METHOD AND APPARATUS FOR IMPROVING ENERGY EFFICIENCY OF AN ICE MAKER SYSTEM

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ABSTRACT
Method and apparatus for ice maker systems are disclosed. One exemplary method comprises the step of, in a harvesting cycle of an ice maker system wherein a heating element is turned on at a first time instance to generate heat to separate ice from an ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin, controlling an amount of heat generated by the heating element between the first time instance and the second time instance.
FIG. 9

Heater cycles to maintain warm mold while saving energy

Heater on continuously for fast harvest

Ice maker wait usage

Ice maker mold temperature

Power, Watts

Temperature, °F

Time, seconds
METHOD AND APPARATUS FOR IMPROVING ENERGY EFFICIENCY OF AN ICE MAKER SYSTEM

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to ice maker systems, and more particularly to energy efficiency of an ice maker system.

[0002] Some ice maker systems, for example, ones that are deployed in freezer portions of refrigerators, are known to include heating elements for separating the ice from the ice mold used to form the ice. That is, heat is applied to the ice mold via a heating element so that the bond formed between the ice and the ice mold during ice formation is broken. This allows the ice to be more easily released from the ice mold. Separation and release of the ice from the ice mold may be referred to as “harvesting” the ice.

[0003] The ice mold then has to cool down after the ice harvesting so that ice formation can begin again in the next cycle. In existing ice maker systems, the ice mold is typically cooled by convection cooling provided by the chilled ambient air in the freezer portion of the refrigerator in which the ice maker system resides. However, since the ice maker system draws its electric power from the refrigerator, the refrigerator must therefore expend extra energy so that the freezer portion can remove the heat introduced by the heating element during the harvesting cycle.

[0004] Accordingly, a harvesting cycle that utilizes a heating element adds significantly to the overall energy used by the refrigerator in which it resides, and thus has a significant impact on the overall energy efficiency of the refrigerator.

BRIEF DESCRIPTION OF THE INVENTION

[0005] As described herein, the exemplary embodiments of the present invention overcome one or more disadvantages known in the art.

[0006] One aspect of the present invention relates to a method comprising, in a harvesting cycle of an ice maker system wherein a heating element is turned on at a first time instance to generate heat to separate ice from an ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin; controlling an amount of heat generated by the heating element between the first time instance and the second time instance.

[0007] Another aspect of the present invention relates to an apparatus comprising: a heating element, wherein, in a harvesting cycle of an ice maker system, the heating element is turned on at a first time instance to generate heat to separate ice from an ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin; and a device for controlling an amount of heat generated by the heating element between the first time instance and the second time instance.

[0008] Advantageously, in accordance with illustrative methods and apparatus of the invention, the energy efficiency of the ice maker system is improved and thus, the overall energy efficiency of an appliance (e.g., refrigerator) in which the ice maker system resides is improved.

[0009] These and other aspects and advantages of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. Moreover, the drawings are not necessarily drawn to scale and, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In the drawings:

[0011] FIG. 1 is a diagram of a refrigerator, in accordance with an embodiment of the invention;

[0012] FIG. 2 is a diagram of an ice maker system in a freezer portion of a refrigerator, in accordance with an embodiment of the invention;

[0013] FIG. 3 is a diagram of an ice maker system, in accordance with an embodiment of the invention;

[0014] FIG. 4 is a diagram of a bottom view of an ice maker system, in accordance with an embodiment of the invention;

[0015] FIG. 5 is a diagram of a heating element control circuit, in accordance with an embodiment of the invention;

[0016] FIG. 6 is a diagram of a temperature versus time for an ice maker system, in accordance with an embodiment of the invention;

[0017] FIG. 7 is a diagram of a heating element control circuit, in accordance with another embodiment of the invention;

[0018] FIG. 8 is a diagram of a sensor placement for an ice maker system, in accordance with an embodiment of the invention; and

[0019] FIG. 9 is a diagram of exemplary traces for an ice maker system operating with heater control techniques, in accordance with one or more embodiments of the invention.

DETAILS DESCRIPTION OF THE EXEMPLARY EMBODIMENTS OF THE INVENTION

[0020] One or more of the embodiments of the invention will be described below in the context of an ice maker system in a refrigerator appliance, such as a household refrigerator. However, it is to be understood that methods and apparatus of the invention are not intended to be limited to ice maker systems in household refrigerators. Rather, methods and apparatus of the invention may be applied to and deployed in any other suitable environments in which it would be desirable to improve the energy efficiency of an ice maker system and thus the appliance or system in which the ice maker system is deployed.

[0021] It is known that the U.S. Department of Energy (DOE) test for refrigerators is being revised for implementation by as early as 2014. The new test will attempt to capture the energy use required to make ice. A goal of this modification is for the energy test to more closely reflect the usage patterns of the customer.

[0022] The draft DOE test estimates that the average consumer uses about one to two pounds of ice per day. It is realized that a typical existing crescent cube automatic ice maker system increases the overall energy use of the refrigerator by about 50 to 60 Kilowatt hours (Kwhr) per year when producing one pound of ice per day.

[0023] It is further realized that two thirds of the energy used to make ice using such a typical existing ice maker
system is required to energize the harvest heater and to then remove this added heat. Methods and apparatus of the invention provide solutions that reduce the energy required to harvest ice by a significant amount, e.g., approximately 10 to 20 kWhr per year. This would translate to reducing the overall appliance energy use by approximately two to four percent.

As will be described in illustrative detail below, one embodiment (illustratively depicted in the context of FIGS. 5 and 6) reduces harvest heat by using a positive temperature control resistor (PTCR) in the heater circuit of the ice maker system (e.g., an electromechanical ice maker system), and in other embodiments (illustratively depicted in the context of FIGS. 7 and 8), circuit and/or algorithmic controls are provided on ice maker systems (e.g., electronic ice maker systems) to reduce harvest heat. These embodiments seek to prevent the harvest heater from adding more heat than is needed to harvest the ice.

Before describing these illustrative embodiments, an illustrative operating environment and ice maker system in which such embodiments may be implemented are described in the context of FIGS. 1 through 4.

FIG. 1 illustrates an exemplary refrigerator 100 within which an ice maker system according to an embodiment of the invention may be deployed. As is typical, a refrigerator has a freezer portion 102 and a refrigerator portion 104. The refrigerator portion typically maintains foods and products stored therein at temperatures at or below about 40 degrees Fahrenheit in order to preserve the items therein, and the freezer portion typically maintains foods and products at temperatures below about 32 degrees Fahrenheit in order to freeze the items therein.

While the exemplary refrigerator 100 in FIG. 1 illustrates the freezer portion 102 and the refrigerator portion 104 in a side-by-side configuration, it is to be understood that other configurations are known, such as top freezer configurations where the freezer portion 102 is situated on top of the refrigerator portion 104, and bottom freezer configurations where the freezer portion 102 is situated below the refrigerator portion 104. Also, viewing the refrigerator 100 from the front, the freezer portion 102 may be located to the right of the refrigerator portion 104, as opposed to being located to the left as shown in FIG. 1.

It is to be appreciated that an ice maker system according to an embodiment of the invention may be deployed in the freezer portion 102 of the refrigerator 100. However again, methods and apparatus of the invention are not intended to be limited to deployment in a refrigerator such as the one depicted in FIG. 1.

FIG. 2 shows an ice maker system 200 deployed in a refrigerator, in accordance with an embodiment of the invention. In this exemplary embodiment, the ice maker system 200 is shown as being mounted on the inside door 205 of the freezer portion of a household refrigerator (e.g., the freezer portion 102 of the refrigerator 100 in FIG. 1). However, methods and apparatus of the invention are not intended to be limited to such a configuration. By way of example only, the ice maker system 200 may alternatively be mounted on an inside wall (not shown) of the freezer portion of the refrigerator. By way of further example, the ice maker system 200 may be mounted at the top of the freezer portion, facing outward, with an ice storage bucket assembly mounted on the inside of the freezer door. In general, the ice maker system 200 automatically makes ice that is deposited in ice storage bucket assembly 210.

FIG. 3 shows ice maker system 200 in greater detail. As shown, ice maker system 200 comprises an ice mold body 302 with ice formation compartments 303, a rake assembly 304 with ejector blades 305, stationary blades 306, motor and control circuitry assembly 308, shut-off arm 310, and harvest heater 312. FIG. 4 shows a bottom view of the ice maker system 200.

It is to be understood that the ice maker system 200 includes other components such as, but not limited to, a water inlet assembly (for use in supplying water to the compartments of the ice mold for freezing). Also, assembly 308 may contain control circuitry for use in monitoring, sensing, processing and otherwise controlling the timing of the various stages of the ice formation and harvesting cycles. However, for the sake of clarity of illustration, these and other typical components are not shown or explained further unless useful for a better understanding of the illustrative embodiments of the invention. One of ordinary skill in the art will know and understand their typical functions and operations in the context of the illustrative detailed descriptions herein. The ice maker 200 operates as follows.

At the beginning of an ice formation cycle, the control circuitry activates a valve in the water inlet assembly to allow water to fill the ice formation compartments 303 of the ice mold body 302. The ice mold body 302 is made of a metal material and the compartments in which the ice is formed can be a variety of shapes, e.g., crescent shaped or semi-circle shaped. For example, the ice mold body may be die cast (formed) from aluminum, zinc, steel, iron, or other suitable materials. Typically, each compartment may be attached by a small notch so that when filled with water and frozen, each ice cube attaches to the ice cube next to it. This releases the ice cubes from the ice cube maker easier.

Once the ice mold body 302 is filled (compartments 303 and notches therebetween), the ice maker system 200 waits for the water in the ice mold body 302 to freeze. The cooling unit in the refrigerator in which the ice maker system resides removes the heat needed to freeze water. A thermostat (not shown) in the ice maker system 200 moniters the temperature level of the ice mold body 302. A thermostat could also be used rather than a thermostat. When the temperature drops to a predetermined level, indicating that the water has sufficiently frozen, the ice formation cycle is complete and the ice harvesting cycle begins.

In the ice harvesting cycle, which begins at a given time instance, the control circuitry activates the harvest heater 312. As shown, the harvest heater is located below the ice mold body 302 (see FIG. 4). As the harvest heater 312 generates heat, it warms the bottom of the ice mold body 302, loosening the ice cubes from the inside surfaces of the ice formation compartments 303, and the ice mold body 302 in general. This allows the ice to be more easily releasable from the ice mold body 302.

After a predetermined time elapses, a motor (not shown) in assembly 308 is then activated by the control circuitry. Typically, the motor rotates a gear (not shown), which rotates another gear (not shown) attached to a shaft that is part of the rake assembly 304. As shown in FIG. 3, the shaft runs the length of the ice mold body 302 and has a series of ejector blades (or rake fingers) 305 extending out perpendicularly from the length of the shaft. As the ejector blades 305 rotate in a rotational direction denoted by the letter A in FIG. 3, they scoop the ice cubes up and out of the ice mold body 302,
pushing them to the front of the ice maker system 200. Since the ice cubes are connected to one another, they move as a single block.

[0036] At the front of the ice maker system 200, there are plastic notches 309 in the housing that match up with the ejector blades 305. The ejector blades 305 pass through these notches 309. Also, formed in between the notches 309 are stationary blades 306 which prevent the ice cubes from falling back into the ice mold body 302 as they are pushed toward the front of the ice maker system 200. The ice cubes are pushed out of the front of the ice maker system 200 where they fall and are collected in an ice bucket below the ice maker system, e.g., ice storage bucket assembly 210 in FIG. 2.

[0037] As is known, the shut-off arm 310 is used to detect whether or not the ice storage bucket assembly 210 is full with ice, in which case its location causes the control circuitry to shut off the ice maker system 200 so that no more ice is automatically made. However, assuming that the shut-off arm 310 is at position that indicates that the ice storage bucket assembly 210 is not yet filled and thus more ice can be made, the control circuitry causes a next ice formation cycle to begin, i.e., activate the water inlet valve to allow water to fill the ice formation compartments 303 of the ice mold body 302. However, recall that the introduction of heat to the ice mold body 302 during the harvesting cycle requires that the ice mold body 302 cool sufficiently to allow ice to form again. While the chilled ambient air in the freezer portion 102 in which ice maker system 200 resides provides the cooling means, it is to be understood that the need to cool the ice mold body 302 extends the time duration of the next ice formation cycle and makes the refrigerator cooling unit work harder, i.e., draw more current and thus expend more energy.

[0038] It is to be noted that the ejector blades 305 of the rake assembly 304 typically make approximately one full (360 degree) rotation and end at the same position at which they started, e.g., in between (as they are shown in FIG. 3) or slightly above the stationary blades 306. In existing electromechanical ice maker systems, it is at this given time instance (i.e., when rake assembly returns to start position) that the heater shutter 312 is shut off. The time period between the time instance when the heater is turned on (at the beginning of the harvesting cycle) and the time instance when the heater shutter 312 is turned off may typically be approximately three minutes for a standard ice maker system.

[0039] In testing of an existing ice maker system, it has been realized that a thermometer wedged between the harvest heater and the ice mold body warms up to approximately 350 degrees Fahrenheit during a harvesting cycle. A thermocouple attached to the ice mold body approximately 1 half inch from the harvest heater warmed to over approximately 50 degrees Fahrenheit. However, it has been further realized that a successful harvest can occur at any mold temperature above approximately 32 degrees Fahrenheit. That is, the ice mold body only needs to be warm enough to melt a thin layer of ice to facilitate cube harvest, i.e., to separate the ice cubes from the mold body so that they can be released from the mold body by the rake assembly.

[0040] Thus, it is realized that minimizing the amount of heat added during harvest reduces the direct energy used by the heater. Because the harvest heat is applied inside the refrigerator, the refrigerator system energy use also increases to remove this heat.

[0041] Applying the heat more slowly in order to reduce the temperature gradient between the heater and the mold might reduce the amount of heat required to harvest the cube. But this may increase the amount of time to harvest ice cubes and decrease the rate at which ice is made. It is also advantageous to harvest the cubes quickly to decrease the amount of time the harvest heater is energized and transferring heat into the freezer portion.

[0042] Methods and apparatus of the invention embody solutions that provide the amount of harvest heat needed quickly without causing the ice mold body or the heating elements (harvest heater) to become too warm and wasting energy.

[0043] FIG. 5 illustrates a first embodiment of the invention. It is to be understood that this illustrative embodiment is particularly suitable for electromechanical ice maker systems, but is not intended to be limited thereto. As shown, the schematic of heating element control circuit 500 illustrates a current source 502, a device 504 referred to as a positive temperature coefficient (PTC) resistor, and the heating element of the harvest heater, i.e., heating resistor 506. As is known, a PTC resistor is a resistor whose resistive property (resistance) varies as a function of temperature such that, at low temperatures, the resistor exhibits low resistance and at higher temperatures, it exhibits higher resistance.

[0044] Note that the heating resistor 506 may be formed by one or more resistors. Typically, in a resistive heater, a current (e.g., source 502) is applied to the one or more resistor elements. As a result, the one or more resistor elements, which are in proximity to the ice mold, generate heat which warms the ice mold to a suitable temperature so as to separate the ice from the inside wall of the ice mold compartment in which the ice resides. This was shown and explained above in the context of FIGS. 3 and 4 (heater 312). It is to be appreciated that the resistive heating element (or its associated assembly) is typically in contact (i.e., very close proximity) with the ice mold so as to optimize heat transfer between the resistive heating element and the ice mold.

[0045] Thus, by operatively coupling PTC resistor 504 in series with the heating resistor 506, the amount of heat generated by the heating element is advantageously controlled. That is, assuming that the ice maker system 200 is an electromechanical system such that, in the harvesting cycle, the harvest heater 312 is turned on at a first time instance (to generate heat to separate the ice from the ice mold body 302), and turned off at a second time instance (such as when the rake assembly 304 makes a full rotation as explained above), the PTC resistor 504 reduces electric power provided to the heating resistor 506 between the first time instance and the second time instance when the amount of heat generated by the heating resistor reaches a predetermined level; that level being dictated by the resistive property of the selected PTC resistor.

[0046] That is, as the temperature associated with the heat generated by the heating resistor 506 increases, the resistance of the PTC resistor 504 increases, thus restricting the current that flows through the PTC resistor 504 to the heating resistor 506. Consequently, with less current thus flowing through the heating resistor 506, the heating resistor 506 generates less heat and the temperature stops increasing. Advantageously, the use of the PTC resistor allows the heater to rapidly warm up to a suitable temperature for harvest while limiting the amount of overshoot.

[0047] The PTC resistor could be selected to limit the heater temperature to approximately 130 degrees Fahrenheit, thus saving energy as compared to the existing approach that
allows the heater to remain on from the first time instance (i.e., beginning of harvesting cycle) to the second time instance (i.e., the rake assembly makes a full rotation). An additional advantage is that the relatively lower temperature could allow for removal of any heater guard.

[0048] In one embodiment, a PTC resistor can be selected that provides low resistance, e.g., approximately 1 to 10 ohms, at temperatures approximately below 32 degrees Fahrenheit, and that provides high resistance, e.g., approximately 100 to 10,000 ohms, at higher temperatures such as approximately 130 degrees Fahrenheit. This would allow the harvest heater to heat to approximately 130 degrees quickly after the start of the harvesting cycle (i.e., first time instance) but then remain at or about this temperature for the remainder of the harvesting cycle until the harvest heater is shut off (i.e., at the second time instance).

[0049] A temperature versus time comparison is illustrated in FIG. 6. As denoted by reference letter A, with the use of PTC resistor 504, it is shown that the heater output is reduced as the heating resistor 506 reaches approximately 130 degrees Fahrenheit. As denoted by reference letter B, which correlates to A (when PTC resistor is used), it is shown that the heater output is reduced as the ice mold temperature reaches approximately 32 degrees Fahrenheit. As denoted by reference letter D, the plot indicating approximately 185 seconds represents the time the heater stays on for existing ice maker systems. The plot denoted reference letter C will be explained below.

[0050] FIG. 7 illustrates a second embodiment of the invention. It is to be understood that this illustrative embodiment is particularly suitable for electronic ice maker systems, but is not intended to be limited thereto. As shown, the schematic of heating element control circuit 700 illustrates a current source 702, a heater relay 704 in the form of a triac (triode for alternating current), and a harvest heater 706.

[0051] As is known, a triac is a bidirectional electronic switch that can conduct current in either direction (terminal A1 to terminal A2, or vice versa) when triggered (i.e., turned on). It is triggered by either a positive or negative voltage applied to its gate terminal (G). Once triggered, the triac continues to conduct until the current through it drops below a certain threshold level (i.e., holding current), such as at the end of a half-cycle of an alternating current signal (e.g., from current source 702). It is realized that applying a trigger signal to the gate at a controllable point in an alternating current cycle allows for control of the percentage of current that flows through the triac (e.g., triac 704) to the load (e.g., harvest heater 706).

[0052] In accordance with an embodiment of the invention, the effective output wattage of the heater 706 can be reduced by cycling the triac 704 via a control signal 708 provided at a heater relay control (e.g., triac gate terminal). As described above, the control signal has the effect of controlling a percentage of the current that flows through the triac 704 to the heater 706, thus controlling the output of the heater 706. The control signal 708 can also turn on and off the triac 704 to effectuate the reduction in energy use.

[0053] In an electronic ice maker system, the control signal 708 may be generated as a function of one or more feedback attributes including, but not limited to, rake position, time, and mold temperature.

[0054] In one embodiment, as illustrated in FIG. 8, rake position may be sensed and, as a result thereof, the triac 704 can be cycled so as to reduce the output of the heater 706.

[0055] Recall that the rake assembly (see FIG. 3) includes a shaft that runs the length of the ice mold body and has a series of ejector blades (or rake fingers) extending outward perpendicularly from the length of the shaft. FIG. 8 shows a cross sectional view of the shaft looking into the length of the shaft with one ejector blade 305 visible. As the ejector blades rotate, they scoop the ice cubes up and out of the ice mold body 302, pushing them to the front of the ice maker system. This is depicted by steps 802 and 804 of FIG. 8.

[0056] However, existing ice maker systems can only sense whether the rake is in one predetermined position, i.e., the start/end position. This is determined by sensor 806. Advantageously, in accordance with this embodiment of the invention, by adding a second sensor 808 at a position along the ice mold body 302, for example, where the ejector blade 305 contacts the ice mold body 302, it can be sensed when the cubes have started to move and the heater 706 can be turned to a lower wattage via control signal 708 and triac 704 at this time. It is to be understood that the sensors can be any suitable type of device capable of sensing the position of the rake, e.g., a resettable micro switch, a magnetic switch, etc.

[0057] Thus, in existing ice maker systems, it is known that the heater will typically stay on about three minutes, with the heater being on for about 90 seconds before the rake starts and stays on until the cube is pushed free of the mold (this is depicted by the time period labeled A in FIG. 9). It stays on this long because the system is sensing mold temperature (via a thermostat) which remains relatively cold while the ice is still in contact with the mold. Thus, the heater comes on at a first time instance (at start of the ice harvesting cycle) and is turned off at a second time instance (when mold temperature reaches a certain level as per thermostat).

[0058] However, by adding a second rake position sensor to sense when the ejector blade contacts the mold, the output of the heater can be controlled, i.e., reduced, between the two time instances. That is, the control signal 708 is generated in response to rake positions such that the triac 704 is cycled so as to reduce the output of the heater 706 (this is depicted by the time period labeled B in FIG. 9). It is to be appreciated that more than two sensors can be used, e.g., more sensors can be placed along the path of the ejector blades to more closely track the position of the rake assembly. This would give the ability to provide finer control of the heater output.

[0059] It is also to be appreciated that the control signal may be generated by a processor associated with the control circuitry in assembly 308. That is, the rake position sensors may send signals to the processor (indicative of rake position) which in turn generates an appropriate control signal 708 to reduce the heater output. One of ordinary skill in the art will realize other methods and circuitry that can be used to generate an appropriate control signal.

[0060] In another embodiment of the heating element control circuit 700, it is realized that mold temperature can also provide a good indication of an appropriate time to reduce heater (706) watts. As the mold temperature approaches approximately 32 degrees Fahrenheit (as determined by the thermostat proximate to the ice mold), the heater wattage can be reduced to limit the amount of extra heat used. Again, this would be accomplished by the processor generating an appropriate control signal 708. This method can allow the heater to stay on longer when required by a colder freezer temperature and still save energy when making ice repeatedly during testing of heavy operations.
[0061] In yet another embodiment of the heating element control circuit 700, time can also be used to reduce heater (706) watts. It is realized that it typically takes about 90 seconds to warm the mold from approximately 10 degrees Fahrenheit to approximately 32 degrees Fahrenheit for harvest. After 90 seconds, the effective wattage could be reduced via an appropriate control signal 708. This is depicted in FIG. 6 as reference letter C. Alternatively, the effective wattage can be reduced in stages starting after about 60 seconds, by way of example only.

[0062] As mentioned above, embodiments of an ice maker system 200 according to the invention can use one or more of rake position, mold temperature and time (as well as other suitable feedback attributes) to generate the control signal 708 and thus control the heat output of the harvest heater 706.

[0063] It is to be appreciated also that while exemplary time instances are given above for when the harvest heater turns on (first time instance) and off (second time instance), heater control techniques of the invention can be implemented between other time instances. That is, heater control techniques of the invention can be applied to control the heater output between time instances other than those illustratedly mentioned herein.

[0064] FIG. 9 is a watt trace of an ice maker system operating with improved heater control techniques of the invention. The x-axis represents power (watts) and the y-axis represents time (seconds). Note the high watts for approximately the first 90 seconds (time period A in FIG. 9) while the heater is on full time. The heater then starts cycling (time period B in FIG. 9), delivering about half the power, until the rake returns to the home or the thermostat reads a high value, this takes about another 90 seconds. Once the cubes are free, the thermostat reading stays high (above approximately 35 degrees Fahrenheit) and the heater stays off. The heater temperature only reaches about 130 or 135 degrees Fahrenheit or less versus 250 degrees Fahrenheit on the existing ice maker production design. One exemplary plot of the ice maker mold temperature, in accordance with the inventive control techniques, is shown in FIG. 9 and plot C. Note that the x-axis thus represents temperature (Fahrenheit) with respect to plot C.

[0065] Thus, by way of one example only and given the plots shown in FIG. 9, the “first time instance” referred to above may be at or just before about 26000 seconds and the “second time instance” referred to above may be at or just after about 268000 seconds. Therefore, between these two time instances, the inventive heater control techniques are applied to reduce the heater output and thus make the ice maker system more efficient.

[0066] It is to be appreciated that the ice maker systems described herein may have control circuitry including, but not limited to, a microprocessor (processor) that is programmed, for example, with suitable software or firmware, to implement one or more techniques as described herein. In other embodiments, an ASIC (Application Specific Integrated Circuit) or other arrangement could be employed. One of ordinary skill in the art will be familiar with ice maker systems and given the teachings herein will be enabled to make and use one or more embodiments of the invention; for example, by programming a microprocessor with suitable software or firmware to cause the ice maker system to perform illustrative steps described herein. Software includes but is not limited to firmware, resident software, microcode, etc. As is known in the art, part or all of one or more aspects of the invention discussed herein may be distributed as an article of manufac-
ture that itself comprises a tangible computer readable recordable storage medium having computer readable code means embodied thereon. The computer readable program code means is operable, in conjunction with a computer system or microprocessor, to carry out all or some of the steps to perform the methods or create the apparatuses discussed herein. A computer usable medium may, in general, be a recordable medium (e.g., floppy disks, hard drives, compact disks, EEPROMs, or memory cards) or may be a transmission medium (e.g., a network comprising fiber-optics, the worldwide web, cables, or a wireless channel using time-division multiple access, code-division multiple access, or other radio-frequency channel). Any medium known or developed that can store information suitable for use with a computer system may be used. The computer-readable code means is any mechanism for allowing a computer or processor to read instructions and data, such as magnetic variations on magnetic media or height variations on the surface of a compact disk. The medium can be distributed on multiple physical devices. As used herein, a tangible computer-readable recordable storage medium is intended to encompass a recordable medium, examples of which are set forth above, but is not intended to encompass a transmission medium or disembodied signal. A microprocessor may include and/or be coupled to a suitable memory.

[0067] Furthermore, it is also to be appreciated that methods and apparatus of the invention may be implemented in electronic ice maker systems under control of one or more microprocessors and computer readable program code, as described above, or in electromechanical ice maker systems where operations and functions are under substantial control of mechanical control systems rather than electronic control systems.

[0068] Thus, while there have been shown and described and pointed out fundamental novel features of the invention as applied to exemplary embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. Moreover, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Furthermore, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or described or suggested form or embodiment as a general matter of design choice. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

What is claimed is:

1. A method comprising:
in a harvesting cycle of an ice maker system wherein a heating element is turned on at a first time instance to generate heat to separate ice from an ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin;
controlling an amount of heat generated by the heating element between the first time instance and the second time instance.
2. The method of claim 1, wherein the step of controlling an amount of heat generated by the heating element between the first time instance and the second time instance comprises reducing electric current provided to the heating element.

3. The method of claim 2, wherein the reduction of electric current provided to the heating element is effectuated by a positive temperature coefficient resistor operatively coupled between the heating element and a source of the electric current provided to the heating element.

4. The method of claim 3, wherein the positive temperature coefficient resistor decreases an amount of electric current provided to the heating element by the electric current source as the amount of heat generated by the heating element increases.

5. The method of claim 3, wherein the positive temperature coefficient resistor is selected such that an amount of heat is generated by the heating element, after the first time instance, to allow the ice to separate from the ice mold body but is limited thereafter until the heating element is turned off at the second time instance.

6. The method of claim 1, wherein the step of controlling an amount of heat generated by the heating element between the first time instance and the second time instance comprises controlling a relay device that provides electric current to the heating element.

7. The method of claim 6, wherein the relay device is controlled as a function of time.

8. The method of claim 6, wherein the relay device is controlled as a function of a temperature of the ice mold body.

9. The method of claim 6, wherein the relay device is controlled as a function of a position of a rake assembly used to release the ice from the ice mold body.

10. The method of claim 6, wherein the step of controlling the relay device that provides electric current to the heating element further comprises applying a control signal to a control terminal of the relay device.

11. The method of claim 10, wherein the control signal applied to the control terminal of the relay device is generated as a function of one or more of time, a temperature of the ice mold body, and a position of a rake assembly used to release the ice from the ice mold body.

12. The method of claim 6, wherein the relay device comprises a triac.

13. An apparatus comprising:
   a heating element, wherein, in a harvesting cycle of an ice maker system, the heating element is turned on at a first time instance to generate heat to separate ice from an ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin; and
   a device for controlling an amount of heat generated by the heating element between the first time instance and the second time instance.

14. The apparatus of claim 13, wherein the device for controlling an amount of heat generated by the heating element between the first time instance and the second time instance comprises a positive temperature coefficient resistor.

15. The apparatus of claim 14, wherein the positive temperature coefficient resistor is operatively coupled between the heating element and a source of the electric current provided to the heating element.

16. The apparatus of claim 15, wherein the positive temperature coefficient resistor decreases an amount of electric current provided to the heating element by the electric current source as the amount of heat generated by the heating element increases.

17. The apparatus of claim 14, wherein the positive temperature coefficient resistor is selected such that an amount of heat is generated by the heating element, after the first time instance, to allow the ice to separate from the ice mold body but is limited thereafter until the heating element is turned off at the second time instance.

18. The apparatus of claim 13, wherein the device for controlling an amount of heat generated by the heating element between the first time instance and the second time instance comprises a relay device.

19. The apparatus of claim 18, wherein relay device controls electric current provided to the heating element.

20. The apparatus of claim 19, wherein a control signal is applied to a control terminal of the relay device so as to control the electric current provided to the heating element and reduce the heat generated by the heating element.

21. The apparatus of claim 20, wherein the control signal applied to the control terminal of the relay device is generated as a function of one or more of time, a temperature of the ice mold body, and a position of a rake assembly used to move the ice out of the ice mold body.

22. The apparatus of claim 18, wherein the relay device comprises a triac.

23. An apparatus for making ice, comprising:
   an ice mold body for forming ice;
   a heating element, wherein, in a harvesting cycle, the heating element is turned on at a first time instance to generate heat to separate ice from the ice mold body formed in the ice mold body during a preceding ice formation cycle, and turned off at a second time instance to allow the ice mold body to cool so that a next ice formation cycle can begin; and
   a device for controlling an amount of heat generated by the heating element between the first time instance and the second time instance; and
   a mechanism for releasing the ice from the ice mold body in the harvesting cycle.

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