OVEN APPLIANCE AND A METHOD FOR OPERATING AN OVEN APPLIANCE

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Appl. No.: 14/452,616

Filed: Aug. 6, 2014

Publication Classification

Int. Cl.
F24C 7/08
(2006.01)

U.S. Cl.
CPC ........................ F24C 7/081 (2013.01); F24C 7/088 (2013.01)

ABSTRACT

An oven appliance with one or more features for minimizing the time to preheat the cooking chamber is provided. Features for adequately heating the air and the surfaces of the cooking chamber are also provided. Further, a method for operating an oven appliance to minimize the preheat time and adequately heat the air and surfaces of the cooking chamber is provided.
OVEN APPLIANCE AND A METHOD FOR OPERATING AN OVEN APPLIANCE

FIELD OF THE INVENTION

[0001] The subject matter of the present disclosure relates generally to an oven appliance and a method for operating an oven appliance to preheat the oven cavity.

BACKGROUND OF THE INVENTION

[0002] Oven appliances generally include a cabinet that defines a cooking chamber for baking or broiling food items therein. Oven appliances also generally include a self-cleaning feature for cleaning the cooking chamber. To heat the cooking chamber for baking or for self-cleaning, oven appliances include one or more heating elements positioned at a top portion, bottom portion, or both of the cooking chamber. Some oven appliances also include a convection heating element and fan for convection cooking cycles. The heating element or elements may be used for various cycles of the oven appliance, such as a preheat cycle, a cooking cycle, or a self-cleaning cycle.

[0003] In certain configurations of oven appliances, the bake heating element may be positioned beneath the floor of the cooking chamber to enlarge the volume of the cooking chamber and hide the heating element from the view of a user of the oven appliance. However, such hidden bake ovens have relatively slow preheat cycle times because the floor of the cooking chamber must be kept cool enough to avoid enamel crazing. Further, the air in the center of the cooking chamber may be heated to the preheat temperature before the surfaces of the cooking chamber are adequately heated for radiation heat transfer to the food items to be cooked.

[0004] Accordingly, an oven appliance with features for minimizing the preheat time and adequately heating the air and surfaces of the cooking chamber would be useful. Further, a method for operating an oven appliance to minimize the preheat time and adequately heat the air and surfaces of the cooking chamber would be beneficial.

BRIEF DESCRIPTION OF THE INVENTION

[0005] The present invention provides an oven appliance with one or more features for minimizing the time to preheat the cooking chamber. Features for adequately heating the air and the surfaces of the cooking chamber are also provided. Further, a method for operating an oven appliance to minimize the preheat time and adequately heat the air and surfaces of the cooking chamber is provided. Additional aspects and advantages of the invention will be set forth in part in the following description, may be apparent from the description, or may be learned through practice of the invention.

[0006] In a first exemplary embodiment, a method for operating an oven appliance having a cooking chamber configured for receipt of food items for cooking and having a bake heating element, a broil heating element, a convection heating element, and a fan comprises the steps of establishing a cooking chamber temperature set point $T_{pre}$; activating the convection heating element and the fan; determining whether the convection heating element and the fan have been activated for a predetermined period of time $t_{cove}$ and, if so, then deactivating the convection heating element; activating the broil heating element; determining whether the bake heating element has been activated for a predetermined period of time $t_{bhade}$ and, if so, then deactivating the bake heating element; sensing whether the temperature in the cooking chamber has reached $T_{pre}$ and, if so, then providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

[0007] In a second exemplary embodiment, a method for operating an oven appliance having a cooking chamber configured for receipt of food items for cooking and having a bake heating element, a broil heating element, a convection heating element, and a fan comprises the steps of establishing a cooking chamber temperature set point $T_{pre}$; activating the convection heating element and the fan; sensing whether the temperature in the cooking chamber has reached at least a temperature $T_{cove}$ and, if so, then deactivating the convection heating element; activating the bake heating element; determining whether the bake heating element has been activated for a predetermined period of time $t_{bhade}$ and, if so, then deactivating the bake heating element; activating the broil heating element; sensing whether the temperature in the cooking chamber has reached $T_{pre}$ and, if so, then providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

[0008] In a third exemplary embodiment, an oven appliance includes a cabinet, and the cabinet defines a cooking chamber configured for the receipt of food items for cooking. The cooking chamber has a top wall, a bottom wall, a back wall, and opposing side walls. The oven appliance also includes a bake heating element, a broil heating element, and a convection heating element, and the heating elements are configured to heat the cooking chamber. Further, the oven appliance includes a fan and a controller; the controller is in operative communication with the heating elements and the fan. The controller is configured for establishing a cooking chamber temperature set point $T_{pre}$; activating the convection heating element and the fan; determining whether the convection heating element and the fan have been activated for a predetermined period of time $t_{cove}$ and, if so, then deactivating the convection heating element; activating the broil heating element; determining whether the bake heating element has been activated for a predetermined period of time $t_{bhade}$ and, if so, then deactivating the bake heating element; activating the broil heating element; sensing whether the temperature in the cooking chamber has reached $T_{pre}$ and, if so, then providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

[0009] These and other features, aspects, and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0011] FIG. 1 provides a front view of an exemplary embodiment of an oven appliance of the present invention.

[0012] FIG. 2 is a cross-sectional view of the oven appliance of FIG. 1 taken along the 2-2 line of FIG. 1.

[0013] FIG. 3 provides a chart illustrating an exemplary method for operating an oven appliance according to the present subject matter.
FIG. 4 provides a chart illustrating another exemplary method for operating an oven appliance according to the present subject matter.

FIG. 5 provides a chart illustrating another exemplary method for operating an oven appliance according to the present subject matter.

FIG. 6 provides a chart illustrating another exemplary method for operating an oven appliance according to the present subject matter.

DETAILED DESCRIPTION OF THE INVENTION

Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

Referring to FIGS. 1 and 2, for this exemplary embodiment, oven appliance 100 includes an insulated cabinet 102 with an interior cooking chamber 104 defined by a top wall 112, a bottom wall 114, a back wall 116, and opposing side walls 118, 120. Cooking chamber 104 is configured for the receipt of one or more food items to be cooked. Oven appliance 100 includes a door 108 pivotally mounted, e.g., with one or more hinges (not shown), to cabinet 102 at the opening 106 of cabinet 102 to permit selective access to cooking chamber 104 through opening 106. A handle 110 is mounted to door 108 and assists a user with opening and closing door 108. For example, a user can pull on handle 110 to open or close door 108 and access cooking chamber 104.

Oven appliance 100 can include a seal (not shown) between door 108 and cabinet 102 that assists with maintaining heat and cooking fumes within cooking chamber 104 when door 108 is closed as shown in FIGS. 1 and 2. Multiple parallel glass panes 122 provide for viewing the contents of cooking chamber 104 when door 108 is closed and assist with insulating cooking chamber 104. A baking rack 142 is positioned in cooking chamber 104 for the receipt of food items or utensils containing food items. Baking rack 142 is slidably received onto embossed ribs or sliding rails 144 such that rack 142 may be conveniently moved into and out of cooking chamber 104 when door 108 is open.

A heating element at the top, bottom, or both of cooking chamber 104 provides heat to cooking chamber 104 for cooking. Such heating element(s) can be gas, electric, microwave, or a combination thereof. For example, in the embodiment shown in FIG. 2, oven appliance 100 includes a top heating element 124 and a bottom heating element 126, where bottom heating element 126 is positioned adjacent to and below bottom wall 114. One or more openings in bottom wall 114, such as openings 150, allow heated air to flow from beneath bottom wall 114 and into cooking chamber 104. Other configurations with or without wall 114 may be used as well.

Oven appliance 100 also has a convection heating element 136 and convection fan 138 positioned adjacent back wall 116 of cooking chamber 104. Convection fan 138 is powered by a convection fan motor 139. Convection heating element 136 may be capable of at least a 4000W input to cooking chamber 104, or two or more separate convection elements may be used to achieve a 4000W or more input to cooking chamber 104. In certain embodiments, oven appliance 100 may also include a bidirectional triode thyristor (not shown), i.e., a triode for alternating current (triac), to regulate the operation of convection heating element 136 such that an appropriate wattage is provided for particular cycles of oven appliance 100, such as a preheat cycle or a convection cooking cycle. Other methods of regulating the wattage supplied by convection element 136 may also be used.

Oven appliance 100 includes a user interface 128 having a display 130 positioned on an interface panel 132 and having a variety of controls 134. Interface 128 allows the user to select various options for the operation of oven 100 including, e.g., temperature, time, and/or various cooking and cleaning cycles. Operation of oven appliance 100 can be regulated by a controller 140 that is operatively coupled, i.e., in communication with, user interface 128, heating elements 124, 126, and other components of oven 100 as will be further described.

For example, in response to user manipulation of the user interface 128, controller 140 can operate the heating element(s). Controller 140 can receive measurements from a temperature sensor 146 placed in cooking chamber 104 and, e.g., provide a temperature indication to the user with display 130. Controller 140 can also be provided with other features as will be further described herein.

Controller 140 may include a memory and one or more processing devices such as microprocessors, CPUs, or the like, such as general or special purpose microprocessors operable to execute programming instructions or micro-control code associated with operation of oven appliance 100. The memory may represent random access memory such as DRAM or read only memory such as ROM or FLASH. In one embodiment, the processor executes programming instruction stored in memory. The memory may be a separate component from the processor or may be included onboard within the processor.

Controller 140 may be positioned in a variety of locations throughout oven appliance 100. In the illustrated embodiment, controller 140 is located next to user interface 128 within interface panel 132. In other embodiments, controller 140 may be located under or next to the user interface 128 otherwise within interface panel 132 or at any other appropriate location with respect to oven appliance 100. In the embodiment illustrated in FIG. 1, input/output (“I/O”) signals are routed between controller 140 and various operational components of oven appliance 100 such as heating elements 124, 126, 136, convection fan 138, controls 134, display 130, sensor 146, alarms, and/or other components as may be provided. In one embodiment, user interface 128 may represent a general purpose I/O (“GPIO”) device or functional block.

Although shown with touch type controls 134, it should be understood that controls 134 and the configuration of oven appliance 100 shown in FIG. 1 is provided by way of example only. More specifically, user interface 128 may include various input components, such as one or more of a variety of electrical, mechanical, or electro-mechanical input devices including rotary dials, push buttons, and touch pads. User interface 128 may include other display components, such as a digital or analog display device designed to provide
operational feedback to a user. User interface 128 may be in communication with controller 140 via one or more signal lines or shared communication busses.

[0027] While oven 100 is shown as a wall oven, the present invention could also be used with other cooking appliances such as, e.g., a stand-alone oven, an oven with a stove-top, or other configurations of such ovens.

[0028] Oven appliance 100 may have several cooking and cleaning cycles, including a preheat cycle. Generally, the preheat cycle ensures the cooking chamber is thermally “soaked,” such that the air temperature in the center of the cooking chamber has reached the cooking temperature and the surfaces of the cooking chamber are heated to a temperature for radiation heat transfer from the surfaces. Oven appliance 100 may include several features to shorten the preheat cycle time while also avoiding undesirable conditions such as, e.g., enamel crazing of the bottom surface 114 of cooking chamber 104.

[0029] As an example, convection heating element 136 may be set to be at least a 4000W heating element, or more than one convection heating element may be used to achieve at least 4000W of convection heating power. Further, methods of operating oven appliance 100 may utilize the convection heating element and fan, followed by the bake and broil heating elements, during the preheat cycle to properly heat soak cooking chamber 104 in a shortened period of time. For example, operation of convection heating element 136 and fan 138 may be cycled with bake heating element 126 and broil heating element 124 to heat the air in and surfaces of cooking chamber 104. Such features and methods of operating oven appliance 100 will be further described below.

[0030] FIG. 3 illustrates an exemplary method of operating oven appliance 100. Method 200 may be performed by controller 140 or any other suitable device or devices. At step 202, a cooking chamber temperature set point Tpre, for a preheat cycle is established. The temperature set point Tpre may be determined using the cooking temperature selected by the user of the oven appliance, e.g., the temperature set point Tpre may be the cooking temperature selected by the user or a temperature over or under the selected cooking temperature. In alternative embodiments, temperature set point Tpre may be a predetermined temperature that is used for each preheat cycle, regardless of the cooking temperature selected by the user. Other values of and methods for determining the temperature set point Tpre may be used as well.

[0031] After establishing temperature set point Tpre, at step 204, convection heating element 136 and fan 138 are activated, i.e., powered on to heat cooking chamber 104. In alternative embodiments, convection heating element 136 may be activated without activating fan 138. In still other embodiments, as described above, more than one convection heating element may be provided in cooking chamber 104, which may be activated together or separately, with or without activating fan 138.

[0032] At step 206, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point Tpre. If so, at step 208 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point Tpre, i.e., that the preheat cycle is complete. The signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point Tpre. By way of example, the signal may be a notification displayed on user interface 128 of the appliance, an LED light, a buzzer, and/or any other appropriate visual and/or audible signal.

[0033] However, if it is determined at step 206 that the temperature in cooking chamber 104 has not reached the temperature set point Tpre, method 200 includes step 210, where controller 140 determines whether convection heating element 136 and convection fan 138 have been activated for a predetermined period of time tpre. If not, method 200 may return to step 204 such that convection heating element 136 and convection fan 138 remain activated. If convection heating element 136 and convection fan 138 have been activated for time tpre, method 200 continues to step 212. At step 212, convection heating element 136 is deactivated; fan 138 may also be deactivated at step 214.

[0034] Once convection heating element 136 is deactivated, bake heating element 126 is activated at step 214 to continue heating cooking chamber 104. At step 216, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point Tpre. If so, at step 218 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point Tpre, i.e., that the preheat cycle is complete. As described with respect to step 208, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point Tpre.

[0035] Conversely, if it is determined at step 216 that the temperature in cooking chamber 104 has not reached the temperature set point Tpre, method 200 includes step 220, where controller 140 may determine whether bake heating element 126 has been activated for a predetermined period of time tpre. If not, method 200 may return to step 214 such that bake heating element 126 remains activated. If bake heating element 126 has been activated for time tpre, method 200 continues to step 222. At step 222, bake heating element 126 is deactivated.

[0036] Then, at step 224, broil heating element 124 is activated to heat cooking chamber 104. At step 226, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point Tpre. If so, at step 228 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point Tpre, i.e., that the preheat cycle is complete. As described with respect to steps 208 and 218, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point Tpre.

[0037] However, if it is determined at step 226 that the temperature in cooking chamber 104 has not reached the temperature set point Tpre, method 200 includes step 230, where the controller may determine whether broil heating element 124 has been activated for a predetermined period of time tpre. If not, method 200 may return to step 224 such that broil heating element 124 remains activated. If broil heating element 124 has been employed for time tpre, method 200 may include step 232 of deactivating broil heating element 124 and then return to step 224 and activate bake element 126 to continue heating cooking chamber 104 to reach temperature set point Tpre. In alternative embodiments, method 200 may return to step 204 rather than step 214 and reactivate convection heating element 136 and fan 138, or in certain embodiments, method 200 may return to step 204 and reactivate only convection heating element 136. Further, as described, oven appliance 100 may include multiple convec-
The predetermined period of time $t_{\text{conv}}$ may be longer than predetermined periods of time $t_{\text{bake}}$ and $t_{\text{broil}}$. Further, predetermined period of time $t_{\text{bake}}$ may be longer than time $t_{\text{broil}}$. As an example, for a preheat cycle for a selected cooking temperature of 350°F, time $t_{\text{conv}}$ may be about 300 seconds, time $t_{\text{bake}}$ may be about 90 seconds, and time $t_{\text{broil}}$ may be about 20 seconds. Other values for $t_{\text{conv}}$, $t_{\text{bake}}$, and $t_{\text{broil}}$ may also be used, and the values for $t_{\text{conv}}$, $t_{\text{bake}}$, and $t_{\text{broil}}$ may vary based on the selected cooking temperature and its associated temperature set point $T_{\text{pre}}$.

In other embodiments, method 200 may include a different order of operation of convection heating element 136, bake heating element 126, and/or broil heating element 124, e.g., bake heating element 126 may be activated, followed by broil heating element 124, and then convection heating element 136, where each heating element may be activated for a predetermined period of time and then deactivated before the next heating element is activated, as described above. In still other embodiments, heating elements 124, 126, 136 may be activated at the same time or in pairs, e.g., convection heating element 136 may be activated, then bake heating element 126 and broil heating element 124 may be activated at the same time. Alternatively, method 200 may include a delay period between the operation of each heating element, i.e., in certain embodiments, no heating element is in use for the delay period of time after each heating element is deactivated. The delay period may be, e.g., about one second. Other arrangements of method 200 also may be used.

FIG. 4 illustrates another exemplary method of operating oven appliance 100, which may be performed by controller 140 or any other suitable device or devices. At step 302 of method 300, the cooking chamber temperature set point $T_{\text{pre}}$ for the preheat cycle is established. As described with respect to exemplary method 200, the temperature set point $T_{\text{pre}}$ may be determined by the cooking temperature selected by the user of the oven appliance, e.g., the temperature set point $T_{\text{pre}}$ may be the cooking temperature selected by the user or a temperature over or under the selected cooking temperature. In alternative embodiments, temperature set point $T_{\text{pre}}$ may be a predetermined temperature that is used for each preheat cycle, regardless of the cooking temperature selected by the user. Other values of and methods for determining the temperature set point $T_{\text{pre}}$ may be used as well.

After establishing temperature set point $T_{\text{pre}}$, convection heating element 136 and fan 138 are activated at step 304 to heat cooking chamber 104. In alternative embodiments, convection heating element 136 may be activated at step 304 without activating fan 138. In still other embodiments, as described above, more than one convection heating element may be provided in cooking chamber 104, which may be energized and operated together or separately, with or without energizing and operating fan 138.

At step 306, controller 140 may determine if the temperature in cooking chamber 104, as measured by, e.g., temperature sensor 146, has reached the temperature set point $T_{\text{pre}}$. If so, at step 308 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$, i.e., that the preheat cycle is complete. The signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$. By way of example, the signal may be a notification displayed on user interface 128 of the appliance, an LED light, a buzzer, and/or any other appropriate visual and/or audible signal.

However, if it is determined at step 306 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{\text{pre}}$, method 300 includes step 310, where the controller may determine whether the temperature in cooking chamber 104 has reached at least a predetermined temperature $T_{\text{con}}$. Temperature $T_{\text{con}}$ is less than the temperature set point $T_{\text{pre}}$ and may be, e.g., the difference between the temperature set point $T_{\text{pre}}$ and a temperature offset $T_{\text{offset}}$. Temperature offset $T_{\text{offset}}$ may be determined experimentally and programmed into controller 140. As an example, if temperature offset $T_{\text{offset}}$ is determined to be and is programmed as 100°F, if temperature set point $T_{\text{pre}}$ is established as 350°F, at step 302, then temperature $T_{\text{con}}$ would be 250°F. Temperature $T_{\text{con}}$ may be determined in other ways as well. If at step 310 the temperature within cooking chamber 104 has not reached at least temperature $T_{\text{con}}$, method 300 may return to step 304, such that convection heating element 136 and convection fan 138 remain activated. If the temperature has reached at least temperature $T_{\text{con}}$, method 300 continues to step 312. At step 312, convection heating element 136 is deactivated; fan 138 may also be deactivated at step 312.

At step 314, bake heating element 126 is activated to heat cooking chamber 104. At step 316, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point $T_{\text{pre}}$. If so, at step 318 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$, i.e., that the preheat cycle is complete. As described with respect to step 308, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$.

Otherwise, if it is determined at step 316 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{\text{pre}}$, method 300 includes step 320, where controller 140 determines whether bake heating element 126 has been used for a predetermined period of time $t_{\text{bake}}$. If not, method 300 may return to step 314 such that bake heating element 126 remains activated to heat cooking chamber 104. If bake heating element 126 has been used for time $t_{\text{bake}}$, method 300 continues to step 322, where bake heating element 126 is deactivated.

Then, at step 324, broil heating element 124 is activated to heat cooking chamber 104. At step 326, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point $T_{\text{pre}}$. If so, at step 328 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$, i.e., that the preheat cycle is complete. As described with respect to steps 308 and 318, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{\text{pre}}$.

However, if it is determined at step 326 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{\text{pre}}$, method 300 includes step 330, where the controller may determine whether broil heating element 124 has been employed for a predetermined period of time $t_{\text{broil}}$. If not, method 300 may return to step 324 such that broil heating element 124 remains activated. If broil heating element 124 has been employed for time $t_{\text{broil}}$, method 300 may include step 332 of deactivating broil heating element.
124, and then method 300 may return to step 314 and activate bake element 126 to continue heating cooking chamber 104 to reach temperature set point $T_{pre}$. In alternative embodiments, method 300 may return to step 304 rather than step 314 and reactivates convection heating element 136 and fan 138, or in certain embodiments, method 300 may return to step 304 and reactivates only convection heating element 136. Further, as described, oven appliance 100 may include multiple convection heating elements 136, and one or more convection heating elements may be reactivated if method 300 returns to step 304 from step 332.

[0048] The predetermined period of time $t_{bake}$ may be longer than time $t_{cool}$. As an example, for a preheat cycle for a selected cooking temperature of 350°F, time $t_{bake}$ may be about 90 seconds, and time $t_{cool}$ may be about 20 seconds. Other values for $t_{bake}$ and $t_{cool}$ may also be used, and the values for $t_{bake}$ and $t_{cool}$ may vary based on the selected cooking temperature and its associated temperature set point $T_{pre}$.

[0049] In other embodiments, method 300 may include a different order of operation of convection heating element 136, bake heating element 126, and/or broil heating element 124, e.g., bake heating element 126 may be activated, followed by broil heating element 124, and then convection heating element 136, where each heating element may be activated for a predetermined period of time and then deactivated before the next heating element is activated, as described above. In still other embodiments, heating elements 124, 126, 136 may be activated at the same time or in pairs, e.g., convection heating element 136 may be activated, then bake heating element 126 and broil heating element 124 may be activated at the same time. Alternatively, method 300 may include a delay period between the operation of each heating element, i.e., in certain embodiments, no heating element is in use for the delay period of time after convection heating element 136 is operated, bake heating element is used, and broil heating element is employed. The delay period may be, e.g., about one second. Other arrangements of method 300 also may be used. For example, a combination of the embodiments of FIGS. 3 and 4, including both time $t_{cool}$ and temperature $T_{cool}$, may be used.

[0050] Referring now to FIG. 5, another exemplary method of operating oven appliance 100 is illustrated. As described with respect to exemplary methods 200 and 300, method 400 may be performed by controller 140 or any other suitable device or devices. At step 402 of method 400, the cooking chamber temperature set point $T_{pre}$ for the preheat cycle is established. As described with respect to exemplary methods 200 and 300, the temperature set point $T_{pre}$ may be determined by the cooking temperature selected by the user of the oven appliance, e.g., the temperature set point $T_{pre}$ may be the cooking temperature selected by the user or a temperature over or under the selected cooking temperature. In alternative embodiments, temperature set point $T_{pre}$ may be a predetermined temperature that is used for each preheat cycle, regardless of the cooking temperature selected by the user. Other values of and methods for determining the temperature set point $T_{pre}$ may be used as well.

[0051] After establishing temperature set point $T_{pre}$, convection heating element 136 and fan 138 are activated at step 404 to heat cooking chamber 104. In alternative embodiments, convection heating element 136 may be activated at step 404 without activating fan 138. In still other embodiments, as described above, more than one convection heating element may be provided in cooking chamber 104, which may be energized and operated together or separately, with or without energizing and operating fan 138.

[0052] Then, at step 406, bake heating element 126 is activated. At step 408, controller 140 may determine whether bake heating element 124 has been activated for a predetermined period of time $t_{bake}$. If so, method 400 proceeds to step 410 and bake heating element 126 is deactivated. If not, bake heating element 126 remains activated until it has been activated for time $t_{bake}$. In alternative embodiments, broil heating element 124, rather than bake heating element 126, may be activated at step 406 such that at step 408, controller 140 determines whether broil heating element 124 has been activated for a predetermined period of time $t_{bake}$.

[0053] Continuing to step 412, controller 140 may determine if the temperature in cooking chamber 104, as measured by, e.g., temperature sensor 146, has reached the temperature set point $T_{pre}$. If so, at step 414 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{pre}$; i.e., that the preheat cycle is complete. The signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{pre}$. By way of example, the signal may be a notification displayed on user interface 128 of the appliance, an LED light, a buzzer, and/or any other appropriate visual and/or audible signal.

[0054] However, if it is determined at step 412 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{pre}$, method 400 includes step 416, where controller 140 determines whether convection heating element 136 and convection fan 138 have been activated for a predetermined period of time $t_{con}$. If not, method 400 may return to step 404 such that convection heating element 136 and convection fan 138 remain activated. If convection heating element 136 and convection fan 138 have been activated for time $t_{con}$, method 400 continues to step 418. At step 418, convection heating element 136 is deactivated; fan 138 may also be deactivated at step 418.

[0055] At step 420, bake heating element 126 is activated to heat cooking chamber 104. At step 422, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point $T_{pre}$. If so, at step 424 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{pre}$; i.e., that the preheat cycle is complete. As described with respect to step 414, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{pre}$.

[0056] Otherwise, if it is determined at step 422 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{pre}$, method 400 includes step 426, where controller 140 determines whether bake heating element 126 has been used for a predetermined period of time $t_{bake}$. If not, method 400 may return to step 420 such that bake heating element 126 remains activated to heat cooking chamber 104. If bake heating element 126 has been used for time $t_{bake}$, method 400 continues to step 428, where bake heating element 126 is deactivated.

[0057] Then, at step 430, broil heating element 124 is activated to heat cooking chamber 104. At step 432, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point $T_{pre}$. If so, at step 434 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{pre}$.
T_{pre}, i.e., that the preheat cycle is complete. As described with respect to steps 414 and 424, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point T_{pre}. [0058] However, if it is determined at step 432 that the temperature in cooking chamber 104 has not reached the temperature set point T_{pre}, method 400 includes step 436, where the controller may determine whether broil heating element 124 has been employed for a predetermined period of time t_{broil}. If not, method 400 may return to step 430 such that broil heating element 124 remains activated. If broil heating element 124 has been employed for time t_{broil}, method 400 may include step 438 of deactivating broil heating element 124, and then method 400 may return to step 420 and activate bake element 126 to continue heating cooking chamber 104 to reach temperature set point T_{pre}. In alternative embodiments, method 400 may return to step 404 rather than step 420 and reactivate convection heating element 136 and fan 138, or in certain embodiments, method 400 may return to step 404 and re-activate only convection heating element 136. Further, as described, oven appliance 100 may include multiple convection heating elements 136, and one or more convection heating elements may be reactivated if method 400 returns to step 404 from step 438.

[0059] The predetermined period of time t_{conv} may be longer than predetermined periods of time t_{bake} and t_{broil}. Further, predetermined period of time t_{bake} may be longer than time t_{broil}. As an example, for a preheat cycle for a selected cooking temperature of 350°F, time t_{conv} may be about 300 seconds, time t_{bake} may be about 90 seconds, and time t_{broil} may be about 20 seconds. Other values for t_{tconv}, t_{bake}, and t_{broil} may also be used, and the values for t_{tconv}, t_{bake}, and t_{broil} may vary based on the selected cooking temperature and its associated temperature set point T_{pre}.

[0060] In other embodiments, method 400 may include a different order of operation of convection heating element 136, bake heating element 126, and/or broil heating element 124, e.g., convection heating element 136 may be activated, then broil heating element 124 may be activated, and both elements 136 and 124 may be deactivated before bake heating element 126 is activated. As an additional example, convection heating element 136 may be activated, then bake heating element 126 may be activated, then convection heating element may be deactivated, then bake heating element 126 may be deactivated before broil heating element 124 is activated. Alternatively, method 400 may include a delay period between the operation of each heating element or a pair of heating elements, i.e., in certain embodiments, no heating element is in use for the delay period of time after convection heating element 136 is activated at step 418. The delay period may be, e.g., about one second. Other arrangements of method 400 also may be used.

[0061] FIG. 6 illustrates another exemplary method of operating oven appliance 100, which may be performed by controller 140 or any other suitable device or devices. At step 502 of method 500, the cooking chamber temperature set point T_{pre} for the preheat cycle is established. As described with respect to exemplary methods 200, 300, and 400, the temperature set point T_{pre} may be determined by the cooking temperature selected by the user of the oven appliance, e.g., the temperature set point T_{pre} may be the cooking temperature selected by the user or a temperature over or under the selected cooking temperature. In alternative embodiments, temperature set point T_{pre} may be a predetermined temperature that is used for each preheat cycle, regardless of the cooking temperature selected by the user. Other values of and methods for determining the temperature set point T_{pre} may be used as well.

[0062] After establishing temperature set point T_{pre}, convection heating element 136 and fan 138 are activated at step 504 to heat cooking chamber 104. In alternative embodiments, convection heating element 136 may be activated at step 504 without activating fan 138. In still other embodiments, as described above, more than one convection heating element may be provided in cooking chamber 104, which may be energized and operated together or separately, with or without energizing and operating fan 138.

[0063] Then, at step 506, bake heating element 126 is activated. At step 508, controller 140 may determine whether bake heating element 124 has been activated for a predetermined period of time t_{bake}. If so, method 500 proceeds to step 510 and bake heating element 126 is deactivated. If not, bake heating element 126 remains activated until it has been activated for time t_{bake}. In alternative embodiments, broil heating element 124, rather than bake heating element 126, may be activated at step 506 such that at step 508, controller 140 determines whether broil heating element 124 has been activated for a predetermined period of time t_{bake}. Continuing to step 512, controller 140 may determine if the temperature in cooking chamber 104, as measured by, e.g., temperature sensor 146, has reached the temperature set point T_{pre}. If so, at step 514 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point T_{pre}, i.e., that the preheat cycle is complete. The signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point T_{pre}. By way of example, the signal may be a notification displayed on user interface 128 of the appliance, an LED light, a buzzer, and/or any other appropriate visual and/or audible signal.

[0065] However, if it is determined at step 512 that the temperature in cooking chamber 104 has not reached the temperature set point T_{pre}, method 500 includes step 516, where the controller may determine whether the temperature in cooking chamber 104 has reached at least a predetermined temperature T_{conv}. Temperature T_{conv} is less than the temperature set point T_{pre} and may be, e.g., the difference between the temperature set point T_{pre} and a temperature offset T_{offset}. Temperature offset T_{offset} may be determined experimentally and programmed into controller 140. As an example, if temperature offset T_{offset} is determined to be and is programmed as 100°F, if temperature set point T_{pre} is established as 350°F, at step 502, then temperature T_{conv} would be 250°F. Temperature T_{conv} may be determined in other ways as well. If at step 516 the temperature within cooking chamber 104 has not reached at least temperature T_{conv}, method 500 may return to step 504, such that convection heating element 136 and convection fan 138 remain activated. If the temperature has reached at least T_{conv}, method 500 continues to step 518. At step 518, convection heating element 136 is deactivated; fan 138 may also be deactivated at step 518.

[0066] At step 520, bake heating element 126 is activated to heat cooking chamber 104. At step 522, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point T_{pre}. If so, at step 524 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point T_{pre}, i.e., that the preheat cycle is complete. As described with
respect to step 514, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{pre}$.

[0067] Otherwise, if it is determined at step 522 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{pre}$, method 500 includes step 526, where controller 140 determines whether bake heating element 126 has been used for a predetermined period of time $t_{bake}$. If not, method 500 may return to step 520 such that bake heating element 126 remains activated to heat cooking chamber 104. If bake heating element 126 has been used for time $t_{bake}$, method 500 continues to step 528, where bake heating element 126 is deactivated.

[0068] Then, at step 530, broil heating element 124 is activated to heat cooking chamber 104. At step 532, controller 140 may determine if the temperature in cooking chamber 104 has reached the temperature set point $T_{pre}$. If so, at step 534 a signal may be provided to a user of oven appliance 100 that cooking chamber 104 has reached temperature set point $T_{pre}$, i.e., that the preheat cycle is complete. As described with respect to steps 514 and 524, the signal may be, e.g., any audible and/or visual signal that indicates to the user that cooking chamber 104 has reached temperature set point $T_{pre}$.

[0069] However, if it is determined at step 532 that the temperature in cooking chamber 104 has not reached the temperature set point $T_{pre}$, method 500 includes step 536, where the controller may determine whether broil heating element 124 has been employed for a predetermined period of time $t_{bake}$. If not, method 500 may return to step 530 such that broil heating element 124 remains activated. If broil heating element 124 has been employed for time $t_{bake}$, method 500 may include step 538 of deactivating broil heating element 124, and then method 500 may return to step 520 and activate bake element 126 to continue heating cooking chamber 104 to reach temperature set point $T_{pre}$. In alternative embodiments, method 500 may return to step 504 rather than step 520 and reactivate convection heating element 136 and fan 138, or in certain embodiments, method 500 may return to step 504 and reactivate only convection heating element 136. Further, as described, oven appliance 100 may include multiple convection heating elements 136, and one or more convection heating elements may be reactivated if method 500 returns to step 504 from step 538.

[0070] The predetermined period of time $t_{bake}$ may be longer than predetermined period of time $t_{pre}$. As an example, for a preheat cycle for a selected cooking temperature of 350°F, time $t_{bake}$ may be about 90 seconds and time $t_{pre}$ may be about 20 seconds. Other values for $t_{bake}$ and $t_{pre}$ may also be used, and the values for $t_{bake}$ and $t_{pre}$ may vary based on the selected cooking temperature and its associated temperature set point $T_{pre}$.

[0071] In other embodiments, method 500 may include a different order of operation of convection heating element 136, bake heating element 126, and/or broil heating element 124, e.g., convection heating element 136 may be activated, then broil heating element 124 may be activated, and both elements 136 and 124 may be deactivated before bake heating element 126 is activated. As a further example, convection heating element 136 may be activated, then bake heating element 126 may be activated, then convection heating element may be deactivated, then bake heating element 126 may be deactivated before bake heating element 126 is activated. Alternatively, method 500 may include a delay period between the operation of each heating element or a pair of heating elements, i.e., in certain embodiments, no heating element is in use for the delay period of time after convection heating element 136 is deactivated at step 518. The delay period may be, e.g., about one second. Other arrangements of method 500 also may be used. For example, a combination of the embodiments of FIGS. 5 and 6, including both time $t_{con}$ and temperature $T_{con}$, may be used.

[0072] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A method for operating an oven appliance, the oven appliance having a cooking chamber configured for receipt of food items for cooking, the oven appliance also having a bake heating element, a broil heating element, a convection heating element, and a fan, the method comprising the steps of:
   a) establishing a cooking chamber temperature set point $T_{pre}$;
   b) activating the convection heating element and the fan;
   c) determining whether the convection heating element and the fan have been activated for a predetermined period of time $t_{con}$; and, if so, then deactivating the convection heating element;
   d) activating the bake heating element;
   e) determining whether the bake heating element has been activated for a predetermined period of time $t_{bake}$; and, if so, then deactivating the bake heating element;
   f) activating the broil heating element;
   g) sensing whether the temperature in the cooking chamber has reached $T_{pre}$ and, if so then
   h) providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

2. The method of claim 1, further comprising the step of sensing whether the temperature in the cooking chamber has reached the temperature set point $T_{pre}$ during the step of determining whether the convection heating element and the fan have been activated for a predetermined period of time $t_{con}$ and, if so, then
   a) providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

3. The method of claim 1, further comprising the step of sensing whether the temperature in the cooking chamber has reached the temperature set point $T_{pre}$ during the step determining whether the bake heating element has been activated for a predetermined period of time $t_{bake}$ and, if so, then
   a) providing a signal to a user of the oven appliance that the cooking chamber temperature has reached $T_{pre}$.

4. The method of claim 1, further comprising the steps of:
   a) activating the bake element during the step of activating the convection element;
   b) determining whether the bake element has been activated for the predetermined period of time $t_{bake}$ and, if so, then deactivating the bake element.
5. The method of claim 1, further comprising the steps of:
activating the broil element during the step of 
activating the convection element;
determining whether the broil element has been activated for 
the predetermined period of time \( t_{\text{broil}} \) and, if so, then 
deactivating the broil element.

6. The method of claim 1, further comprising the steps of 
determining whether the broil heating element has been acti 
vated for a predetermined period of time \( t_{\text{broil}} \) during the step 
of sensing whether the temperature in the cooking chamber 
has reached \( T_{\text{pre}} \) and, if so, then 
deactivating the broil heating element; and 
repeating the step of deactivating the bake heating element.

7. A method for operating an oven appliance, the oven appliance 
having a cooking chamber configured for receipt of 
food items for cooking, the oven appliance also having a bake 
heating element, a broil heating element, a convection heating 
element, and a fan, the method comprising the steps of:
establishing a cooking chamber temperature set point \( T_{\text{pre}} \); 
activating the convection heating element and the fan;
sensing whether the temperature in the cooking chamber 
has reached at least a temperature \( T_{\text{conv}} \) and, if so, then 
deactivating the convection heating element; 
activating the bake heating element;
determining whether the bake heating element has been 
used for a predetermined period of time \( t_{\text{bake}} \) and, if so, then 
deactivating the bake heating element;
activating the broil heating element;
sensing whether the temperature in the cooking cham 
ber has reached \( T_{\text{pre}} \) and, if so, then 
providing a signal to a user of the oven appliance 
that the cooking chamber temperature has reached \( T_{\text{pre}} \).

8. The method of claim 7, further comprising the step of 
sensing whether the temperature in the cooking chamber has 
reached the temperature set point \( T_{\text{pre}} \) during the step of 
sensing whether the temperature in the cooking chamber has 
reached at least a temperature \( T_{\text{conv}} \) and, if so, then 
providing a signal to a user of the oven appliance that the 
cooking chamber temperature has reached \( T_{\text{pre}} \).

9. The method of claim 7, further comprising the step of 
sensing whether the temperature in the cooking chamber has 
reached the temperature set point \( T_{\text{pre}} \) during the step deter 
mining whether the bake heating element has been activated 
for a predetermined period of time \( t_{\text{bake}} \) and, if so, then 
providing a signal to a user of the oven appliance that the 
cooking chamber temperature has reached \( T_{\text{pre}} \).

10. The method of claim 7, further comprising the steps of: 
activating the bake element during the step of activating the 
convection element;
determining whether the bake element has been activated 
for the predetermined period of time \( t_{\text{bake}} \) and, if so, then 
deactivating the bake element.

11. The method of claim 7, further comprising the steps of: 
activating the broil element during the step of activating the 
convection element;
determining whether the broil element has been activated 
for the predetermined period of time \( t_{\text{broil}} \) and, if so, then 
deactivating the broil element.

12. The method of claim 7, further comprising the step of 
determining whether the broil heating element has been acti 
vated for a predetermined period of time \( t_{\text{broil}} \) during the step 
of sensing whether the temperature in the cooking chamber 
has reached \( T_{\text{pre}} \) and, if so, then 
deactivating the broil heating element; and 
repeating the step of activating the bake heating element.

13. An oven appliance, comprising:
a cabinet, the cabinet defining a cooking chamber config 
ured for receipt of food items for cooking, the cooking 
chamber having a top wall, a bottom wall, a back wall, and 
opposing side walls;
a bake heating element, a broil heating element, and a 
convection heating element, the heating elements config 
ured to heat the cooking chamber;
a fan; and 
a controller in operative communication with the heating 
elements and the fan, the controller configured for 
establishing a cooking chamber temperature set point \( T_{\text{pre}} \); 
activating the convection heating element and the fan;
determining whether the convection heating element 
and the fan have been activated for a predetermined 
period of time \( t_{\text{conv}} \) and, if so, then 
deactivating the convection heating element; 
activating the bake heating element;
determining whether the bake heating element has 
been activated for a predetermined period of time \( t_{\text{bake}} \) and, if so, then 
deactivating the bake heating element; 
activating the broil heating element; 
sensing whether the temperature in the cooking 
chamber has reached \( T_{\text{pre}} \) and, if so, then 
providing a signal to a user of the oven appliance 
that the cooking chamber temperature has 
reached \( T_{\text{pre}} \).

14. The oven appliance of claim 13, wherein the bake 
heating element is disposed below the bottom wall of the 
cooking chamber.

15. The oven appliance of claim 13, wherein the convection 
heating element is at least a 4000W element.

16. The oven appliance of claim 13, wherein the controller 
is further configured for sensing whether the temperature in 
the cooking chamber has reached the temperature set point \( T_{\text{pre}} \) 
while determining whether the convection heating element 
and the fan have been activated for a predetermined 
period of time \( t_{\text{conv}} \) and, if so, then 
providing a signal to a user of the oven appliance that the 
cooking chamber temperature has reached \( T_{\text{pre}} \).

17. The oven appliance of claim 13, wherein the controller 
is further configured for sensing whether the temperature in 
the cooking chamber has reached the temperature set point \( T_{\text{pre}} \) 
while determining whether the bake heating element has 
been activated for a predetermined period of time \( t_{\text{bake}} \) and, if so, then 
providing a signal to a user of the oven appliance that the 
cooking chamber temperature has reached \( T_{\text{pre}} \).

18. The oven appliance of claim 13, wherein the controller 
is further configured for 

19. The oven appliance of claim 13, wherein the controller 
is further configured for
activating the broil element during the step of activating the
convection element;
determining whether the broil element has been activated
for the predetermined period of time $t_{\text{pred}}$ and, if so, then
deactivating the broil element.