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(54) **CONTROL DEVICE, CONTROL METHOD, AND INDUCTION COOKER**

(57) The present invention provides a control device for an induction cooker, the control device comprising a driving circuit (4) configured to controllably drive an induction coil (6) of the induction cooker (2) with a power signal (5), a controller (7) coupled to the driving circuit (4) and configured to control the driving circuit (4) with a control signal (8) to drive the induction coil (6) with the power signal (5), and a first measurement device (9) con-

figured to measure a temperature (10) of the induction coil (6) and provide the measured temperature to the controller (7), wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the measured temperature (10) and adapt the control signal (8) according to the determined filling level. The present invention further provides a respective method and an induction cooker.

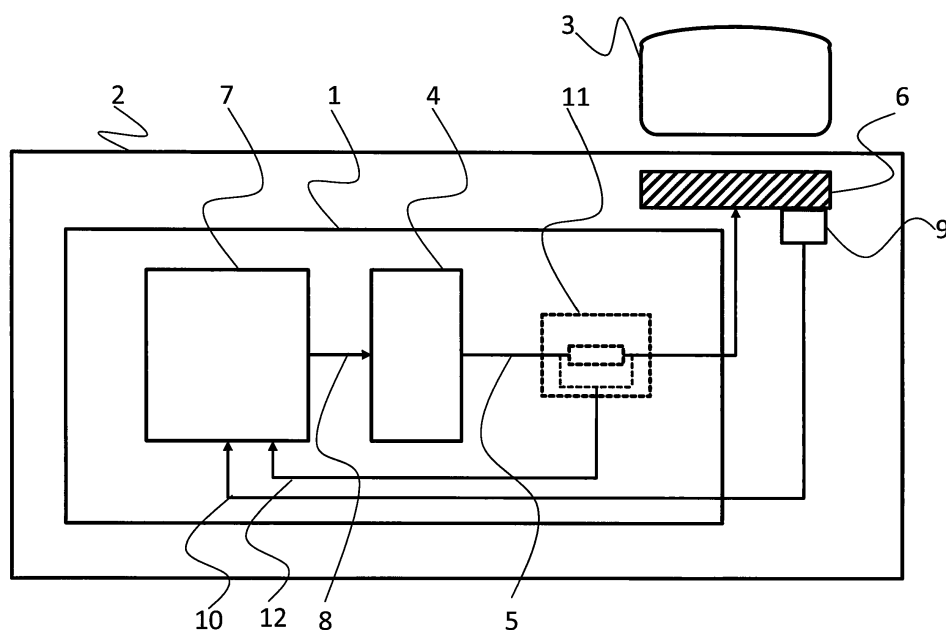


Fig. 1

Description

TECHNICAL FIELD

[0001] The invention relates to a control device and a control method for an induction cooker. Further, the present invention refers to a respective induction cooker.

BACKGROUND

[0002] Although applicable to any system that uses energy transfer via induction to heat an element, the present invention will be mainly described in combination with induction cookers.

[0003] Induction cookers are usually used to heat cooking vessels by magnetic induction. Usually a high frequency power signal is provided to an induction coil. This generates a magnetic field around the induction coil, which is magnetically coupled to a conductive cooking vessel, such as a pan, placed over the induction coil. The magnetic field then generates eddy currents in the cooking vessel, causing the cooking vessel to heat.

[0004] In particular, the output power of the induction coil is a function of the power signal input, the coil inductance, the resistance of the cooking vessel, and the resonance frequency of the system. In known induction cookers, the induction coil is usually driven with a power signal at the resonance frequency of the system. The closer the system is driven to its resonance frequency, the more efficient the power can be delivered to the system.

[0005] When heating a cooking vessel with an induction cooker it is important to know the state of the induction cooking system, e.g. the induction cooker and the cooking vessel. It is e.g. important to detect if a cooking vessel is placed on the induction cooker.

[0006] Accordingly, there is a need for an improved power control in induction cookers.

SUMMARY

[0007] The present invention provides a control device with the features of claim 1, a control method with the features of claim 8, and an induction cooker with the features of claim 15.

[0008] Accordingly a control device for an induction cooker comprises a driving circuit configured to controllably drive an induction coil of the induction cooker with a power signal, a controller coupled to the driving circuit and configured to control the driving circuit with a control signal to drive the induction coil with the power signal, and a first measurement device configured to measure a temperature of the induction coil and provide the measured temperature to the controller, wherein the controller is configured to determine the filling level of a cooking vessel based on the measured temperature and e.g. adapt the control signal according to the determined filling level, e.g. turn off the power signal if the cooking ves-

sel is empty.

[0009] Further, a control method for controlling an induction cooker comprises the steps of controllably driving an induction coil of the induction cooker with a power signal of a predetermined first frequency, measuring a temperature of the induction coil, and determining the filling level of a cooking vessel based on the measured temperature.

[0010] Finally, an induction cooker comprises an induction coil, and a control device according to the present invention.

[0011] Induction cookers usually use a fixed operating frequency range for the power signal, which drives the induction coils. The fixed operating frequency range usually starts at the resonance frequency of the induction coil and ends at a safety limit frequency. The maximum efficiency for the power transfer to the cooking vessel is achieved at the resonance frequency of the system of induction coil and cooking vessel.

[0012] Increasing the frequency will lower the transferred energy. However, at increased frequencies, the impedance of the induction coil will fall and the current through the induction coil will raise. Therefore, a maximum frequency is defined, which is not surpassed.

[0013] Further, the effect a cooking vessel has on the input impedance and the resonance frequency of the induction coil can be taken into account when selecting the fixed frequency range. The operating frequency range can e.g. be selected for a virtual idealized or standardized cooking vessel, which represents an average of the existing cooking vessels. Objects, which are placed over the induction coil to cook, like e.g. pans or pots, will be referred to as cooking vessels throughout this description.

[0014] An empty cooking vessel should not be heated with the induction cooker, since this could damage the induction coils and/or the cooking vessel. The present invention uses the knowledge that a plurality of physical variables in the induction cooker change with the filling state of the cooking vessel.

[0015] The present invention uses this knowledge and provides an improved control of the induction cooker, where empty cooking vessels can be detected and the control of the induction cooker, e.g. the output power, can be amended accordingly.

[0016] If a cooking vessel is placed over the induction coil, the induction coil can transfer energy to the cooking vessel. However, if the cooking vessel is empty, the cooking vessel cannot forward or dissipate the transferred energy as heat to any liquid. This will lead to an increasing temperature of the cooking vessel. Since the magnetic field or energy provided by the induction coil cannot be dissipated, the temperature of the induction coil will also raise.

[0017] This rise of temperature can be measured with the first measurement device and then be evaluated by the controller.

[0018] The temperature can therefore serve as an ad-

equate physical variable to determine the filling state of the vessel.

[0019] Further embodiments of the present invention are subject of the further subclaims and of the following description, referring to the drawings.

[0020] In an embodiment, the controller can be configured to determine the filling level of a cooking vessel based on the temperature gradient of the measured temperature, also called the rate of change, especially the rate of increase, after initially providing the induction coil with the power signal. With a filled cooking vessel, the temperature of the induction coil will only raise slowly. In contrast, when an empty cooking vessel is placed over the induction coil, as explained above, the heat cannot be dissipated and the temperature of the induction coil will raise sharply compared to the temperature raise with an empty cooking vessel.

[0021] In reality every cooking vessel will produce a specific temperature gradient when being placed empty on the induction cooker. However, e.g. an idealized cooking vessel can be taken as the basis for determining the filling states based on the temperature gradient. The idealized cooking vessel can e.g. represent an average of the existing cooking vessels.

[0022] In another embodiment, the controller can be configured to determine an empty cooking vessel if the temperature gradient is higher than a gradient threshold value. The gradient threshold value can e.g. be a value that for all possible cooking vessels or at least for a majority of possible cooking vessels indicates the empty state of the respective cooking vessel. Providing a single gradient threshold value allows easily detecting empty cooking vessels without the need to perform complex calculations, like e.g. mapping a temperature gradient to a filling state. Instead, with the gradient threshold value the cooking vessel can simply be determined to be empty in a binary yes/no fashion.

[0023] In an embodiment, the controller can be configured to control the driving circuit with the control signal to provide the power signal of a configurable operating frequency, which is higher than a first threshold value and lower than a second threshold value, and the controller can be configured to determine the filling level of a cooking vessel based on the frequency gradient of the frequency of the power signal, also called the rate of change, especially the rate of increase, after initially providing the induction coil with the power signal. With a filled cooking vessel the frequency of the power signal will be almost constant for a predetermined output power level, since the desired power can be transferred to the cooking vessel. In contrast, when an empty cooking vessel is placed over the induction coil and the same predetermined output power level is set, the required output power cannot be transferred to the empty cooking vessel. The induction cooker power control, which can also be provided inside the controller but is not the subject of the present invention, will therefore increase the frequency of the power signal to increase the output power.

[0024] Therefore, analyzing or monitoring the frequency gradient of the frequency of the power signal can serve as an additional indicator to detect an empty cooking vessel on the induction cooker.

5 **[0025]** There exist proportional or so called P algorithms that compare the actual output power to a predetermined power value and depending on the power difference increase the frequency of the power signal. The frequency raises continuously with a filled cooking vessel, since every control cycle the output power is slightly less than the predetermined power value. However, for an empty cooking vessel, the output power may reach the predetermined power value quickly and some cycles later the output power may drop, because there is a strong magnetic interaction between the induction coil and the vessel. These magnetic interaction is directly proportional to the output power. When the vessel is heated this strong magnetic interaction however decreases, because heating may affect the magnetic permeability of the material of the cooking vessel. Therefore, the input frequency will be increased stepwise to achieve the required output power. In an embodiment, the controller can therefore be configured to determine whether the frequency of the power signal is stepwise increased to achieve a predetermined output power with the induction coil, and to determine the cooking vessel to be empty if the frequency of the power signal is stepwise increased, instead of e.g. linearly. The frequency of the power signal increases linearly if e.g. a full cooking vessel is only partially placed over the induction coil and only partly covers the induction coil. However, if an empty cooking vessel is placed on the induction coil, the frequency of the power signal is increased stepwise by the induction cooker power control. This can e.g. be identified by analyzing the derivative of the derivative of the frequency of the power signal.

30 **[0026]** In an embodiment, the control device can comprise a second measurement device configured to measure a current through the induction coil and provide the measured current to the controller, wherein the controller can be configured to determine the filling level of a cooking vessel based on the measured current. Especially in combination with the detection of the frequency of the power signal the monitoring of a current through the induction coil can provide further information about the cooking vessel. As already explained, the inherent control of the induction coil will increase the frequency of the power signal to increase the transmitted power. However, if the cooking vessel is empty it cannot dissipate the energy and the power transmitted by the induction coil will decrease. Decreasing current with static or increasing frequency therefore indicates that the filling level of the cooking vessel is low or the cooking vessel is empty. The oscillating magnetic field that is generated by the induction coil induces a magnetic flux which repeatedly magnetizes the cooking vessel. The cooking vessel will act like a lossy magnetic core of a transformer. Large eddy currents will therefore be generated in the vessel,

which because of the resistance of the cooking vessel heat the cooking vessel. Since the cooking vessel cannot transfer the energy to any liquid, the power transfer in the lossy magnetic core, i.e. the output power, decreases. This decrease is mainly due to the resistance of the materials of the cooking vessel and the induction coil decreasing when they are heated.

[0027] In an embodiment, the controller can be configured to calculate an output power of the induction coil based on the measured current, and to determine an empty cooking vessel if the output power is lower than a power threshold value. With increasing frequency the transmitted energy or power usually increases in an induction cooker system. However, if the cooking vessel is empty, the transmitted power will continually decrease instead of increase. Therefore, monitoring the power at the induction coil allows easily determining the cooking vessel to be empty in a binary yes/no fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] For a more complete understanding of the present invention and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings. The invention is explained in more detail below using exemplary embodiments, which are specified in the schematic figures of the drawings, in which:

- Fig. 1 shows a block diagram of an embodiment of a control device according to the present invention in an embodiment of an induction cooker according to the present invention;
- Fig. 2 shows a diagram with temperatures for filled and empty cooking vessels;
- Fig. 3 shows a diagram with driving frequencies for filled and empty cooking vessels;
- Fig. 4 shows another diagram with driving frequencies for filled and empty cooking vessels;
- Fig. 5 shows a diagram with output power curves for filled and empty cooking vessels; and
- Fig. 6 shows a flow diagram of an embodiment of a method according to the present invention.

[0029] In the figures like reference signs denote like elements unless stated otherwise.

DETAILED DESCRIPTION OF THE DRAWINGS

[0030] In Fig. 1 a control device 1 is installed in an induction cooker 2, which is used to heat a cooking vessel 3. The control device 1 comprises a driving circuit 4, which provides a power signal 5 to an induction coil 6 of

the induction cooker 2. It is understood, that the induction coil 6 is only shown schematically and can comprise further elements, like e.g. parallel capacitors.

[0031] Electrical power must be transferred from the induction coil 6 to the cooking vessel 3 to heat up the cooking vessel 3. Therefore, the driving circuit 4 is controlled by controller 7 via control signal 8 to operate the power signal 5 at a configurable operating frequency that can e.g. depend on the desired output power. The such driven induction coil 6 will therefore generate a magnetic field, which in turn will induce eddy currents in the cooking vessel 3. Because of the electrical resistance of the material of the cooking vessel 3, the eddy currents will heat up the cooking vessel 3.

[0032] The controller 7 is further coupled to a first measurement device 9, which will measure the temperature 10 of the induction coil 6. Based on the measured temperature 10, the controller 7 determines the filling level of a cooking vessel 3.

[0033] The controller 7 can e.g. determine the filling level of a cooking vessel 3 based on the temperature gradient of the measured temperature 10 after initially providing the induction coil 6 with the power signal 5. With an empty cooking vessel 3 the temperature gradient of the measured temperature 10 will be higher than with a filled cooking vessel 3. Therefore, the controller 7 can e.g. determine an empty cooking vessel 3 if the temperature gradient is higher than a predetermined gradient threshold value.

[0034] The gradient threshold value can e.g. be predetermined separately for every power level of the induction cooker 2. The gradient threshold value can e.g. be higher for higher power levels and vice versa. In any case, the gradient threshold value will depend on the detailed implementation of the respective induction cooker 2 and can e.g. be experimentally determined. For example experiments can be performed with cooking vessels 3 of different filling levels and the gradient threshold value can be determined such that an empty cooking vessel 3 is detected with required or high enough accuracy.

[0035] In a further embodiment, the controller 7 can be configured to control the driving circuit 4 with the control signal 8 to provide the power signal 5 of a configurable operating frequency, which is higher than a first threshold value and lower than a second threshold value, based on a desired power output level. The controller 7 during operation of the induction cooker 2 will therefore adapt the frequency of the power signal 5 to achieve the required or desired power output level.

[0036] The first threshold value for the frequency can e.g. be the resonance frequency of the induction coil 6 and the cooking vessel 3, i.e. the resonance frequency of the coupled system consisting of induction coil 6 and the cooking vessel 3. The second threshold value can e.g. be a maximum allowed frequency for the respective system. When the frequency is higher than the resonance frequency of the system, the impedance of the system will fall, therefore the current will rise. The second

threshold value will therefore limit the maximum current through system of the induction coil 6 and the cooking vessel 3.

[0037] The initial first and second threshold values can e.g. be determined based on a virtual idealized or standardized cooking vessel 3, which represents an average of the existing cooking vessels 3.

[0038] The details of the control algorithm for setting the frequency of the power signal 5 can be implemented in the controller 7 and are not part of the present invention.

[0039] The controller 7 can then e.g. be configured to determine the filling level of a cooking vessel 3 based on the frequency gradient of the frequency of the power signal 5 after initially providing the induction coil 6 with the power signal 5. The controller 4 can e.g. determine the cooking vessel 3 to be empty, if the frequency gradient is higher than a frequency gradient threshold. Again, the frequency threshold value can e.g. be predetermined separately for every power level of the induction cooker 2. In any case, the frequency gradient threshold value will depend on the detailed implementation of the respective induction cooker 2 and can e.g. be experimentally determined. For example experiments can be performed by heating up cooking vessels 3 of different filling levels and the frequency gradient threshold value can be determined such that an empty cooking vessel 3 is detected with required or high enough accuracy.

Certain control algorithms for setting the frequency of the power signal 5, as already explained above, may increase the frequency of the power signal 5 stepwise with an empty cooking vessel 3. Therefore, the controller 7 may be configured to determine whether the frequency of the power signal 5 is stepwise increased to achieve a predetermined output power with the induction coil 6. In case that the frequency of the power signal 5 is increased stepwise, the controller 7 may then determine the cooking vessel 3 to be empty.

[0040] In Fig. 1 in the control device 1 a second measurement device 11 is shown in dashed lines to indicated that this second measurement device 11 can be optionally added to the control device 1 in an embodiment. The second measurement device 11 can e.g. be a current sensor 11 configured to measure a current 12 through the induction coil 6 and provide the measured current 12 to the controller 7. The controller 7 can then e.g. determine the filling level of the cooking vessel 3 based on the measured current 12.

[0041] With an empty cooking vessel 3 the output power will fall, even if a high output power is set in the controller 7. The controller 7 can therefore calculate the output power of the induction cooker 2, e.g. the induction coil 6, based on the measured current 12 and detect an empty cooking vessel 3 if the output power falls below a predetermined power threshold value.

[0042] Again, the power threshold value can e.g. be predetermined separately for every power level of the induction cooker 2. The power threshold value can e.g. be higher for higher power levels and vice versa. In any

case, the power threshold value will depend on the detailed implementation of the respective induction cooker 2 and can e.g. be experimentally determined. For example experiments can be performed with cooking vessels 3 of different filling levels and the power threshold value can be determined such that an empty cooking vessel 3 is detected with required or high enough accuracy.

[0043] It is understood, that any of the above mentioned criteria can be combined. The controller 7 can therefore e.g. determine an empty cooking vessel 3 based on the measured temperature 10 and the frequency of the power signal 5, or based on the measured temperature 10 and the measured current 12 or output power, or based on the frequency of the power signal 5 and the measured current 12 or output power, or based on the measured temperature 10, the frequency of the power signal 5 and the measured current 12 or output power.

[0044] The controller 7 of the present invention can e.g. be implemented in hardware or software. The controller 7 can also be any combination of hardware and software. The controller 7 can e.g. comprise an integrated circuit with respective input/output interfaces and a respective computer program or code that in combination implement the above detailed features.

[0045] Fig. 2 shows a diagram with a temperature curve 20 for a filled cooking vessel and a temperature curve 21 (dashed curve) for an empty cooking vessel. In Fig. 2 the abscissa refers to time and the ordinate to temperature. As already explained above the exact absolute values will deviate from application to application and from induction cooker to induction cooker. Therefore, no absolute values are shown in the diagram.

[0046] The diagram shows the development of the measured temperature of the induction coil of the induction cooker, after power is applied to the induction coil at time 0. It can be seen that the temperature raises steadily until it settles about a constant temperature value for the filled cooking vessel.

[0047] However, for the empty cooking vessel the temperature raises much faster, i.e. with a larger gradient and does not settle at the constant temperature value, since the cooking vessel cannot dissipate the energy to any liquid. This state can also be called a thermal "short circuit".

[0048] It becomes clear from the diagram of Fig. 2 that the temperature of the induction coil can be a good measure for detecting an empty vessel.

[0049] Fig. 3 shows a diagram with a frequency curve 30 for a filled cooking vessel and a frequency curve 31 for an empty cooking vessel. In Fig. 3 the abscissa refers to time t and the ordinate to frequency F . As already explained above the exact absolute values will deviate from application to application and from induction cooker to induction cooker. Therefore, no absolute values are shown in the diagram. In the diagram two threshold values 32, 33 are shown. The frequency of the induction cooker will vary below the first or lower threshold value 32 and the second or higher threshold value 33.

[0050] It can be seen that the frequency curve 30 for the filled cooking vessel raises shortly after applying the power signal and then returns to the lower threshold value 32. However, the temperature curve for the empty cooking vessel will stepwise increase until it reaches the upper threshold value 33.

[0051] After the upper threshold value 33 is reached, e.g. without providing the desired output power, a safety shutdown can e.g. be performed.

[0052] It becomes clear from the diagram of Fig. 3 that the frequency of the power signal or the gradient of the power signal can be a good measure for detecting an empty vessel.

[0053] Fig. 4 shows another diagram with a frequency curve 40 for a filled cooking vessel and a frequency curve 41 for an empty cooking vessel. In Fig. 4 the abscissa refers to time t and the ordinate to frequency F . As already explained above the exact absolute values will deviate from application to application and from induction cooker to induction cooker. Therefore, no absolute values are shown in the diagram. The diagram shows the development of the frequency of the power signal of the induction coil of the induction cooker, after power is applied to the induction coil at time 0. In the diagram two threshold values 42, 43 are shown. The frequency of the induction cooker will vary below the first or lower threshold value 42 and the second or higher threshold value 43.

[0054] In contrast to Fig. 3, the frequency curve 40 refers to a full cooking vessel that is only partially, e.g. 40%, placed over the induction coil. In this case the controller will continually raise the frequency of the power signal to achieve a higher output power.

[0055] However, in contrast to the stepwise increase of the frequency curve 41 for the empty cooking vessel, the frequency curve 40 for the full cooking vessel raises continuously without any steps or jumps, as was already explained above.

[0056] Therefore, by analyzing the frequency of the power signal for jumps or stepwise increases an empty cooking vessel can be distinguished from a full cooking vessel that is only partially covering the induction coil.

[0057] Fig. 5 shows a diagram with a power curve 50 for a filled cooking vessel and a power curve 51 for an empty cooking vessel. In Fig. 5 the abscissa refers to time t and the ordinate to the power P . As already explained above the exact absolute values will deviate from application to application and from induction cooker to induction cooker. Therefore, no absolute values are shown in the diagram. The diagram shows the development of the output power of the induction coil of the induction cooker after power is applied to the induction coil at time 0.

[0058] It can be seen that for a full cooking vessel the output power reaches the predetermined power level, e.g. chosen by the user, and settles at that power level.

[0059] With the empty cooking vessel however the power level drops continuously, even though the same power level is set as for the full cooking vessel.

[0060] In consequence the output power level can also serve to detect an empty cooking vessel.

[0061] Fig. 6 shows a flow diagram of a control method for an induction cooker 2.

[0062] The control method comprises controllably driving S1 an induction coil 6 of the induction cooker 2 with a power signal 5 of a predetermined first frequency. The control method further comprises measuring S2 a temperature 10 of the induction coil 6, and determining S3 the filling level of a cooking vessel 3 based on the measured temperature 10.

[0063] Determining S3 the filling level can comprise determining the filling level of a cooking vessel 3 based on the temperature gradient of the measured temperature 10 after initially providing the induction coil 6 with the power signal 5. An empty cooking vessel 3 can e.g. be determined if the temperature gradient is higher than a gradient threshold value.

[0064] Further, controllably driving S1 can comprise providing the power signal 5 of a configurable operating frequency, which is higher than a first threshold value 32, 42 and lower than a second threshold value 33, 43, based on a desired power output level. Determining S3 the filling level can then comprise determining the filling level of a cooking vessel 3 based on the frequency gradient of the frequency of the power signal 5 after initially providing the induction coil 6 with the power signal 5.

[0065] The method can also comprise determining whether the frequency of the power signal 5 is stepwise increased to achieve a predetermined output power with the induction coil 6, and determining the cooking vessel 3 to be empty if the frequency of the power signal 5 is stepwise increased.

[0066] Further, the control method can comprise measuring a current 12 through the induction coil 6, wherein determining S3 the filling level can comprise determining the filling level of a cooking vessel 3 based on the measured current 12.

[0067] Finally, the control method can also comprise calculating an output power of the induction coil 6 based on the measured current 12 and determining an empty cooking vessel 3 if the output power is lower than a power threshold value.

[0068] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations exist. It should be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration in any way. Rather, the foregoing summary and detailed description will provide those skilled in the art with a convenient road map for implementing at least one exemplary embodiment, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope as set forth in the appended claims and their legal equivalents. Generally, this appli-

cation is intended to cover any adaptations or variations of the specific embodiments discussed herein.

[0069] The present invention provides a control device for an induction cooker, the control device comprising a driving circuit (4) configured to controllably drive an induction coil (6) of the induction cooker (2) with a power signal (5) of a predetermined first frequency, a controller (7) coupled to the driving circuit (4) and configured to control the driving circuit (4) with a control signal (8) to drive the induction coil (6) with the power signal (5), and a first measurement device (9) configured to measure a temperature (10) of the induction coil (6) and provide the measured temperature to the controller (7), wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the measured temperature (10) and adapt the control signal (8) according to the determined filling level. The present invention further provides a respective method and an induction cooker.

List of reference signs

[0070]

1	control device
2	induction cooker
3	cooking vessel
4	driving circuit
5	power signal
6	induction coil
7	controller
8	control signal
9	measurement device
10	temperature
20, 21	temperature curve
30, 31	frequency curve
32, 33	threshold value
40, 41	frequency curve
42, 43	threshold value
50, 51	power curve

S1 - S3 method steps

Claims

- Control device (1) for an induction cooker (2), the control device (1) comprising:
 - a driving circuit (4) configured to controllably drive an induction coil (6) of the induction cooker (2) with a power signal (5),
 - a controller (7) coupled to the driving circuit (4) and configured to control the driving circuit (4) with a control signal (8) to drive the induction coil (6) with the power signal (5), and
 - a first measurement device (9) configured to measure a temperature (10) of the induction coil

(6) and provide the measured temperature (10) to the controller (7),

wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the measured temperature (10).

- Control device (1) according to claim 1, wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the temperature gradient of the measured temperature (10) after initially providing the induction coil (6) with the power signal (5).

- Control device (1) according to claim 2, wherein the controller (7) is configured to determine an empty cooking vessel (3) if the temperature gradient is higher than a gradient threshold value.

- Control device (1) according to any one of the preceding claims, wherein the controller (7) is configured to control the driving circuit (4) with the control signal (8) to provide the power signal (5) of a configurable operating frequency, which is higher than a first threshold value (32, 42) and lower than a second threshold value (33, 43), based on a desired power output level, and wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the frequency gradient of the frequency of the power signal (5) after initially providing the induction coil (6) with the power signal (5).

- Control device (1) according to claim 4, wherein the controller (7) is configured to determine whether the frequency of the power signal (5) is stepwise increased to achieve a predetermined output power with the induction coil (6), and to determine the cooking vessel (3) to be empty if the frequency of the power signal (5) is stepwise increased.

- Control device (1) according to any one of the preceding claims, comprising a second measurement device (11) configured to measure a current (12) through the induction coil (6) and provide the measured current (12) to the controller (7), wherein the controller (7) is configured to determine the filling level of a cooking vessel (3) based on the measured current (12).

- Control device (1) according to claim 6, wherein the controller (7) is configured to calculate an output power of the induction coil (6) based on the measured current (12) and determine an empty cooking vessel (3) if the output power is lower than a power threshold value.

- Control method for an induction cooker (2), the con-

control method comprising:

controllably driving (S1) an induction coil (6) of the induction cooker (2) with a power signal (5) of a predetermined first frequency, 5
measuring (S2) a temperature (10) of the induction coil (6), and
determining (S3) the filling level of a cooking vessel (3) based on the measured temperature (10). 10

an induction coil (6), and
a control device (1) according to any one of claims 1 - 7.

9. Control method according to claim 8, wherein determining (S3) the filling level comprises determining the filling level of a cooking vessel (3) based on the temperature gradient of the measured temperature (10) after initially providing the induction coil (6) with the power signal (5). 15
10. Control method according to claim 9, comprising determining an empty cooking vessel (3) if the temperature gradient is higher than a gradient threshold value. 20
11. Control method according to any one of the preceding claims 8 to 10, wherein controllably driving (S1) comprises providing the power signal (5) of a configurable operating frequency, which is higher than a first threshold value (32, 42) and lower than a second threshold value (33, 43), based on a desired power output level, 25
and wherein determining (S3) the filling level comprises determining the filling level of a cooking vessel (3) based on the frequency gradient of the frequency of the power signal (5) after initially providing the induction coil (6) with the power signal (5). 30
35
12. Control method according to claim 11, comprising determining whether the frequency of the power signal (5) is stepwise increased to achieve a predetermined output power with the induction coil (6), and determining the cooking vessel (3) to be empty if the frequency of the power signal (5) is stepwise increased. 40
13. Control method according to any one of the preceding claims 8 to 12, comprising measuring a current (12) through the induction coil (6), wherein determining (S3) the filling level comprises determining the filling level of a cooking vessel (3) based on the measured current (12). 45
50
14. Control method according to claim 13, comprising calculating an output power of the induction coil (6) based on the measured current (12) and determining an empty cooking vessel (3) if the output power is lower than a power threshold value. 55
15. Induction cooker (2), comprising

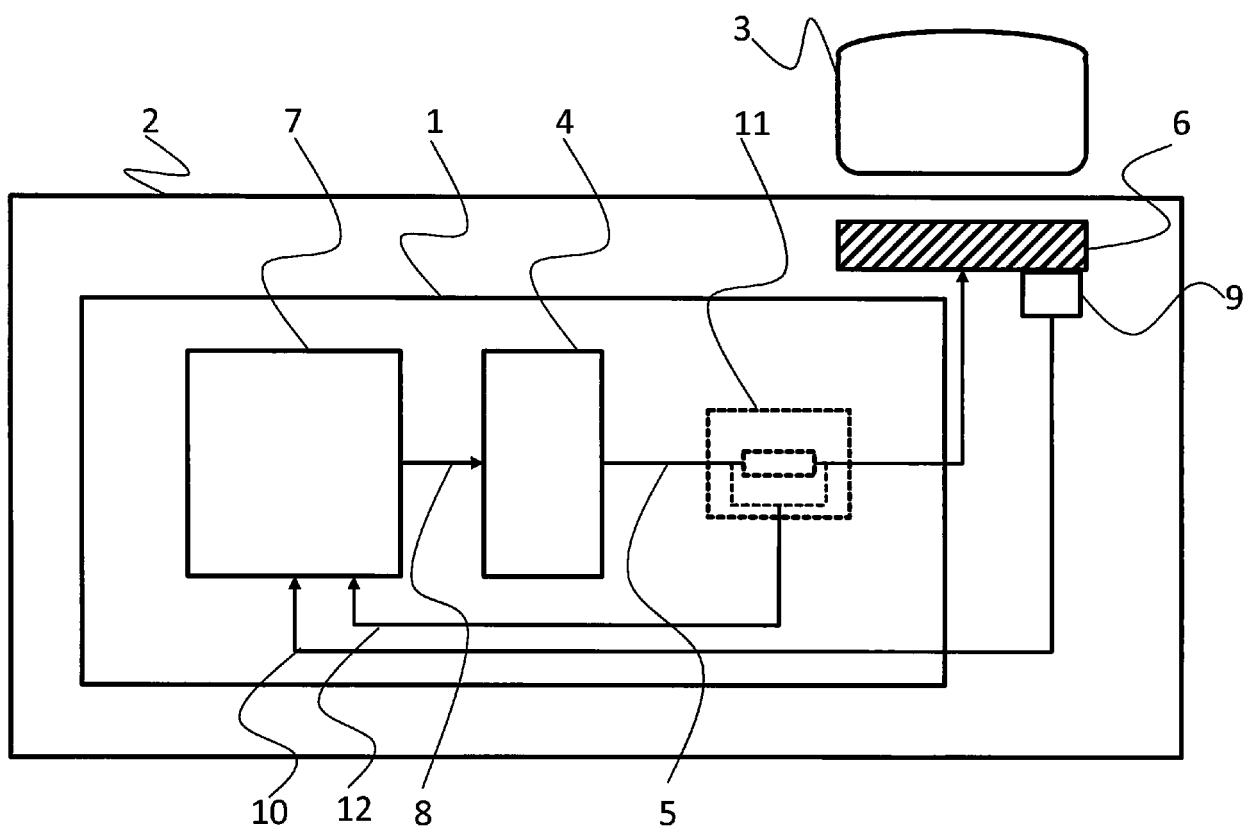


Fig. 1

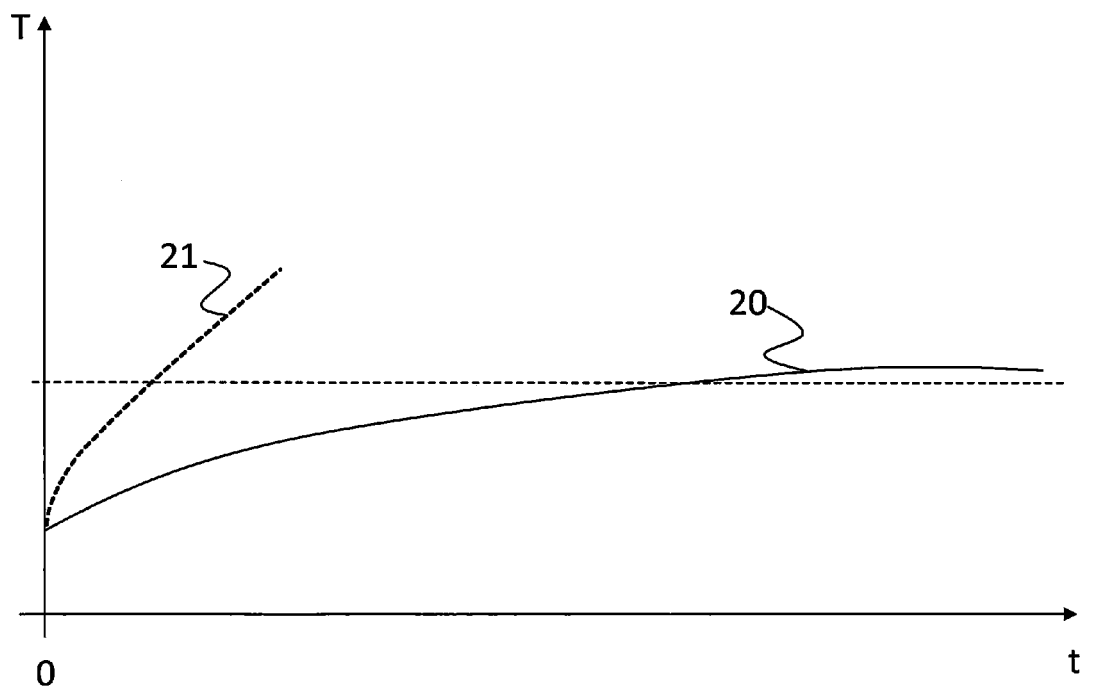


Fig. 2

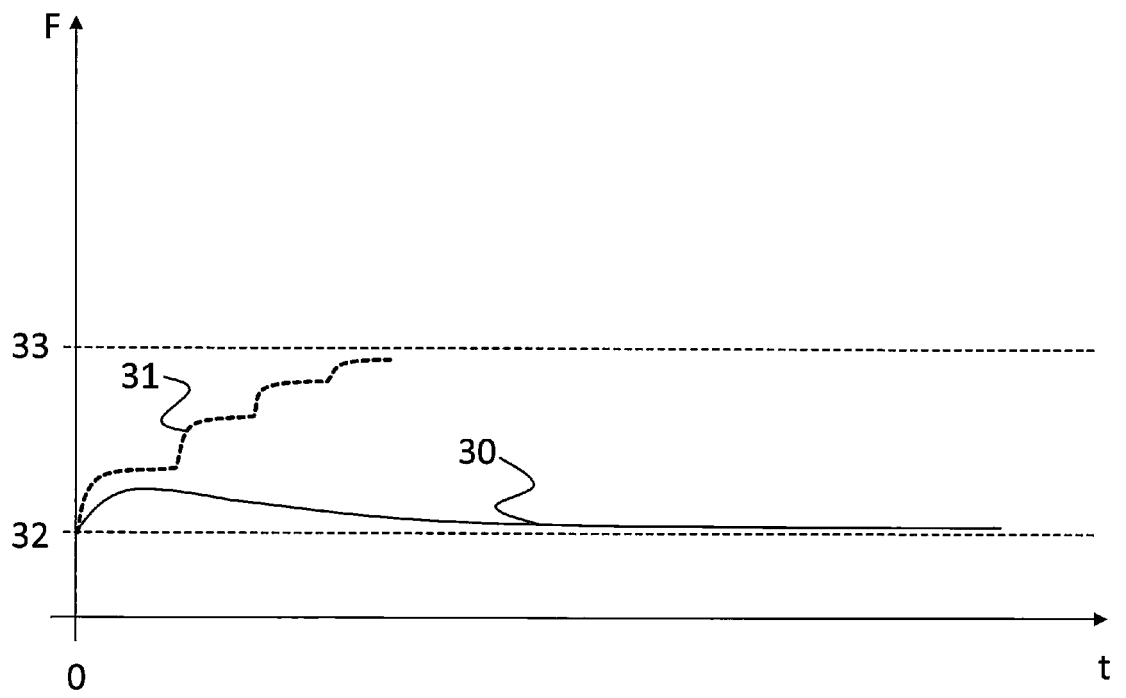


Fig. 3

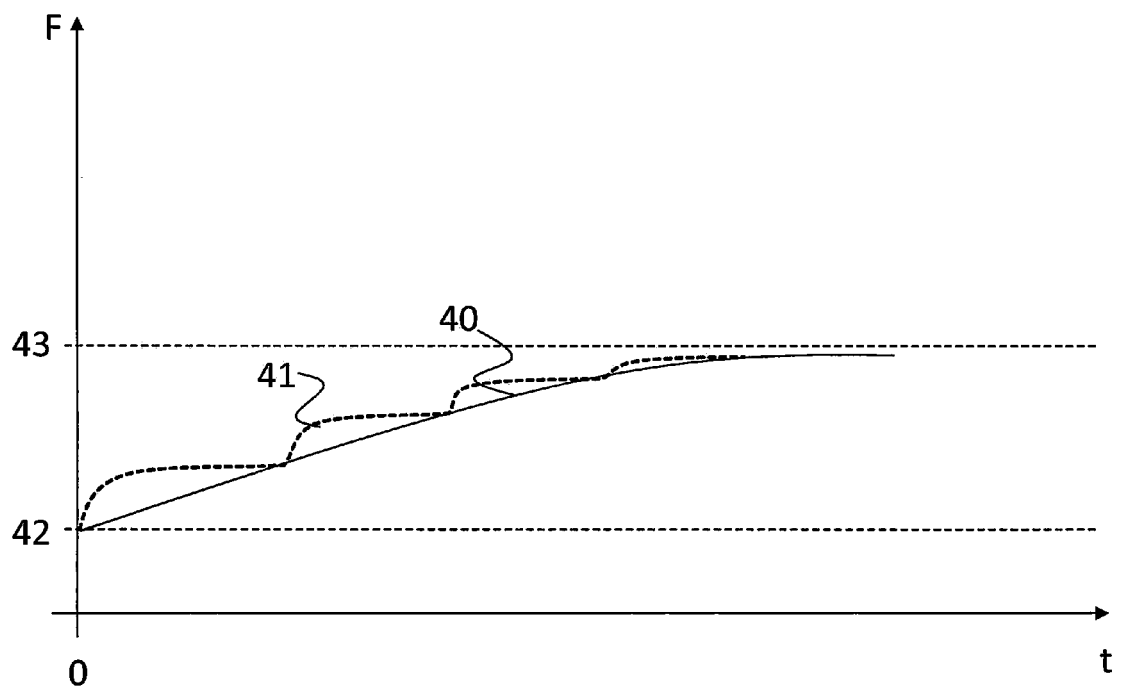


Fig. 4

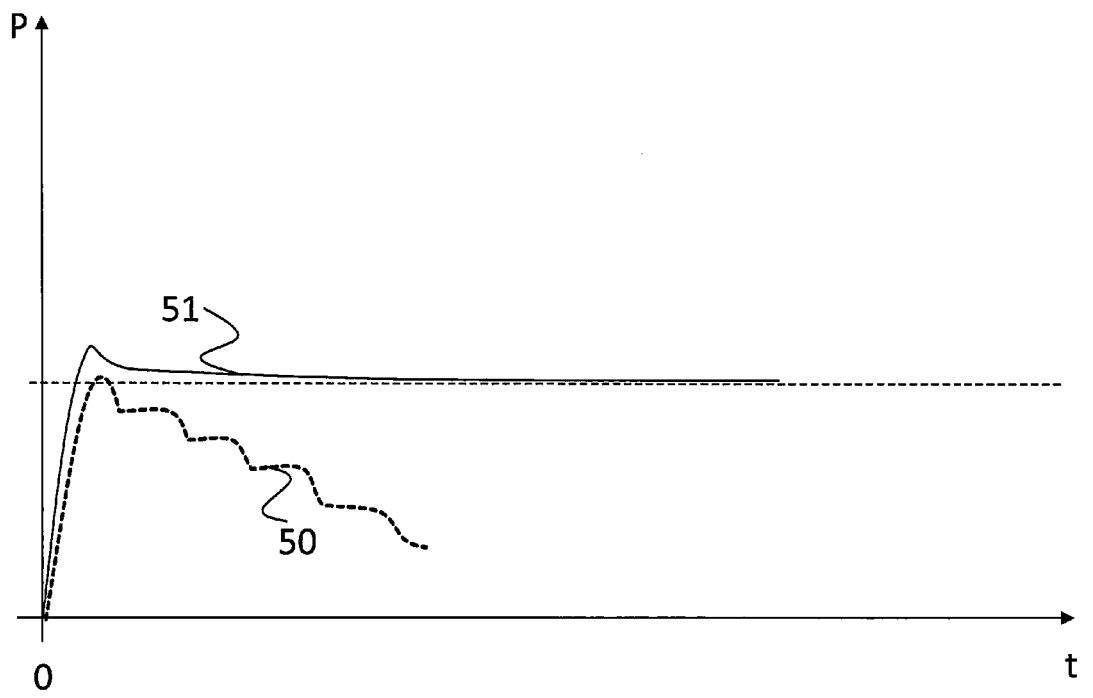


Fig. 5

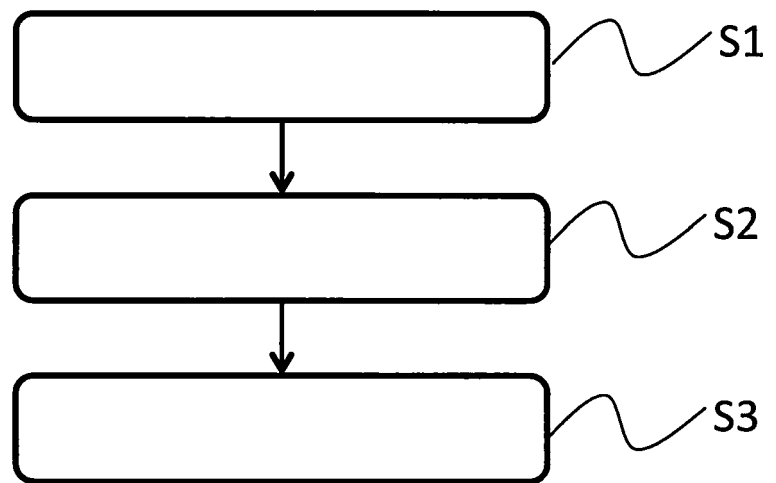


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 16 20 6195

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 775 783 A2 (DELTA ELECTRONICS INC [TW]) 10 September 2014 (2014-09-10) * abstract * * paragraph [0030]; claims 5,6 *	1-15	INV. H05B6/06
A	US 2016/073451 A1 (REISCHMANN MICHAEL [US] ET AL) 10 March 2016 (2016-03-10) * abstract; claim 1 *	1,8,15	
A	EP 2 312 909 A1 (WHIRLPOOL CO [US]; TEKA IND SA [ES]) 20 April 2011 (2011-04-20) * abstract *	1,8,15	
A	EP 1 672 959 A2 (CERAMASPEED LTD [GB]) 21 June 2006 (2006-06-21) * abstract; claim 1 *	1,8,15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H05B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 June 2017	Examiner Garcia, Jesus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 20 6195

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-06-2017

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35

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45

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 2775783	A2	10-09-2014	EP 2775783 A2	10-09-2014
			JP 5699185 B2	08-04-2015
			JP 2014175303 A	22-09-2014
			TW 201436646 A	16-09-2014
			US 2014251980 A1	11-09-2014

US 2016073451	A1	10-03-2016	AU 2015311645 A1	23-03-2017
			EP 3189708 A1	12-07-2017
			US 2016073451 A1	10-03-2016
			WO 2016037177 A1	10-03-2016

EP 2312909	A1	20-04-2011	CA 2717240 A1	19-04-2011
			EP 2312909 A1	20-04-2011
			ES 2542700 T3	10-08-2015
			US 2011089156 A1	21-04-2011

EP 1672959	A2	21-06-2006	AT 484939 T	15-10-2010
			EP 1672959 A2	21-06-2006
			ES 2354346 T3	14-03-2011
			US 2006118544 A1	08-06-2006
