

COFFEE ROASTING SYSTEM WITH ROASTING AND COOLING SUBSYSTEMS,
AND METHODS FOR THE SAME

Cross-Reference to Related Applications

[0001] The present application claims priority to and is a continuation-in-part of U.S. pat. appl. No. 17/391,579 entitled “Coffee Roasting System with Roasting and Cooling Subsystems, and Methods for the Same” and filed on Aug. 2, 2021, a continuation-in-part of U.S. pat. appl. No. 17/391,581 entitled “Coffee Roasting System with Roasting and Cooling Subsystems, and Methods for the Same” and filed on Aug. 2, 2021, a continuation-in-part of U.S. pat. appl. No. 17/482,858 entitled “Coffee Roasting System with Roasting and Cooling Subsystems” and filed on Sept. 23, 2021, and a continuation-in-part of U.S. pat. appl. No. 17/482,862 entitled “Coffee Roasting System with Roasting and Cooling Subsystems, and Methods for the Same” and filed on Sept. 23, 2021, the content of each of which is incorporated herein by reference in its entirety.

Field of the Disclosure

[0002] The present disclosure pertains to the roasting of food products, for example beans, such as coffee beans. In one or more embodiments, the present disclosure describes a roasting system having an improved system for roasting and cooling the beans. In one or more embodiments, the present disclosure describes a roasting system having a compact and thermally efficient heating system. In one or more embodiments, the present disclosure describes an automated roasting system having a compact roasting subsystem that maximizes uniformity of roasting and allows viewing of the roasting process. In one or more embodiments, the present disclosure describes a roasting system having an improved system for removing heat, moisture, and effluents from exhausted fluid streams.

Background

[0003] Food roasting machines are in wide use. One particularly common roasting machine is utilized to prepare coffee beans to be either packaged or ground and brewed. A typical roasting machine includes a roasting chamber for supporting, agitating, and roasting beans. It is desirable to provide an automated way of roasting, cooling, and unloading beans that minimizes an overall cycle time. Also, one challenge is to provide a highly productive and yet compact roasting system. A heater is used to provide a roasting temperature profile inside of the roasting chamber. Known heaters involve bulky insulation or give off an undesirable amount of excess

heat. Another challenge is to provide a compact roasting system while providing very uniform roasting and allow viewing of the roasting process. In a typical roasting machine, a bean cooler is used to cool the beans after they are roasted. The roasting process occurs at high temperatures. During this process, water vapor, particulates, and noxious gases can be produced and are carried by a fluid stream that passes through the roasting chamber and out of the bean cooler. Part of the fluid stream needs to be exhausted. There is a further need to efficiently treat the exhausted fluid stream.

Brief Description of the Figures

[0004] FIG. 1 is a schematic diagram of an embodiment of a roasting system for processing a batch of coffee beans. FIG. 1 illustrates connections between elements that are either fluidic connections or concern a physical transfer of a batch of beans.

[0005] FIG. 2 is a simplified electrical block diagram for the roasting system of FIG. 1. FIG. 2 illustrates electrical or wireless connections between elements including a controller.

[0006] FIG. 3 is a flowchart of an embodiment of a roasting process for a batch of beans.

[0007] FIG. 4 is an isometric view of an embodiment of a portion of a bean cooling subsystem otherwise referred to as a “bean cooler”.

[0008] FIG. 5 is a vertical cross-section view of an embodiment of a bean cooler.

[0009] FIG. 6A is a side view of an embodiment of a cooling platform in isolation.

[0010] FIG. 6B is an isometric view looking down upon an embodiment of a cooling platform in isolation.

[0011] FIG. 7A is a vertical section view illustrating a portion of an embodiment of a bean cooler with a platform in a closed configuration to support a batch of beans during cooling.

[0012] FIG. 7B is a vertical section view illustrating a portion of an embodiment of a bean cooler with a platform in an open configuration to allow a cooled batch of beans to exit the bean cooler.

[0013] FIG. 8 is a flowchart depicting an embodiment of a method of cooling and releasing or dispensing a batch of beans.

[0014] FIG. 9 is a flowchart depicting an embodiment of a method of roasting and cooling a batch of beans.

[0015] FIG. 10 is an is schematic representation of a portion of a roasting system with emphasis on a (main) heater and cyclone separator. The heater includes a heater power supply and heater windings. The heater windings include resistive heating coils for converting electrical energy into thermal energy. The heater windings are integrated with a portion of the cyclone separator.

[0016] FIG. 11A is an isometric view of an example of a cyclone separator that includes integrated heater windings.

[0017] FIG. 11B is a sectional view of the cyclone separator of FIG. 11A that includes integrated heater windings.

[0018] FIG. 12 is an isometric view of a portion of the cyclone separator of FIG. 11A with emphasis on electrodes and insulating substrates that support and isolate the heater windings.

[0019] FIG. 13 is an isometric view of an embodiment of a roasting subsystem.

[0020] FIG. 14 is a cross-sectional view of an embodiment of a roasting subsystem.

[0021] FIG. 15 is side view of an embodiment of an agitator coupled to a bearing in isolation.

[0022] FIG. 16 is an isometric view of an embodiment of an agitator coupled to an agitator actuator in isolation.

[0023] FIG. 17 is a flowchart of an embodiment of a method of operating a roasting system.

[0024] FIG. 18 is a schematic diagram of a portion of a roasting system to put emphasis on an embodiment of an air exit subsystem. The air exit subsystem has a purpose of removing heat, water vapor, and noxious effluents arising during a roasting and cooling process.

[0025] FIG. 19 is a “front side” isometric drawing illustrating an embodiment of a heat sink coupled to a filter.

[0026] FIG. 20 is a “back side” isometric drawing illustrating an embodiment of a heat sink coupled to a filter.

[0027] FIG. 21 is a horizontal cross-sectional view of a heat sink.

[0028] FIG. 22 is an isometric view of an upper portion of the air exit subsystem with emphasis on a housing that provides fluidic coupling to and between a heat sink and filter.

[0029] FIG. 23 is an isometric cutaway view looking down on an embodiment of an air exit subsystem.

Summary

[0030] In a first aspect of the disclosure, a bean roasting system includes a roasting subsystem configured to receive and to thermally roast beans, a cooling subsystem, an air exit subsystem that is fluidically coupled to the cooling subsystem, and a controller. The cooling subsystem includes an outer housing containing a holding chamber, a cooling platform defining a lower bound of the holding chamber, a vibration actuator coupled to the cooling platform, and a platform actuator coupled to the cooling platform. The controller is configured to operate the air exit subsystem to maintain a flow of air up through the holding chamber, operate the roasting subsystem to transfer a batch of beans from the roasting subsystem to the holding chamber, operate the vibration actuator to vibrate the cooling platform, operate the air exit subsystem and operate the vibration actuator accelerates cooling of the batch of beans, and operate the platform actuator to transport the batch of beans in a downward direction and out of the cooling subsystem.

[0031] In one implementation the cooling subsystem includes an upper subunit, a middle subunit, and a lower subunit. The middle subunit includes the cooling platform. The upper subunit defines a chute for receiving the batch of beans from the roasting subsystem. The upper subunit can further define an air conduit that is coupled to the air exit subsystem and receives the flow of air from the holding chamber. The air exit can include an exit fan that is coupled to the air conduit and is configured to maintain the flow of air.

[0032] In another implementation the cooling platform can include a plurality of resilient supports that couple the cooling platform to the outer housing. The vibration actuator is coupled between the outer housing and the cooling platform and imparts relative vibratory motion between the cooling platform and the outer housing which flexes the resilient supports. The relative vibratory motion is primarily lateral motion that is generally parallel to an upper surface of the cooling platform.

[0033] In yet another implementation, the cooling platform includes a plurality of rotatable leaves. The platform actuator is configured to rotate the plurality of rotatable leaves to transport the batch of beans out of the bean cooler. The cooling platform can include a generally rectangular frame. The plurality of rotatable leaves are individually rotatably mounted to the rectangular frame with an axis of rotation that is generally along the rectangular frame. The rotatable leaves define at least one line along which the leaves meet. During rotation, the leaves rotate downwardly about the axis of rotation and away from the at least one line. The plurality

of rotatable leaves can include four leaves and the at least one line can include two crossed lines. The rectangular frame can have a generally square shape.

[0034] In a further implementation, the cooling subsystem includes a lower subunit below the cooling platform. The lower subunit generally converges in a downward direction to facilitate dispensing the batch of beans into a container or bag. The platform actuator is coupled between the lower subunit and the cooling platform.

[0035] In a yet further implementation, the bean roasting system includes a “ventless” air handling system. “Ventless” implies that the air handling system recirculates heated air through the roasting subsystem and other components including at least one heater and at least one component for removing particles and gaseous effluents from the heated air. The air handling system can include two air flow branches (or loops) that are coupled by a bypass. The air handling system can include more than one heater including a main heater and an auxiliary heater. The other components can include a cyclone for removing the particulates and a catalytic converter for removing the gaseous effluents. All components of the bean roasting system can be electric.

[0036] In a second aspect of the disclosure, a method of manufacturing roasted beans includes providing and operating components of a bean roasting system. The bean roasting system includes a roasting subsystem configured to receive and to thermally roast beans, a cooling subsystem, and an air exit subsystem that is fluidically coupled to the cooling subsystem. The cooling subsystem includes an outer housing containing a holding chamber, a cooling platform defining a lower bound of the holding chamber, a vibration actuator coupled to the cooling platform, and a platform actuator coupled to the cooling platform. The method includes operating the air exit subsystem to maintain a flow of air up through the holding chamber, operating the roasting subsystem to transfer a batch of beans from the roasting subsystem to the holding chamber, operating the vibration actuator to vibrate the cooling platform, operating the air exit subsystem and operating the vibration actuator accelerates cooling of the batch of beans, and operating the platform actuator to transport the batch of beans in a downward direction and out of the cooling subsystem.

[0037] In another aspect of the disclosure, a bean roasting system includes a roasting subsystem and an air handling subsystem. The roasting subsystem is configured to receive and to thermally roast a batch of beans. The air handling subsystem is coupled to the roasting subsystem and includes a blower, a cyclone separator, and a heater. The blower is configured

to impart air motion. The air passes through the air handling subsystem. The cyclone separator is configured to remove particulates from the air handling subsystem. The heater is configured to heat the air passing through the air handling subsystem. The heater includes a heater portion that is incorporated into the cyclone separator. The heater portion generates heat and heats air passing through the cyclone separator. The heater can generate heat and heat air based upon resistive heating through heater windings, ignition of a fuel such as natural gas, or generation of hot plasma to name some examples.

[0038] In one implementation the cyclone separator includes an air outlet, and air inlet, and a particulate outlet. The heater portion is incorporated into the air outlet. When the heater is based upon resistive heating, the heater portion can be or include heater windings that are incorporated into the air outlet.

[0039] In another implementation, the cyclone separator has a vertical cyclone axis that is central to a spiral rotation of particulates as they pass from an upper portion of the cyclone separator to the particulate outlet. The heater portion can include heater windings that surround the cyclone axis.

[0040] In yet another implementation, the cyclone separator includes a cyclone housing including an upper housing and a lower housing. The heater portion extends vertically from above the upper housing into the upper housing. The cyclone separator includes an air outlet having an outlet housing that extends into the upper housing and defines a vertical air outlet passageway. The heater portion is disposed within the outlet housing and within the air outlet passageway. The upper housing defines a vertical axis. The heater portion can include heater windings that spiral around the vertical axis.

[0041] In a further implementation, the heater provides a majority of a thermal energy for roasting the batch of beans. The bean roasting system can also include an auxiliary heater that is physically separate from the cyclone separator.

[0042] In a yet further implementation, the bean roasting system also includes a controller coupled to the blower and the heater and other components of the bean roasting system. The controller is configured to operate the blower, the heater, and other components of the bean roasting system to provide a predetermined temperature profile in the roasting subsystem to roast the batch of beans.

[0043] In yet another aspect of the disclosure, a method of manufacturing roasted beans includes providing and operating the bean roasting system as described.

[0044] In a further aspect of the disclosure, a bean roasting system includes a roasting subsystem and an air handling subsystem. The roasting subsystem includes a housing, an agitator actuator, an agitator, a bearing and a door. The housing has an inner surface defining an inner chamber for holding a batch of beans during a thermal roasting process. The inner chamber has a horizontal axis. The agitator is coupled to the agitator actuator and includes a central shaft and a blade set mounted to the central shaft. The bearing is disposed at a rear end portion of the housing. The bearing supports the central shaft and is configured to prevent the blade set from contacting the inner surface of the housing. The door has a transparent window disposed at a front end portion of the housing. The transparent window is configured to allow viewing of the inner chamber during the thermal roasting process. The air handling system is coupled to the roasting subsystem, includes a blower and heater, and is configured to circulate heated air through the roasting subsystem during the thermal roasting process. The roasting subsystem provides a very uniform roast for the batch of beans which can be viewed through the transparent window. The roasting subsystem is also very compact while holding a large batch of beans.

[0045] In one implementation, the housing includes a first conduit defining an air inlet and a second conduit defining an air outlet and a bean inlet. The first conduit can be located adjacent to the rear end portion of the housing and configured to receive heated air flow in a vertically downward direction from the air handling subsystem. The second conduit can be located adjacent to the front end portion of the housing and configured to output air flow in a vertically upward direction to the air handling subsystem. The second conduit can have a larger cross sectional area than the first conduit and is can be configured to slow down a rate of airflow into the air handling subsystem in an upward direction to reduce entrainment of the batch of beans into the air handling subsystem. The second conduit is also configured to receive an unroasted batch of beans from a hopper.

[0046] In another implementation, the housing includes a hatch. The blade set can be configured to impart a stirring motion of the batch of beans to facilitate exit of the batch of beans through the hatch when the batch of beans is being unloaded from the chamber. The stirring motion can include back and forth horizontal components.

[0047] In yet another implementation, the blade set can include an inner spiral auger and an outer set of blades. The inner spiral auger is configured to impart a horizontal motion of the batch of beans along a first horizontal direction. The outer set of blades is configured to impart a horizontal motion of beans along a second horizontal direction that opposes the first horizontal direction to enhance mixing of the batch of beans during the thermal roasting process. The blade set can include a plurality of radial spokes that support the outer set of blades outside of the inner spiral auger. This blade configuration and imparted motion also enhances efficiency and completeness when unloading beans.

[0048] In a further implementation, the central shaft is a hollow cylindrical shaft. The bearing radially surrounds the hollow cylindrical shaft at the rear end portion of the housing. This structure enables full support of the blade set without a separate support bearing at a front end portion of the housing.

[0049] In a yet further implementation, the agitator actuator includes a motor and a power coupling mounted behind the rear end portion of the housing. The power coupling is configured to transfer rotational power from the motor to the agitator. The motor extends in a frontward direction from the power coupling and overlaps with the housing along the horizontal axis. This structure provides an efficient rotational power delivery to the agitator in a compact structure of the roasting subsystem.

[0050] In another implementation, the bean roasting system includes a hopper, a bean cooling subsystem, and a controller. The controller is configured to operate the hopper to release the batch of beans from the hopper to the inner chamber, operate the agitator actuator to rotate the actuator and to stir the batch of beans within the inner chamber, operate the air handling subsystem to circulate heated air through the inner chamber according to the thermal roasting process, and operate the bean release actuator and the agitator actuator to release beans from the inner chamber to the bean cooling subsystem.

[0051] In a still further aspect of the disclosure, a bean roasting system includes a roasting drum, an air handling system, a bean cooler, and an air exit subsystem. The roasting drum is configured to receive and to thermally roast beans. The air handling system is configured to circulate a fluid stream through the roasting drum. The bean cooler is configured to receive and cool the beans from the roasting drum. The air exit subsystem is configured to receive and treat a first fluid stream from the air handling system and a second fluid stream from the bean cooler. The air exit subsystem includes a heat sink and a filter. The heat sink defines two

parallel fluid paths including a first fluid path and a second fluid path. The air exit subsystem includes a metal body configured to receive heat from the first fluid path and the second fluid path. The first fluid path is fluidically coupled to receive the first fluid stream from the air handling system. The second fluid path is fluidically coupled to receive the second fluid stream from the bean cooler. The filter is fluidically coupled to the first and second air flow paths. The bean roasting system can be described with respect to X, Y, and Z axes that are mutually perpendicular. The X-axis and Y-axis are lateral axes that are generally horizontal. The Z-axis is vertical and generally aligned with a gravitational reference.

[0052] The function of the air exit subsystem is to remove heat, water vapor, and noxious effluents from the fluid streams including the first fluid stream and the second fluid stream. This design has advantages: (A) The heat is transferred from the fluid streams is transferred to the metal body of the heat sink. Having a single metal body coupled to both parallel fluid paths provides a better heat capacity for each one. This is advantageous because operation is asynchronous: The first fluid stream passes through the heat sink during the operation of roasting a batch of beans. After this, the second fluid stream passes through the heat sink as the batch of beans is being cooled. Thus a larger heat capacity heat sink is leveraged by both fluid streams. (B) Both fluid streams leverage a single filter. This allows for a single larger capacity and more effective filtration for each fluid stream.

[0053] In one implementation, the air exit subsystem includes a housing that defines a housing fluid path. The housing fluid path merges the first fluid stream and the second fluid stream to provide a merged fluid stream. The housing fluid path also fluidically couples the merged fluid stream to the filter. The housing includes an exit fan disposed within the housing fluid path. The merged fluid stream generally traverses the housing fluid path along the lateral Y-axis. Next, the merged fluid stream passes downward (-Z) into the filter along the vertical Z-axis. Finally, the merged fluid path passes through filters in the filter along the X-axis.

[0054] In another implementation, the air exit subsystem includes a housing. The first fluid stream enters the housing along the Y-axis and then traverses the first fluid path primarily along the Z-axis. The first fluid path directs the first fluid stream in a downward (-Z) direction and then an upward (+Z) direction with respect to the Z-axis before the first fluid stream re-enters the housing.

[0055] In yet another implementation, the air exit subsystem includes a housing. The second fluid stream enters the second fluid path upward (+Z) along the Z-axis before entering the housing.

[0056] In a further implementation, the heat sink further includes a first plurality of fins extending from the metal body into the first fluid path and a second plurality of fins extending from the metal body into the second fluid path.

[0057] In a yet further implementation, the bean roasting system includes a controller. The controller is configured to operate the roasting drum, the air handling system, and the bean cooler. The controller is configured to operate the roasting drum and the air handling system to receive and to thermally roast a batch of beans. The controller is configured to operate the bean cooler to cool the batch of beans. The controller is configured to operate the air exit subsystem to receive and treat the first fluid stream and the second fluid stream. Operating the air exit subsystem includes passing the first fluid stream through the first fluid path, passing the second fluid stream through the second fluid path, and passing the first fluid stream and the second fluid stream to the filter.

Detailed Description

[0058] FIG. 1 is a schematic diagram of an embodiment of a roasting system 2. FIG. 1 discloses fluid paths between various functional elements. The fluid paths tend to conduct gaseous fluids such as air, water vapor, and gaseous emissions from beans being roasted or cooled. In addition, particulates from the roasting process can also be transmitted or entrained through the fluid paths. FIG. 1 also discloses a path for a batch of beans from a bean load to a bean exit.

[0059] Roasting system 2 includes a hopper 4 for loading and receiving a quantity or batch of unroasted beans. The hopper 4 feeds the unroasted beans into a roasting drum 6 or roasting subsystem 6 within which the batch of beans is heated and roasted, for example, according to a pre-programmed roasting process. Adjacent or below the roasting drum 6 is a bean cooling subsystem 8 or bean cooler 8 for receiving the batch of beans when they are in a just-roasted state (still hot), holding the batch of beans until they are cooled, and then dispensing the batch of beans into a receiving container such as a bag (not shown).

[0060] The roasting drum 6 is coupled to an air handling system 10 that includes a main heater 12, a catalytic converter 14, a blower 16, an auxiliary heater 17, a bypass 18, a velocity decelerator 20, a cyclone separator 22, and chaff collector 24. The air handling system 10

determines a temperature versus time roasting profile through controlled operation of the main heater 12, blower 16, auxiliary heater 17, bypass 18, and possibly other components of the air handling system 10. An air stream (indicated by arrows) recirculates through the air handling system 10. The air handling system 10 receives and removes particles and gaseous effluents emitted during the roasting process. The particles are captured by the cyclone 22, which deposits them in the chaff collector 24, which is periodically emptied. The gaseous effluents are collected by the catalytic converter 14.

[0061] The air handling system 10 defines two different branches or loops of air flow that are coupled by the bypass 18. One branch circulates from the bypass 18 to a decelerator 20, through the cyclone 22, main heater 12, catalytic converter 14, blower 16, and auxiliary heater 17, before returning to the bypass 18. Another branch passes from the bypass 18 to the roasting drum 6, to the decelerator 20, the cyclone 22, main heater 12, catalytic converter 14, blower 16, and auxiliary heater 17, before returning to bypass 18.

[0062] Part of an airstream generated by the blower 16 passes through an air exit subsystem 19 including a heat sink 26, an exit fan 28, and a filter 30 before being passed to environmental air (labeled as “air outlet” in FIG. 1). The heat sink 26 has the effect of condensing water vapor from the exit airstream as well as cooling the exit airstream. The condensed water vapor drips into a water collection receptacle 32. Replacement air (labeled “air inlet” in FIG. 1) from the environment air enters the blower 16. The overall effect is to remove water vapor from the air handling system 10 and to condense the water into the water collection receptacle 26.

[0063] The bean cooler 8 is also coupled to the air exit subsystem 19. The exit fan 28 therefore draws air out of the bean cooler 8 through the heat sink 26. This has the effect of accelerating cooling of the batch of beans.

[0064] FIG. 2 is a simplified electrical block diagram of the roasting system 2. Relative to FIG. 1, like element numbers refer to like components. However, whereas FIG. 1 focuses on fluidics and the physical motion of beans, FIG. 2 focuses on electrical or wireless connections between components.

[0065] A controller 34 includes a processor 36 coupled to an information storage device 38. The information storage device 38 is a non-volatile or non-transient information storage device 38 that stores software instructions. When executed by the processor 36, the software instructions can control portions of the roasting system 2 that the controller 34 is configured to control. For example, the controller 34 can control any of the hopper 4, drum 6, bean cooler

8, main heater 12, blower 16, auxiliary heater 17, bypass 18, exit fan(s) 28, and other portions of the roasting system 2. The controller 34 can receive information from one or more sensors 40 for monitoring a status of portions of roasting system 2. The controller 34 is configured to control various actuators including an agitator actuator 42, a bean release actuator 44, a vibration actuator 46, and a platform actuator 48.

[0066] The agitator actuator 42 is configured to agitate the batch of beans within the drum 6 during the roasting process. The bean release actuator 44 is configured to release the batch of beans after roasting so that they can enter the bean cooler 8. The vibration actuator 46 is configured to vibrate the batch of beans and to enhance uniformity and rate of cooling of the batch of beans. The platform actuator 48 is configured to release the batch of beans after cooling to be dispensed into a container or bag.

[0067] In an embodiment, the agitator actuator 42 is configured to rotate an agitator. The agitator can include an agitator blade set supported by a central shaft. The agitator actuator can include a motor and a power coupling that couples the motor to the central shaft. The power coupling can include a gearbox and/or a belt that provides rotative coupling between the motor and the central shaft. In an embodiment, the bean release actuator 44 includes a pneumatic cylinder configured to open and close a hatch formed into a lower surface of the drum 6.

[0068] In an embodiment, the vibration actuator 46 can include a motor coupled to an elliptical cam or gear that couples to and shakes a cooling platform, which in turn supports a batch of beans while cooling. In other embodiments the vibration actuator 46 can take other forms such as a motor with an elliptical weight or a piezoelectric transducer stack. In an embodiment, the platform actuator 48 can include one or more pneumatic cylinders configured to open and close an opening in the cooling platform.

[0069] FIG. 3 is a flowchart of an embodiment of a roasting process 50 that is controlled by the controller 34. According to 52, controller 34 receives roasting parameters and a start signal. The roasting parameters can be indicative of a temperature-versus-time profile for roasting. The roasting parameters may also include a temperature profile before and after a bean cracking event is detected.

[0070] According to 54, a batch of beans is automatically or manually loaded into the hopper 4. Step 54 is showed in a dashed outline to highlight that it can be performed before or after step 52.

[0071] According to step 56, the roasting system 10 is operated to agitate and heat the batch of beans to begin and executing a bean roasting process. Executing the roasting process includes more particular processes including (1) operating the hopper to release the batch of beans into the drum, (2) operating the agitator actuator 42 to begin stirring and agitating the batch of beans, and (3) operating the air handling system 10 to heat the drum and to remove byproducts of the roasting process. The temperature in the drum ramps up and then stabilizes at a roasting temperature.

[0072] According to 58, a power used by the air handling system 10 to maintain the roasting temperature (by heating the drum) is monitored. The power is used to compensate for heat losses from the air handling system as well as a phase change that occurs as water is released from the batch of beans. The power usage will tend to be fairly stable and to drop during roasting initially. However, when the beans begin cracking, an exposure of water from within the beans will result in the air handling system 10 using more power to compensate for a phase change in the water from liquid to gaseous phase. The controller will then detect an increase in the power input in step 58. This increase in power is referred to as an “inflection point” in the monitored power level.

[0073] According to 60, detection of the inflection point in power level causes the process to proceed to step 62. Otherwise, the process loops back to steps 56 and 58 to continue to maintain the roasting temperature and monitor the input power.

[0074] Once the inflection point is determined, the controller 34 computes or determines a remaining temperature profile (temperature versus time) to complete the roasting process according to step 62. According to step 64, the controller applies the determined remaining temperature profile to the batch of beans.

[0075] According to 66, the controller controls the drum 6 and bean cooler 8 to cool and release the batch of beans. This ends at step 68 with the beans released into a container such as a bag.

[0076] In the illustrations and description herein, mutually orthogonal axes X, Y, and Z will be used. The Z-axis is generally vertical and generally aligned with a gravitational reference. By “generally” it is by design but may vary according to manufacturing tolerances. The X-axis and Y-axis are generally horizontal and lateral.

[0077] FIG. 4 is an isometric view of an embodiment of a portion of the bean cooling subsystem or bean cooler 8. Bean cooler 8 includes an upper subunit 100, a middle subunit 102, and a lower subunit 104. The upper subunit 100 defines a chute 106 for receiving the

batch of beans from the roasting subsystem 6. The middle subunit 102 is for containing the batch of beans while cooling. The lower subunit 104 has a generally tapered shape in a downward (-Z) direction to facilitate dispensing the batch of beans from the bean cooler 8 into a bag or container (not shown).

[0078] FIG. 5 is a vertical cross-section view of the embodiment of the bean cooler 8 shown in FIG. 4. Bean cooler 8 includes an outer housing 108 that forms part of the middle 102 and lower 104 subunits. Within the outer housing 108 (e.g., disposed within an interior of the outer housing 108) is a cooling platform 110. The outer housing 108 also contains (or defines or disposes) a holding chamber 112 that is vertically bounded by the upper subunit 100 and the cooling platform 110.

[0079] A plurality of resilient supports 114 couple the cooling platform 110 to the outer housing 108. The resilient supports 114 are formed from a flexible material such as rubber so that the cooling platform 110 can move or vibrate relative to the outer housing 108. Not shown in FIG. 5 is the vibration actuator 46, which is coupled between the outer housing 108 and the cooling platform 110. The vibration actuator 46 is configured to impart primarily lateral vibratory motion (along the lateral X and Y axes) of the cooling platform 110 relative to the outer housing 108.

[0080] The platform actuator 48 is coupled between the lower subunit 104 portion of the outer housing 108 and the cooling platform 110. The platform actuator 108 is configured to move the platform actuator 110 to allow a cooled batch of beans to fall through the lower subunit 104 and into a container such as a bag. More details of the action of the platform actuator 48 will be discussed with respect to FIGS. 7A and 7B.

[0081] The bean cooler 8 defines (or forms) an air flow path 116 that extends (1) up through the lower subunit 104, (2) up through the cooling platform 110, (3) up through the holding chamber 112, (4) into and through a conduit 118 within the upper subunit 100 (and through a filter chamber 120), and (5) and out to the heat sink 26 (shown in FIG 1). The exit fan 28 (shown in FIGS. 1 and 2), the air flow path 116 and other components (heat sink 26, filter 30) form an air exit subsystem 19 for transporting environmental air through the holding chamber 112.

[0082] The vibration actuator 46 and air exit subsystem 19 work synergistically to uniformly and rapidly cool the batch of beans. The vibration induced by the vibration actuator 46 combined with the airflow to separate and randomly translate and rotate the batch of beans.

The batch of beans therefore individually receive cooling airflow on all sides, providing the rapid and more uniform cooling.

[0083] FIG. 6A is a side view of the cooling platform 110 shown in FIG. 5 without showing several other components of the bean cooler 8 of FIG. 5. As stated earlier, the cooling platform 110 is coupled to the outer housing 108 via four resilient supports 114. Also shown is a coupler 122 that couples the cooling platform 110 to the vibration actuator 46 (not shown in FIGS. 6A and 6B). The vibration actuator 46 can include a motor with an elliptical cam or gear that connects to and shakes the coupler 122. Vibration actuator 46 can take other forms such as a motor with an elliptical weight.

[0084] FIG. 6B is an isometric top view of the cooling platform 110 shown in FIG. 5 without showing several other components of the bean cooler 8 of FIG. 5. The cooling platform 110 includes a rectangular or square frame 124 that is coupled directly to the resilient support 114. Cooling platform 110 also includes four rotatable leaves 126 (also referred to herein collectively as a “floor”). The rotatable leaves 126 individually include a proximal side 128 coupled to the frame 124 by a flexure or hinge 130. The rotatable leaves 126 meet along two crossed lines 132. The rotatable leaves 126 define an area array of perforations 133 to allow air flow path 116 to uniformly pass through the batch of beans being cooled.

[0085] FIGS. 7A and 7B are vertical section views that illustrate the middle 102 and lower subunits 104 of the bean cooler 8 in two configurations of the cooling platform 110. FIG. 7A illustrates the cooling platform 110 in an upper or holding configuration as previously illustrated in FIGS. 5, 6A, and 6B. This is a configuration for holding a hot batch of beans that are in a process of cooling.

[0086] The platform actuator 48 includes a pneumatic actuator 134 that is rotatively coupled to a follower 136. The pneumatic actuator 134 is controlled by controller 34 (shown in FIG. 2) and is rotatably coupled to outer housing 108. The follower 136 is rotatively coupled to a rotatable leaf 126 and to the outer housing 108. In the illustrative embodiment, there are four pneumatic actuators 134 each of which is operatively coupled (via one follower 136 from a group of four followers 136) to one of the four rotatable leaves 126 and each of which is configured to raise and lower one of the rotatable leaves 126.

[0087] FIG. 7A illustrates the cooling platform 110 in a closed configuration in which the leaves 126 are substantially horizontal and meet along the crossed lines 132. FIG. 7B illustrates the cooling platform 110 in an open configuration in which the leaves 126 define an oblique

angle with respect to the lateral axes X (not shown but having a direction into the page) and Y. As illustrated, the platform actuators 48 are configured to individually rotate the rotatable leaves 126 between the closed (shown in FIG. 7A) and open (shown in FIG. 7B) configurations. Expansion of the pneumatic actuators 134 rotate the leaves 126 from the closed configuration (shown in FIG. 7A) to the open configuration (shown in FIG. 7B). Retraction of the pneumatic actuators 134 rotate the leaves 126 from the open configuration (shown in FIG. 7B) to the closed configuration (shown in FIG. 7A).

[0088] FIG. 8 depicts an embodiment of a method 140 of cooling and dispensing the batch of beans. Method 140 can correspond, for example, to 66 of FIG. 3. According to 142, the exit fan 28 (as part of the air exit subsystem 19) is transporting air along the air flow path 116 including up through the holding chamber 112. At 142, the leaves 126 of cooling platform 110 are in the closed configuration (shown in FIG. 7A).

[0089] According to 144, the controller 34 operates and activates the vibration actuator 46. According to 146, the controller 34 operates the bean release actuator 44. In one embodiment, this opens a hatch in the drum 6, which allows a freshly roasted and hot batch of beans to fall from the drum 6, through the chute 106, and into the holding chamber 112 above the cooling platform 110.

[0090] According to 148, the beans are allowed to cool while the cooling platform 110 is being vibrated by the vibration actuator 46 and the air is rising through the batch of beans along the air flow path 116. When the beans are cooled (either according to a predetermined cooling time and/or a temperature sensor signal) the controller 34 operates the four platform actuators 48 and thus rotates the leaves 126 to the open configuration (shown in FIG. 7A). The batch of beans can then slide and fall out of the holding chamber 112, through the lower subunit 104, and into a container such as a bag.

[0091] The ordering of steps of method 140 can vary. For example, step 146 (dropping beans into bean cooler 8) can occur before step 144 (starting vibration of vibration actuator 46).

[0092] FIG. 9 is a flowchart depicting an embodiment of a method 160 of roasting and cooling a batch of beans. Method 160 can be performed, for example, by the roasting system 2 under control of controller 34 when the processor 36 executes software instructions stored on the non-transient information storage device 38.

[0093] According to 162, a batch of unroasted beans are thermally roasted in a roasting subsystem (e.g., roasting subsystem 6) to provide a hot and roasted batch of beans. According

to 164, the batch of hot roasted beans are transferred from the roasting subsystem to a holding chamber (e.g., holding chamber 112) of a cooling subsystem (e.g., cooling subsystem 8). While cooling, the batch of beans is supported by a cooling platform (e.g., cooling platform 110).

[0094] According to 166, a flow of air is maintained through the holding chamber to accelerate cooling of the batch of beans. Also according to 168, the cooling platform is vibrated to accelerate the cooling of the batch of beans. The result of a synergistic aspect of 166 and 168 is that the batch of beans is rapidly cooled to provide a cooled batch of beans. According to 170, the cooled batch of beans is transported in a downward direction and out of the cooling subsystem.

[0095] The transporting of 170 can include moving or configuring a floor of the cooling platform from a closed configuration (shown in FIG. 7A) to an open configuration (shown in FIG. 7B). The batch of beans transports in the downward direction and out of the cooling subsystem in response to the floor moving from the closed to the open configuration.

[0096] FIG. 10 is a schematic representation of a portion 200 of the roasting system 2 with emphasis on the main heater 12 and cyclone separator 22. In the illustrated embodiment, the main heater 12 includes a heater power supply 202 coupled to heater portion or windings 204. The heater windings 204 include one or more coils of resistive material configured to convert electrical energy into thermal energy. Under control of controller 34, the heater power supply 202 is configured to apply electrical power to the heater windings 204, which increase in temperature and heat the cyclone separator 22 and air passing through the cyclone separator 22.

[0097] In the illustrated embodiments of FIGS. 10, 11A, and 11B, the heater windings 204 are integrated with the cyclone separator 22. Stated another way, the heater windings 204 are physically supported and electrically isolated (isolated to avoid shorting between portions of the windings) within the cyclone separator 22. The cyclone separator 22 includes a cyclone housing 206 and an air outlet 208 that is coupled to the cyclone housing 206 and contains the heater windings 204.

[0098] FIGS. 11A and 11B are isometric and sectional views, respectively, of an example of the cyclone separator 22 in isolation. In the forgoing description, mutually orthogonal axes X, Y, and Z are used. The Z-axis is generally vertical and generally aligned with a gravitational

reference. By “generally” it is by design but may vary according to manufacturing tolerances. The X-axis and Y-axis are generally horizontal and lateral.

[0099] The cyclone housing 206 defines a central axis 210 that is generally parallel to the Z-axis. Cyclone housing 206 includes a cylindrical upper housing 212 and a conical lower housing 214. The conical lower housing 214 tapers in a downward direction from the upper housing 212 to a particulate outlet 216. The upper housing 212 has an annular top 218. The air outlet 208 is generally cylindrical and extends through the annular top 218. A plurality of electrodes 220 extend radially out of the air outlet 208 and couple to the heater windings 204 and to the heater power supply 202 (shown in FIG. 10). The upper housing 212 also includes an air inlet 222.

[0100] In the illustrated embodiment, the central axis 210 is substantially common to the heater windings 204, air outlet 208, the upper housing 212, and the lower housing 214. The air outlet 208 includes a cylindrical housing 224 that extends from outside of the cyclone housing 206, through the annular top 218 and into the upper housing 212. The heater windings 204 are disposed inside the cylindrical housing 224 and likewise extend from outside of the cyclone housing 206, through the annular top 218 and into the upper housing 212. In other words, the heater windings 204 are disposed such that one portion of the heater windings 204 are disposed above the cyclone housing 206 and another portion of the heater windings 204 are disposed within the cyclone housing 206. The air outlet 208 defines a vertical air outlet flow path 226 for air being pumped from the air outlet 208 to the blower 16 (shown in FIG. 1). The heater windings 204 are helically disposed within the cylindrical housing 224 and within the air outlet flow path 226.

[0101] During a roasting operation, air from the roasting drum 6 enters the air inlet 222 along a direction that is substantially or nearly tangential to the circular and cylindrical geometry of the upper housing 212. Alternatively, the air from the roasting drum 6 can enter the air inlet 222 generally along another vector and then be redirected as to be nearly tangential to the circular and cylindrical geometry of the upper housing. During use, the air is laden with particulates from the roasting process. The particulates circulate in a downward spiral as they lose velocity and fall toward the particulate outlet 216. The particulates exit the particulate outlet 216 and fall into the chaff collector 24 (shown in FIG. 1). The downward spiral of the particulate trajectory is along an inside conical surface of the lower housing 214 and tends to be about the vertical axis 210. The conical surface of the lower housing 214 is configured to

direct a spiral movement of the particulates from the upper housing 212 to the particulate outlet 216 at a lower end portion 217 of the lower housing 214.

[0102] Locating (or disposing or integrating) the heater windings 204 within the interior of the air outlet 208 has various advantages including thermal efficiency and compactness. The addition of the heater windings 204 have a negligible impact on the size of the cyclone separator 22. Moreover, the heater windings 204 convectively heat the cylindrical housing 224 and upper housing 212, which increases a metallic surface area in contact with a stream of air along the air outlet flow path 226 that exits the cyclone separator 22. As a result, there is a very effective convective heat transfer of thermal energy from the heater windings 204 to air that passes out of the air outlet 208.

[0103] The illustration of the heater windings 204 within the air outlet 208 is schematic in nature. FIG. 12 is an isometric drawing of a portion a particular embodiment of the cyclone separator 22. The illustrated embodiment includes six pairs of electrodes 220 that extend from an outside cylindrical surface of the air outlet 208 to within the air outlet flow path 226, which is a cylindrical space within the air outlet 208. (Although some of electrodes 220 are only partially visible and others of electrodes 220 are not visible in FIG. 12, it should be understood that each electrode 220 is partially disposed outside of air outlet 208 and partially disposed inside of air outlet 208.) Within the air outlet flow path 226 are three intersecting insulating substrates 228. The heater windings 204 (not shown in FIG. 12) include a plurality of helical coils that extend from the electrodes 220 and are supported by the insulating substrates 228. More specifically, each insulating substrate 228 has multiple holes that are in a substantially vertical arrangement and that are located to receive a portion of a heater winding from the heater windings 204. Collectively, the insulating substrates 228 provide a support for and maintain a proper spacing and physical separation of the helical coils of the heater windings 204. This maximizes (or at least improves) convective heat transfer from the heater windings 204 to an air stream passing through the air outlet 208 and prevents shorting between the heater windings 204.

[0104] While a particular embodiment of a heater 12 is shown in FIGS. 10, 11A, 11B, and 12, alternative embodiments of heater 12 can be used. As a first alternative embodiment, heater 12 can include a plasma generator configured to generate a plasma within the air outlet flow path 226. As a second alternative embodiment, heater 12 can include a natural gas jet device that emits a flame into the air outlet flow path 226. Therefore, the “heater portion” of heater

12 can include one or more of a plasma emitter, a gas jet flame, resistive heater windings, and other heating devices that are configured to heat air passing through the air outlet flow path 226 of the air outlet 208.

[0105] FIGS. 13 and 14 are isometric and cross-sectional views of an embodiment of a roasting subsystem 6 respectively. Roasting subsystem 6 includes a housing 300 having an inner surface 302. The inner surface 302 defines a chamber 304 for holding the batch of beans during a thermal roasting process. The housing 300, inner surface 302 and chamber 304 have a common horizontal axis 306. The housing 300 has a rear end portion 308 and a front end portion 310 with respect to the horizontal axis 306. As shown in FIGS. 13 and 14, the housing 300, inner surface 302 and chamber 304 each can have substantially cylindrical shape.

[0106] The bean roasting subsystem 6 includes a first conduit 312, which is adjacent to the rear end portion 308 of the housing 300 and functions as an air inlet. As shown in FIG. 1, heated air from the air handling system 10 enters the first conduit 312 and then enters the chamber 304 in a vertically downward (-Z) direction.

[0107] A second conduit 314 is adjacent to the front end portion 310 of the housing 300. The second conduit 314 functions as an air outlet and a bean inlet. A batch of beans is loaded from the hopper 4, through the second conduit 314 and into the chamber 304. Air from the chamber 304 exits from the second conduit 314 in an upward direction and then passes to cyclone 22 (see also FIG. 1). The second conduit 314 has a larger cross sectional area than the first conduit 312 to slow down a velocity of air exiting upward to avoid entraining beans but with a velocity to entrain smaller effluent particles to be removed by the cyclone 22.

[0108] The housing 300 includes a hatch 316 configured for unloading the batch of beans after the roasting process is complete. The hatch 316 is along a lower portion of the housing 300 and above the bean cooler 8. The hatch 316 is coupled to the bean release actuator 44. The bean release actuator 44 is configured to swing or move the hatch 316 between two positions – a closed position at which the hatch 316 is flush with a lower portion of the inner surface 302 and an open position at which the hatch 316 is lowered below the inner surface 302 to allow beans to fall into the bean cooling subsystem 8.

[0109] A door 318 having a transparent window 320 is mounted to the front end portion 310 of the housing 300. The door 318 is configured to be opened from a closed state to allow a front access to the chamber 304. The transparent window 320 is a large circular transparent plate to allow viewing of the chamber 304 during a roasting process. The transparent window

320 can be formed from a high temperature glass, a quartz, or other high temperature and transparent material.

[0110] Positioned within the chamber 304 is an agitator 322. Agitator 322 includes a central shaft 324 coupled to a blade set 326. The central shaft 324 is hollow cylindrical shaft 324 and is configured to rotate about the horizontal axis 306. Mounted to the rear end portion 308 of the housing 300 is a bearing 328 that surrounds and rotatively supports a rear portion 330 of the central shaft 324.

[0111] The combination of the bearing 328 and the hollow cylindrical shaft 324 is configured to provide support to maintain a spacing between the blade set 326 and the inner surface 302 of the housing 300 without any axial bearing support at a front portion 331 of the central shaft 324. For example, the bearing 328 can be sized and configured to support the weight of the hollow cylindrical shaft 324 in a cantilevered position. As such, in implementations where the cylindrical shaft 324 presents a greater moment arm (e.g., due to a larger outer radius, smaller inner radius, longer length and/or greater weight) than for other implementations, then the bearing 328 can have a greater length (along the horizontal axis 306) and/or stiffness than would be the case for other implementations. Although the cylindrical shaft 324 is described as being hollow, it should be understood that in different embodiments, the cylindrical shaft can be solid. Whether the cylindrical shaft is hollow or solid, and depending on the material(s) used to form the cylindrical shaft, the cylindrical shaft will present a certain moment arm and the bearing 328 will be sized and configured to support the weight of the cylindrical shaft in a cantilevered position.

[0112] For another example, the bearing 328 can be sized and configured as a function of the location of the bearing 328 relative to the rear portion of the housing 300. In particular, the more that a portion the bearing 328 is disposed within the chamber 302, the more that the portion of the bearing 328 will be subject to the higher temperatures within the chamber 302. As such, the bearing 328 can be configured based, at least in part, on the size of the portion of the bearing 328 within the chamber 302 and the temperatures and related time profile of temperatures within the chamber 302 to which the bearing 328 will be subject.

[0113] Although the bearing 328 is shown in FIG. 14 as having a substantially uniform inner radius and outer radius, it should be understood that non-uniform values are possible. For example, in an embodiment, the bearing can have a uniform inner radius, and an outer radius for the portion of the bearing outside of the chamber 302 that is greater than an outer radius for

the portion of the bearing inside of the chamber 302. In an alternative embodiment, the bearing can have a uniform inner radius, and an outer radius for the portion of the bearing outside of the chamber 302 that is less than an outer radius for the portion of the bearing inside of the chamber 302. In some embodiments, the inner radius of the bearing can be non-uniform, for example, to correspond to a non-uniform outer radius of the hollow cylindrical shaft 324. In some embodiments, both the inner radius and the outer radius of the bearing can be non-uniform, for example, accordingly to one or more of the embodiments mentioned above.

[0114] With respect to the illustrated embodiment of FIG. 14, the horizontal axis 306 is generally common to the housing 300, the cylindrical inside or inner surface 302, and the chamber 304. The horizontal axis 306 is also generally common to the cylindrical shaft 324 of the agitator 322 and is the axis of rotation of the agitator 322. The rear 308 and front 310 portions of the housing 300 are generally opposing circular end portions. The term “front” refers to a side at which a user views the roasting system 2 when it is in operation and can see a batch of beans being agitated inside the chamber 304. Opposing rear 330 and front 331 ends of the cylindrical shaft correspond to the opposing rear 308 and front 310 ends or portions of the housing 300.

[0115] FIG. 15 is a side view of the agitator 322 and bearing 328 in isolation. The blade set 326 includes an inner helical auger 332. The blade set 326 also includes a set of outer blades 334 supported by radial spokes 336. As the agitator 322 rotates about the horizontal axis, the inner helical auger 332 imparts a horizontal motion of beans in the +Y direction (toward the door 318 or the front end portion 310 of the housing). At the same time, the outer blades 334 impart a motion of the beans in the -Y direction (toward the rear end portion 308 of the housing 300). The opposing directions of motion impartation mixes the beans during the roasting process, helping to provide a more uniform roasting. This motion impartation is also useful when the beans are unloaded from the chamber 304.

[0116] FIG. 16 is an isometric view of the agitator 322 and agitator actuator 42 in isolation. The agitator actuator 42 includes a power coupling 338 and motor 340. The power coupling 338 is coupled to the rear end portion 308 of the housing 300 (FIG. 13). The power coupling 338 includes a gear train or pulley system (inside the illustrated housing 339) to provide rotational coupling from the motor 340 to the central shaft 324 of the agitator 322. In the illustrated embodiment, the motor 340 extends from the power coupling 338 in a frontward or

+Y direction and overlaps with the housing along the horizontal Y-axis. This geometrical arrangement allows for a more compact overall geometry of the roasting subsystem 6.

[0117] FIG. 17 is a flowchart of an embodiment of a method 350 of operating the bean roasting system 2. Method 350 is performed by controller 34. According to 352, the hopper 4 is operated to dispense a batch of beans into the roasting subsystem 6. The batch of beans passes from the hopper 4, through the second conduit 314, and into the inner chamber 304.

[0118] According to 354, the agitator actuator 42 is operated to rotate the actuator 322 about axis 306. According to 356, the air handling system 10 including heaters 12 and 17 and blower 16 are operated to provide heated air to the inner chamber 304 according to a bean roasting temperature versus time profile. During step 356, the heated air from the air handling system 10 enters the inner chamber 304 via first conduit 312 at an incoming velocity and then exits the inner chamber via second conduit 314 at an exit velocity that is of lower magnitude than the incoming velocity.

[0119] When the roasting process is complete, the bean release actuator 44 is activated to open the hatch 316 to release the beans from the roasting subsystem 6 to the bean cooling subsystem 8. While the hatch 316 is open, the agitator 322 continues to rotate. The outer blades 334 impart motion of the beans along the Y-axis to facilitate a more complete transfer of the batch of beans from the roasting subsystem 6 to the bean cooler 8.

[0120] FIG. 18 is a schematic diagram of a portion of the roasting system 2 to put emphasis on an embodiment of the air exit subsystem 19. It is to be understood that the roasting system 2 includes additional components illustrated in FIGS. 1 and 2, which are left out of FIG. 18 for simplicity.

[0121] Illustrated in FIG. 18 are two fluid streams including first fluid stream 402 and second fluid stream 404. In referring to a “fluid stream” it is primarily a gaseous air stream that can be laden various gaseous, vaporous, and/or small particulate components. The first fluid stream 402 comes from the air handling system 10, which circulates a fluid stream through the roasting drum 6. This first fluid stream 402 is extremely hot and laden with water vapor, particulates, and noxious gaseous effluents. A need exists to effectively and efficiently cool the first fluid stream 402 and to remove the gaseous, vaporous, and/or small particulate components. In the illustrated embodiment, the first fluid stream 402 leaves the output of the blower 16 before arriving at the air exit subsystem 19. The second fluid stream 404 is also very hot upon arrival from the cooling subsystem (bean cooler) 8.

[0122] The heat sink 26 is illustrated in FIG. 18 as having two heat sink portions including first heat sink portion 26A and second heat sink portion 26B. The two heat sink portions 26A and 26B are conductively thermally coupled to each other as one common connected metal body 400. The first heat sink portion 26A receives the first fluid stream 402 from the blower 16. The second heat sink portion 26B receives the second fluid stream 404 from the cooling subsystem (bean cooler) 8. The second heat sink portion 26B is operatively coupled to water collection receptacle 32 (e.g., a container or a bottle for receiving water from the second heat sink portion 26B).

[0123] The first fluid stream 402 and the second fluid stream 404 merge to form a merged fluid stream 406. The exit fan 28 receives and pushes the merged fluid stream 406 through the filter 30 before the merged fluid stream 406 exits into a surrounding environment (“AIR OUTLET”).

[0124] FIGS. 19-23 illustrate an embodiment of the exit air subsystem 19. In the foregoing illustrations the mutually orthogonal (perpendicular) axes X, Y, and Z are used. The X-axis and Y-axis are lateral axes that are generally (or substantially) horizontal. The Z-axis is a vertical axis and is generally aligned with a gravitational reference. By “generally” (or “substantially”) it is meant that this is by design to within manufacturing tolerances but may not be exact. In addition, all references to the X, Y, and Z directions are understood to be generally (or substantially) in such directions and some variation is permitted as appropriate for the situation. For example, when discussing the direction of fluid stream, it should be understood that the fluid stream may not pass exactly in the discussed directions but could vary due to pressure differences and/or temperature differences, etc.

[0125] FIG. 19 is an isometric drawing illustrating the heat sink 26 coupled to the filter 30 by a housing 408. From the perspective of FIG. 19, the first heat sink portion 26A is facing a viewer. Also illustrated is a path of the first fluid stream 402. First fluid stream 402 enters the housing 408 along the Y-axis in the +Y direction. The first fluid stream 402 then passes a first time through the first heat sink portion 26A in a downward -Z direction along the Z-axis. Then the first fluid stream 402 passes a second time through the first heat sink portion 26A in an upward +Z direction along the Z-axis. Having the first fluid stream 402 pass through the first heat sink portion 26A two times maximizes (or improves) heat transfer from the first fluid stream 402 to the heat sink 26. In alternative embodiments, the first fluid stream 402 can pass through the first heat sink portion 26A more than two times. A water collection trough 403 is coupled to a lower end of the first heat sink portion 26A. Water collection trough 403 forms

at least a part of the water collection receptacle 32 (that can include a bottle (not shown) for receiving water from the water collection trough 403). As the first fluid stream 402 passes through the heat sink portion 26A it cools and the carried water vapor condenses onto surfaces of the heat sink portion 26A and then flows down into the collection trough 403.

[0126] FIG. 20 is an isometric drawing illustrating the heat sink 26 coupled to the filter 30 from the perspective of second heat sink portion 26B facing a viewer. The second fluid stream 404 passes through the second heat sink portion 26B in an upward +Z direction along the Z-axis until it reaches the housing 408. In alternative embodiments, the second fluid stream passes through the heat sink portion 26B more two or more times. Then the first fluid stream passes laterally in a +Y direction until it merges with the first fluid stream 402, which results in the merged fluid stream 406.

[0127] FIG. 21 is a horizontal cross-sectional view of the heat sink 26. More specifically, FIG. 21 is a cross-sectional view taken from a horizontal plane cut through the heat sink 26 shown in FIGS. 19 and 20, and looking down (in the -Z direction). Heat sink 26 defines two internal and “parallel” fluid paths including a first fluid path 410 and a second fluid path 412. The two internal fluid paths (410 and 412) are referred to as “parallel” because fluid streams 402 and 404 mostly flow along the Z-axis as they pass through the heat sink 26. More specifically, the fluid stream 402 (shown in FIG. 19) can travel along the internal fluid path 410 (shown in FIG. 21), which is down in a -Z direction into the page (shown in the left bottom quadrant in FIG. 21) and then up in a +Z direction out of the page (shown in the left upper quadrant in FIG. 21). Similarly, the fluid stream 404 (shown in FIG. 20) can travel along the internal fluid path 412 (shown in FIG. 21), which is up in a +Z direction out of the page (shown in the right upper and right bottom quadrants in FIG. 21).

[0128] As is also illustrated in FIG. 19, the first fluid stream 402 first flows up and then down through the internal fluid path 410. As is also illustrated in FIG. 20, the second fluid stream 404 flows up through the second fluid path 412. Returning to FIG. 21, heat sink 26 includes a first plurality of fins 414, which extend from the metal body 400 and into the first fluid path 410. Heat sink 26 includes a second plurality of fins 416, which extend from the metal body 400 and into the second fluid path 412. As indicated the “DOWN/UP” first fluid path 410 is defined within the first heat sink portion 26A. The “UP” second fluid path 412 is defined within the second heat sink portion 26B.

[0129] In the illustrated embodiment, the metal body 400 and fins 414 and 416 are monolithically formed from cast aluminum. This provides a very high conductive heat transfer from the fins to the metal body 400. The metal body 400 being common to both sets of fins 414 and 416 provides a large heat sink capacity for removing heat from the fluid streams 402 and 404. In other implementations, the metal body 400 and fins 414 and 416 can be formed by techniques other than being monolithically formed (e.g., portions formed separately and then connected together), and from materials other than cast aluminum (e.g., aluminum, steel, cast iron, etc.).

[0130] In the illustrated embodiment, the fluid path 410 has the DOWN and UP segments that have a vertical extent of 33 inches or a total of 66 inches counting the DOWN and UP segment sequence. This provides a considerable structural length exposure to maximize (or improve) heat transfer. In the illustrated embodiment, the UP fluid path 412 has a vertical extent of 42 inches. It is typically desirable to maximize (or improve) heat transfer from the fluid streams 410 and 412 because the bean roasting system 2 may be located, for example, in a small facility such as a coffee shop facility. This will transfer most of the heat to the metal body 400 and not to the local atmosphere so as not to overwhelm air conditioning of the facility as the merged fluid stream 406 is output. The cooling also helps improve a life of replaceable components in the filter 30.

[0131] FIG. 22 is an isometric view of an upper portion of the air exit subsystem 19 with emphasis on a portion of the housing 408. Housing 408 defines a housing fluid path 418 through which the fluid streams 402, 404, and 406 flow. The housing fluid path 418 merges the first fluid stream 402 and the second fluid stream 404 to provide the merged fluid stream 406. The housing 408 includes the exit fan 28. The merged fluid stream 406 flows along the Y-axis and then into the filter 30.

[0132] FIG. 23 is an isometric cutaway view looking down upon the air exit subsystem 19. The filter 30 includes an input fluid path 420, a high efficiency particular air (HEPA) filter 422, a carbon treatment filter 424, and exit openings 426. Being driven by the exit fan 28, the merged fluid stream 408 flows downward (-Z) along the Z axis into and along the input fluid path 420 and then laterally in the +X direction along the X-axis through the HEPA filter 422, the carbon treatment (activated charcoal) filter 424, and out the exit openings 426.

[0133] The specific embodiments and applications thereof described above are for illustrative purposes only and do not preclude modifications and variations encompassed by the scope of the following claims.

[0134] The skilled artisan will understand that the drawings primarily are for illustrative purposes, and are not intended to limit the scope of the subject matter described herein. The drawings are not necessarily to scale; in some instances, various aspects of the subject matter disclosed herein may be shown exaggerated or enlarged in the drawings to facilitate an understanding of different features. In the drawings, like reference characters generally refer to like features (e.g., functionally similar and/or structurally similar elements).

[0135] To address various issues and advance the art, the entirety of this application (including the Cover Page, Title, Headings, Background, Summary, Brief Description of the Drawings, Detailed Description, Embodiments, Abstract, Figures, Appendices, and otherwise) shows, by way of illustration, various embodiments in which the embodiments may be practiced. The advantages and features of the application are of a representative sample of embodiments only, and are not exhaustive and/or exclusive. Rather, they are presented to assist in understanding and teach the embodiments, and are not representative of all embodiments. As such, certain aspects of the disclosure have not been discussed herein. That alternate embodiments may not have been presented for a specific portion of the innovations or that further undescribed alternate embodiments may be available for a portion is not to be considered to exclude such alternate embodiments from the scope of the disclosure. It will be appreciated that many of those undescribed embodiments incorporate the same principles of the innovations and others are equivalent. Thus, it is to be understood that other embodiments may be utilized and functional, logical, operational, organizational, structural and/or topological modifications may be made without departing from the scope and/or spirit of the disclosure. As such, all examples and/or embodiments are deemed to be non-limiting throughout this disclosure.

[0136] Also, no inference should be drawn regarding those embodiments discussed herein relative to those not discussed herein other than it is as such for purposes of reducing space and repetition. For instance, it is to be understood that the logical and/or topological structure of any combination of any program components (a component collection), other components and/or any present feature sets as described in the figures and/or throughout are not limited to a fixed operating order and/or arrangement, but rather, any disclosed order is exemplary and all equivalents, regardless of order, are contemplated by the disclosure.

[0137] Various concepts may be embodied as one or more methods, of which at least one example has been provided. The acts performed as part of the method may be ordered in any suitable way. Accordingly, embodiments may be constructed in which acts are performed in an order different than illustrated, which may include performing some acts simultaneously, even though shown as sequential acts in illustrative embodiments. Put differently, it is to be understood that such features may not necessarily be limited to a particular order of execution, but rather, any number of threads, processes, services, servers, and/or the like that may execute serially, asynchronously, concurrently, in parallel, simultaneously, synchronously, and/or the like in a manner consistent with the disclosure. As such, some of these features may be mutually contradictory, in that they cannot be simultaneously present in a single embodiment. Similarly, some features are applicable to one aspect of the innovations, and inapplicable to others.

[0138] In addition, the disclosure may include other innovations not presently described. Applicant reserves all rights in such innovations, including the right to embodiment such innovations, file additional applications, continuations, continuations-in-part, divisionals, and/or the like thereof. As such, it should be understood that advantages, embodiments, examples, functional, features, logical, operational, organizational, structural, topological, and/or other aspects of the disclosure are not to be considered limitations on the disclosure as defined by the embodiments or limitations on equivalents to the embodiments. Depending on the particular desires and/or characteristics of an individual and/or enterprise user, database configuration and/or relational model, data type, data transmission and/or network framework, syntax structure, and/or the like, various embodiments of the technology disclosed herein may be implemented in a manner that enables a great deal of flexibility and customization as described herein.

[0139] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[0140] As used herein, in particular embodiments, the terms “about” or “approximately” when preceding a numerical value indicates the value plus or minus a range of 10%. Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range is encompassed within the disclosure. That the upper and lower limits of these smaller ranges can independently be

included in the smaller ranges is also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the disclosure.

[0141] The indefinite articles “a” and “an,” as used herein in the specification and in the embodiments, unless clearly indicated to the contrary, should be understood to mean “at least one.”

[0142] The phrase “and/or,” as used herein in the specification and in the embodiments, should be understood to mean “either or both” of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with “and/or” should be construed in the same fashion, i.e., “one or more” of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the “and/or” clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to “A and/or B”, when used in conjunction with open-ended language such as “comprising” can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[0143] As used herein in the specification and in the embodiments, “or” should be understood to have the same meaning as “and/or” as defined above. For example, when separating items in a list, “or” or “and/or” shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as “only one of” or “exactly one of,” or, when used in the embodiments, “consisting of,” will refer to the inclusion of exactly one element of a number or list of elements. In general, the term “or” as used herein shall only be interpreted as indicating exclusive alternatives (i.e. “one or the other but not both”) when preceded by terms of exclusivity, such as “either,” “one of,” “only one of,” or “exactly one of.” “Consisting essentially of,” when used in the embodiments, shall have its ordinary meaning as used in the field of patent law.

[0144] As used herein in the specification and in the embodiments, the phrase “at least one,” in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily

including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase “at least one” refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, “at least one of A and B” (or, equivalently, “at least one of A or B,” or, equivalently “at least one of A and/or B”) can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

[0145] In the embodiments, as well as in the specification above, all transitional phrases such as “comprising,” “including,” “carrying,” “having,” “containing,” “involving,” “holding,” “composed of,” and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases “consisting of” and “consisting essentially of” shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

[0146] Some embodiments and/or methods described herein can be performed by software (executed on hardware), hardware, or a combination thereof. Hardware modules (e.g., a controller) may include, for example, a processor, a field programmable gate array (FPGA), and/or an application specific integrated circuit (ASIC). Software modules (executed on hardware) can include instructions stored in a memory that is operably coupled to a processor, and can be expressed in a variety of software languages (e.g., computer code), including C, C++, Java™, Ruby, Visual Basic™, and/or other object-oriented, procedural, or other programming language and development tools. Examples of computer code include, but are not limited to, micro-code or micro-instructions, machine instructions, such as produced by a compiler, code used to produce a web service, and files containing higher-level instructions that are executed by a computer using an interpreter. For example, embodiments may be implemented using imperative programming languages (e.g., C, Fortran, etc.), functional programming languages (Haskell, Erlang, etc.), logical programming languages (e.g., Prolog), object-oriented programming languages (e.g., Java, C++, etc.) or other suitable programming

languages and/or development tools. Additional examples of computer code include, but are not limited to, control signals, encrypted code, and compressed code.

[0147] The term “processor” should be interpreted broadly to encompass a general purpose processor, a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a controller, a microcontroller, a state machine and so forth. Under some circumstances, a “processor” may refer to an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field programmable gate array (FPGA), etc. The term “processor” may refer to a combination of processing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core or any other such configuration.

[0148] The term “memory” (or “information storage”) should be interpreted broadly to encompass any electronic component capable of storing electronic information. The term memory may refer to various types of processor-readable media such as random access memory (RAM), read-only memory (ROM), non-volatile random access memory (NVRAM), programmable read-only memory (PROM), erasable programmable read only memory (EPROM), electrically erasable PROM (EEPROM), flash memory, magnetic or optical data storage, registers, etc. Memory is said to be in electronic communication with a processor if the processor can read information from and/or write information to the memory. Memory that is integral to a processor is in electronic communication with the processor.

[0149] The terms “instructions” and “code” should be interpreted broadly to include any type of computer-readable statement(s). For example, the terms “instructions” and “code” may refer to one or more programs, routines, sub-routines, functions, procedures, etc. “Instructions” and “code” may comprise a single computer-readable statement or many computer-readable statements.

[0150] While specific embodiments of the present disclosure have been outlined above, many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, the embodiments set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the disclosure.

What is claimed:

1. A bean roasting system, comprising:
 - a roasting subsystem configured to receive and to thermally roast beans;
 - a cooling subsystem coupled to the roasting subsystem, the cooling subsystem including:
 - an outer housing defining a holding chamber;
 - a cooling platform defining a lower bound of the holding chamber;
 - a vibration actuator coupled to the cooling platform; and
 - a platform actuator coupled to the cooling platform;
 - an air exit subsystem that is fluidically coupled to the cooling subsystem; and
 - a controller configured to:
 - operate the air exit subsystem to produce a flow of air through the holding chamber;
 - operate the roasting subsystem to transfer a batch of beans from the roasting subsystem to the holding chamber;
 - operate the vibration actuator to vibrate the cooling platform, operating the air exit subsystem and operating the vibration actuator accelerates cooling of the batch of beans; and
 - operate the platform actuator to transport the batch of beans out of the cooling subsystem.
2. The bean roasting system of claim 1, wherein:
 - the cooling subsystem includes an upper subunit, a middle subunit, and a lower subunit, the holding chamber and the cooling platform disposed in the middle subunit,
 - the upper subunit defines a chute to receive the batch of beans from the roasting subsystem.
3. The bean roasting system of claim 2, wherein the upper subunit defines an air conduit that is coupled to the air exit subsystem and is configured to receive the flow of air from the holding chamber.
4. The bean roasting system of claim 3, wherein the air exit subsystem includes an exit fan that is coupled to the air conduit and is configured to substantially maintain the flow of air.

5. The bean roasting system of claim 1, further comprising a plurality of resilient supports that couple the cooling platform to the outer housing.
6. The bean roasting system of claim 5, wherein the vibration actuator is coupled between the outer housing and the cooling platform and is configured to impart relative vibratory motion between the cooling platform and the outer housing that flexes the resilient supports in response to the relative vibratory motion.
7. The bean roasting system of claim 6, wherein the relative vibratory motion is primarily lateral motion that is generally parallel to an upper surface of the cooling platform.
8. The bean roasting system of claim 1, wherein the cooling platform includes a plurality of rotatable leaves, the platform actuator is configured to rotate the plurality of rotatable leaves to transport the batch of beans.
9. The bean roasting system of claim 1, wherein:
 - the cooling platform is generally rectangular with four peripheral sides and includes a plurality of leaves, each leaf from the plurality of leaves individually has an axis of rotation about one of the four peripheral sides, the plurality of leaves meet along at least one line,
 - the platform actuator includes a plurality of actuators, each actuator from the plurality of actuators individually configured to rotate one leaf from the plurality of leaves about the axis of rotation to open the cooling platform along the at least one line to allow the batch of beans to fall out of the holding chamber.
10. The bean roasting system of claim 1, wherein:
 - the cooling platform is generally square with four peripheral sides and includes four leaves that each individually has an axis of rotation about one of the four peripheral sides and that collectively have edges that meet along two crossed lines,
 - the platform actuator includes an actuator for each leaf from the four leaves, the platform actuator configured to cause all four leaves to tilt down and away from the crossed lines to allow the batch of beans to fall out of the holding chamber.
11. The bean roasting system of claim 1, wherein the cooling subsystem includes a lower subunit below the cooling platform, the lower subunit is generally converging in a downward direction to facilitate dispensing the batch of beans into a container or bag.

12. The bean roasting system of claim 11, wherein the platform actuator is coupled between the lower subunit and a portion of the cooling platform.
13. A method of roasting beans, comprising:
providing a bean roasting system including:
a roasting subsystem configured to receive and to thermally roast beans;
a cooling subsystem including:
an outer housing containing a holding chamber;
a cooling platform defining a lower bound of the holding chamber;
a vibration actuator coupled to the cooling platform; and
a platform actuator coupled to the cooling platform; and
an air exit subsystem that is fluidically coupled to the cooling subsystem;
operating the air exit subsystem to maintain a flow of air up through the holding chamber;
operating the roasting subsystem to transfer a batch of beans from the roasting subsystem to the holding chamber;
operating the vibration actuator to vibrate the cooling platform, operating the air exit subsystem and operating the vibration actuator accelerates cooling of the batch of beans; and
operating the platform actuator to transport the batch of beans in a downward direction and out of the cooling subsystem.
14. The method of claim 13, wherein the cooling subsystem includes a plurality of resilient supports that couple the cooling platform to the outer housing, operation of the vibration actuator causes a relative vibratory motion between the cooling platform and the outer housing which is allowed by flexure of the resilient supports.
15. The method of claim 14, wherein the relative vibratory motion is primarily lateral motion that is substantially parallel to an upper surface of the cooling platform.
16. The method of claim 13, wherein the cooling platform includes a plurality of rotatable leaves, operating the platform actuator causes a downward rotation of the plurality of rotatable leaves.
17. The method of claim 13, wherein:

the cooling platform is substantially rectangular with four peripheral sides and includes a plurality of leaves, each leaf from the plurality of leaves individually has an axis of rotation about one of the four peripheral sides, the plurality of leaves meet along at least one line when the plurality of leaves are closed,

the platform actuator includes a plurality of actuators individually configured to rotate one leaf from the plurality of leaves about the axis of rotation to open the cooling platform along the at least one line to allow the batch of beans to fall out of the holding chamber.

18. The method of claim 13, wherein:

the cooling platform is substantially square with four peripheral sides and includes a four leaves, each leaf from the plurality of leaves individually has an axis of rotation about one of the four peripheral sides, the plurality of leaves have edges that meet along two crossed lines when the plurality of leaves are closed,

the platform actuator includes an actuator for each leaf from the four leaves, operating of the platform actuator causes all four leaves to open, and tilt down and away from the crossed lines, to allow the batch of beans to fall out of the holding chamber.

19. A method, comprising:

thermally roasting a batch of beans within a roasting subsystem;

transferring, after the thermally roasting, the batch of beans from the roasting subsystem to a holding chamber of a cooling subsystem that includes a cooling platform;

maintaining, after the transferring, a flow of air through the holding chamber to accelerate cooling of the batch of beans;

vibrating, during at least a portion of the maintaining, the cooling platform to accelerate cooling of the batch of beans; and

transporting, after the batch of beans are cooled, the batch of beans in a downward direction and out of the cooling subsystem.

20. The method of claim 19, wherein the transporting includes moving a floor of the cooling platform from a closed configuration to an open configuration, the batch of beans transporting in the downward direction and out of the cooling subsystem in response to the floor moving from the closed configuration to the open configuration.

21. A bean roasting system, comprising:
a roasting subsystem configured to receive and to thermally roast a batch of beans;
and
an air handling subsystem coupled to the roasting subsystem, the air handling subsystem including:
a blower configured to impart motion to air to pass the air through at least a portion of the air handling subsystem; and
a cyclone separator configured to remove particulates,
the cyclone separator including a heater configured to heat the air passing through at least a portion of the air handling subsystem, the heater including a heater portion that is disposed within the cyclone separator.
22. The bean roasting system of claim 21, wherein:
the cyclone separator includes an air outlet, an air inlet, and a particulate outlet,
the heater portion is disposed within the air outlet.
23. The bean roasting system of claim 21, wherein:
the cyclone separator has a vertical cyclone axis that is substantially central, during operation of the bean roasting system, to a spiral rotation of particulates as they pass from an upper portion of the cyclone separator to a particulate outlet of the cyclone separator,
the heater portion includes heater windings that surround a portion of the vertical cyclone axis.
24. The bean roasting system of claim 21, wherein the cyclone separator includes a cyclone housing including an upper housing and a lower housing, the heater portion extends vertically from above the upper housing into the upper housing.
25. The bean roasting system of claim 24, wherein the cyclone separator includes an air outlet, the air outlet having an outlet housing that extends into the upper housing and defines a vertical air outlet flow path, the heater portion includes heater windings that are disposed within the vertical air outlet flow path.
26. The bean roasting system of claim 25, wherein the upper housing is generally cylindrical and the lower housing is generally conical and configured to direct a spiral

movement of the particulates from the upper housing to a particulate outlet at a lower end portion of the lower housing.

27. The bean roasting system of claim 26, wherein the upper housing defines a vertical axis, the heater windings spiral around the vertical axis.

28. The bean roasting system of claim 21, wherein the heater is configured to provide a majority of a thermal energy for roasting the batch of beans.

29. The bean roasting system of claim 21, wherein the air handling subsystem defines, during operation of the bean roasting system, at least one air flow loop that passes from the cyclone to the blower to the roasting subsystem, and back to the cyclone.

30. The bean roasting system of claim 21, further comprising a controller coupled to the blower and the heater, the controller configured to operate at least the blower and the heater to provide a predetermined temperature profile in the roasting subsystem to roast the batch of beans.

31. A method of roasting beans, comprising:

providing a bean roasting system including:

a roasting subsystem configured to receive and to thermally roast a batch of beans; and

an air handling subsystem coupled to the roasting subsystem, the air handling subsystem includes:

a blower;

a cyclone separator configured to remove particulates from the air handling subsystem; and

a heater including a heater portion that is incorporated into the cyclone separator;

operating the blower to impart air motion through the air handling subsystem;

operating the cyclone separator to remove particulates from the air handling

subsystem; and

operating the heater portion to heat the air passing through the air handling subsystem.

32. The method of claim 31, wherein the cyclone separator includes an air outlet, an air inlet, and a particulate outlet, the heater portion is disposed within the air outlet, the method further including:
- imparting the motion of air into the air inlet, out of the air outlet, and causing particulates that are entrained by the air motion to pass out of the particulate outlet.
33. The method of claim 31, wherein:
- the cyclone separator has a vertical cyclone axis that is substantially central to, during use of the bean roasting system, a spiral rotation of particulates as they pass from an upper portion of the cyclone separator to the particulate outlet.
34. The method of claim 31, wherein the cyclone separator includes a cyclone housing including an upper housing and a lower housing, the heater portion extends vertically from outside of the upper housing into the upper housing.
35. The method of claim 34, wherein the cyclone separator includes an air outlet, the air outlet having an outlet housing that extends into the upper housing and defines a vertical air outlet passageway, the heater portion includes heater windings that are disposed within the air outlet passageway.
36. The method of claim 35, wherein the upper housing is generally cylindrical and the lower housing is generally conical and configured to enhance, during use of the bean roasting system, a spiral movement of the particulates from the upper housing to a particulate outlet at a lower end of the lower housing.
37. The method of claim 36, wherein the upper housing defines a vertical axis, the heater windings spiral around the vertical axis during use of the bean roasting system.
38. The method of claim 31, wherein the heater is configured to provide a majority of a thermal energy for roasting the batch of beans.
39. The method of claim 11, wherein the air handling subsystem defines at least one loop that passes from the cyclone to the blower to the roasting subsystem, and back to the cyclone.
40. A method, comprising:
- thermally roasting a batch of beans within a roasting subsystem;

imparting, during the thermally roasting, motion to air through at least a portion of an air handling subsystem coupled to the roasting subsystem;

removing, during the thermally roasting, particulates from the air handling subsystem via a cyclone separator having a heater portion disposed within the cyclone separator; and

applying, during the thermally roasting, energy to the heater portion to heat the air passing through the at least a portion of the air handling subsystem.

41. A bean roasting system, comprising:

a roasting subsystem including:

a housing having an inner surface defining an inner chamber for holding a batch of beans during a thermal roasting process, the inner chamber having a horizontal axis;

an agitator actuator;

an agitator coupled to the agitator actuator, the agitator includes a central shaft and a blade set mounted to the central shaft;

a door having a transparent window disposed at a front end portion of the housing; and

a bearing disposed at a rear end portion of the housing, the bearing supporting the central shaft and configured to prevent the blade set from contacting the inner surface of the housing and the door; and

an air handling subsystem coupled to the roasting subsystem, the air handling subsystem including a blower and a heater and configured to circulate heated air through the inner chamber during the thermal roasting process.

42. The bean roasting system of claim 41, wherein the housing includes:

a first conduit that defines an air inlet; and

a second conduit that defines an air outlet and a bean inlet.

43. The bean roasting system of claim 42, wherein the first conduit is located adjacent to the rear end portion of the housing and configured to receive heated air flow in a vertically downward direction from the air handling subsystem.

44. The bean roasting system of claim 43, wherein the second conduit is located adjacent to the front end portion of the housing and configured to output air flow in a vertically upward direction to the air handling subsystem.

45. The bean roasting system of claim 42, wherein the second conduit has a cross-sectional area greater than a cross-sectional area of the first conduit and configured to slow down a rate of airflow into the air handling subsystem in a upward direction to reduce entrainment of the batch of beans.
46. The bean roasting system of claim 41, wherein the housing includes a hatch, the blade set is configured to impart a stirring motion to the batch of beans to facilitate exit of the batch of beans through the hatch when the batch of beans is being unloaded from the chamber.
47. The bean roasting system of claim 41, wherein the blade set is configured to impart a circulating motion of beans of the batch of beans along the horizontal axis during rotation of the blade set.
48. The bean roasting system of claim 41, wherein the blade set includes:
an inner spiral auger configured to impart a horizontal motion of beans along a first horizontal direction during rotation of the blade set; and
an outer set of blades configured, during rotation of the blade set, to impart a horizontal motion of beans along a second horizontal direction that opposes the first horizontal direction to enhance mixing of the batch of beans during the thermal roasting process.
49. The bean roasting system of claim 41, wherein the central shaft is a hollow cylindrical shaft, the bearing radially surrounds the hollow cylindrical shaft at the rear end portion of the housing.
50. The bean roasting system of claim 41, wherein the agitator actuator includes a motor and a power coupling (1) mounted behind the rear end portion of the housing and (2) that is configured to transfer rotational power from the motor to the agitator.
51. The bean roasting system of claim 50, wherein the motor extends in a frontward direction from the power coupling and overlaps with the housing along the horizontal axis.
52. A bean roasting system, comprising:
a hopper;
a roasting subsystem including:

a housing having an inner surface defining an inner chamber for holding a batch of beans during a thermal roasting process, the inner chamber having a horizontal axis, the housing including a hatch coupled to a bean release actuator;

an agitator actuator;

an agitator coupled to the agitator actuator, the agitator includes a central shaft and a blade set mounted to the central shaft;

a bearing disposed at a rear end portion of the housing that supports the central shaft and is configured to prevent the blade set from contacting the inner surface of the housing; and

a door having a glass window disposed at a front end portion of the housing configured to allow viewing of the thermal roasting process;

an air handling subsystem coupled to the roasting subsystem, the air handling subsystem including a blower and a heater;

a bean cooling subsystem; and

a controller configured to:

operate the hopper to release the batch of beans from the hopper to the inner chamber;

operate the agitator actuator to rotate the actuator and to stir the batch of beans within the inner chamber;

operate the air handling subsystem to circulate heated air through the inner chamber according to the thermal roasting process; and

operate the bean release actuator and the agitator actuator to release beans from the inner chamber to the bean cooling subsystem.

53. The bean roasting system of claim 52, wherein the housing includes a first conduit and a second conduit, operating the air handling subsystem circulates the heated air into the first conduit and out of the second conduit, operating the hopper releases the beans from the hopper, through the second conduit, and to the inner chamber.

54. The bean roasting system of claim 53, wherein the second conduit has a larger cross area than the first conduit to provide a slower velocity of air leaving than entering the housing.

55. A method of roasting beans, comprising:
providing a hopper;
providing a roasting subsystem including:

a housing having an inner surface defining an inner chamber for holding a batch of beans during a thermal roasting process, the inner chamber having a horizontal axis, the housing including a hatch coupled to a bean release actuator;

an agitator actuator;

an agitator coupled to the agitator actuator, the agitator includes a central shaft and a blade set mounted to the central shaft;

a bearing disposed at a rear end portion of the housing that supports the central shaft and is configured to prevent the blade set from contacting the inner surface of the housing; and

a door having a glass window disposed at a front end portion of the housing and configured to allow viewing of the thermal roasting process;

providing an air handling subsystem coupled to the roasting subsystem, the air handling subsystem including a blower and a heater;

providing a bean cooling subsystem coupled to the roasting subsystem;

operating the hopper to release the batch of beans from the hopper to the inner chamber;

operating the agitator actuator to rotate the agitator and to stir the batch of beans within the inner chamber;

operating the air handling subsystem to circulate heated air through the inner chamber according to the thermal roasting process; and

operating the bean release actuator and the agitator actuator to release beans from the inner chamber to the bean cooling subsystem.

56. The method of claim 55, wherein:

the housing includes a first conduit and a second conduit,

operating the air handling subsystem circulates the heated air into the first conduit and out of the second conduit,

operating the hopper releases the beans from the hopper, through the second conduit, and to the inner chamber.

57. The method of claim 56, wherein the second conduit has a cross-sectional area greater than a cross-sectional area of the first conduit to provide a slower velocity of air leaving than entering the housing.

58. A method, comprising:

releasing a batch of beans from a hopper to an inner chamber of a housing having a (1) a hatch, (2) a door having a glass window disposed at a front end portion of the housing and configured to allow viewing of a thermal roasting process, (3) an agitator disposed within an interior of the inner chamber and having a rotatable shaft and a blade set coupled to the rotatable shaft, and (4) a bearing disposed at a rear end portion of the housing and supporting the rotatable shaft to prevent the blade set from contacting an inner surface of the inner chamber;

stirring, via the actuator, the batch of beans within the inner chamber;

circulating heated air through the inner chamber according to the thermal roasting process; and

releasing, via the hatch, beans from the inner chamber to a bean cooling subsystem.

59. A bean roasting system, comprising:

a roasting drum configured to receive and to thermally roast beans;

an air handling system configured to circulate a first fluid stream through the roasting drum;

a bean cooler configured to receive and cool the beans from the roasting drum; and

an air exit subsystem configured to receive and treat the first fluid stream from the air handling system and a second fluid stream from the bean cooler, the air exit subsystem including:

a heat sink defining a first fluid path and a second fluid path substantially parallel to the first fluid path and including a metal body;

the metal body configured to receive heat from the first fluid path and the second fluid path;

the first fluid path fluidically coupled to the air handling system to receive the first fluid stream from the air handling system;

the second fluid path fluidically coupled to the bean cooler to receive the second fluid stream from the bean cooler; and

a filter fluidically coupled to the first fluid path and the second fluid path.

60. The bean roasting system of claim 59, further comprising a housing defining a housing fluid path that fluidically couples the first fluid path and the second fluid path to the filter and merges the first fluid stream and the second fluid stream to provide a merged fluid stream.

61. The bean roasting system of claim 60, wherein the housing includes an exit fan disposed within the housing fluid path.
62. The bean roasting system of claim 61, wherein, during operation, the merged fluid stream generally traverses the housing fluid path along a lateral Y-axis, then passes into the filter along a vertical Z-axis, and then passes through filters in the filter along a lateral X-axis, the X-axis, the Y-axis, and the Z-axis are mutually orthogonal.
63. The bean roasting system of claim 60, wherein, during operation, the first fluid stream enters the housing along a Y-axis and then traverses along the first fluid path along the Z-axis, the Y-axis and the Z-axis are mutually orthogonal.
64. The bean roasting system of claim 59, wherein, during operation, the first fluid path and the second fluid path direct air streams along a vertical Z-axis.
65. The bean roasting system of claim 64, wherein, during operation, the first fluid path first directs the first fluid stream in a downward direction and then in an upward direction along the Z-axis.
66. The bean roasting system of claim 65, wherein, during operation, the first fluid stream enters the air exit subsystem along a lateral Y-axis before entering the first fluid path, the lateral Y-axis is orthogonal to the vertical Z-axis.
67. The bean roasting system of claim 64, wherein, during operation, the second fluid path directs the second fluid stream in an upward direction along the vertical Z-axis.
68. The bean roasting drum of claim 59, wherein the air handling system includes a blower, the first fluid stream traverses from the blower to the first fluid path during operation.
69. The bean roasting system of claim 59, wherein the heat sink further includes:
a first plurality of fins extending from the metal body into the first fluid path; and
a second plurality of fins extending from the metal body into the second fluid path.
70. The bean roasting system of claim 59, further comprising a controller configured to operate the roasting drum, the air handling system, and the bean cooler.
71. A method of roasting a batch of beans, comprising:
providing a roasting drum;

providing an air handling subsystem;

providing a bean cooler to receive and to cool the batch of beans from the roasting drum;

providing an air exit subsystem configured to receive and treat a first fluid stream from the air handling system and a second fluid stream from the bean cooler, the air exit subsystem including:

- a heat sink defining a first fluid path and a second fluid path substantially parallel to the first fluid path, the heat sink including a metal body;
- the metal body configured to receive heat from the first fluid path and the second fluid path; and
- a filter fluidically coupled to the first fluid path and the second fluid paths;

operating the roasting drum and the air handling system to receive and to thermally roast a batch of beans; and

operating the air exit subsystem to receive and treat the first fluid stream and the second fluid stream, operating the air exit subsystem includes:

- passing the first fluid stream through the first fluid path;
- passing the second fluid stream through the second fluid path; and
- passing the first fluid stream and the second fluid stream to the filter.

72. The method of claim 71, wherein the air exit subsystem includes a housing defining a housing fluid path and contains an exit fan, the method further comprising:

- operating the exit fan;
- merging the first fluid stream and the second fluid stream into a merged fluid stream within the housing fluid path; and
- passing the merged fluid stream to the filter.

73. The method of claim 71, wherein the air exit subsystem includes a housing, the method further comprising:

- receiving the first fluid stream into the housing along a Y-axis; and passing, after receiving the first fluid stream into the housing, the first fluid stream from the housing and through the first fluid path along a Z-axis.

74. The method of claim 71, wherein passing the first fluid path primarily extends along a vertical Z-axis, passing the first fluid stream through the first fluid path includes passing the

first fluid stream along the Z-axis in a downward direction and then passing the first fluid stream along the Z-axis in an upward direction.

75. The method of claim 71, wherein passing the second fluid path primarily extends along a vertical Z-axis, passing the second fluid stream through the second fluid path includes passing the first fluid stream along the Z-axis in an upward direction.

76. The method of claim 71, wherein the heat sink further includes a first plurality of fins extending from the metal body into the first fluid path, the method further including convectively transferring heat from the first fluid stream into the first plurality of fins and conductively transferring heat from the first plurality of fins to the metal body.

77. The method of claim 71, wherein the heat sink further includes a second plurality of fins extending from the metal body into the second fluid path and the method further including convectively transferring heat from the second fluid stream into the second plurality of fins and conductively transferring heat from the second plurality of fins to the metal body.

78. A bean roasting system, comprising:
a hopper;
a roasting drum;
an air handling system;
a bean cooler;
an air exit subsystem configured to receive and treat a first fluid stream from the air handling system and a second fluid stream from the bean cooler, the air exit subsystem including:

a heat sink defining two parallel fluid paths including a first fluid path and a second fluid path and including:

a metal body;

a first plurality of fins extending from the metal body into the first fluid path;

a second plurality of fins extending from the metal body into the second fluid path;

the metal body configured to receive heat from the first fluid path and the second fluid path;

the first fluid path fluidically coupled to receive the first fluid stream from the air handling system;

the second fluid path fluidically coupled to receive the second fluid stream from the bean cooler;

a filter fluidically coupled to the first and second air flow paths; and

a controller configured to:

- operate the hopper to transfer a batch of beans to the roasting drum;
- operate the roasting drum and the air handling system to roast the batch of beans;
- operate the bean cooler to receive and cool the batch of beans; and
- operate the air exit subsystem to:
 - treat the first fluid stream to extract heat, water vapor, and effluents; and
 - treat the second fluid stream to extract heat and effluents.