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 63/564,222, filed March 12, 2024, and 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 embodiments, a beverage machine is provided. The beverage machine comprises a liquid supply configured to provide a liquid for forming a beverage, a brew chamber configured to receive a beverage tablet, the brew chamber being fluidly connected to the liquid supply via a first flow path, the brew chamber comprising a first crush plate and a second crush plate, and a hydraulic chamber fluidly connected to the liquid supply via a second flow path. The first flow path diverges from the second flow path upstream of the brew chamber and the hydraulic chamber. The hydraulic chamber is configured to move at least one of the first and second crush plates to compress and deform the beverage tablet between the first crush plate and the second crush plate as liquid enters the hydraulic chamber from the liquid supply.

[0005] According to some embodiments, a method of forming a beverage is provided, the method comprising receiving a beverage tablet between a first crush plate and a second crush plate of a brew chamber, the second crush plate being operatively connected to a hydraulic chamber, introducing liquid from a liquid supply into the hydraulic chamber to

increase a volume of the hydraulic chamber and move the second crush plate towards the first crush plate, compressing and deforming the beverage tablet between the first crush plate and the second crush plate as the volume of the hydraulic chamber increases, and introducing liquid from the liquid supply to the beverage tablet. The liquid introduced to the beverage tablet bypasses the hydraulic chamber as the liquid moves from the liquid supply to the beverage tablet.

[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. 10 shows a perspective view of a brew chamber according to an embodiment;

[0018] FIG. 11 shows a sectional view of the brew chamber of FIG. 10 with a second brew chamber section in a retracted configuration;

[0019] FIG. 12 shows a sectional view of the brew chamber of FIG. 10 with a second brew chamber section in an extended configuration;

[0020] FIG. 13A shows a partial side section view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator retracted position;

[0021] FIG. 13B shows a top sectional view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator retracted position;

[0022] FIG. 13C shows a bottom view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator retracted position;

[0023] FIG. 14A shows a partial side section view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator extended position;

[0024] FIG. 14B shows a top sectional view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator extended position;

[0025] FIG. 14C shows a bottom view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator extended position;

[0026] FIG. 15A shows a partial side section view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator partially retracted position;

[0027] FIG. 15B shows a top sectional view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator partially retracted position;

[0028] FIG. 15C shows a bottom view of the brew chamber of FIG. 10 with a brew chamber actuator in an actuator partially retracted position;

[0029] brew chamberFIG. 16A shows a simplified cross-sectional view of a sensor assembly of the brew chamber of FIG. 2 sensing a lack of a beverage tablet;

[0030] FIG. 16B 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;

[0031] FIG. 16C 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;

[0032] FIG. 16D 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;

[0033] FIG. 17 is a schematic representation of an upstream fluid system of a beverage machine according to an embodiment;

[0034] FIG. 18 is a cross-sectional view of a brew chamber of a beverage machine according to an embodiment;

[0035] FIG. 19 is a cross-sectional view of the brew chamber of FIG. 18 with a hydraulic chamber of the brew chamber in a filled configuration;

[0036] FIG. 20A is a schematic representation of a brew chamber fluid system according to an embodiment;

[0037] FIG. 20B is a schematic representation of a brew chamber fluid system according to an alternative embodiment;

[0038] FIG. 21A shows a schematic representation of a solenoid valve in a closed position according to an embodiment;

[0039] FIG. 21B shows a schematic representation of the solenoid valve of FIG. 21A in an open configuration according to an embodiment;

[0040] FIG. 22 is a perspective view of a portion of a brew chamber including a first crush plate according to an embodiment;

[0041] FIG. 23 is a perspective view of a portion of a brew chamber including a second crush plate according to an embodiment;

[0042] FIG. 24 is a cross-sectional side view of the portion of the brew chamber of FIG. 23;

[0043] FIG. 25A is a front view of the portion of the brew chamber of FIG. 23;

[0044] FIG. 25B is a front view of the portion of the brew chamber of FIG. 22; and

[0045] FIG. 26 shows a cross-sectional side view of a portion of a brew chamber according to an embodiment.

DETAILED DESCRIPTION

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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).

[0050] 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.

[0051] 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.

[0052] 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.

[0053] 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.

[0054] 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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

[0062] 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.

[0063] 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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.

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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.

[0084] The inlet piercing needles 232 are coupled to move with the plunger head 214, and are aligned with openings 213 (see FIG. 26) 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.

[0085] 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.

[0086] 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.

[0087] 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.

[0088] 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.

[0089] 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 (such as brew chamber actuator 648 discussed below), 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 250.

[0090] 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.

[0091] 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.

Hydraulics for closing the second brew chamber section

[0092] FIG. 10 shows a perspective view of a brew chamber 600 of a beverage machine in a closed configuration according to an embodiment. FIGs. 11 and 12 show cross-sectional views of brew chamber 600 with second brew chamber section 646 in respective retracted and extended positions. In some embodiments, as discussed above, a hydraulic arrangement may be used to move second brew chamber section 646 from the retracted position shown in FIG. 11 to the extended position (also referred to as the closed position) shown in FIG. 12 to form an enclosed brew chamber volume 601. The second brew chamber section 646 may be operatively coupled to a brew chamber actuator 648, which includes

hydraulic chamber 652 and brew chamber piston 654. The brew chamber actuator 648 may be actuated by any suitable mechanism to move the second brew chamber section 646 to the closed position. For instance, in some embodiments, a microswitch 650 (see FIG. 10) may detect closure of the lid 608 as the lid 608 is closed. In some embodiments, closure of the lid causes a component that is coupled to or part of the lid to make contact with the microswitch, and opening the lid causes the component to cease making contact with the microswitch. In other embodiments, the opposite may occur – opening the lid causes a component that is coupled to or part of the lid to make contact with the microswitch, and closing the lid causes the component to cease making contact with the microswitch. When the microswitch detects closure of the lid 608, the controller may be triggered to actuate the brew chamber actuator 648 to move the brew chamber section to the closed position.

[0093] After the brew chamber actuator 648 is actuated, an upstream fluid system (see, e.g. upstream fluid system 300 discussed below) may deliver fluid to the hydraulic chamber 652 via inlet 656, which causes the brew chamber piston 654 to move to the extended position. As seen in FIGs. 11 and 12, an edge 688 of the brew chamber piston 654 may contact the chamber contact member 690 of the second brew chamber section 646 to move the second brew chamber section 646 to the extended position. In some embodiments, after a brew operation is completed, the hydraulic chamber 652 may be drained via outlet 658, to a disposal unit, and piston spring(s) 660 and chamber spring(s) 661 (discussed below and shown in FIGs. 13C, 14C, and 15C) may act to move the brew chamber piston back to the retracted position.

Brew Chamber Lock

[0094] In some embodiments, the inventors have recognized that it may be desirable for the second brew chamber section 646 to lock against the frame 604 in the extended position, as such a configuration may distribute forces from built-up pressure in the enclosed brew chamber volume 601 to the frame 604 rather than concentrating such forces on an actuator which moves the second brew chamber section to the extended position (e.g. brew chamber actuator 648, a motor, etc.). Such a configuration may limit the likelihood of the second brew chamber section 646 moving to the retracted position during a beverage forming operation. Additionally, locking the second brew chamber section in the extended position may also serve to lock the first brew chamber section 602 in the closed configuration. The inventors have therefore recognized a benefit to a lock configured to lock the second brew

chamber section against the frame 604 after the second brew chamber section 646 moves to the extended position.

[0095] FIGs. 13A-13C show respective side partial sectional, bottom, and top sectional views of a lock with the brew chamber actuator 648 in a retracted position. FIGs.14A-14C show respective side partial sectional, bottom, and top sectional views of a lock with the brew chamber actuator 648 in an extended position. FIGs. 15A-15C show respective side partial sectional, bottom, and top sectional views of a lock with the brew chamber actuator 648 in a retracted position.

[0096] Brew chamber 600 may include one or more locks 662 configured to lock the second brew chamber section 646 against the frame 604 when the second brew chamber section is in the extended position. For instance, as seen in FIG. 13B, the brew chamber 600 includes two locks 662. As seen in FIG. 13A, each lock 662 may include a slider 666 and a pawl 664.

[0097] The slider 666 is slidably disposed within a channel 670 of the second brew chamber section 646. The slider 666 is biased toward a slider engaged position (toward the right as seen in FIGs. 13A-13C) by a spring 668 disposed in the channel 670.

[0098] The pawl 664 is rotatably attached to the second brew chamber section. As seen in FIGs. 13A and 13B, the pawl 664 may include a pawl axle 665, and the pawl 664 may rotate about a pawl axis of rotation P_A extending through the pawl axle 665.

[0099] As seen in FIG. 13B, the pawl engaging portion 676 of slider 666 is in contact with and pushes against pawl 664 due to the biasing force from spring 668. As a result, the slider 666 exerts a moment on the pawl 664, urging the pawl 664 to want to pivot about pawl axle 665. However, when the second brew chamber section 646 is in the chamber retracted position (as shown in FIG. 13B), the pawl 664 is blocked from rotating due to contact against frame wall 680. As a result, the pawl 664 and slider 666 are biased towards respective pawl engaged positions and slider engaged positions, but prevented from moving to these engaged positions by frame wall 680 while the second brew chamber section 646 is in the chamber retracted position shown in FIGs. 13A-13C.

[00100] When the brew chamber actuator 648 is in the actuator retracted position shown in FIGs. 13A-13C, the brew chamber piston 654 is biased towards the actuator retracted position and the second brew chamber section 646 is biased toward the chamber retracted position shown in FIGs. 13A-13C by respective piston springs 660 and chamber springs 661 (as seen in FIG. 13C). The second brew chamber section 646 is operatively coupled to the brew chamber actuator 648 via brew chamber piston 654, as will be discussed

further below. It should be understood that while the embodiments of FIGs. 13A-15C show the brew chamber actuator 648 as a hydraulic actuator having an actuator linkage in the form of a brew chamber piston 654 connected to the second brew chamber section 646, any suitable actuator may be used to move the second brew chamber section 646 (e.g. a motor, a linkage assembly coupling the second brew chamber section to the lid 608, etc.), and any suitable actuator linkage may connect the second brew chamber section to the actuator, as the disclosure is not so limited.

[00101] When the brew chamber piston 654 is moved towards the actuator extended position, an edge 688 of piston slot 687 contacts chamber contact member 690 of the second brew chamber section 646 (see FIGs. 11-12, 13C, and 14C), moving the second brew chamber section 646 to the chamber extended position shown in FIGs. 14A-14C. Because the pawl 664 and slider 666 are disposed in the channel 670 of the second brew chamber section 646, the slider 666 and pawl 664 translate with the second brew chamber section relative to frame 604 and frame wall 680 as the second brew chamber section 646 moves to the chamber extended position.

[00102] Once the second brew chamber section 646 moves to the chamber extended position, the pawl 664 is aligned with hole 672 in the frame 604, as seen in FIGs. 14A and 14B. Because the pawl 664 is no longer being blocked from rotating outwards by frame wall 680, the spring 668 is able to bias the slider 666 to the slider engaged position, which in turn pushes against the pawl 664 to rotate the pawl about the pawl axle 665 to the pawl engaged position, where the pawl 664 protrudes into hole 672, as seen in FIG. 14B. When the slider 666 is in the slider engaged position, leading edge 682 of a pawl engaging portion 676 extends past edge 684 of the pawl 664, such that leading edge 682 is out of contact with the pawl 664.

[00103] During a beverage forming operation, pressure in the enclosed brew chamber volume 601 will exert a force on the second brew chamber section 646 towards the chamber retracted position. However, the second brew chamber section 646 is prevented from translating back to the retracted position by contact between the pawl 664 and edge 673 of the hole 672. Pawl 664 itself is prevented from moving back to the pawl disengaged position by the pawl engaging portion 676 of the slider 666. Because the leading edge 682 of the pawl engaging portion 676 extends past pawl edge 684, contact forces from the pawl 664 and edges of the hole 672 are transmitted to face 686 of the pawl engaging portion 676 rather than leading edge 682. As a result, the pawl engaging portion 676 is pressed against inside surface

671 of the channel 670 by these forces, binding the slider 666 against the channel 670, and therefore the pawl 664, in respective engaged positions.

[00104] As discussed above, and as seen in FIGs. 13C and 14C, the second brew chamber section 646 connects to the brew chamber piston 654 by disposing a chamber contact member 690 in piston slot 687. The piston slot 687 is sized and shaped to allow for a gap G_P between slot edges 688 and chamber contact member 690. This gap G_P allows for lost motion between the brew chamber piston 654 and the second brew chamber section 646. After a brewing operation has been completed, the hydraulic chamber 652 may be emptied, and piston springs 660 may move the brew chamber piston 654 towards the actuator partially retracted position shown in FIG. 15C. The brew chamber piston 654 is able to move towards the actuator retracted position even while the second brew chamber section 646 is locked against the frame 604 due to the lost motion between the second brew chamber section 646 and the brew chamber piston 654 created by gap G_P. As the brew chamber piston 654 moves to the actuator partially retracted position, piston arm 674 contacts piston engaging portion 678 of slider 666, pushing the slider 666 to the slider disengaged position against the spring 668. As seen in FIG. 15B, movement of the slider 666 to the disengaged position provides sufficient clearance in the channel 670 for the pawl 664 to rotate back into the channel 670 via the contact forces between the edge 673 and the pawl 664, unlocking the second brew chamber section 646 from the frame 604 and allowing chamber springs 661 to move the second brew chamber section 646 back to the chamber retracted position shown in FIGs. 13A-13C. (Springs 661 are shown with portions removed to show components which would otherwise be hidden in FIG. 15C. Edges of these removed portions are indicated by broken lines in springs 661.)

[00105] In some embodiments, the inventors have recognized that it may be desirable for the beverage machine to be able to sense when the second brew chamber section has been locked to the frame 604. Therefore, in some embodiments, the slider 666 includes a sensor engaging portion 692 configured to engage with a sensor 694 (e.g. by pressing a button on a microswitch) when the slider 666 is moved to the slider engaged position, as seen in FIG. 14A. When the sensor 694 is engaged, the sensor 694 may be configured to send a signal to a controller of the beverage machine which the controller interprets as the second brew chamber section 646 being in the locked state.

[00106] It should be understood that, after the brew chamber is closed, a beverage may be formed in substantially the same way in both brew chamber 200 and brew chamber 600. Therefore, it should be understood that any features described herein with relation to brew

chamber 200 may also be applied to brew chamber 600, and vice versa, as the disclosure is not so limited.

Sensor System for Tablet Size Detection

[00107] 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 control the upstream fluid system 300 to deliver liquid to the brew chamber fluid system 500 with different flow parameters (e.g. volume, pressure, etc.) and/or 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).

[00108] 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. 16A-16C 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.

[00109] 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. 16A, 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. 16B, 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. 16C, 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.

[00110] 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.

[00111] 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. 16D. 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. 16D, the microswitch being triggered twice and left in the triggered state, as seen in FIG. 16D, 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.

[00112] 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. Additionally, while the above sensor system is described in the context of brew chamber 200, it is contemplated that a similar sensor system may be implemented in use with brew chamber 600, as the disclosure is not so limited.

[00113] 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

[00114] FIG. 17 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 200/600. 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 200/600. 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.

[00115] 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.

[00116] 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.

[00117] 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.

[00118] 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.

[00119] 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.

[00120] 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

[00121] 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 200/600 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. 18 and 19 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. 20A and 20B shows schematic representations of the brew chamber fluid system 500. It should be understood that the brew chamber configuration shown in FIGS. 18-20B 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. 18-20B. For example, the rotating brew chamber section arrangement and/or grippers described in FIGS. 1-9 may be used in the FIGS. 18-20B arrangement. Additionally, it should be understood that, with the exception of the brew chamber actuator 648, brew chamber 600 may connect to the brew chamber fluid system 500 in substantially the same way as brew chamber 200. Additionally, after the brew chamber is closed, a beverage may be formed in substantially the same way in both brew chamber 200 and brew chamber 600. Therefore, it should be understood that any features described herein regarding the relationship of brew chamber fluid system 500 to brew chamber 200 may also be applied to brew chamber 600, as the disclosure is not so limited.

[00122] 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.

[00123] 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.

[00124] 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.

[00125] 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.

[00126] 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.

[00127] In some embodiments, such as the embodiment shown in FIGs. 20A and 20B 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. 20A and 20B, 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.

[00128] 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 via pre-wet outlet 514. 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.

[00129] 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. 18-19, 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.

[00130] 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.

[00131] 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.

[00132] 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.

[00133] 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.

[00134] 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. 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, this automatically set threshold pressure may be alterable by a user via user interface 110.

[00135] 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.

[00136] 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.

[00137] 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.

[00138] 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.

[00139] FIG. 20B 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. 20B may function similarly to the brew chamber fluid system 500 in FIG. 20A (e.g. by delivering water to and draining water from brew chamber volume 601, and/or plunger hydraulic chamber 698).

Solenoid valve arrangement

[00140] 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).

[00141] 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.

[00142] FIGs. 21A and 21B 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.

[00143] 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. 21A, 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. 21B, 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.

[00144] 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.

[00145] 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. 21A. 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).

[00146] 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. 21B. 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.

Crush Plates

[00147] As discussed above, the beverage machine 100 may include first and second crush plates 206 and 207. FIG. 22 shows a perspective view of a portion of the brew chamber with first crush plate 206 according to an embodiment. As discussed above, first crush plate 206 may comprise an annular surface 272, with outlet needles 234 having distal tip ends 235 that are disposed at a depth that is below that of the annular surface 272 of the first crush plate 206. Such a configuration may prevent or limit an amount of piercing of the beverage tablet 400 by the outlet piercing needles 234 prior to expansion of the beverage tablet during a brewing process. As discussed above with respect to FIGS. 7-9, first crush plate 206 may include a recess 252 into which a first end 406 of the beverage tablet 400 expands during a brew operation, causing the first end 406 to conform to the annular shape of the first crush plate 206.

[00148] FIGS. 23 and 24 show a perspective and cross-sectional side view, respectively, of a portion of brew chamber 200 with second crush plate 207 according to an embodiment. In some embodiments, second crush plate 207 may include a rippled surface having a plurality of ripples 209. Such a rippled surface may allow for more complete and/or more even fracturing of the body 402 of the beverage tablet when the beverage tablet 400 is deformed. The rippled surface may extend radially from a central region 270 of the second crush plate. In some embodiments, each ripple 209 may be tapered, such that the width W of the ripple 209 is narrower near central region 270 of the second crush plate, and wider near edge 256 of the second crush plate. As discussed above with respect to FIGS. 1-9, the second crush plate may include openings 213 configured to align with inlet piercing needles 232. In

some embodiments, as discussed above, inlet piercing needles 232 always protrude from second crush plate 207. In some embodiments, as discussed above, inlet piercing needles 232 selectively protrude from second crush plate 207. In some embodiments, as seen in FIG. 24, the second crush plate 207 may be tapered, such that a central region 255 of the crush plate protrudes further than the edges 256 of the crush plate. As seen in FIG. 24, the central region 255 is noncoplanar with the edges 256 of the crush plate along the same diameter. Such a configuration may allow for more complete and/or more even fracturing of body 402. In some embodiments, as the beverage tablet 400 is deformed, the second end 408 of the beverage tablet is configured to conform to the rippled surface and/or taper of second crush plate 207.

Needle Configuration

[00149] As discussed above, the beverage machine 100 may include inlet piercing needles 232 configured to introduce liquid into the beverage tablet 400, and outlet piercing needles 234 may be configured to allow water to exit the beverage tablet 400.

[00150] FIG. 25A shows a front view of inlet piercing needles 232, and FIG. 25B shows a front view of outlet piercing needles 234, with an overlay of inlet piercing needle locations 233 shown in dashed lines. FIG. 26 shows a cross sectional side view of a portion of brew chamber 200.

[00151] In some embodiments, it may be desirable for brew chamber 200 to include a different number of inlet piercing needles as compared to the number of outlet piercing needles. In some embodiments, brew chamber 200 includes nine inlet piercing needles. In some embodiments, brew chamber 200 includes eighteen outlet piercing needles. However, any number or combination of numbers of inlet piercing needles and outlet piercing needles is contemplated. In some embodiments, inlet piercing needles may be arranged as a single central needle 254 with a ring of needles 260 surrounding the central needle. In some embodiments, the outlet piercing needles has a first ring of needles 262, and a second ring of needles 264 surrounding the first ring of needles 262. In some embodiments, as the beverage tablet 400 expands, the first ring of needles 262 pierces the beverage tablet 400 before the second ring of needles 264.

[00152] In some embodiments, it may be desirable for inlet piercing needles 232 to be misaligned with outlet piercing needles 234. Such a configuration may limit or prevent liquid from flowing directly through the beverage tablet 400 from the inlet piercing needles to the outlet piercing needles in a straight path, and may instead encourage the liquid to take a

tortuous path through the beverage tablet. This may help to increase extraction of the beverage material from the beverage tablet. Therefore, as seen in FIGs. 25B and 26, inlet piercing needles 232 may be misaligned with outlet piercing needles 234, such that no inlet needle piercing location 233 is aligned with an outlet piercing needle. Put differently, as seen in FIG. 26, the inlet and outlet needles may be misaligned such that no straight line may extend between a tip of any inlet needle and a tip of any outlet needle which is parallel to sidewalls 210 of brew chamber 200. Alternatively, as seen in FIG. 26, the inlet and outlet needles may be misaligned such that no straight line may extend between a tip of any inlet needle and a tip of any outlet needle which is parallel to a line 268 extending from center 266 of the first crush plate 206 to center 258 of the second crush plate 207.

[00153] In some embodiments, the inlet piercing needles may have a different diameter than the outlet piercing needles. For example, as shown in FIG. 26, the inlet piercing needles 232 may have a larger diameter D2 than a diameter D1 of the outlet piercing needles 234.

[00154] 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.

What is claimed is:

CLAIMS

1. A beverage machine comprising:

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

a brew chamber configured to receive a beverage tablet, the brew chamber being fluidly connected to the liquid supply via a first flow path, the brew chamber comprising a first crush plate and a second crush plate; and

a hydraulic chamber fluidly connected to the liquid supply via a second flow path,

wherein the first flow path diverges from the second flow path upstream of the brew chamber and the hydraulic chamber, and

wherein the hydraulic chamber is configured to move at least one of the first and second crush plates to compress and deform the beverage tablet between the first crush plate and the second crush plate as liquid enters the hydraulic chamber from the liquid supply.

2. The beverage machine of claim 1, wherein the hydraulic chamber is configured to expand as liquid enters the hydraulic chamber from the liquid supply.

3. The beverage machine of claim 2, wherein the hydraulic chamber is operatively connected to the second crush plate, such that the second crush plate is pushed towards the first crush plate as the hydraulic chamber expands.

4. The beverage machine of claim 1, further comprising a drain fluidly connecting the hydraulic chamber to a disposal unit, and further comprising a drain valve configured to open after a beverage is formed to allow liquid to flow from the hydraulic chamber to the disposal unit via the drain.

5. The beverage machine of claim 2, wherein the hydraulic chamber is configured to continue to expand while the liquid from the liquid supply is introduced to the brew chamber.

6. The beverage machine of claim 1, further comprising at least one controllable valve configured to selectively permit flow of liquid along the first flow path and the second flow path.

7. The beverage machine of claim 6, wherein the at least one controllable valve comprises a first controllable valve disposed in the first flow path between the brew chamber and the liquid supply configured to selectively permit flow of liquid along the first flow path, and a second controllable valve disposed in the second flow path between the hydraulic chamber and the liquid supply configured to selectively permit flow of liquid along the second flow path.

8. The beverage machine of claim 7, further comprising a pressure transducer configured to detect pressure in the first flow path and the second flow path.

9. The beverage machine of claim 8, further comprising a controller configured to control the first controllable valve and second controllable valve to selectively deliver liquid to the hydraulic chamber and the brew chamber based on the pressure sensed by the pressure transducer.

10. The beverage machine of claim 9, wherein the controller is configured to open the second controllable valve and close the first controllable valve until pressure in the hydraulic chamber reaches a threshold pressure, and configured to close the second controllable valve and open the first controllable valve once the threshold pressure in the hydraulic chamber is reached.

11. The beverage machine of claim 10, wherein the threshold pressure is configured to be altered based at least partially on a parameter a of beverage tablet in the brew chamber and/or a desired beverage to be formed.

12. The beverage machine of claim 7, further comprising a third flow path configured to fluidly connect the liquid supply to the brew chamber.

13. The beverage machine of claim 12, further comprising a third controllable valve disposed in the third flow path and configured to selectively permit flow of liquid from the liquid supply along the third flow path.

14. The beverage machine of claim 12, wherein the first flow path is configured to fluidly connect the liquid supply to the brew chamber via a first brew chamber inlet, and wherein the

third flow path is configured to fluidly connect the brew chamber to the liquid supply via a second brew chamber inlet.

15. The beverage machine of claim 12, wherein the third flow path is configured to pre-wet the beverage tablet prior to deformation of the beverage tablet.

16. The beverage machine of claim 12, wherein the hydraulic chamber is a first hydraulic chamber, and further comprising a fourth flow path configured to fluidly connect the liquid supply to a second hydraulic chamber, the second hydraulic chamber configured to move at least a portion of the brew chamber to a closed position as liquid enters the second hydraulic chamber from the liquid supply.

17. The beverage machine of claim 16, further comprising a fourth controllable valve disposed along the fourth flow path and configured to selectively permit flow of liquid from the liquid supply along the fourth flow path.

18. A method of forming a beverage, the method comprising:

receiving a beverage tablet between a first crush plate and a second crush plate of a brew chamber, the second crush plate being operatively connected to a hydraulic chamber;

introducing liquid from a liquid supply into the hydraulic chamber to increase a volume of the hydraulic chamber and move the second crush plate towards the first crush plate;

compressing and deforming the beverage tablet between the first crush plate and the second crush plate as the volume of the hydraulic chamber increases; and

introducing liquid from the liquid supply to the beverage tablet,

wherein the liquid introduced to the beverage tablet bypasses the hydraulic chamber as the liquid moves from the liquid supply to the beverage tablet.

19. The method of claim 18, further comprising draining water from the hydraulic chamber into a disposal unit.

20. The method of claim 18, further comprising piercing the beverage tablet with at least one inlet piercing needle, wherein the step of introducing liquid to the beverage tablet

comprises introducing liquid into the beverage tablet through the at least one inlet piercing needle.

21. The method of claim 18, further comprising introducing liquid into the brew chamber to pre-wet the beverage tablet before introducing liquid from the liquid supply into the hydraulic chamber.

22. The method of claim 18, further comprising introducing liquid into the hydraulic chamber until a pressure in the hydraulic chamber reaches a threshold pressure before introducing liquid to the beverage tablet.

23. The method of claim 22, further comprising adjusting the threshold pressure based at least in part on a parameter of the beverage tablet.