BEVERAGE MACHINE WITH BREW CHAMBER FLUID SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. § 119(e) of U.S. provisional application serial number 63/564,301, filed March 12, 2024, and U.S. provisional application serial number 63/565,828, filed March 15, 2024, the disclosures of each of which are incorporated by reference in their entireties.

FIELD

[0002] Disclosed embodiments are related to beverage machines for forming beverages from package-free beverage tablets and methods of forming beverages with package-free beverage tablets.

BACKGROUND

[0003] Tablets of compacted beverage ingredients can be used for forming a beverage. In some arrangements, such beverage tablets are mixed directly with hot water to form a beverage. In some arrangements, water is permitted to percolate through beverage tablets to form a beverage.

SUMMARY

[0004] According to some aspects, a beverage machine is provided. The beverage machine comprises a machine housing, a liquid supply configured to provide a liquid for forming a beverage, a brew chamber configured to hold a beverage tablet for mixing with liquid from the liquid supply to form a beverage, and a sensor configured to detect a size of a beverage tablet in the brew chamber based on a physical dimension of the beverage tablet and to communicate a signal corresponding to the detected size to a controller of the beverage machine.

[0005] According to some aspects, a method of determining a size and/or presence of a beverage tablet in a beverage machine is provided, the method comprising receiving a beverage tablet into a portion of a brew chamber, closing the brew chamber, and determining a size of the beverage tablet using one or more sensors configured to detect a physical dimension of the beverage tablet during and/or after closing of the brew chamber.

[0006] It should be appreciated that the foregoing concepts, and additional concepts discussed below, may be arranged in any suitable combination, as the present disclosure is not limited in this respect. Further, other advantages and novel features of the present disclosure will become apparent from the following detailed description of various non-limiting embodiments when considered in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF DRAWINGS

[0007] The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures may be represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

[0008] FIG. 1 shows a simplified cross-sectional view of a beverage machine according to an embodiment;

[0009] FIG. 2 shows a simplified cross-sectional view of a brew chamber of the beverage machine of FIG. 1 in an open configuration;

[0010] FIG. 3 shows a simplified cross-sectional view of the brew chamber of FIG. 2 in a partially closed configuration;

[0011] FIG. 4 shows a simplified cross-sectional view of the brew chamber of FIG. 2 in a partially closed configuration closer to the closed configuration than shown in FIG. 3;

[0012] FIG. 5 shows a simplified cross-sectional view of the brew chamber of FIG. 2 in a partially closed configuration closer to the closed configuration than shown in FIG. 4;

[0013] FIG. 6 shows a simplified cross-sectional view of the brew chamber of FIG. 2 in a closed configuration;

[0014] FIG. 7 shows a simplified cross-sectional view of the brew chamber of FIG. 2 with a beverage tablet in a compressed configuration;

[0015] FIG. 8 shows a simplified cross-sectional view of the brew chamber of FIG. 2 with a beverage tablet in an expanded configuration;

[0016] FIG. 9 shows a simplified cross-sectional view of the brew chamber of FIG. 2 with a beverage tablet in an ejected configuration;

[0017] FIG. 10A shows a simplified cross-sectional view of a sensor assembly of the brew chamber of FIG. 2 sensing a lack of a beverage tablet;

[0018] FIG. 10B shows a simplified cross-sectional view of a sensor assembly of the brew chamber of FIG. 2 sensing a size of a first beverage tablet;

[0019] FIG. 10C shows a simplified cross-sectional view of a sensor assembly of the brew chamber of FIG. 2 sensing a size of a second beverage tablet;

[0020] FIG. 10D shows a simplified cross-sectional view of an alternative embodiment of a sensor assembly of the brew chamber of FIG. 2 sensing a size of a beverage tablet;

[0021] FIG. 11 is a schematic representation of an upstream fluid system of a beverage machine according to an embodiment;

[0022] FIG. 12 is a cross-sectional view of a brew chamber of a beverage machine according to an embodiment;

[0023] FIG. 13 is a cross-sectional view of the brew chamber of FIG. 12 with a hydraulic chamber of the brew chamber in a filled configuration;

[0024] FIG. 14A is a schematic representation of a brew chamber fluid system according to an embodiment;

[0025] FIG. 14B is a schematic representation of a brew chamber fluid system according to an alternative embodiment;

[0026] FIG. 15A shows a schematic representation of a solenoid valve in a closed position according to an embodiment; and

[0027] FIG. 15B shows a schematic representation of the solenoid valve of FIG. 15A in an open configuration according to an embodiment.

DETAILED DESCRIPTION

[0028] Aspects herein relate to a beverage machine configured to form beverages using beverage tablets such as the beverage tablets disclosed in embodiments below. Many brewed beverages are conventionally prepared by enclosing an amount of loose particles of beverage ingredient, such as loose coffee grinds or tea leaves, into a beverage machine. Use of loose particles of beverage ingredient to prepare brewed beverages may be inconvenient as it may require additional steps of measuring out a specific amount beverage of ingredient. Additionally, loose particles of beverage ingredient carries the potential for spillage while preparing and transporting the desired amount of beverage ingredient to and from the beverage machine.

Additionally, many brewing machines that use loose particles of beverage ingredient require cleaning after each use to remove loose particles from the inside of the machine.

[0029] Single serve beverage pods have been implemented to alleviate some of these concerns. However, such beverage pods generally contain loose beverage ingredient in a disposable packaging. Utilizing such packaging may generate additional waste.

[0030] The inventors have therefore recognized benefits of providing package-less beverage consumables that can be used with a beverage machine to form a beverage. In some embodiments, a beverage consumable comprises a tablet which includes beverage ingredient compacted into a desired shape and density. The tablet may be at least partially surrounded by a coating. Such beverage tablets may allow for the increased convenience of single-serve beverage consumables while reducing waste.

[0031] The beverage tablet may be able to hold its own shape, and thus may not require individual packaging to prevent dispersing of the beverage material prior to use in forming a beverage. The beverage tablet may be configured to be received within a beverage machine without packaging such that the beverage tablet (e.g. the beverage ingredients and/or coating) directly contacts the beverage machine (e.g. a brew chamber) during a brewing process (e.g. without requiring the beverage machine to pierce through or otherwise open packaging to access the beverage ingredients).

[0032] In some embodiments, the beverage tablet comprises a solid body comprising a beverage ingredient. For example, one or more beverage ingredients of the beverage tablet may be formed into a solid body by compression, adhesion, solidification in a mold, or any of a variety of other suitable methods for making a rigid body from one or more beverage ingredients.

[0033] In some embodiments, a package-less beverage consumable (e.g., a beverage tablet) may include a coating disposed along at least a portion of the outer surface at the periphery of the consumable. In some embodiments, the coating may bind the beverage ingredients within the interior of the consumable. In some embodiments, the beverage ingredients held within the coating may be loose, such as loose ground coffee, or compacted. The coating may be a food grade binder, an alginate, edible, soluble, or any other suitable material. In some embodiments, the coating may serve as a barrier to reduce infiltration of oxygen and/or moisture so as to maintain freshness of the beverage ingredients. Material of the package-less beverage consumable, including a coating of the consumable if one is present, may

directly contact some portion of the beverage machine, such as the brew chamber, before brewing the beverage, without intervening packaging in-between.

[0034] In some embodiments, the beverage tablet may be formed in a variety of sizes, and the beverage machine may be capable of receiving and forming beverages from beverage tablets in the variety of sizes. In some embodiments, the beverage machine may be configured to form different styles of brewed beverages (e.g. espresso, double-shot espresso, drip coffee, iced coffee, etc.) from different sized beverage tablets. For instance, a smaller beverage tablet may be configured to form an espresso, while a larger beverage tablet may be configured to form drip coffee, and an even larger beverage tablet may be used to form iced coffee. In some embodiments, the beverage tablet may be generally cylindrical, and different sizes of beverage tablet may be formed by altering a height of the beverage tablet. In some embodiments, the beverage tablet may have generally flat end surfaces. In some embodiments, the beverage tablet may have domed end surfaces.

[0035] In some embodiments, the beverage machine may include a brew chamber configured to receive a beverage tablet in an open configuration and to move to a closed configuration, where the beverage material inside the beverage tablet is mixed with water from a liquid supply to form a beverage. The brew chamber may be configured to receive beverage tablets having different heights.

[0036] According to some aspects described herein, the beverage machine may have a moveable beverage tablet holder that moves a beverage tablet during a brew process. In some embodiments, the brew chamber includes a first brew chamber section rotatably disposed in a housing of the beverage machine, and a second brew chamber section slidably disposed in the housing. The first brew chamber section may be configured to receive the beverage tablet when the brew chamber is in the open configuration. As the brew chamber moves towards the closed configuration, grippers coupled to the first brew chamber section may grasp the beverage tablet and the first brew chamber section may rotate into the housing, while the second brew chamber section may translate towards the first brew chamber section. The first and second brew chamber sections may meet, forming a sealed brew chamber, and the beverage tablet may be positioned inside of the sealed brew chamber between crush plates disposed on the first and second brew chamber sections.

[0037] In some embodiments, to form a beverage, the beverage tablet may first be received between first and second crush plates of the brew chamber. A brew chamber fluid system may then be used to perform various operations to form the beverage.

[0038] In some embodiments, water may be delivered to the brew chamber to pre-wet the beverage tablet via a pre wet flow path. Pre-wetting the beverage tablet may soften the coating of the beverage tablet. After the beverage tablet is pre-wet, the water may be drained from the brew chamber into a disposal unit. Water may then be pumped into a hydraulic chamber adjacent to the brew chamber via a hydraulic chamber flow path. As water is pumped into the hydraulic chamber, the chamber expands to accommodate the water. A wall of the brew chamber may be operatively connected to the second crush plate, such that the wall and the second crush plate are pushed towards the first crush plate as the hydraulic chamber is filled. Movement of the second crush plate towards the first crush plate may compress and deform the beverage tablet between the first crush plate and the second crush plate. In some embodiments, as the beverage tablet is compressed and deformed, the body of beverage material in the beverage tablet is fractured and breaks into smaller pieces. It should be appreciated that, in some embodiments, the beverage tablet may have a coating that contains the pieces of the fractured tablets within an enclosed space such that the tablet pieces do not disperse into the brew chamber. In some embodiments, an inlet piercing mechanism (e.g. inlet piercing needles) may pierce the beverage tablet as the beverage tablet is compressed and deformed. Water may then be pumped into the beverage tablet though the inlet needles via an inlet needle flow path and mix with the beverage material to form the beverage.

[0039] In some embodiments, pre-wet flow path, hydraulic chamber flow path, and inlet needle flow path may diverge upstream of the brew chamber and hydraulic chamber. In some embodiments, flow between the flow paths is controlled by actively or passively controlled check valves, or by a combination of controllable check valves (e.g. solenoid check valves, electric ball valves, etc.) and passive check valves. In some embodiments, flow along the pre-wet flow path is controlled via a controllable check valve, while flow along the hydraulic chamber flow path and inlet needle flow path is controlled via passive check valves disposed on each respective flow path. In some embodiments, the check valve on the hydraulic chamber flow path has a lower cracking pressure than the check valve on the inlet needle flow path. In some embodiments, introducing water into the beverage tablet may cause the beverage tablet to expand

until the beverage tablet contacts an outlet piercing mechanism (e.g. outlet piercing needles), which may then pierce the beverage tablet and allow the beverage to exit the beverage tablet. The outlet piercing mechanism may be fluidly connected to a brew chamber outlet, allowing the beverage to exit the brew chamber. In other embodiments, the outlet piercing mechanism may contact the tablet at the same time as the inlet piercing mechanism. In yet other embodiments, the outlet piercing mechanism may contact the tablet after the inlet piercing mechanism, but before the beverage tablet is expanded.

[0040] In some embodiments, the brew chamber outlet may be fluidly connected to a high pressure outlet flow path and a low pressure outlet flow path, the outlet flow paths configured to provide a variable brew pressure for forming different types of brewed beverages which require different brew pressures (e.g. espresso, drip coffee, etc.). In some embodiments, the high pressure flow path may include a valve configured to create sufficient brew pressure to allow for the formation of crema. In some embodiments, the low pressure outlet flow path may include a valve. In some embodiments, the high pressure flow path check valve is a passive valve, and the low pressure flow path valve is a controllable valve. When the low pressure valve is open, the beverage is directed along the low pressure flow path to a dispensing outlet, which results in a beverage formed with a lower brew pressure. When the low pressure valve is closed, the beverage is directed along the high pressure outlet flow path to a dispensing outlet, which results in a beverage formed with a higher brew pressure.

[0041] In some embodiments, the beverage machine may be configured to automatically eject the beverage tablet from the brew chamber after a brew operation is completed. In some embodiments, a second brew chamber section may translate away from a first brew chamber section, exposing an opening below the brew chamber. The used beverage tablet may fall through the opening into a disposal unit.

[0042] In some embodiments, the beverage machine may include an upstream fluid system configured to condition and deliver water to the brew chamber fluid system. The upstream fluid system may be capable of delivering water with different parameters (e.g. pressure, temperature, volume, etc.) In some embodiments, the beverage machine may include a sensor system configured to detect a physical dimension of the beverage tablet, such as height. Based on this detected physical dimension, a controller of the upstream fluid system may then

display certain associated options to a user on a user interface and/or control parameters of the water delivered to the brew chamber.

[0043] Turning to the figures, specific non-limiting embodiments are described in further detail. It should be understood that the various systems, components, features, and methods described relative to these embodiments may be used either individually and/or in any desired combination as the disclosure is not limited to only the specific embodiments described herein.

Brew chamber Structure and Operation

[0044] FIG. 1 shows a simplified cross-sectional view of a beverage machine in an open configuration according to an embodiment. As discussed above, it may be desirable for beverage machine 100 to be capable of forming a beverage from beverage tablets comprised of compressed beverage material, as such beverage tablets may be more convenient than loose beverage material, but may require less packaging than conventional beverage cartridges. Beverage machine 100 may include a brew chamber 200 configured to receive a beverage tablet 400 and form a beverage using the beverage tablet 400. As will be discussed below, brew chamber 200 may be configured to receive a beverage tablet in an open configuration and form the beverage in a closed configuration. Beverage machine 100 may also include an upstream fluid system 300 configured to condition and deliver water from a liquid supply 302 to operate the brew chamber 200 and mix with beverage material in the beverage tablet 400 to form the beverage. In some embodiments, brew chamber 200 and upstream fluid system 300 may be at least partially contained in housing 108.

[0045] In some embodiments, beverage machine 100 may include a lid 102. Lid 102 may be configured to move between a lid open position to permit a beverage tablet to be placed in the brew chamber 200, and a lid closed position in which the brew chamber 200 is in a closed configuration. In some embodiments, when the lid is in the lid closed position, the brew chamber 200 is fully enclosed in the housing 108. In some embodiments, lid 102 is operatively connected to the brew chamber 200 via linkages, such that moving the lid from the lid open position to the lid closed position moves at least a portion of the brew chamber 200 between an open configuration and a closed configuration.

[0046] In some embodiments, an imaging device 104 may be disposed on lid 102 and configured to image a portion of the beverage tablet 400. This portion of beverage tablet 400

may include surface indicia configured to be read by controller 301 and interpreted as corresponding to a type of beverage tablet 400 (e.g. size, roast level, etc.). Controller 301 may then present brew parameter options (e.g. volume, brew pressure, brew strength, brew temperature) to a user on a user interface 110 and/or otherwise control the upstream fluid system according to the type of beverage tablet detected.

[0047] In some embodiments, the beverage machine 100 may include a dispensing flow path 106 configured to receive the beverage from the brew chamber 200 and allow the beverage to exit the housing 108 through a dispensing outlet disposed at an end of the dispensing flow path 106. In some embodiments, dispensing flow path 106 may include various conditioning chambers configured to condition various fluid parameters (e.g. temperature, turbulence, flow rate, etc.) of the beverage prior to dispensing the beverage.

[0048] As mentioned above, beverage tablet 400 may include a body 402 formed of compacted beverage material. Body 402 may be generally cylindrical, with first end 406 and second end 408. It should be understood that in some embodiments, the ends of the beverage tablet 400 may be substantially identical, such that either end may be the first end 406 or the second end 408. In some embodiments, first and/or second ends are domed. In some embodiments, beverage tablet 400 includes at least one coating 404 configured to at least partially encapsulate the body 402. Coating 404 may be configured to soften when wetted, permitting the coating to stretch without ripping or fracturing.

[0049] FIGS. 2-6 show simplified cross section views of a brew chamber in various stages of closing. In some embodiments, it may be desirable for the brew chamber 200 to receive the beverage tablet 400 in a vertical orientation (as seen in FIG. 2), and then rotate the beverage tablet 400 to a horizontal orientation for performing a brew operation (as seen in FIG. 6). Such a configuration may allow for capturing an image of surface indicia on the first or second end 406 or 408 when a beverage tablet is first received into the brew chamber by the imaging device 104. Such a configuration may also ensure proper positioning and alignment of the beverage tablet during a brew operation. In some embodiments, such a configuration may allow for redirection of compressive forces on the beverage tablet away from the lid 102 to avoid requiring lid 102 to be strong enough to resist these compressive forces.

[0050] Brew chamber 200 may include first brew chamber section 202 and second brew chamber section 204. Brew chamber 200 may have an open configuration, where first brew

chamber section 202 is disconnected from the second brew chamber section 204, and a closed configuration, where the first brew chamber section 202 is connected to the second brew chamber section 204 to form an enclosed brew chamber volume 201, as seen in FIG. 6.

[0051] First brew chamber section 202 may be rotatably disposed in the housing 108, such that the first brew chamber section 202 rotates from a first, vertical-facing position (FIG. 2) to a second, horizontal-facing position (FIG. 6) as the brew chamber moves from the open configuration to the closed configuration. In some embodiments, the first brew chamber section may rotate approximately 90° between the first position and the second position. Second brew chamber section 204 may be slidably disposed in the housing 108, such that the second brew chamber section 204 translates from a retracted position (FIG. 2) to an extended position (FIG. 6) as the brew chamber moves from the open configuration to the closed configuration.

[0052] First brew chamber section 202 may include a first crush plate 206 configured to receive the beverage tablet 400 in a generally vertical orientation when the first brew chamber section 202 is in the vertical-facing position. In some embodiments, first crush plate 206 may be an annular surface configured to contact a perimeter of first end 406 of beverage tablet 400. Second brew chamber section 204 may include a plunger assembly 205, back wall 208, and sidewalls 210. The plunger assembly 205 may be slidably disposed inside the second brew chamber section, such that the plunger assembly may slide relative to the back wall and sidewalls. The plunger assembly may include a plunger 212, with a plunger head 214 and a plunger shaft 216, a second crush plate 207 operatively connected to the plunger head 214, and a spring 218 connecting the plunger shaft 216 to the back wall 208. However, it is also contemplated that the spring 218 may be disposed between any portion of the plunger assembly and the second brew chamber section 204 which allows the plunger assembly to be biased towards the extended position shown in FIG. 2, as the disclosure is not so limited. For instance, in some embodiments, a hydraulic wall 228 may be fixed relative to the second brew chamber section 204 (rather than movable within the second brew chamber section, as shown in FIGs. 1-9), and the spring 218 may be disposed in the hydraulic chamber 226 between the hydraulic wall 228 and the plunger head 214.

[0053] As seen in FIGs. 3 and 4, as the first brew chamber section 202 rotates, the second brew chamber section 204 may translate towards the extended position. Any suitable means may be used to translate the second brew chamber section 204 to the extended position. In some

embodiments, the second brew chamber section 204 may be operatively coupled to the lid 102 and/or a lid actuator such as a handle via one or more linkages, such that closing of the lid (or otherwise operating a lid actuator) causes the second brew chamber section 204 to translate towards the extended position. In some embodiments, a separate actuator, such as a motor or a hydraulic actuator, causes the second brew chamber section to translate towards the extended position. In some embodiments, as seen in FIG. 3, the first brew chamber section 202 begins rotating before the second brew chamber section 204 begins translating. In some embodiments, the second brew chamber section 204 begins translating as soon as the first brew chamber section 202 begins rotating. In some embodiments, the second brew chamber section 204 begins translating after the first brew chamber section 202 finishes rotating. As the first brew chamber section 202 rotates from the vertical-facing position to the horizontal-facing position, grippers 220 may contact the beverage tablet 400 to hold the beverage tablet 400 against the first crush plate 206. As a result, as the first brew chamber section rotates from the first, vertical-facing position to the second, horizontal-facing position, the beverage tablet 400 also rotates from the vertical orientation to a horizontal orientation. In some embodiments, the horizontal orientation of the beverage tablet is approximately perpendicular to the vertical orientation of the beverage tablet. In some embodiments, the grippers 220 are held in a partially open position when the first brew chamber section 202 is in the vertical orientation, such that the grippers 220 do not hold the beverage tablet 400 until after the first brew chamber section 202 begins rotating.

[0054] As mentioned above, it may be desirable for the beverage machine 100 to be configured to accept beverage tablets having different volumes to allow for more flexibility in beverage parameters such as volume or brew strength. In some embodiments, beverage tablets 400 may therefore be scalable along a height H. This allows for an increase in volume of the beverage tablet 400, while maintaining the same surface area of first and second ends 406 and 408. This allows the beverage tablet 400 to align with first crush plate 206 and be grasped by the grippers 220, regardless of the height (and thus the size) of the beverage tablet 400 inserted.

[0055] As seen in FIG. 5, in some embodiments, the first brew chamber section 202 reaches the horizontal-facing position before the second brew chamber section 204 reaches the extended position. In some embodiments, the second brew chamber section does not begin translating to the extended position until after the first brew chamber section reaches the horizontal-facing position shown in FIG. 5. As or after the first brew chamber section 202

reaches the horizontal-facing position, second crush plate 207 contacts second end 408 of the beverage tablet 400. As the second brew chamber section 204 continues to translate towards the extended position, the plunger assembly 205 stops translating due to the contact between the second crush plate 207 and the second end 408. Because back wall 208 continues to translate towards the extended position, spring 218 is compressed between back wall 208 and plunger shaft 216. Spring 218 thus pushes second crush plate 207 against the second end 408 of the beverage tablet, resulting in a compressive force exerted on the beverage tablet 400 due to contact between the first and second crush plates 206 and 207. This compressive force may be sufficient to hold the beverage tablet 400 between the first crush plate 206 and second crush plate 207, but not sufficient to significantly deform the beverage tablet. Because a shorter beverage tablet would cause the spring 218 to compress less than a taller beverage tablet would, spring 218 may have mechanical properties (e.g. stiffness and length) sufficient to allow for beverage tablets having different heights to be inserted. The mechanical properties of the spring 218 may be selected such that the shortest desired beverage tablet is held with sufficient force between the first and second crush plates, and such that the tallest desired beverage tablet is not held with a compressive force sufficient to cause significant deformation of the beverage tablet.

[0056] In some embodiments, once the beverage tablet is held against the first crush plate 206 by the second crush plate 207, the grippers 220 may release from the beverage tablet 400. In some embodiments, as seen in FIG. 5, the sidewalls 210 of the second brew chamber section 204 may push the grippers 220 away from the beverage tablet 400 and out of the brew chamber volume 201. In some embodiments, the grippers 220 may be configured to lock into a gripper open position, such that the grippers 220 are prevented from moving back towards the beverage tablet 400 until the brew chamber 200 is moved back towards the open configuration.

[0057] The second brew chamber section 204 then slides to the fully extended position, where sidewalls 210 contact sealing ring 211 on the first brew chamber section, forming a brew chamber volume 201 as seen in FIG. 6. It should be understood that second brew chamber section 204 may press against a face surface of first brew chamber section 202 to form a face seal, as shown in FIG. 6, or may overlap with first brew chamber section 202 to form an overlapping seal, as the disclosure is not so limited.

[0058] Because the beverage tablet 400 may be held against the first crush plate either by the grippers or by the crush plates as the brew chamber moves to the closed configuration,

beverage tablet 400 may be approximately centered inside brew chamber volume 201 when in the closed configuration, such that an approximately equal gap G extends from an outer perimeter of the beverage tablet 400 to an inner perimeter of the sidewalls 210 along the entire outer perimeter of the beverage tablet 400.

[0059] In some embodiments, first brew chamber section 202 includes a brew chamber outlet 222 configured to connect to dispensing flow path 106 when the first brew chamber section 202 is in the horizontal-facing position, and to disconnect from the dispensing flow path 106 when the first brew chamber section 202 is not in the horizontal-facing position. Such a configuration may allow the brew chamber 200 to be connected to the dispensing flow path 106 without requiring flexible tubing or some other bending channel structure. In some embodiments, a sealing gasket may be positioned between brew chamber outlet 222 and dispensing flow path 106 to prevent the beverage from leaking.

[0060] FIGS. 6-9 show simplified cross section views of a brew chamber 200 in various stages of a brew operation. In some embodiments, as will be discussed further below, the beverage machine 100 may include a brew chamber fluid system 500. The brew chamber fluid system 500 may be configured to control the flow of water throughout the brew chamber 200 to perform various aspects of the brew operation.

[0061] Once the brew chamber 200 is in the closed configuration, the beverage tablet 400 may be pre-wet with liquid (e.g. water). Pre-wetting the beverage tablet allows for the coating 404 of the beverage tablet 400 to soften, allowing the coating 404 to be pierced and stretched without significant cracking or fracturing.

[0062] To pre-wet the tablet, liquid (e.g. water) is introduced into the brew chamber 200. In some embodiments, liquid is introduced into the brew chamber 200 through inlet puncture needles 232. In other embodiments, liquid is introduced into the brew chamber 200 via a different inlet. In some embodiments, the brew chamber may include a vent 246, which may be disposed in an upper portion of the sidewalls 210. The vent is configured to be opened while liquid is being introduced into the brew chamber 200. Such a vent 246 may allow ambient air in the brew chamber 200 to escape the brew chamber, allowing liquid to flow into the brew chamber. The beverage tablet 400 is then soaked for a suitable amount of time. In some embodiments, the suitable amount of time is 1-5 seconds. The liquid is then at least partially drained from the brew chamber via a drain 248, which may be disposed in a lower portion of the

sidewalls 210. In some embodiments, the drain leads to a disposal unit. In some embodiments, as discussed further below, liquid is introduced into the brew chamber 200 and drained from the brew chamber 200 via the brew chamber fluid system 500.

[0063] Once the beverage tablet is prewet, the plunger 212 is configured to move towards the beverage tablet. This causes first and second crush plates 206 and 207 to exert a compressive force on the beverage tablet 400 and causes the beverage tablet 400 to deform, as seen in FIG 7. In some embodiments, the vent 246 and drain 248 are open during deformation of the beverage tablet 400 in order to allow any remaining liquid from pre-wetting to exit the brew chamber 200.

[0064] In some embodiments, hydraulic pressure may be used to push the plunger 212. Liquid may be pumped into a hydraulic chamber 226 between plunger head 214 and hydraulic wall 228. The liquid expands the size of the hydraulic chamber 226 by pushing the plunger 212 towards the beverage tablet 400. In some embodiments, as discussed further below, brew chamber fluid system 500 may be configured to supply liquid to the hydraulic chamber 226. However, it is contemplated that any suitable mechanism may be used to push the plunger, such as a motor.

[0065] In some embodiments, as the beverage tablet 400 deforms, the beverage tablet diameter/width increases for at least a portion of the tablet, reducing gap G between the outer perimeter of the beverage tablet and the inner perimeter of the sidewalls 210. In some embodiments, as the beverage tablet deforms, the first end 406 conforms to the shape of first crush plate 206 and/or the second end 408 conforms to the shape of the second crush plate 207, sealing the beverage tablet against the first crush plate 206 and/or the second crush plate 207. More details regarding the crush plates 206 and 207 will be discussed further below.

[0066] The inlet piercing needles 232 are coupled to move with the plunger head 214, and are aligned with openings in the second crush plate 207. In some embodiments, initially, as seen in FIGS. 1-6, the inlet piercing needles 232 do not pass through the openings in the second crush plate 207, as the springs 230 bias the plunger head 214 away from the second crush plate 207. Thus, in some embodiments, prior to deformation of the beverage tablet, the inlet piercing needles 232 are not exposed in the brew chamber and do not make contact with the beverage tablet. Instead, the inlet piercing needles 232 are positioned behind the second crush plate 207. As the beverage tablet 400 deforms, the force exerted by the plunger 212 is sufficient to compress springs 230 between second crush plate 207 and the plunger head 214. This causes the

plunger head 214 to move towards the second crush plate 207 as the beverage tablet 400 is deformed, exposing inlet piercing needles 232. In alternative embodiments, inlet piercing needles 232 may be always disposed above the surface of second crush plate 207. More details regarding the inlet piercing needles will be discussed further below.

[0067] Inlet piercing needles 232 then fully pierce the coating 404 at the second end 406 and enter body 402 of the beverage tablet 400. In some embodiments, inlet piercing needles 232 are hollow needles fluidly connected to the upstream fluid system 300. In some embodiments, outlet piercing needles 234 may partially pierce the beverage tablet 400 when the beverage tablet 400 is deformed.

[0068] In some embodiments, liquid is then introduced into the beverage tablet 400 through the inlet piercing needles 232. This allows the liquid to contact the beverage material of the beverage tablet and form a beverage. This also causes the beverage tablet 400 to expand as liquid is pushed into the beverage tablet, as seen in FIG. 8. The beverage tablet expands until the first end contacts the outlet piercing needles 234. The outlet piercing needles 234 then pierce the beverage tablet, allowing the beverage to exit the brew chamber 200 via brew chamber outlet 222, and flow along dispensing flow path 106 to exit the beverage machine. In some embodiments, as discussed further below, liquid is introduced into the beverage tablet 400 via the brew chamber fluid system 500.

[0069] In some embodiments, a seal (e.g. a gasket) may be positioned on either dispensing flow path 106 or the brew chamber outlet 222. During a brew operation, pressure buildup in brew chamber 200 may tend to exert a force on the first brew chamber section 202, which will push the seal on the brew chamber outlet 222 against flow path 106 allowing for a tighter seal between the brew chamber outlet 222 and the flow path 106. In embodiments where the seal is positioned on the flow path 106 instead of the brew chamber outlet 222, pressure buildup in the brew chamber 200 will push the brew chamber outlet 222 against the seal of the flow path 106, allowing for a tighter seal between brew chamber outlet 222 and flow path 106. In some embodiments, the seal is a pressure activated seal, such that a fluid pressure of the beverage flowing through the brew chamber causes the seal to press against the brew chamber outlet 222 or flow path 106, further tightening the seal between the brew chamber outlet 222 and the dispensing flow path 106.

[0070] In some embodiments, as seen in FIG. 8, as the beverage tablet 400 expands, a portion of first end 406 expands into a recess 252 of the first crush plate 206, conforming to the shape of the first crush plate 206. The portion of first end 406 may therefore have a smaller diameter than the portion of the beverage tablet 400 which does not expand into the recess 252. As seen in FIG. 9, which shows the ejected beverage tablet after brewing, the resulting beverage tablet may have a stepped down portion 405 having a smaller diameter than the rest of the body 407. In some embodiments, it may be desirable to include a blocker plate 236 configured to selectively cover the outlet piercing needles 234. Such a blocker plate may reduce the likelihood of a piercing injury to the user as they load the beverage tablet into the beverage machine (as seen in FIG. 2). Also, in some embodiments, such a blocker plate may increase backpressure in the beverage tablet 400 during a brew operation, as pressure in the beverage tablet 400 must reach a pressure sufficient to push the blocker plate 236 and expose the outlet piercing needles 234. The blocker plate may include springs 238 configured to bias the blocker plate in an expanded configuration, where the blocker plate 236 covers the outlet piercing needles 234. As the beverage tablet 400 expands, springs 238 are compressed and the blocker plate 236 is pushed towards a compressed configuration, exposing the outlet piercing needles 234. More details about the outlet piercing needles 234 will be discussed below.

[0071] As seen in FIG. 9, in some embodiments, it may be desirable to automatically eject the beverage tablet 400 from the brew chamber 200 once a brew operation is complete without any interaction from the user. For instance, in embodiments where lid 102 is linked to the brew chamber 200, as discussed above, it may be desirable to eject the beverage tablet 400 from the brew chamber 200 without requiring actuation of the lid back to the lid open position. Therefore, hydraulic chamber 226 may be drained (as discussed further below) and/or the second brew chamber section 204 may be disengaged from a linkage connecting the second brew chamber section 204 with the rest of the brew chamber 200 and/or lid 102. In some embodiments, a solenoid is used to disconnect the second brew chamber section. Alternatively or in addition, as discussed further below, the second brew chamber section 204 is not connected to the lid 102 and/or first brew chamber section 202 via a linkage, and instead the second brew chamber section 204 may be moved between retracted and extended positions via some other means, such as a motor, a hydraulic actuator, or other suitable arrangement. The second brew chamber section 204 may then be moved towards the retracted position, e.g. via a biasing spring,

a motor, a hydraulic actuator, and/or any other suitable component. As the second brew chamber section is retracted, the compressive force on the beverage tablet is removed, and an opening 240 is exposed below the brew chamber 200. As mentioned above, the grippers 220 may be locked in a gripper open position until the brew chamber 200 is moved back towards the initial open position in which the brew chamber is configured to receive a beverage tablet, so the grippers 220 may not re-grasp the beverage tablet 400. With the second brew chamber section retracted and the compressive force on the beverage tablet removed, the springs 238 may then decompress, pushing the blocker plate 236 towards the expanded configuration, thereby pushing the beverage tablet 400 off of the outlet piercing needles 234 and away from the first brew chamber section, causing the beverage tablet 400 to fall through the opening 240. Alternatively, or in addition, springs 230 may push the second crush plate 207 to an expanded configuration, pushing the beverage tablet off of the inlet piercing needles 232 and away from the second brew chamber section, causing the beverage tablet 400 to fall through the opening 240. Pushing the beverage tablet 400 off the outlet piercing needles 234 and/or inlet piercing needles 232, causes the beverage tablet 400 to fall through the opening 240 out of the brew chamber. In some embodiments, the beverage tablet may fall into a disposal unit.

[0072] In some embodiments, the disposal unit is the same unit where liquid drains from the brew chamber during the pre-wetting operation and/or from the hydraulic actuator(s) after the brew operation is completed.

[0073] Once the rest of brew chamber 200 is moved back to the open configuration, e.g. by moving the lid 102 from the lid closed position to the lid open position, the brew chamber may reset for another brew operation.

Sensor System for Tablet Size Detection

[0074] As mentioned above, in some embodiments, beverage tablet 400 may be scalable along a height H and beverage machine 100 may be configured to form a beverage with beverage tablets 400 having different heights. In some embodiments, it may be desirable to utilize different brew parameters (e.g. crushing force, brew pressure, brew strength, precursor liquid volume, precursor liquid temperature, precursor liquid flow rate, precursor liquid pressure, etc., where water is an example of the precursor liquid) depending on the height of the beverage tablet 400 inserted. In some embodiments, it may be desirable to control the brew chamber fluid

system 500 to deliver liquid along different flow paths depending on the height of the beverage tablet 400 inserted. It may therefore be desirable for the beverage machine 100 to be configured to recognize which beverage tablet is placed in the beverage machine in order to control the upstream fluid system 300 and/or the brew chamber fluid system 500 accordingly. Additionally, or in the alternative, it may be desirable for the beverage machine 100 to be configured to recognize if the brew chamber 200 has been closed, but no beverage tablet 400 has been placed in the brew chamber 200 (in other words, an empty brew chamber 200).

[0075] While the imaging device 104 may be configured to recognize beverage tablet height, it may nevertheless be desirable to have an additional sensor system 241 configured to detect beverage tablet height to function as a backup (e.g. if the indicia on the beverage tablet is removed or not read by the imaging device), to function as a 2-step verification of the beverage tablet height, and/or to recognize if a beverage tablet has not been placed in the beverage machine 100 prior to closing of the brew chamber 200. FIGs. 10A-10C show schematic representations of the sensor system 241 detecting no beverage tablet (empty brew chamber), a shorter beverage tablet, and a taller beverage tablet, respectively. In some embodiments, the sensor system 241 may comprise a microswitch and one or more triggers that interact with one another. In some embodiments, a beverage machine may have no imaging device 104, and may only have a sensor system 241. In some embodiments, a beverage machine may have both an imaging device 104 and a sensor system 241, but may operate without the imaging device 104 (e.g. if the imaging device 104 is not functioning or otherwise unable to image a tablet, the beverage machine may still operate using only the sensor system 241).

[0076] In some embodiments, the second brew chamber section 204 may include a microswitch 242 and a trigger 244. One of the microswitch 242 or the trigger 244 may be disposed on sidewalls 210 or some other portion of the second brew chamber section 204, and the other of the microswitch 242 or trigger 244 may be disposed on the plunger 212 (e.g. on plunger shaft 216). As discussed above in relation to FIGs. 2-6, as or after the first brew chamber section 202 reaches the horizontal-facing position, second crush plate 207 contacts second end 408 of the beverage tablet 400. As the second brew chamber section 204 continues to translate towards the extended position, the plunger 212 stops translating due to the contact between the second crush plate 207 and the second end 408 of beverage tablet 400. If no beverage tablet 400 is in the brew chamber when the second brew chamber section 202 moves to the extended

position, as is the case in FIG. 10A, the second crush plate 207 does not contact any second end of a beverage tablet 400, the plunger 212 does not stop translating with the second brew chamber section 204, and the sidewalls 210 do not move relative to the plunger 212. As a result, trigger 244 never contacts microswitch 242 when no beverage tablet is present in the brew chamber. The controller 301 will then interpret receiving no signal from the microswitch 242 as detecting lack of presence of a beverage tablet 400 in the brew chamber. If a shorter beverage tablet 400 is in the brew chamber, as in FIG. 10B, the sidewalls 210 will move enough relative to the plunger 212 during movement of the second brew chamber section 204 to bring the microswitch 242 into contact with trigger 244, triggering the microswitch 242. The microswitch 242 will then send a signal that the microswitch is triggered to the controller 301. The controller 301 will interpret receiving a triggered signal as indicating that a shorter beverage tablet is in the beverage machine 100. If a taller beverage tablet 400 is in the brew chamber, as in FIG. 10C, the sidewalls 210 will move further relative to the plunger 212 during movement of the second brew chamber section 204 to the extended position than if a shorter beverage tablet 400 were present. In such a situation, the microswitch 242 (together with the sidewalls 210) will move far enough to be triggered by trigger 244, but then continue to move with the sidewalls 210 until the trigger 244 no longer contacts and triggers the microswitch 242. The controller 301 will interpret the microswitch being first triggered and then untriggered as corresponding to the taller beverage tablet 400.

[0077] In some embodiments, the controller 301 may be configured to automatically reset the second brew chamber section by controlling the second brew chamber section 204 to automatically move to the retracted position if no beverage tablet is detected in the brew chamber 200.

[0078] While the above microswitch and trigger system may distinguish between three different states (e.g. tall beverage tablet, short beverage tablet, and lack of a beverage tablet present in the brew chamber), it may be desirable to detect more than three states. Therefore, in some embodiments, the plunger 212 may have multiple triggers 244, as in FIG. 10D. In such a configuration, the controller 301 may be configured to detect how many times the microswitch has been triggered, as well as the final state (e.g. triggered or untriggered) of the microswitch, in order to determine the size and/or presence of a beverage tablet in the brew chamber 200. For instance, in the embodiment of FIG. 10D, the microswitch being triggered twice and left in the

triggered state, as seen in FIG. 10D, may correspond to a second tallest height beverage tablet, while the microswitch being triggered twice and left in an untriggered state may correspond to the tallest beverage tablet 400. Alternatively, in some embodiments, the microswitch 242 may be replaced by a different sensor, such as a potentiometer. The potentiometer may be linked to the plunger 212, such that the plunger 212 may adjust the electrical resistance of the potentiometer depending on the position of the plunger 212 relative to the sidewalls 210. This change in resistance may then be interpreted as a position by the controller 301.

[0079] Of course, any suitable mechanism for detecting the position of the plunger 212 relative to the sidewall 210 may be used. For instance, if a motor is used to drive the plunger 212 against the beverage tablet 400, motor position may be monitored to determine plunger position. Alternatively, the volume of liquid entering the hydraulic chamber 226 may be monitored (e.g. by measuring pump revolutions of a pump 312 of the upstream fluid system 300). Alternatively, a hall effect sensor, or any other suitable position sensing system may be used, as the present disclosure is not so limited.

[0080] Additionally, while some embodiments above disclose detecting size of a beverage tablet 400 as the second brew chamber section is moved to the extended position, it is contemplated that movement of the plunger 212 relative to other portions of the second brew chamber section 204 while the beverage tablet 400 is deformed during a brew operation may be used to detect size of the beverage tablet 400, as the disclosure is not so limited.

Upstream Fluid System

[0081] FIG. 11 is a schematic diagram of an upstream fluid system 300 of a beverage machine in an illustrative embodiment. As mentioned above, beverage machine 100 may include an upstream fluid system 300 located upstream of brew chamber 200. Upstream fluid system 300 may be configured to condition and deliver liquid from liquid supply 302 to the brew chamber fluid system 500, which may then deliver liquid to various components of the brew chamber 200. The upstream fluid system 300 may include, for example, a liquid supply, a liquid heater, pumps, and valves, to name a few components. The beverage machine 100 may include a controller 301 configured to receive a user's input from a user interface 110 and control the upstream fluid system 300 to deliver liquid to the brew chamber fluid system 500 with the desired brew parameters (e.g., temperature, volume, flow rate, etc.). Controller 301 may also be used to

control various controllable valves (e.g. solenoid valves, electric ball valves, etc.) in the brew chamber fluid system 500 in order to direct fluid flow along various flow paths, as discussed further below.

[0082] The upstream fluid system 300 may include a liquid supply 302, such as a cold-water tank. In general, the liquid supply may include a reservoir configured to hold liquid. The water level of the cold-water tank may be monitored by a sensor 304. If the sensor 304 detects that there is insufficient water in the cold-water tank, the sensor may send a signal to a user interface 110 to alert a user. Water from the cold-water tank may pass through a filter 308 and a check valve 310 before being pumped by a pump 312 into a hot water tank 314. The water may be heated within the hot water tank 314 (e.g., via a heating element inside the hot water tank 314), and/or may be heated while traveling along the pathway to the hot water tank 314 (e.g., via an in-line heater). An air pump 322 may be connected to the hot water tank 314 to introduce air into the hot water tank 314 for delivery of hot water to the brew chamber, and for purging the hot water tank and brew chamber fluid system of water and/or beverage. The beverage machine may include a pressure release valve 316 that may be connected to a pressure transducer 318 that monitors pressure levels. In the case that the pressure transducer determines that pressure levels are too high, the pressure release valve may reduce the pressure levels through a vent 320. In some embodiments, the vent 320 is passive, and not controllable. In embodiments in which the vent is controllable, the vent may be directly connected to the hot water tank.

[0083] While the above embodiments of upstream fluid system 300 disclose pump 312 as delivering water to hot water tank 314, and separate air pump 322 moving water from the hot water tank 314 and though brew chamber fluid system 500, it is contemplated that a single pump may move water through the entire upstream fluid system 300 and through the brew chamber fluid system 500. It should be understood that the upstream fluid system 300 disclosed in embodiments above is only exemplary, and that any upstream fluid system configured to condition and/or deliver liquid and/or air to a brew chamber may be used.

[0084] In some embodiments, it may be desirable to deliver unheated water to the brew chamber fluid system 500, e.g. to pre-wet the beverage tablet or to operate the hydraulic system. The upstream fluid system 300 may include a bypass valve 324 between pump 312 and hot water tank 314. In some embodiments, the bypass valve 324 may be controlled by the controller. In other embodiments, the bypass valve 324 may be passive. In some embodiments, the upstream

fluid system 300 may not include bypass valve 324, and heated water is used to pre-wet the beverage tablet and/or operate the hydraulic system.

[0085] In some embodiments, the controller may be configured to detect the beverage tablet height H using sensor system 241. In some embodiments, the controller may control the upstream fluid system to deliver water to the brew chamber fluid system 500 with parameters (e.g. pressure, volume, etc.) and/or control the brew chamber fluid system to deliver water along different flow paths based on the detected height. In some embodiments, the controller may present various options to a user (e.g. beverage volume options) based on the detected height H.

[0086] The beverage machine 100 may include a user interface 110 to allow a user to control the beverage machine. A user interface may include one or more of the following: a display, one or more buttons, and one or more indicator lights. The user may provide commands to the beverage machine through the user interface 110 by, for example, pressing a button or touching a touch screen. The beverage machine may activate a beverage forming cycle, or may perform various other functions in response to the commands from the user. For example, a beverage having a first set of brew parameters (e.g. temperature, volume, strength, etc.) may be formed by the beverage machine 100 in response to a user inputting a first set of commands via the user interface, while a beverage having a second set of brew parameters may be formed by the beverage machine 100 in response to a user inputting a second set of commands via the user interface. Information may be communicated to the user through a display or indicator lights of the user interface.

[0087] It should be understood that a user interface may include any number or combination of the above-mentioned components, or any other appropriate components. In some embodiments, a user interface may include only a single touch screen that both receives commands from a user and communicates information to the user. In other embodiments, a user interface may include multiple buttons and multiple indicator lights. A user interface may include knobs, scroll wheels, mechanical switches, microphones, touch sensors, light sensors, or any other suitable components configured to receive input from a user. Additionally, a user interface may include displays, lights, speakers, haptic devices, or any other suitable components configured to provide information to a user.

Brew chamber Fluid System

[0088] As discussed above, in some embodiments, the beverage machine may have a brew chamber fluid system configured to receive water from the upstream fluid system and control the flow of the water to various components of the brew chamber 200 to perform various steps for forming the beverage (e.g. pre-wetting the beverage tablet, compressing and deforming the beverage tablet, delivering water into the beverage tablet to form the beverage, and dispensing the beverage out of the dispensing outlet.) FIGS. 12 and 13 show an embodiment of a brew chamber 200 with inlets and outlets configured to link the brew chamber 200 to the brew chamber fluid system 500. FIGs. 14A and 14B show schematic representations of the brew chamber fluid system 500. It should be understood that the brew chamber configuration shown in FIGS. 12-14 and described herein may be incorporated into the previously described embodiments shown in FIGS. 1-9. It should also be understood that features of the embodiment shown in FIGS. 1-9 may be incorporated into the embodiment of FIGS. 12-14B. For example, the rotating brew chamber section arrangement and/or grippers described in FIGS. 1-9 may be used in the FIGS. 12-14B arrangement.

[0089] Pump 312 and/or air pump 322 may be configured to deliver water from the upstream fluid system 300 to the brew chamber fluid system 500. In some embodiments, the brew chamber fluid system may then split into a plurality of flow paths.

[0090] In some embodiments, the brew chamber fluid system may include a pre-wet flow path 501. Pre-wet flow path 501 may be fluidly connected to brew chamber inlet 512, and may be configured to deliver water into the brew chamber 200 during pre-wetting of the beverage tablet 400. The pre-wet flow path 501 may include a pre-wet valve 502. The pre-wet valve 502 may be a controllable valve, such as a solenoid valve or an electric ball valve. When pre-wet valve 502 is closed, liquid is prevented from flowing to brew chamber inlet 512. When pre-wet valve 502 is open, liquid is permitted to flow to brew chamber inlet 512.

[0091] In some embodiments, the brew chamber fluid system may include an inlet needle flow path 503. The inlet needle flow path 503 may be fluidly connected to needle inlet 518, and may be configured to deliver water through the inlet needles and into the beverage tablet during formation of the beverage. Inlet needle flow path 503 may include inlet needle valve 504. In some embodiments, inlet needle valve is a controllable valve. In some embodiments, inlet needle valve is a passive valve with a preset cracking pressure. Inlet needle valve may have a higher cracking pressure than pre-wet valve 502 when pre-wet valve 502 is open. In some

embodiments, inlet needle valve 504 has a cracking pressure between 50 psi and 100 psi, although any suitable cracking pressure is contemplated.

[0092] In some embodiments, pre-wet flow path 501 may fluidly connect a portion of the inlet needle flow path 503 upstream of the inlet needle valve 504 with a portion of the inlet needle flow path 503 downstream of the inlet needle valve 504. In this way, pre-wet flow path may act as a bypass of inlet needle check valve 504, with pre-wet valve 502 permitting or preventing bypass of inlet needle valve 504. In these embodiments, water may be delivered through the inlet needles 232 in order to pre-wet the beverage tablet.

[0093] In some embodiments, the brew chamber fluid system may include a hydraulic chamber flow path 505. The hydraulic chamber flow path 505 may be fluidly connected to hydraulic chamber inlet 516, and may be configured to deliver liquid to the hydraulic chamber to compress and deform the beverage tablet. Hydraulic flow path 505 may include hydraulic chamber valve 506. In some embodiments, the hydraulic chamber valve is a controllable valve. In some embodiments, the hydraulic chamber valve is a passive valve with a preset cracking pressure. The hydraulic chamber valve 506 may have a higher cracking pressure than pre-wet valve 502, but a lower cracking pressure than inlet needle valve 504. In some embodiments, hydraulic chamber valve 506 has a cracking pressure of between 15 psi and 35 psi, although any suitable cracking pressure is contemplated.

[0094] In some embodiments, such as the embodiment shown in FIGs. 14A and 14B and discussed below, the brew chamber fluid system may include all three of the pre-wet flow path, inlet needle flow path, and hydraulic chamber flow path. However, in other embodiments, a pre-wet flow path is not included, and only an inlet needle flow path and hydraulic chamber flow path is included. In yet other embodiments, a hydraulic chamber flow path is not included, and only a pre-wet flow path and an inlet needle flow path is included. Additionally, in some embodiments, as shown in FIGs. 14A and 14B, the inlet needle flow path 503 and the hydraulic chamber flow path 505 diverge upstream of the of the brew chamber volume 201/601 and the hydraulic chamber 226/698. However, it is contemplated that in some embodiments, the inlet needle flow path 503 may extend from the hydraulic chamber 226/698, such that liquid flowing to the inlet needles first flows through the hydraulic chamber rather than bypassing the hydraulic chamber, as the disclosure is not so limited.

[0095] When liquid is initially delivered to the brew chamber fluid system 500 from the upstream fluid system 300, liquid may flow along all three flow paths 501, 503, and 505 until the liquid reaches valves 502, 504, and 506. During the pre-wetting phase, pre-wet valve 502 is opened. Liquid therefore flows along the pre-wet flow path 501, through pre-wet inlet 512, and into the brew chamber 200. In some embodiments, liquid may be delivered to brew chamber 200 in a steady flow. In some embodiments, the liquid is delivered to the brew chamber in a series of pulses. In some embodiments, 1-3 pulses are used to deliver the liquid to the brew chamber 200. In some embodiments, delivering liquid to the brew chamber 200 during pre-wetting may cause the liquid to mix with ambient air in the brew chamber, compressing the ambient air and increasing the internal pressure in the brew chamber. During or after pre-wetting is completed, pre-wet valve 502 is closed to prevent liquid from continuing to flow through prewet flow path 501. In some embodiments, once pre-wetting is complete, the beverage machine may have a chamber drain valve 507 that is then opened to allow the liquid in the brew chamber to drain into disposal unit 250. In some embodiments, chamber drain valve 507 is a passive valve with a cracking pressure above ambient pressure when the chamber drain valve is open, such that liquid in the brew chamber 200 must be above ambient pressure in order to flow through chamber drain valve when the chamber drain valve is open.

[0096] Once pre-wet valve 502 is closed, pressure in the flow paths 501, 503, and 505 upstream of valves 502, 504, and 506 builds up until pressure in the hydraulic chamber flow path 505 reaches the cracking pressure of the hydraulic chamber valve 506 and opens the hydraulic chamber valve, allowing water to flow into hydraulic chamber 226 through hydraulic chamber inlet 516. Alternatively, in some embodiments, hydraulic chamber valve 506 is a controllable valve, and is opened once the pre-wet operation is completed. In some embodiments, water mixes with ambient air in the hydraulic chamber, forming an air/water mix in the hydraulic chamber. As seen in FIGs. 12-13, as liquid flows into hydraulic chamber 226, the plunger 212 is pushed against the beverage tablet 400. Pressure buildup in the hydraulic chamber causes the plunger 212 to continue to move towards the beverage tablet, compressing and deforming the beverage tablet and piercing the beverage tablet with inlet piercing needles 232.

[0097] During compression and deformation, pressure in the hydraulic chamber 226, and thus in the flow paths 501, 503, and 505 continues to increase until the pressure in the inlet needle flow path 503 is high enough to reach the cracking pressure of the inlet needle valve 504

and open the inlet needle valve. Alternatively, inlet needle valve may be a controllable valve that is controlled by the controller 301 to open when the beverage tablet 400 is sufficiently deformed. To introduce the liquid to the beverage tablet, water flows towards needle inlet 518, through the inlet piercing needles 232, and into the beverage tablet 400.

[0098] As discussed above with respect to FIGS. 1-9, as liquid flows into the beverage tablet, the beverage tablet expands towards the outlet piercing needles 234, allowing the outlet piercing needles to pierce the beverage tablet and to allow the beverage to exit the beverage tablet.

[0099] In some embodiments, as the beverage exits the beverage tablet through the outlet piercing needles 234, the beverage tablet loses mass due to beverage material exiting the beverage tablet as part of the formed beverage. This allows plunger 212 to move further towards the first crush plate 206, increasing the size of the hydraulic chamber 226 and lowering the pressure in the hydraulic chamber 226. In some embodiments, if the pressure in the hydraulic chamber decreases below the cracking pressure of the inlet needle valve 504, the inlet needle valve closes and water flows into the hydraulic chamber 226 through hydraulic chamber flow path 505 until pressure is again above the inlet needle valve cracking pressure, at which point water resumes flowing through the inlet needle flow path 503.

[00100] In some embodiments, instead of inlet needle valve 504 and hydraulic chamber valve 506 being passive valves with preset cracking pressures, the inlet needle valve 504 and hydraulic chamber valve 506 may be actively controlled valves. The brew chamber fluid system 500 may include a pressure transducer upstream of the valves 504 and 506, which may be configured to measure the pressure in the brew chamber fluid system 500 and send a signal to a controller, such as controller 301. In such a configuration, after the pre-wet operation, the hydraulic chamber valve 506 may be opened, and water may be pumped into the hydraulic chamber until the pressure reaches a threshold pressure. Once the pressure transducer senses that the hydraulic chamber has reached the threshold pressure, the pressure transducer sends a signal to the controller, which then closes the hydraulic chamber valve 506 and opens the inlet needle valve 504.

[00101] In some embodiments, such a configuration of actively controlled hydraulic chamber valves and inlet needle valves may allow for customization of the amount of pressure buildup in the hydraulic chamber, allowing for variance in the amount of crush force applied to

the beverage tablet in different beverage forming operations. A higher threshold pressure to close the hydraulic chamber valve 506 may lead to a higher crush force. Likewise, a lower threshold pressure to close the hydraulic chamber valve 506 may lead to a lower crush force. For instance, in some embodiments the threshold pressure to close the hydraulic chamber valve 506 may be set by a user, either directly or in response to a selected beverage type (e.g. selecting an espresso beverage may cause the controller to set a higher threshold pressure than selecting drip coffee would, leading to a higher crush force exerted on the beverage tablet when forming an espresso beverage). In some embodiments, the threshold pressure may be set based on a parameter of the beverage tablet itself. For instance, imaging device 104 and/or sensor system 241 may be configured to detect one or more parameters of the beverage tablet (e.g. height, diameter, grind size, roast level, etc.), and the controller 301 may be configured to automatically set a threshold pressure based on these one or more parameters. In some embodiments, the detected size of a tablet may trigger the beverage machine to automatically set an associated threshold pressure. For example, in some embodiments, a tablet of the tallest size may be associated with drip coffee, and if the tallest size tablet is detected, the controller may automatically instruct the beverage machine to utilize a lower crush force (and may use a lower threshold pressure to achieve this). In some embodiments, a tablet of the shortest size may be associated with espresso coffee (or other high pressure brewing method), and if the shortest size tablet is detected, the controller may automatically instruct the beverage machine to utilize a higher crush force (and may use a higher threshold pressure to achieve this). In some embodiments, the automatically set threshold pressure may be alterable by a user via user interface 110.

[00102] Once a brew operation is completed, hydraulic chamber drain valve 524 may be opened to allow water to drain from the hydraulic chamber 226. In some embodiments, the hydraulic chamber drain valve is a controllable drain valve. In some embodiments, the water drains from the hydraulic chamber into the disposal unit 250. In some embodiments, after the second brew chamber section has been moved to the retracted position, the upstream fluid system 300 may be configured to deliver some additional water to the hydraulic chamber 226 before opening the hydraulic chamber drain valve in order to ensure the plunger 212 has moved back to the extended position shown in FIG. 2.

[00103] In some embodiments, it may be desirable to include a variable brew pressure system downstream of the brew chamber 200 to allow for brewing beverages at different brew

pressures. Such a configuration may be desirable to allow for brewing of different styles of beverages which require different brew pressures. For instance, it may be desirable to brew at a higher brew pressure to allow for the formation of crema when brewing an espresso, and it may be desirable to brew with a lower brew pressure when brewing a drip coffee beverage.

[00104] In some embodiments, it may therefore be desirable for the brew chamber 200 to include a high pressure outlet flow path 520 and a low pressure outlet flow path 522. High pressure outlet flow path may include a high-pressure valve 508, such as a passive check valve with a cracking pressure sufficient to allow for the formation of crema. Low pressure flow path may include a low pressure valve 510. Low pressure valve 510 may be controllable by the controller 301. If a low pressure brew is desired, the low pressure valve 510 may be opened. Beverage may then flow along the low pressure flow path to the dispensing flow path 106 and out the dispensing outlet. If a high pressure brew is desired, the low pressure valve 510 may be closed. This causes pressure to increase upstream of the high pressure check valve during a brew operation until a sufficient pressure is reached to open high pressure check valve 508, allowing the beverage to flow along the high pressure flow path to the dispensing flow path 106 and out the dispensing outlet.

[00105] In some embodiments, one or more detected tablet parameters, such as size, of a tablet may trigger the beverage machine to automatically set brew pressure. Imaging device 104 and/or sensor system 241 may be configured to detect one or more parameters of the beverage tablet (e.g. height, diameter, grind size, roast level, etc.), and the controller 301 may be configured to automatically set a brew pressure based on these one or more parameters. In some embodiments, the detected size of a tablet may trigger the beverage machine to automatically set an associated brew pressure. For example, in some embodiments, a tablet of the tallest size may be associated with drip coffee, and if the tallest size tablet is detected, the controller may automatically instruct the beverage machine to utilize a lower brew pressure. In some embodiments, a tablet of the shortest size may be associated with espresso coffee (or other high pressure brewing method), and if the shortest size tablet is detected, the controller may automatically instruct the beverage machine to utilize a higher brew pressure. In some embodiments, the automatically set brew pressure may be alterable by a user via user.

[00106] In some embodiments, it may be desirable to deliver air along the brew chamber fluid system 500 to purge the brew chamber of water during various stages of a brew operation.

For instance, it may be desirable to purge the brew chamber of water after the pre-wet operation by delivering a quantity of air through the pre-wet inlet 512. It may also be desirable to deliver a quantity of air through the hydraulic chamber inlet 516 to purge the hydraulic chamber of liquid after a brew operation is complete. It may also be desirable to deliver a quantity of air through the needle inlet 518, beverage tablet 400, high and/or low pressure outlet flow paths, and dispensing flow path, to purge any remaining liquid and/or beverage from these components after a brew operation is complete. The upstream fluid system 300 may therefore include an air pump configured to pump air through the brew chamber fluid system 500. In some embodiments, this air pump may be air pump 322 discussed above. In some embodiments, this air pump may be a separate air pump from air pump 322 discussed above.

[00107] FIG. 14B shows an alternative schematic representation of a brew chamber fluid system 500' for use with brew chamber 600. In embodiments where the second brew chamber section is movable via a hydraulic actuator, such as with brew chamber 600, the brew chamber fluid system 500' may include a fourth flow path 525 which may be configured to deliver water to the hydraulic chamber 652 via the inlet 656. The fourth flow path 525 may include a controllable valve 526 configured to control the flow of water to the hydraulic chamber 652. The fourth flow path 525 may also include a controllable drain valve 528 configured to selectively allow water to drain from the hydraulic chamber 652 to a disposal unit 696. In all other respects, the brew chamber fluid system 500' depicted in FIG. 14B may function similarly to the brew chamber fluid system 500 in FIG. 14A (e.g. by delivering water to and draining water from brew chamber 601, and/or plunger hydraulic chamber 698).

Backpressure Valve Arrangement

[00108] As discussed above, the inventors have recognized that it may be desirable to include a high-pressure valve 508 in a high pressure outlet flow path 520 and a controllable low-pressure valve 510 in a low pressure outlet flow path 522 to allow for both a high brew pressure operation mode (e.g. for espresso), and a low brew pressure mode (e.g. for drip coffee).

[00109] The inventors have recognized that, in some embodiments, rather than including two separate valves on two separate flow paths, it may be desirable to incorporate a single valve downstream of the brew chamber configured to operate in both a high brew pressure mode and a low brew pressure mode. Such a configuration may reduce the number of components needed to

build the beverage machine, potentially reducing complexity, size, and cost of the beverage machine.

[00110] FIGs. 15A and 15B show schematic representations of a solenoid valve 800 in an closed position and an open position, respectively. The solenoid valve 800 may include a valve portion 802 and a solenoid 804. The valve portion 802 may include an inlet conduit 806 extending from valve inlet 808 to a valve seat 810, and an outlet conduit 812 extending from valve seat 810 to valve outlet 814.

[00111] The solenoid valve 800 may include a plunger 816 configured to move between a closed position and an open position. In the closed position, as seen in FIG. 15A, a plunger head 818 of the plunger 816 abuts the valve seat 810, blocking the flow of fluid from the inlet conduit 806 to the outlet conduit 812. In some embodiments, the plunger 816 may be biased to the closed position via valve spring 820. In the open position, as seen in FIG. 15B, the solenoid 804 may be actuated to move the plunger 816 to a retracted position, where the plunger head 818 no longer contacts the valve seat 810, allowing fluid to flow from the inlet conduit 806 to the outlet conduit 812.

[00112] The inlet conduit 806 is arranged to direct upstream fluid (e.g. formed beverage from the brew chamber) directly against face 822 of the plunger head 818 when the plunger 816 is in the closed position. In some embodiments, at least a portion of the inlet conduit 806 extends approximately parallel to a direction of travel of the plunger 816. As a result, the upstream fluid exerts a force on the plunger 816, tending to push the plunger 816 towards the open position against the biasing force from valve spring 820. The force exerted by the upstream fluid may be equal to the contact area between the fluid and face 822 (where the contact area may be equal to the area of the opening 811) multiplied by the fluid pressure. As a result, when the plunger 816 is in the closed position, fluid pressure upstream of the plunger 816 may continue to increase until a threshold cracking pressure is reached, where the fluid in the inlet conduit 806 pushes the plunger 816 towards the open position, allowing fluid to flow from the inlet conduit 806 to the outlet conduit 812, and out of the solenoid valve 800.

[00113] Thus, when a high pressure brew is desired, the solenoid valve 800 may be placed in a first operation mode (e.g. a high brew pressure mode), where the solenoid 804 is not actuated, allowing the valve spring 820 to bias the plunger 816 to the closed position, as shown in FIG. 15A. In this first operation mode, the solenoid valve 800 acts like a check valve,

preventing fluid flow through the solenoid valve 800 until fluid pressure upstream of the solenoid valve 800 reaches a threshold cracking pressure sufficient to overcome the biasing force of the valve spring 820 and push the plunger 816 towards the open position. The threshold cracking pressure may be altered by altering the spring constant of the selected valve spring 820 and/or by changing the contact surface area of face 822 with inlet conduit 806 at valve seat 810 (e.g. by changing the size of the opening 811). In some embodiments, the threshold cracking pressure is between 60 psi and 100 psi.

[00114] When a low pressure brew is desired, the solenoid valve 800 may be placed in a second operation mode (e.g. a low brew pressure mode), where the solenoid 804 is actuated to move the plunger 816 to the open position, as shown in FIG. 15B. As a result, fluid is able to flow through the solenoid valve 800 without needing to build up pressure, resulting in a lower brew pressure in the brew chamber.

[00115] In some embodiments, the controller may automatically initiate an operation mode (e.g. low brew pressure or high brew pressure) based on the type of tablet detected by the imaging device 104 and/or sensor system 241. For example, in some embodiments, a tablet of the tallest size may be associated with drip coffee, and if the tallest size tablet is detected, the solenoid may be operated in a low brew pressure mode, where the solenoid is actuated to move the plunger 816 to the open position. In some embodiments, a tablet of the shortest size may be associated with espresso coffee (or other high pressure brewing method), and if the shortest size tablet is detected, the solenoid 804 may remain unactuated, allowing the valve spring 820 to bias the plunger 816 to the closed position. In some embodiments, the automatically set operation mode (e.g. low brew pressure or high brew pressure) may be alterable by a user via user.

[00116] While the present teachings have been described in conjunction with various embodiments and examples, it is not intended that the present teachings be limited to such embodiments or examples. On the contrary, the present teachings encompass various alternatives, modifications, and equivalents, as will be appreciated by those of skill in the art. Accordingly, the foregoing description and drawings are by way of example only.

CLAIMS

What is claimed is:

1. A beverage machine comprising:

a machine housing;

a liquid supply configured to provide a liquid for forming a beverage;

a brew chamber configured to hold a beverage tablet for mixing with liquid from the liquid supply to form a beverage; and

a sensor configured to detect a size of a beverage tablet in the brew chamber based on a physical dimension of the beverage tablet and to communicate a signal corresponding to the detected size to a controller of the beverage machine.

2. The beverage machine of claim 1, wherein the sensor is configured to detect a lack of a beverage tablet present in the brew chamber.

3. The beverage machine of claim 1, wherein the sensor comprises a microswitch configured to be triggered when a beverage tablet of a first size is present in the brew chamber, and configured to not be triggered when a beverage tablet of a second size is present in the brew chamber, the first size being different than the second size.

4. The beverage machine of claim 3, wherein the sensor is configured to detect a lack of a beverage tablet present in the brew chamber, and wherein the microswitch is configured to be triggered, then untriggered when no beverage tablet is present in the brew chamber.

5. The beverage machine of claim 1, wherein the controller is configured to control at least one fluid parameter of the liquid based on the size of the beverage tablet detected by the sensor.

6. The beverage machine of claim 1, wherein the physical dimension comprises a height of the beverage tablet.

7. The beverage machine of claim 1, wherein a volume of the brew chamber is configured to adapt to correspond to the size of the beverage tablet.

8. The beverage machine of claim 1, wherein the brew chamber comprises a first brew chamber section and a second brew chamber section, the second brew chamber section configured to translate from a retracted position to an extended position to mate with the first brew chamber section to form a closed configuration of the brew chamber.

9. The beverage machine of claim 8, wherein the sensor is disposed in the second brew chamber section.

10. The beverage machine of claim 9, wherein the second brew chamber section comprises a plunger configured to contact the beverage tablet when the second brew chamber section is moved to the extended position, wherein the plunger is configured to move relative to a sidewall of the second brew chamber section due to the contact between the beverage tablet and the plunger, and wherein the sensor is configured to detect the size and/or presence of a beverage tablet in the brew chamber based on a position of the plunger relative to the sidewall after the second brew chamber section has been moved to the extended position.

11. The beverage machine of claim 10, wherein the sensor comprises a microswitch disposed on one of the plunger or the sidewall, and further comprising at least one trigger disposed on the other of the plunger or the sidewall, wherein the at least one trigger is configured to selectively trigger the microswitch depending on the position of the plunger relative to the sidewall after the second brew chamber section has been moved to the extended position.

12. The beverage machine of claim 11, wherein the controller is configured to determine the size and/or presence of a beverage tablet in the brew chamber based at least partially on a number of times the microswitch has been triggered by the at least one trigger as the second brew chamber section moves to the extended position.

13. The beverage machine of claim 12, wherein the controller is configured to determine the size and/or presence of a beverage tablet based on a combination of the number of times the microswitch has been triggered by the at least one trigger as the second brew chamber section moves to the extended position, as well as a final triggered or untriggered state of the microswitch once the second brew chamber section is in the extended position.

14. The beverage machine of claim 8, wherein the sensor is configured to detect a lack of a beverage tablet present in the brew chamber, and wherein the second brew chamber section is configured to automatically move to the retracted position if no beverage tablet is detected in the brew chamber.

15. A method of determining a size and/or presence of a beverage tablet in a beverage machine, the method comprising:

receiving a beverage tablet into a portion of a brew chamber;

closing the brew chamber; and

determining a size of the beverage tablet using one or more sensors configured to detect a physical dimension of the beverage tablet during and/or after closing of the brew chamber.

16. The method of claim 15, wherein the physical dimension comprises a height of the beverage tablet.

17. The method of claim 15, wherein closing the brew chamber comprises moving a second brew chamber section from a retracted position to an extended position to mate with a first brew chamber section.

18. The method of claim 17, further comprising moving a plunger disposed in the second brew chamber section relative to a sidewall of the second brew chamber section via contact between the plunger and the beverage tablet as the second brew chamber section moves to the extended position.

19. The method of claim 18, wherein detecting the size of the beverage tablet comprises detecting the position of the plunger relative to the sidewall after the second brew chamber section moves to the extended position.

20. The method of claim 19, wherein the sensor comprises a microswitch, and wherein detecting the position of the plunger relative to the sidewall comprises selectively triggering the microswitch with at least one trigger as the plunger moves relative to the sidewall.

21. The method of claim 20, wherein the detected position of the plunger relative to the sidewall is determined at least partially based on a number of times the microswitch is triggered as the second brew chamber section moves to the extended position.

22. The method of claim 21, wherein the detected position of the plunger relative to the sidewalls is determined at least partially based on a number of times the microswitch is triggered as the second brew chamber section moves to the extended position, and a final triggered or untriggered state of the microswitch when the second brew chamber section is in the extended position.

23. The method of claim 15, further comprising forming a beverage by:

introducing liquid from a liquid supply into the brew chamber and to the beverage tablet to form a beverage, wherein at least one fluid parameter of the liquid is based on the detected size; and

dispensing the beverage.

24. The method of claim 23, wherein introducing liquid to the beverage tablet comprises piercing the beverage tablet with a least one inlet needle and injecting the liquid into the beverage tablet.

25. The method of claim 24, further comprising a step of prewetting the beverage tablet to soften a coating on an outside of the beverage tablet, wherein the step of prewetting comprises introducing prewetting liquid into the brew chamber.

26. The method of claim 15, further comprising detecting presence or lack of presence of a beverage tablet in the brew chamber after closing the brew chamber.

27. The method of claim 26, further comprising opening the brew chamber if no beverage tablet is detected in the brew chamber.