drying program is the drying cycle thereof. S2 is provided, if in the last phase of the washing cycle a high speed spinning at spinning (e.g. at speed R5 - see phase n of Fig. 10 including the R5 peak) was executed. In the next optional step S4 a first drying phase a is executed providing a pre-drying.

[0064] In optional step S5 a low spin speed impulse phase b is executed. By optional step S5 the drum is rotated at a low spin speed to improve distribution of the laundry within the drum to avoid unwanted influence by an imbalance on the inertia measurement (see above). The drum rotation for laundry distribution is made by the third speed R3, which may be the same as the low spin speed R2 during phase d shown in Fig. 6.

[0065] In step S6 a counter in the control unit for counting the numbers of medium spin speed phases is set to zero.

[0066] In step S8 the inertia determining phase c is executed to determine the weight of the load which is composed of the laundry dry weight and the water bound in the laundry. For this purpose in the example described here in detail, the load signal is the inertia which is measured/estimated and which is caused by the drum load.

[0067] In step S10, if the inertia is above the predetermined inertia threshold Ithr and if the number n of already executed medium spin speed phases d is below a predetermined maximum number n_{max}, then the process proceeds with step S12. As explained before, comparing the inertia with the inertia threshold and finding that the inertia is higher than the threshold results in the conclusion that the laundry is over-wet. Then, prior to drying by using drying air (phase f), a spinning at medium spinning speed (phase d) is to be performed. Comparing the number n with the maximum number n_{max} assures that the loop S10 to S8 (via S18) is not endlessly repeated in case the inertia will not be reduced by spinning the laundry in the drum with the medium spinning phases c, e.... Such endless loop may happen for example if by medium speed spinning no water can be expelled such that the inertia essentially cannot be reduced by step S16. For example the laundry dry weight and the low amount of water bound therein is so high that the inertia threshold is exceeded while actually the laundry is not over-wet.

[0068] Step S12 only indicates that by step S10 over-wet laundry (or an inertia estimate corresponding thereto) was positively detected. By optional step S14 the drum is rotated at a low spin speed R2 to improve distribution of the laundry within the drum to avoid unwanted influence by an imbalance on the inertia measurement (see Fig. 6 above).

[0069] Thereafter, at step S16, the drum is rotated at a medium drum speed R1 as shown in phase d including broad plateau which means an extended time as compared to the peak impulse during phase b. The extended period of rotating with the first medium speed R1 results in spin-dehydrating the laundry.

[0070] When the medium spin speed phase d has been performed at step S16 or during this step S16, at step S18 the counter value is increased by 1 and the procedure advances to step S8 for repeating the inertia detection/estimation as for example shown in phase e of Fig. 6.

[0071] As mentioned, the loop S8-S10-S12...S18-S8 is repeated as long as the counter value n is below the maximum value n_{max}, if the inertia does not drop by step S16. In any case, if the inertia detected at step S8 is below the inertia threshold Ithr (no), then the procedure proceeds to step S20 which only indicates that a normal weight of the laundry (normal-wet) was detected such that no or no further medium speed spinning phase d is required.

[0072] The procedure proceeds to step S21 which is the drying phase f during which the laundry is dried in a conventional way. At the end of the drying phase f or as part of the drying phase f itself, at step S22 optionally a cooling phase g is executed to cool down the laundry temperature so that the laundry can be safely removed from the drum by the user. Then the drying cycle is finished at step S24.

[0073] Fig. 9 shows a diagram with the relation between the inertia I and different types and humidity degrees of laundry similar to Fig. 4 and including low laundry load or volumes. It shows that at low dry laundry weights of IEC-standard laundry the detected Inertia I may be below the threshold Ithr despite the fact that the laundry is over-wet (humidity above 70%). However it was found in this case that the volume of the laundry is low enough that it can start tumbling during the drying phase f such that efficient air/laundry contact for evenly drying the laundry on large surface ratios of the laundry pieces is enabled. Although the drying time is somewhat extended as compared to normal-wet laundry (low humidity) still an acceptable drying efficiency is implemented.

[0074] Fig. 10 shows the drum rotation speed rpm over time t for a cotton laundry treatment program including a washing cycle (only the end phase shown) and a drying cycle. The time diagram shows only the two last phases m and n of the washing cycle. Phase m indicates only some of the drum rotations or the drum rotations speeds during a rinsing phase m. The inclined double lines on the bottom timeline indicate that the actual time period on the respective time line may be extended. A final spin phase n is following the rinsing phase m. During phase m normally the laundry is spun including a high speed spin period at spinning speed R5 which is for example 1350 rpm (compare for example Fig. 5).

[0075] Normally the laundry is sufficiently dehydrated during this phase n to achieve humidity of the laundry in the normal-wet range. However, as indicated by the bent arrow, due to a user option selection, in the final spin phase n the laundry is not spun. This means that the rpm-peak having speed R5 is excluded. I.e. the high speed spin is completely skipped and the bent arrow indicates a jump of the program sequence which does not include the high spin speed peak. Under such situation the laundry is not dehydrated and the laundry is over-wet.

[0076] Optionally at the end of the washing cycle the program is halted such that the user can remove a portion of the laundry load previously washed. The reason is that by the washing cycle in maximum more laundry can be washed than in the following drying cycle can be efficiently dried. Plainly speaking, using the maximum allowable laundry load for the washing cycle represents an over load for the drying cycle and if the program would be continued without removing a portion of the laundry, the drying cycle is extremely long or the final humidity achieved at the end of the drying cycle is too high or at least higher than the intended target humidity.

[0077] Independent of whether some laundry has been removed after the washing cycle during the hold, the drying cycle is started with the initialization (compare step S0). The drying cycle includes in this case the optional detach phase a0 which is provided for the case that no laundry is removed and some of the laundry is adhering to the drum wall. For example if in the spin phase n instead of the high speed spinning at R5 a low or medium speed spinning (e.g. at R2 or R3) was made. However if, for example, the spinning phase n was suppressed, the detach phase a0 can be skipped and the drying cycle can be started with the optional first drying phase a (compare step S4). The optional first drying phase a has been described above.

[0078] For the low speed impulse phase b, the inertia detection phase c, the medium speed spinning phase d, the second inertia detection phase e and the drying phase f, reference is made to the above (see for example Fig. 6). It is noted that in the diagram of Fig. 10 it was detected during the first (n = 0) inertia detection phase c that the inertia is higher than the threshold value Ithr such that the medium speed spinning phase d is included. Then in the second (n = 1) inertia determining step e it was determined (compare step S10) that the inertia is below the threshold Ithr and the drying phase f can be started. After finishing the drying phase f, a cooling phase g (optional step S22) is executed in which the laundry temperature is cooled down for user removal.

[0079] The different phases in the Figures are separated by the vertical dashed lines and at the bottom of Fig. 10 it is indicated, whether the heater H (compare second heat exchanger 20) and the blower B (compare 26) are activated (on) or deactivated (off). In the activated phases (on) the heater H and blower B may be permanently activated or temporarily activated. In particular the heater H is activated, but may be switched on/off in dependency of a temperature control to avoid overheating of the drying air and a damage of the laundry thereby.

[0080] Especially for the situation where the user has removed a portion of the laundry after the washing cycle (laundry load convenient for the washing cycle but representing an overload for the drying cycle), a second drying cycle has to be started for drying the second portion of the laundry load and for which no information about the washing cycle is available. This means that for drying the second portion of the wash load, normally the laundry apparatus has no information of the washing cycle and a drying cycle is started as if no washing cycle was performed before. Then with the inertia detection phase c it is determined whether the freshly loaded laundry is normal-wet or over-wet. The over-wet laundry then requires introduction of phase d for medium spinning for spin dehydration of the laundry before starting an efficient drying phase f, g.

[0081] Fig. 11 shows an example for washing and drying synthetic laundry. The time sequence is the same as in Fig. 10 except that the detach phase a0 and the first drying phase a are omitted. Correspondingly the heater H and the blower B are activated (on) or deactivated (off) at different instances/phases (time points).

[0082] Determining of the load in the drum (laundry dry weight + water amount bound in the laundry) is described above by determining the inertia as a representative example of determining the load. The 'determining' via the inertia - as more or less all other methods of determining the load - represent an estimation of the load for which some experimental corrections or some preparing measures have to be made before a reliable load estimation value results from the measurement. In the above example a high laundry load of normal-dry laundry may 'simulate' an inertia of a normal dry weight load being normal-wet. Or unevenly distributed laundry in the drum may result in imbalance which in turn adversely affects the inertia measurement. In so far the 'determining' of the laundry load (e.g. via the inertia) is often an 'estimation' of the laundry load (inertia). But in any way the estimation is reliable to implement the method with high reliability which might have its limits in exceptional cases only, where the drying cycle has to cope with situations which are not considered to be the 'normal' or 'standard' drying situations.

<u>Reference Numeral List:</u>

2	washer dryer	40	laundry
4	loading opening	42	fluff filter
6	door	44	electrical heater
7	handle	46	control unit
8	display and input panel	48	memory
10	program selector	50	inlet temperature sensor
12	cabinet/ housing	52	outlet temperature sensor
14	heat pump system	54	ambient temperature sensor
16	refrigerant loop	56	heater temperature sensor
18	first heat exchanger (evaporator) / air humidity condenser	58	drum motor inverter
		60	inverter sensor unit

(continued)

20	second heat exchanger (condenser) / electrical heater	62	compressor inverter sensor unit
		64	compressor inverter
22	compressor	A	drying air flow
24	expansion device	B	blower
26	blower	RF	refrigerant flow
28	drying air channel	H	heater
30	tub	R1...R6	first ... sixth drum rotation speed
32	outlet	I	inertia
34	inlet	Ithr	inertia threshold
36	drum (laundry compartment)	T	lower torque/inertia determination speed
38	drum motor		

Claims

1. Method for drying laundry to be implemented in a washing and drying apparatus (2), the washing and drying apparatus (2) comprising:

a tub (30),
a drum (36) arranged within the tub (30) and being adapted to receive laundry (40) for treatment within the drum,
a washing arrangement adapted to wash the laundry received in the drum (36),
a drying arrangement comprising a drying air heater (20, H) and a drying air fan (26, B), wherein the washing and drying apparatus is adapted to dry the laundry received in the drum (36), and
a load detector (46, 60) for detecting a load signal indicative of the load received in the drum (36),

wherein the drying method comprises:

starting (S0) a drying program,
detecting (d, S8) the load signal (I),
evaluating (S10) the detected load signal (I),
in dependency of the load evaluation, executing (S16) a spin cycle (d) or not executing a spin cycle, and
drying (f, S22) the laundry (40) received in the drum (36) in a drying cycle.

2. The method of claim 1, wherein the step of evaluating (S10) the detected load signal (I) is or comprises comparing the detected load signal with a threshold value (Ithr) and wherein, when the detected load signal is above the threshold value, the spin cycle (d) is executed.

3. The method of claim 1 or 2, wherein in the spin cycle (d), the drum (36) is rotated with a first drum rotation speed (R1) in the range of 300 to 700 rpm or with a speed profile having a maximum first rotation speed (R1) in the range of 300 to 700 rpm.

4. The method of claim 1, 2 or 3, wherein during the period of the spin cycle (d), during the period of the load detection (c) or during the periods (c, d) of load detection and spin cycle:

the heater (20, H) is OFF and the drying air fan (26, B) is OFF,
the heater is OFF and the drying air fan is at least partially ON,
the heater is at least partially ON and the drying air fan is OFF, or
the heater is at least partially ON and the drying air fan is at least partially ON.

5. The method of any of the previous claims, wherein the washing and drying apparatus (2) comprises at least one temperature sensor (50, 52, 54, 56) adapted to detect a temperature at the drying arrangement, at the washing arrangement or at the drying and washing arrangement, and wherein the method further comprises:

detecting and evaluating the temperature, and
in dependency of the evaluated temperature and in dependency of the load evaluation (S8, c):

not executing the spin cycle (d), or
deactivating the drying air heater (20, H) during the spin cycle (d).

6. The method of any of the previous claims, wherein the method further comprises:

repeating the steps (S8, S10, S16) of detecting the load signal, evaluating the detected load signal and executing the spin cycle until the detected load signal (l) is lower than a predetermined second load threshold (lthr) or a counter (n) has reached a predetermined number (n_{max}) of repetitions or a time limit is expired.

7. The method of any of the previous claims, wherein after the spin cycle (d) a laundry detach cycle is executed, in which the drum is alternatively rotated clockwise and counterclockwise or in counter rotation compared to the rotation direction used during the spin cycle.

8. The method of any of the previous claims, wherein between the step of starting (S0) the drying program and before detecting (S8, c) the load signal (l) a time period (a0, a) of predetermined duration is provided.

9. The method of claim 8, wherein, during the time period (a0, a) after program start and before detecting the load signal (l), the drying air heater is ON and the drying air fan is ON.

10. The method of any of the previous claims, wherein, during or prior to the step (S8, c) of detecting the load signal, the drum (36) is rotated at a second rotation speed (R2) or is accelerated up to a speed, which is lower than a or the first rotation speed (R1) used in the spin cycle (d) and which is equal to or greater than the minimum speed required to keep the laundry (40) adhering to the inner surface of the drum (36) during full rotations.

11. The method of any of the previous claims, wherein the method further comprises the steps of:

detecting whether the drying program to be executed is part of a washing and drying program and assessing whether during the washing program an after-rinse spinning cycle (n) normally executed subsequent to the last laundry rinsing cycle (m) has been skipped;
when the after-rinse spinning cycle (n) was skipped, then executing during the drying program the spin cycle (d) at a or the first drum speed (R1) and then detecting (S8, e) the load signal (l); and
when the after-rinse spinning cycle (n) was not skipped, then executing during the drying program a spin cycle (b) at a or the second speed (R2) and then detecting (c) the load signal (l) or detecting (c) the load signal.

12. The method of any of the previous claims, wherein the method further comprises after starting (S0) the drying program and before detecting (d, S8) the load signal (l):

rotating (b) the drum at a second speed (R2) or with a speed profile including a second speed (R2).

13. The method of any of the previous claims, wherein the operation parameters of the drum rotation with a or the first speed (R1) and/or the parameter of the drum rotation with the second speed (R2) are based on one or more of the following:

- a laundry treatment program or laundry treatment options set by a user via an input selector (8, 10) of the washing and drying apparatus (2);
- a laundry type as set by a user or as estimated by the washing and drying apparatus;
- the duration of the laundry treatment program set by a user or as estimated by the washing and drying apparatus; and
- in case that the drying program is part of a washing and drying program, an estimation of the water content in the laundry at the beginning of a drying program based on the laundry weight difference between the dry laundry weight at the beginning of a drying and washing program and the laundry wet weight at the end of the washing part of the washing and drying program.

14. The method of any of the previous claims, wherein the drying arrangement comprises a drying air condensation device (18), and wherein the method comprises:

when the drying air heater (20, H) is activated (on), activating the drying air condensation device (18), or
when the drying air heater (20, H) is deactivated (off), at least temporary deactivating the drying air condensation

device (18).

15. The method of any of the previous claims, wherein the drying arrangement comprises a or the drying air condensation device (18), and wherein the method comprises:

deactivating the drying air heater (20, H) while the drying air condensation device is activated, or activating the drying air heater (20, H) while the drying air condensation device is deactivated.

16. The method of any of the previous claims, wherein after the drying cycle (f) a laundry cooling cycle (g) is provided by: deactivating the drying air heater (20, H) while the drying air blower (26) is at least partially activated and while the drum (36) is rotated in clockwise direction, in counter clockwise direction or in clockwise and counter-clockwise direction for cooling down the laundry.

17. The method of any of the previous claims, wherein the or a laundry cooling cycle (g) is skipped in dependency of at least one of:

- a user selection input via an input selector (8, 10) of the washing and drying apparatus (2);
- the laundry type as input by a user or as estimated by the washing and drying apparatus; and
- the duration of the laundry treatment program set by a user or estimated by the washing and drying apparatus.

Fig. 1

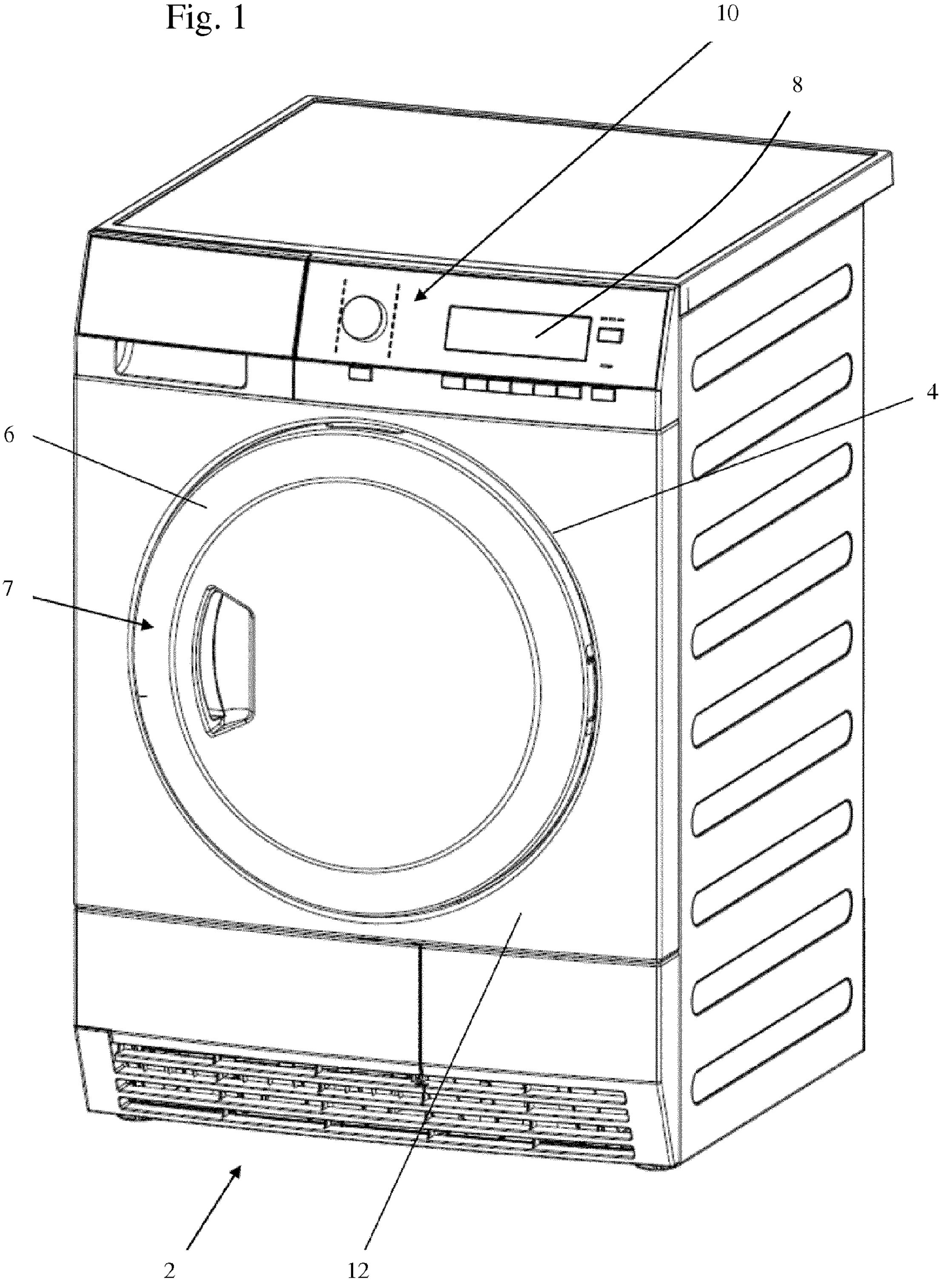
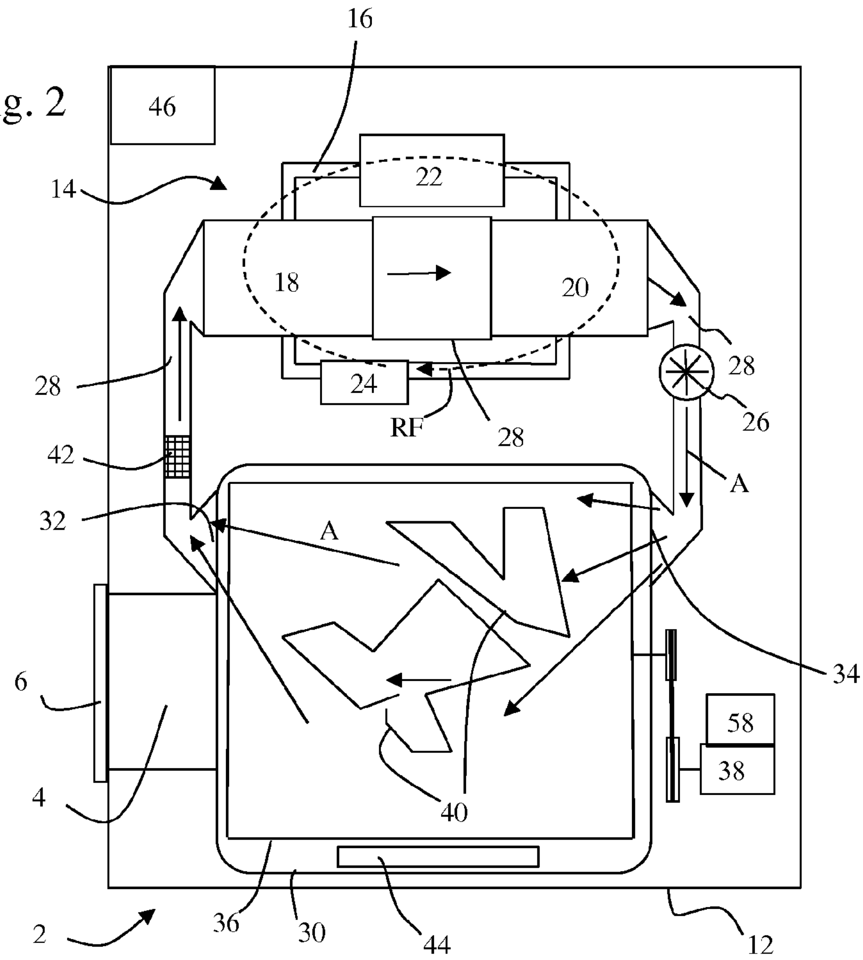


Fig. 2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18
20
28
28
24
RF
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26
42
A
32
A
34
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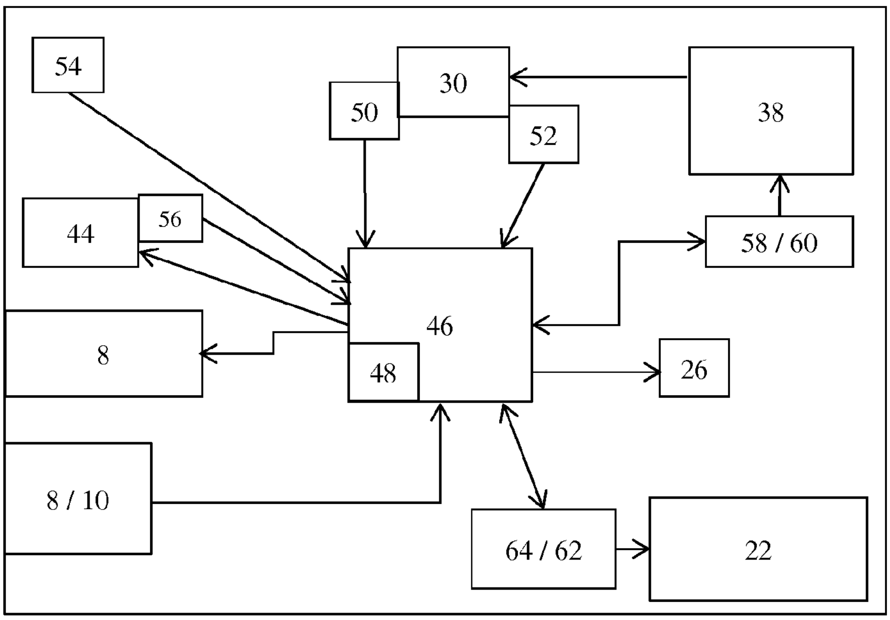
36
30
44
12

Fig. 3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38
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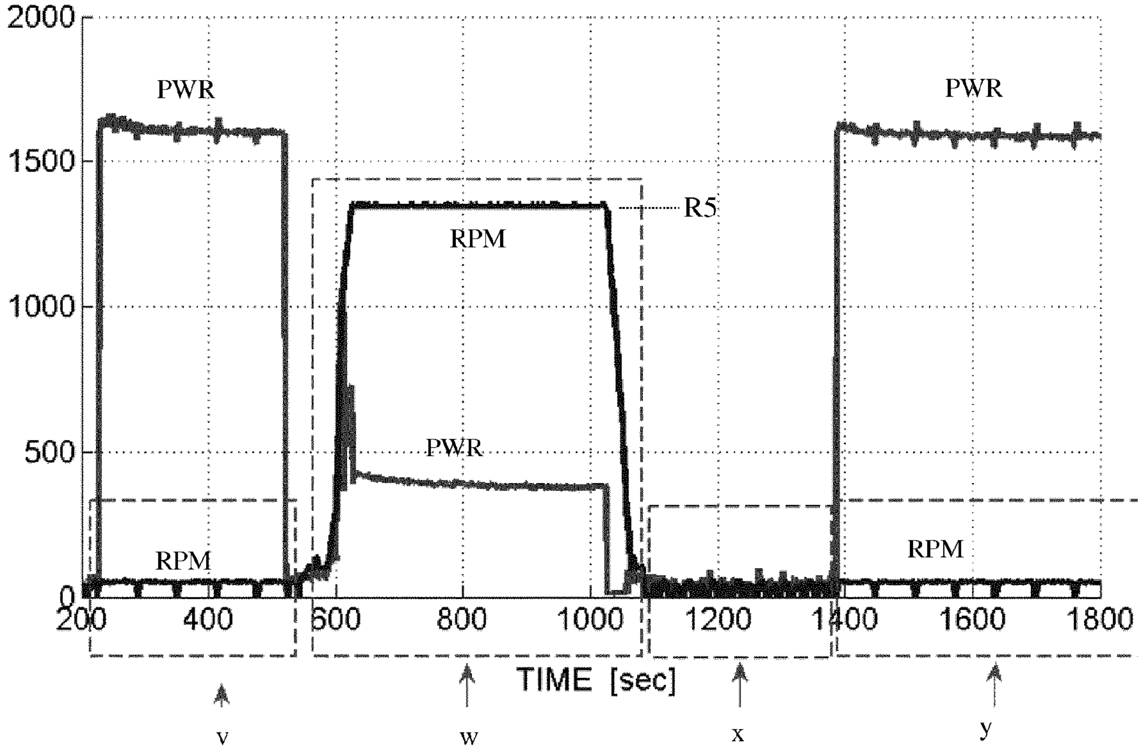
56
58 / 60
46
8
48
26
8 / 10
64 / 62
22

Fig. 5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1000
500
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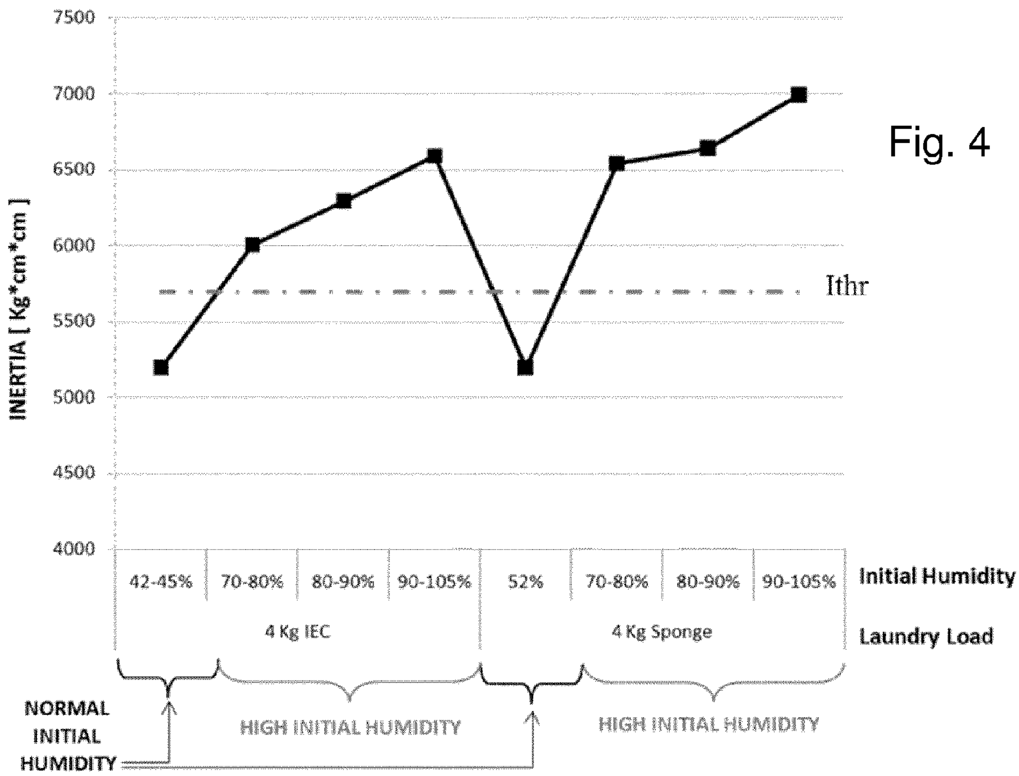
PWR
RPM
R5
PWR
PWR
RPM
RPM
200
400
600
800
1000
1200
1400
1600
1800
TIME [sec]
v
w
x
y

Fig. 4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7000
6500
6000
5500
5000
4500
4000
INERTIA [Kg*cm*cm]
Ithr
42-45%
70-80%
80-90%
90-105%
52%
70-80%
80-90%
90-105%
Initial Humidity
4 Kg IEC
4 Kg Sponge
Laundry Load
NORMAL INITIAL HUMIDITY
HIGH INITIAL HUMIDITY
HIGH INITIAL HUMIDITY

Fig. 6

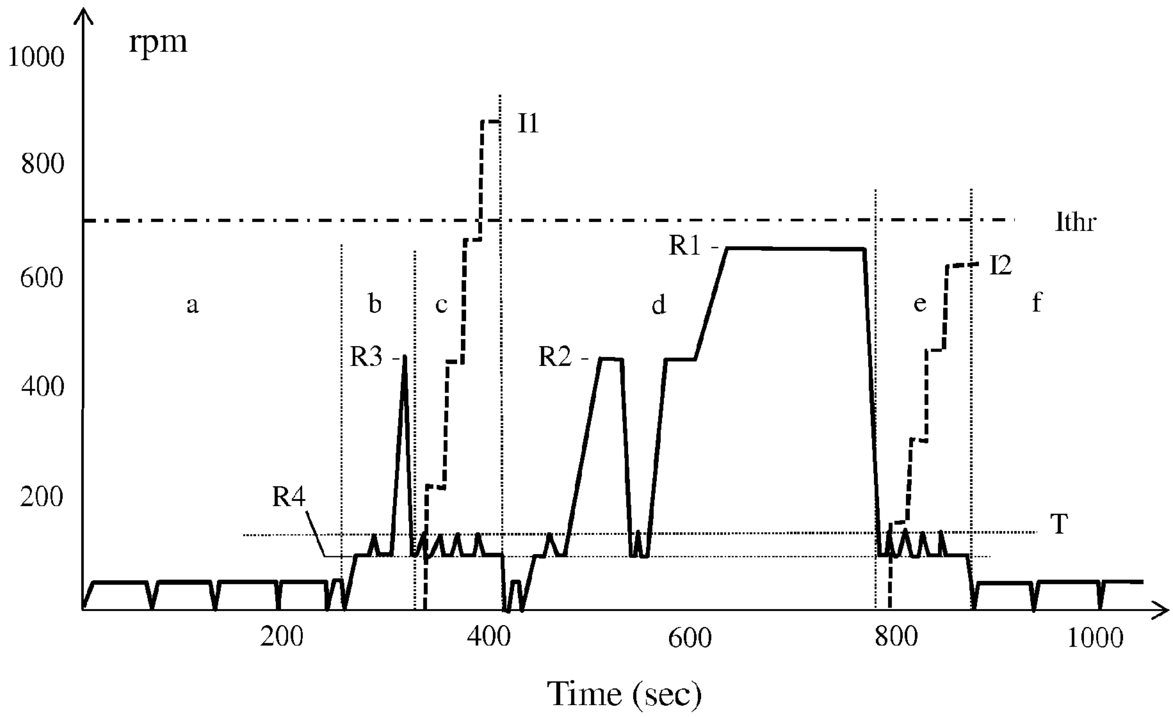
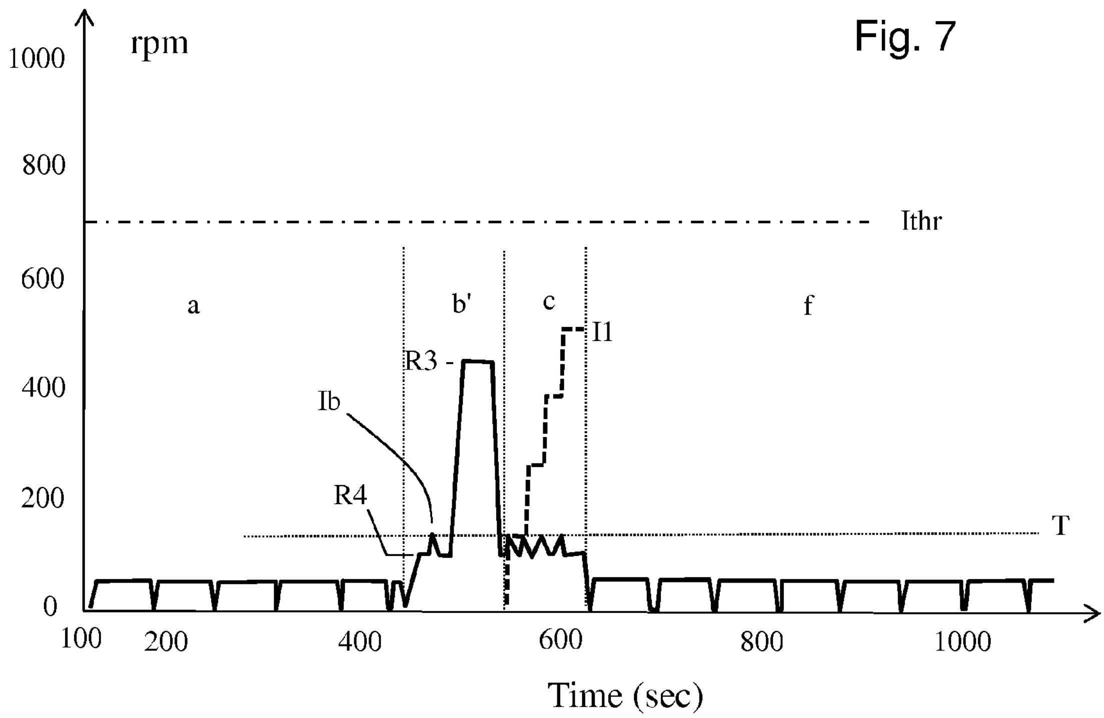

1000
800
600
400
200
rpm
I1
Ithr
R1 -
I2
a
b
c
d
e
f
R3 -
R2 -
R4
T
200
400
600
800
1000
Time (sec)

Fig. 7


1000
800
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200
0
rpm
Ithr
a
b'
c
f
I1
R3 -
Ib
R4
T
100
200
400
600
800
1000
Time (sec)

Fig. 8

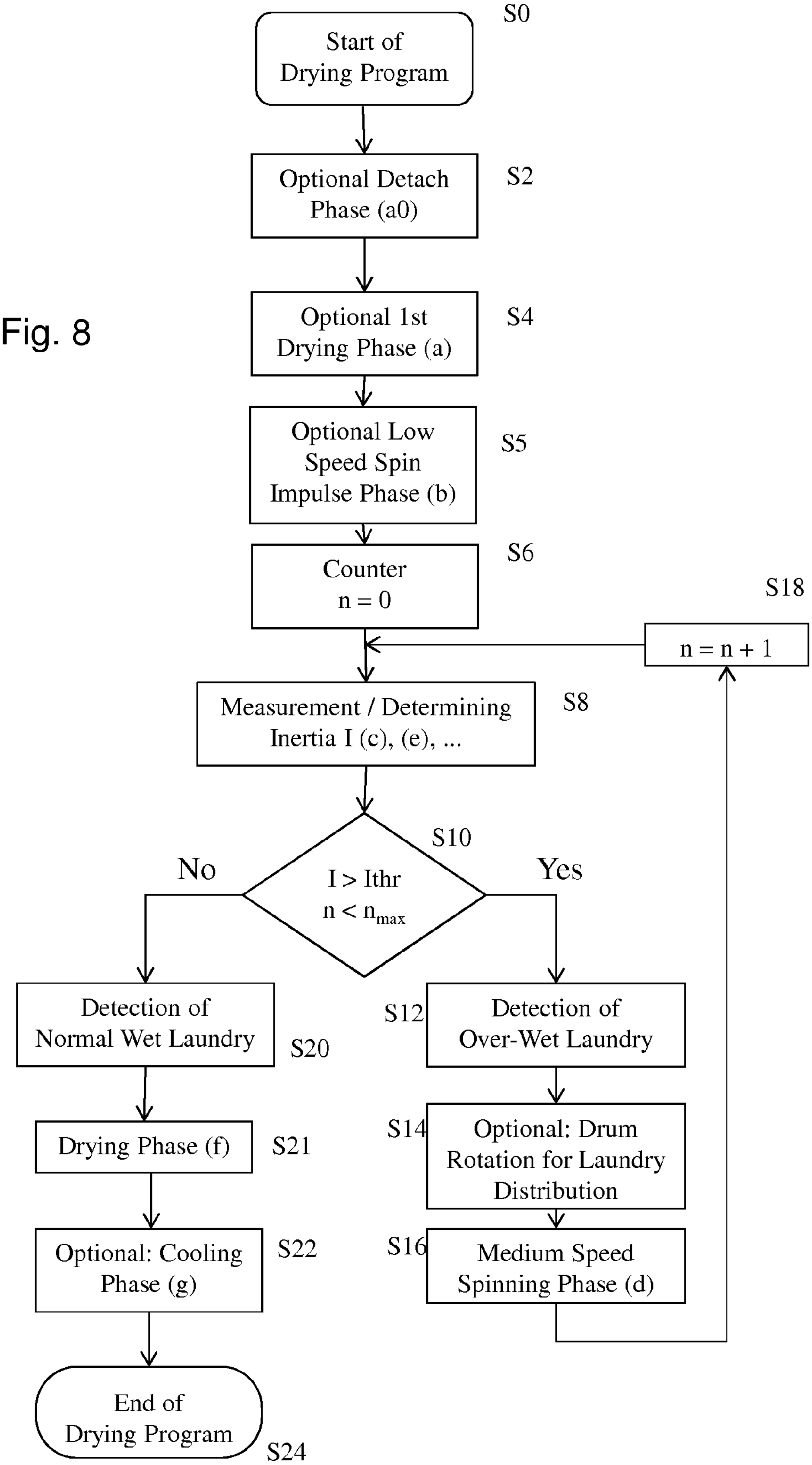

Start of Drying Program
S0
Optional Detach Phase (a0)
S2
Optional 1st Drying Phase (a)
S4
Optional Low Speed Spin Impulse Phase (b)
S5
Counter n = 0
S6
S18
n = n + 1
Measurement / Determining Inertia I (c), (e), ...
S8
S10
No
Yes
I > Ithr
n < n_{max}
Detection of Normal Wet Laundry
S20
S12
Detection of Over-Wet Laundry
Drying Phase (f)
S21
S14
Optional: Drum Rotation for Laundry Distribution
Optional: Cooling Phase (g)
S22
S16
Medium Speed Spinning Phase (d)
End of Drying Program
S24

Fig. 9

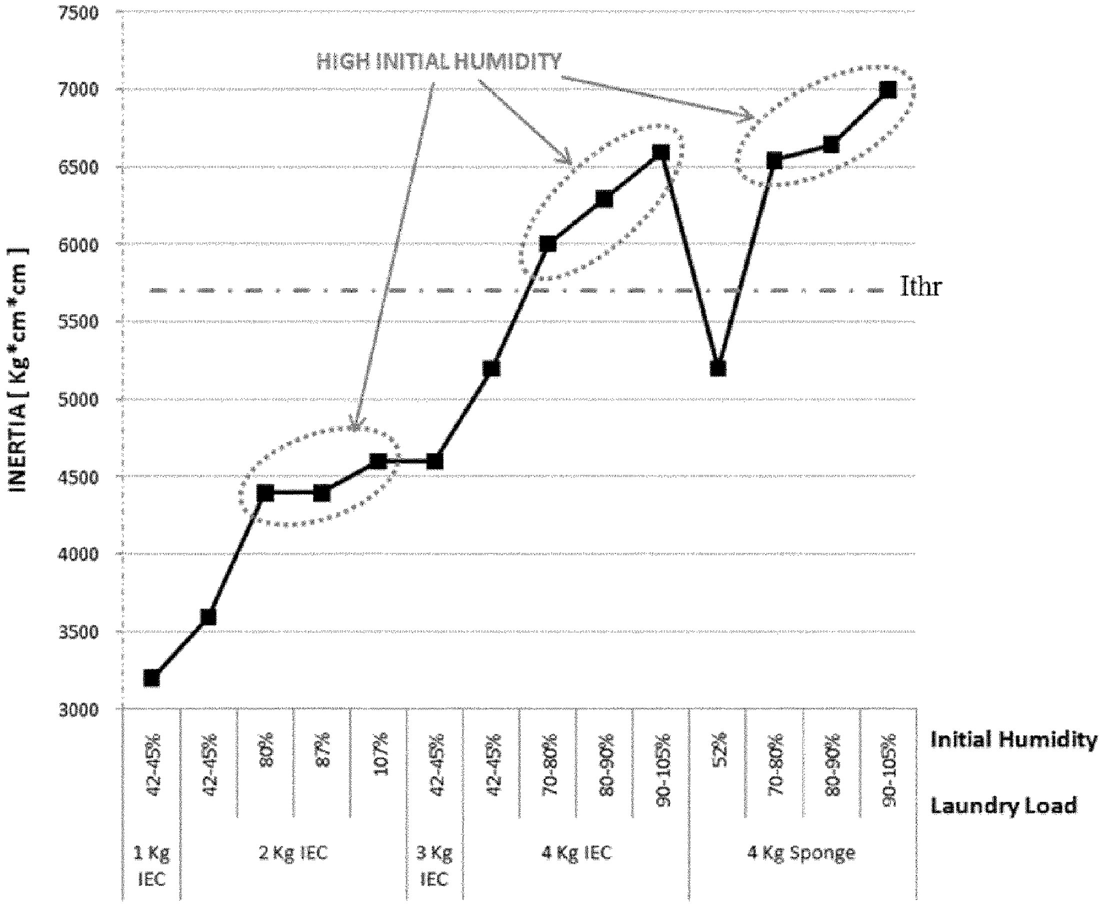


Fig. 12

Speed Range in rpm	R1 Medium Spin Drying	R2 Low Spin Impulse	R3 Laundry Distribution Impulse	R4 min. Inertia Detection	T max. Inertia Detection	T - R4 Speed Ramp Inertia Det.	R5 Dehydration Spinning	R6 Tumbling for Drying
General	300 - 800	200 - 700	200 - 700	70 - 200	90 - 400	5 - 50	800 - 1800	10 - 80
Recommended	400 - 750	300 - 600	300 - 600	90 - 170	110 - 300	10 - 40	900 - 1600	15 - 70
Optimal	500 - 700	350 - 520	350 - 520	100 - 150	120 - 200	20 - 30	1000 - 1400	20 - 50

Further Values/Ranges in Text - All values arbitrarily combinable

Fig. 10

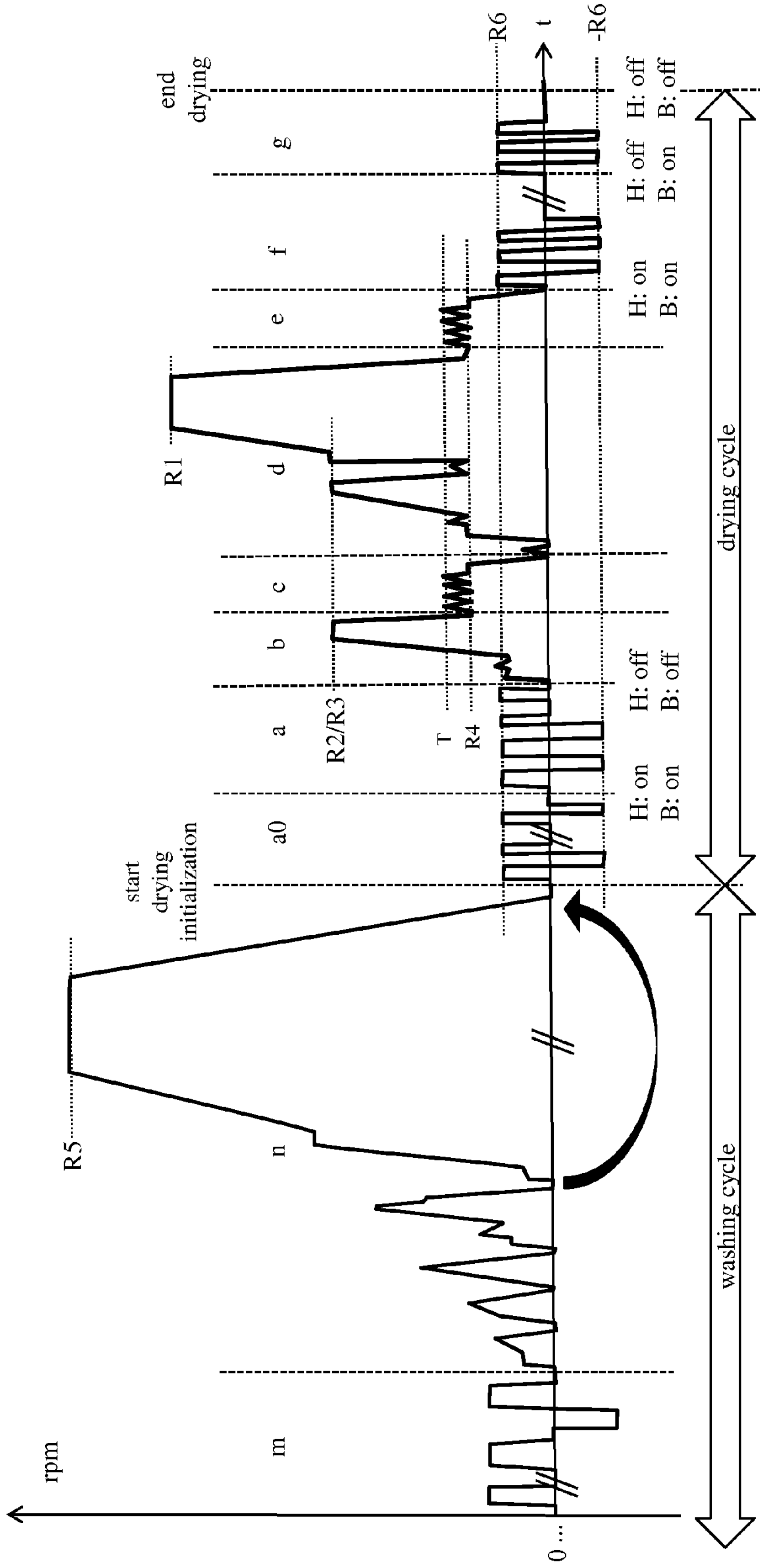
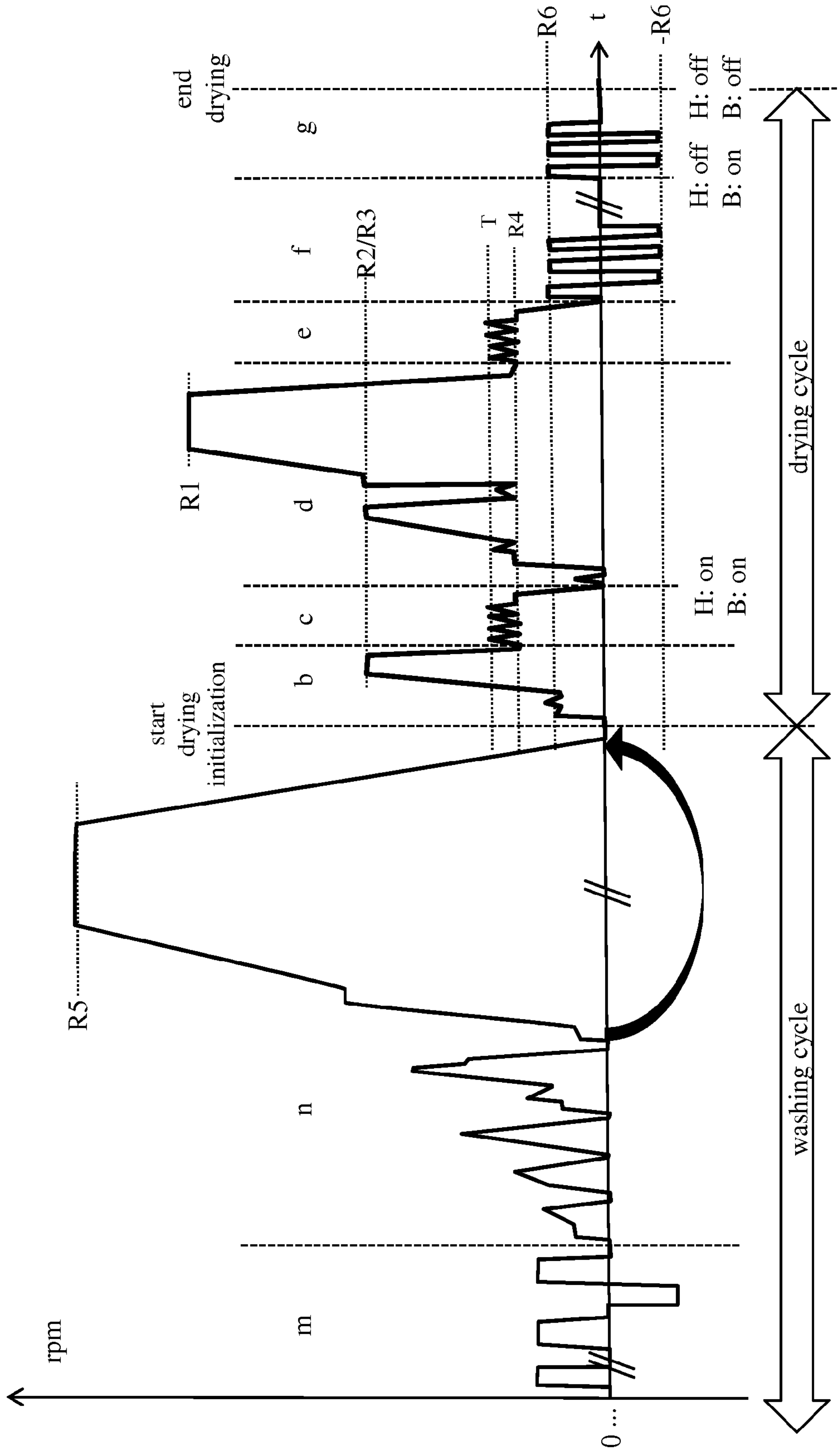

rpm
0
m
n
R5
start
drying
initialization
a0
a
b
c
d
e
f
g
end
drying
R1
R2/R3
T
R4
R6
-R6
t
H: on
B: on
H: off
B: off
H: on
B: on
H: off
B: on
H: off
B: off
washing cycle
drying cycle

Fig. 11


rpm
0
m
n
R5
start
drying
initialization
b
c
d
R1
e
f
R2/R3
T
R4
g
end
drying
R6
t
-R6
H: on
B: on
H: off
B: on
H: off
B: off
washing cycle
drying cycle

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 4031

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 December 2015	Kising, Axel

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