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(54) METHOD AND APPARATUS FOR PUMP CONTROL

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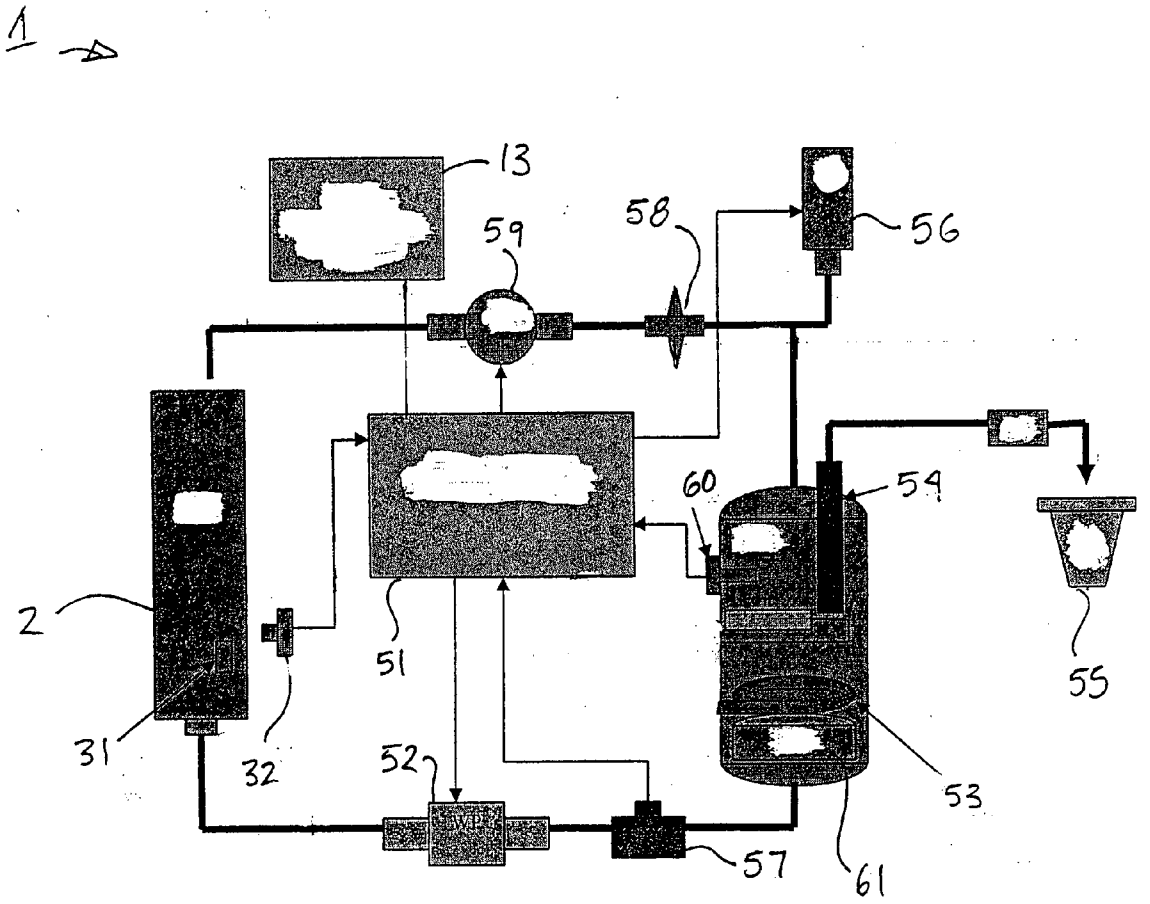
(57) ABSTRACT

A method and apparatus for controlling a pump adapted to cause liquid to flow from a first location to a second location. The pump may be operated in a calibration period, and based on performance characteristics for the pump, an operation index may be assigned to the pump. The operation index may be used to control subsequent operation of the pump. For example, the operation index may be used to identify an operation time for the pump to deliver a predetermined volume of liquid. Performance characteristics used to determine the operation index may include a voltage supplied to the pump and/or a volume flow rate of the pump.



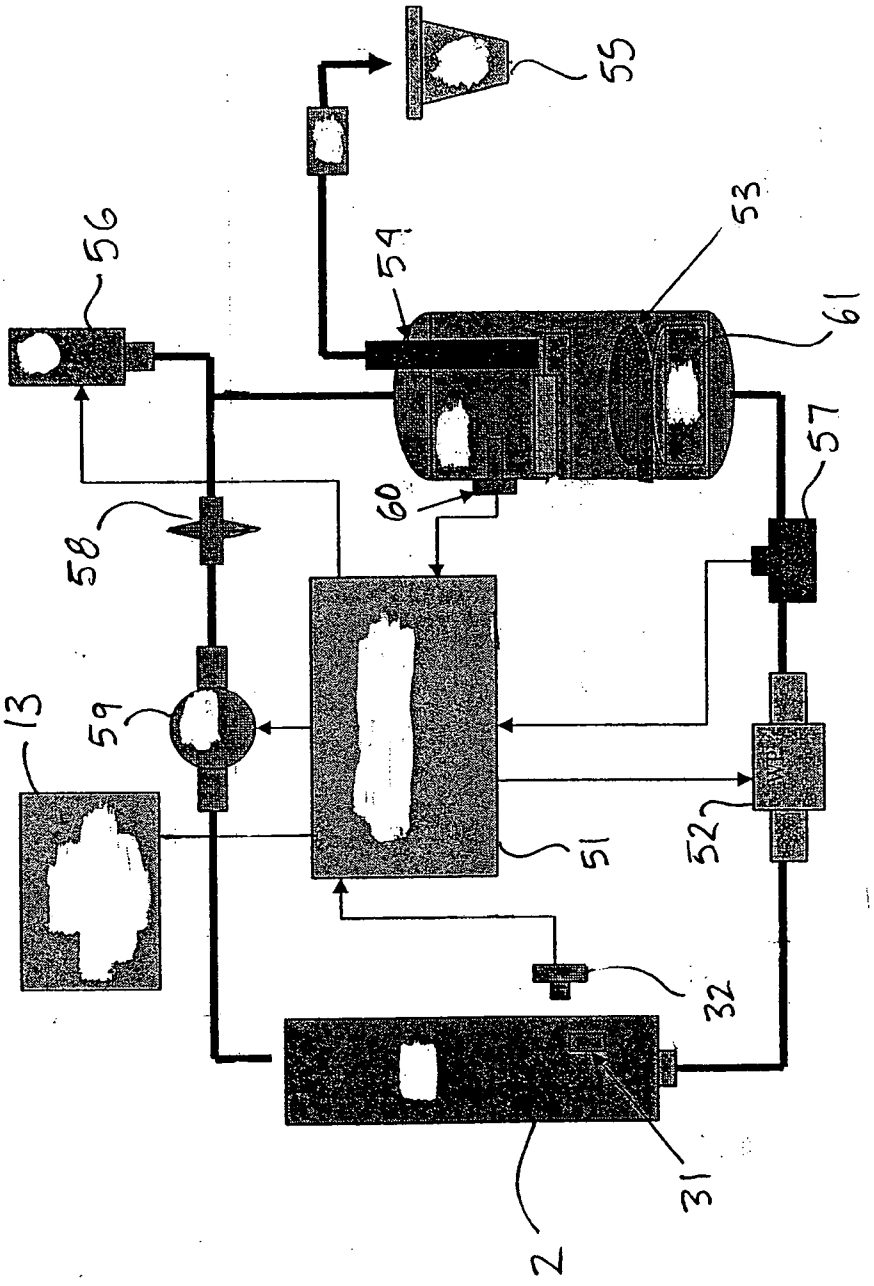


FIG. 1

3016, 3066, 3115, 3165, 3215, 3265, 3315, 3364, 3414, 3464, 3514, 3563, 3613, 3663, 3713, 3762, 3812, 3862, 3912, 3961, 4011, 4061, 4111, 4161, 4210, 4260, 4310, 4360, 4409, 4459, 4509, 4559, 4608, 4658, 4708, 4758, 4807, 4857, 4907, 4957, 5007, 5056, 5106, 5156, 5206, 5255, 5305, 5355, 5405, 5454

FIG. 2

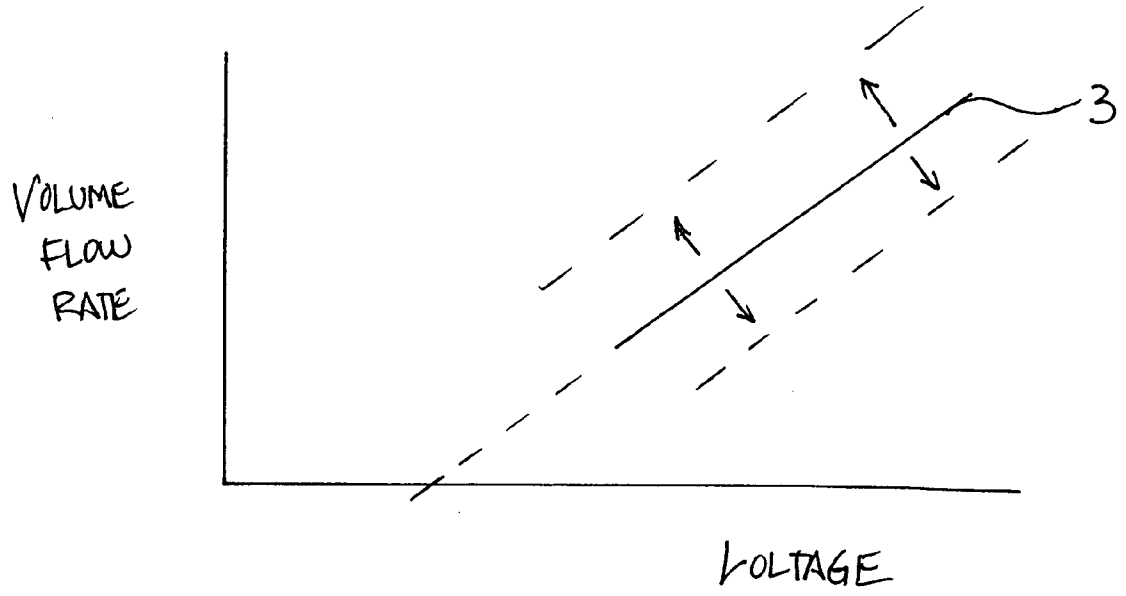


FIG. 3

METHOD AND APPARATUS FOR PUMP CONTROL

BACKGROUND OF INVENTION

[0001] 1. Field of Invention

[0002] This invention relates to methods and apparatus for pump control.

[0003] 2. Related Art

[0004] Volume control for beverage forming machines, such as coffee brewers, can be important to the quality of the formed beverage(s). For example, standard drip coffee makers typically include a water reservoir that is filled with a desired volume of water by a user that is used by the machine to make a volume of coffee. Such reservoirs often include a sight glass or other arrangement that allows the user to define the amount of water in the reservoir. As a result, the user may have a certain amount of control over the amount of water used by the machine to make the coffee beverage.

SUMMARY OF INVENTION

[0005] The inventors have appreciated that some beverage forming machines, such as single serve coffee brewers, require an accurate water volume to form a quality beverage, but do not operate in such a way as to allow a user to control the amount of water actually used. For example, some coffee brewers have a water storage tank that holds sufficient water for several beverages. Although the user may be able to define the ultimate size of the beverage produced, the brewer itself controls the amount of water used to make the beverage, e.g., by automatically drawing a desired amount of water from a storage tank and providing the water for coffee brewing. Some such brewers use a flowmeter to determine the volume of water provided and control the operation of a water pump so that a controlled volume of water is used for brewing purposes.

[0006] In one aspect of the invention, a beverage forming system includes a beverage forming apparatus adapted to form a beverage at least in part from a liquid. The beverage forming apparatus may include a pump adapted to cause liquid to flow from a first location to a second location, e.g., for use in brewing a coffee beverage. A controller associated with the system may be adapted to control the pump to operate based on an operation index to deliver a predetermined volume of liquid from the first location to the second location, e.g., so that a carefully defined volume of water is used to make the beverage. In one embodiment, the operation index may represent the pump's ability to provide a volume flow rate for given voltage supplied to the pump. In one aspect, the controller may be adapted to cause the pump to operate during a calibration period, such as when the beverage forming system is first put into use by a user, to determine the operation index. The controller may determine the operation index based on a performance characteristic of the pump during the calibration period, such as a power supply characteristic of power supplied to the pump during the calibration period (such as a voltage provided to the pump) and/or a performance of the pump during the calibration period (such as a time for the pump to deliver a specific volume of liquid given a specific voltage).

[0007] In another aspect of the invention, a beverage forming system includes a beverage forming apparatus adapted to form a beverage at least in part from a liquid. The beverage forming apparatus may include a pump adapted to cause liquid to flow from a first location to a second location, e.g., for use in brewing a coffee beverage. A controller associated with the system may be adapted to control the pump to operate for an operation time and deliver a predetermined volume of liquid from the first location to the second location. The operation time for the pump may be determined based on an operation index, e.g., that represents an ability of the pump to provide a volume flow rate for a given voltage supplied to the pump, and/or may be determined based on a voltage to be supplied to the pump during the operation time. For example, if the voltage supplied to the pump varies, the controller may adjust the operation time to ensure that the pump provides a suitable volume of liquid.

[0008] In another aspect of the invention, a method for calibrating the operation of a pump used in a beverage forming machine includes providing a beverage forming machine including at least one pump adapted to cause liquid to flow from a first location to a second location. The pump may be operated for calibration purposes, and a performance characteristic of the pump during operation may be measured. For example, it may be determined how long it takes for the pump to provide a defined volume of fluid and/or a voltage supplied to the pump during calibration. An operation index may be assigned to the pump based on the performance characteristic, and the operation index may be used in subsequent operation of the pump to control its operation. Thus, variations in pump operation may be accounted for, and the pump may be controlled to provide a desired volume of liquid, whether or not the desired volume is precisely the same as the volume used in calibration. In one embodiment, the voltage or other characteristic of power provided to the pump during the calibration may be used to determine the operation index in addition to at least one other performance characteristic for the pump.

[0009] In another aspect of the invention, a method for controlling the operation of a pump used in a beverage forming machine may include providing a beverage forming machine including at least one pump adapted to cause liquid to flow from a first location to a second location. A power supply characteristic of power supplied to the pump to cause the pump to operate to deliver a predetermined volume of liquid may be determined, and an operation time for the pump to deliver a predetermined volume of liquid may be determined based on the power supply characteristic. The pump may then be operated according to the determined operation time. The power supply characteristic may be determined before the pump operates during the operation time, e.g., the voltage may be estimated, or the power supply characteristic may be detected during pump operation, e.g., the voltage supplied to the pump may be integrated, and the integrated voltage used to determine the operation time.

[0010] These and other aspects of the invention will be apparent from the following description and claims.

BRIEF DESCRIPTION OF DRAWINGS

[0011] Aspects of the invention are described below with reference to illustrative embodiments, wherein like elements reference like numerals, and wherein:

[0012] **FIG. 1** shows schematic diagram of a beverage forming system in accordance with an aspect of the invention;

[0013] **FIG. 2** shows an exemplary lookup table for determining a pump operation index in accordance with an aspect of the invention; and

[0014] **FIG. 3** shows an exemplary volume flow rate vs. voltage curve for a pump in an illustrative embodiment.

DETAILED DESCRIPTION

[0015] Aspects of the invention may be practiced using any suitable pump/control arrangement and/or with any associated beverage forming system. Several different embodiments are described herein for purposes of illustration. However, these illustrative embodiments should not be used to narrowly interpret the scope of the invention. For example, embodiments are described below in which a beverage forming apparatus includes a water storage tank and a metering chamber, from which liquid is provided to a brew chamber. However, aspects of the invention are not limited to this type of arrangement. For example, aspects of the invention may be used in systems including no metering chamber, e.g., water is supplied directly from a storage tank to a brew chamber, and/or in systems having no brew chamber, e.g., systems in which a beverage is formed without brewing. In addition, various aspects of the invention are described herein, and these various aspects may be used in any suitable combination with each other, or alone.

[0016] In one aspect of the invention, a beverage forming system controller may control a pump, such as a water pump, to operate based on an operation index associated with the pump. The operation index may represent an ability of the pump to deliver a particular volume flow rate, and thus the ability of the pump to deliver a specific volume of liquid over a corresponding pump operation time. As used herein, an "operation time" may be any suitable measure for a duration of operation for the pump, including a period of time, a number of pump cycles (e.g., shaft revolutions or strokes), a total power delivered to the pump, an integrated voltage applied to the pump, or other measure by which a duration that the pump is operated may be based. The operation index may be adjustable, e.g., to allow the controller to set the operation index for the pump at an initial start up and/or at some time after the pump has been put into service. Thus, the operation index may allow the controller to control the operation of the pump so that it delivers a predetermined volume of liquid even if the pump's performance characteristics (such as a nominal volume flow rate or supplied voltage) changes over time.

[0017] Also, the operation index may allow the controller to accommodate pump-to-pump variation that may exist, e.g., when a pump is replaced in a beverage forming system or as between pumps in two different systems that include a same control arrangement. For example, although pumps may have the same design, specifications and be made by the same manufacturer, performance of different pump units of the same model may vary widely, in one case up to a 20% variation. Thus, one pump provided in one beverage forming apparatus may operate differently from another pump in another beverage forming apparatus. For example, one pump may provide a volume flow rate that is different from another pump, even though the power supply, water supply and other operation parameters are the same. Thus, in accordance with one aspect of the invention, the controllers in different systems may be otherwise configured in nearly identical ways, yet the controller in one beverage forming system may use a first operation index for the pump in its system, whereas the controller in another system may use a second operation index for the other pump. As a result, variations between the two pumps may be accommodated, and the operation of the pumps controlled so that the pumps provide a desired volume of liquid in each system.

[0018] For example, in one embodiment, the controller may operate the pump for a specific operation time so that the pump provides a desired total volume, e.g., for forming a beverage. If the pumps in two different systems perform differently, the pumps will provide different total volumes of liquid if they are both run for a same operation time. As discussed above, volume control can be important in forming beverages, e.g., to provide consistency, quality taste or appearance, or other beverage characteristics. The operation index may take variations in pump performance into account and allow each controller to control its respective pump, e.g., determine an operation time for the pump, so that the pump delivers the same required volume in both systems.

[0019] In one embodiment, a controller may use a power supply characteristic of power supplied to the pump to determine an appropriate operation time for the pump. For example, even if two pumps in two different beverage forming systems otherwise perform identically, if the two pumps are provided with different power voltages during operation, the pumps will typically provide different volume flow rates, in one exemplary case representing up to an 80% variation. Thus, the controller may take a power supply characteristic, such as a voltage of power to be supplied to the pump during operation, into account so that the pump can be controlled to accurately provide the desired volume of liquid.

[0020] In another embodiment, a controller in a beverage forming system may use both an operation index and a power supply characteristic to determine an operation time for a pump. By using both the operation index and power supply characteristic, the controller may be capable of accurately controlling the pump, even in the case of pump performance and/or power supply variations. For example, the controller may determine an operation time for the pump based on the operation index, and then make adjustments to the time during pump operation based on the voltage supplied to the pump.

[0021] In one aspect of the invention, a controller in a beverage forming system may control the pump to operate during a calibration period, and based on the performance characteristics of the pump determine an operation index for the pump. For example, at the time a beverage forming system is first operated, the controller may cause the pump to operate to provide a specific volume of liquid, e.g., to fill a chamber in the system. The controller may determine a calibration time that corresponds to a time taken for the pump to provide the volume of liquid. Based on the calibration time (which may effectively represent a volume flow rate for the pump during the calibration period), the controller may assign an operation index to the pump. Thus, the operation index may represent the pump's ability to provide a volume flow rate. The operation index may be used by the controller to subsequently control the pump when delivering the specific volume delivered by the pump during the calibration period and/or for other volumes. For example,

during subsequent operation of the pump to deliver a predetermined volume, the controller may determine an operation time for the pump to operate to provide the predetermined volume. The pump may then be operated for the operation time, and stopped.

[0022] The controller may also take a power supply characteristic of power provided to the pump during the calibration period into account when determining the operation index. For example, the controller may determine a voltage for power supplied to the pump during the calibration period and use that voltage, together with the calibration time, to determine the operation index for the pump. Subsequently, the controller may use a voltage supplied to the pump with the operation index to determine an operation time for the pump. Such an approach may be useful in applications where the voltage provided to the pump varies, e.g., because of operation of other parts of the system, such as a water heater, or variations in line voltage provided to the system, such as variations caused by the operation of devices in the electrical grid to which the system is connected.

[0023] **FIG. 1** shows a schematic block diagram of various components included in a beverage forming system **1** in an aspect of the invention. Water or other liquid from a tank **2** may be provided by a water pump **52** to a metering tank or chamber **53**. Operation of the water pump **52** and other components of the system **1** may be controlled by a controller **51**, e.g., including a programmed processor and/or other data processing device along with suitable software or other operating instructions, one or more memories, input/output interfaces, communication buses or other links, a display, switches, relays, triacs, or other components necessary to perform desired input/output or other functions. The chamber **53** may be filled with a desired amount of liquid by any suitable technique, such as running the water pump **52** for a predetermined time, sensing a water level in the chamber **53** using a conductive probe sensor or capacitive sensor, detecting a pressure rise in chamber **53**, or using any other viable techniques. For example, the controller **51** may detect that the chamber **53** is completely filled when a pressure sensor **57** detects a rise in pressure indicating that the water has reached the top of the chamber **53**. Water in the tank may be heated, if desired, by way of a heating element **61** whose operation is controlled by the controller using input from a temperature sensor **60**. Water in the chamber **53** may be dispensed via a tube **54** to a brew chamber **55** or other beverage forming station. The brew chamber **55** may include any beverage making ingredient, such as ground coffee, tea, a flavored drink mix, or other substance. Liquid may be discharged from the chamber **53** by pressurizing the chamber with air provided by an air pump **56** that causes the liquid to be discharged out of the tube **54**. Completion of the dispensing from the chamber **53** may be detected in any suitable way, such as by detecting a pressure drop with the pressure sensor **57**, by detecting a water level change in the chamber **53**, or using any other viable techniques.

[0024] In one embodiment, the controller **51** may control the pump **52** to deliver a specific, predetermined volume of water to the chamber **53** for beverage forming purposes such that the chamber **53** is not entirely filled. The controller **51** may control the volume of water delivered by the pump by causing the pump **52** to operate for a specified operation time. For example, operation of the pump **52** for a time period of 5-15 seconds may provide a suitable volume for preparation of a beverage, such as 6 ounces. As is discussed in more detail below, the controller **51** may determine the operation time for the pump based on one or more factors so as to provide close control of the volume delivered by the pump.

[0025] When filling the chamber **53** with water from the tank **2**, the chamber **53** may be vented by opening a line including a filter **58** and a valve **59**. The filter **58** may prevent undesired items, such as minerals, scale deposits or other, from interfering with the operation of the valve **59**. A user may input commands or other information to the controller **51**, and/or the controller **51** may provide information to the user via a user input/display **13**. The user input/display **13** may include an LCD or other suitable display, and/or one or more operation buttons, knobs or other devices that may be used to control the system operation. A sensor **32** may also communicate with the controller **51** and provide a low liquid indication to the controller **51** when a float **31** or other device is detected to be at or below a specified level in the tank **2**. A low level indication may be provided to a user, e.g., via the user input/display **13**, suggesting that the tank **2** be refilled.

[0026] In one embodiment, the controller **51** may control the water pump **52** to operate during a calibration period to assess the performance of the pump. This may be done during a first time that the system **1** is powered up and operated by a user (such as the first time that the user introduces water into the tank **2**), and/or at a time after initial start up (such as after every 100 operation cycles, once every 6 months, etc.). The controller **51** may assess the performance of the pump during the calibration period, and then base its subsequent control of the pump on the assessment. As discussed above, in one embodiment, the controller **51** may normally control the pump to deliver a specific, predetermined volume of water to the chamber **53** such that the chamber **53** is not entirely filled. After calibration is performed, control of the volume of water delivered by the pump **52** may be based on an operation time, which may be determined based on the assessment of pump performance during the calibration period.

[0027] During the calibration period, the controller **51** may command to pump **52** to start pumping with the chamber **53** completely empty. (The chamber **53** may be known by the controller **51** to be empty at a time when water is first introduced into the system by a user, or the controller **51** may completely drain the chamber, or request that the user do so, by a drain line not shown in **FIG. 1**.) Alternately, the controller **51** may detect an amount of water present in the chamber **53** when the pump **52** starts operation during the calibration period. When a desired amount of liquid has been supplied to the chamber **53**, e.g., when the chamber **53** is detected to be completely full by detection of a pressure rise by the pressure sensor **57**, or the controller **51** otherwise detects a desired volume of water has been transferred to the chamber, the controller **51** may stop operation of the pump **52**. An alternative is for the controller **51** to cause the pump **52** to operate for a set period of time and detect the amount of liquid delivered by the pump **52** to the chamber **53**. In any case, the controller **51** may determine (or effectively determine) the volume flow rate of the pump **52** during the calibration period based on the time elapsed during the calibration period and the volume delivered.

[0028] Based on the volume flow rate during the calibration period, the controller **51** may determine an operation index for the pump that represents the pump's ability to provide a volume flow rate. This operation index may be used to determine operation times for the pump when subsequently controlling the pump to deliver other predetermined volumes of liquid. For example, in a subsequent operation, the controller **51** may control the pump to deliver a volume that is ½ of the volume delivered during the calibration period. The operation index may be used to determine the operation time for the pump for delivering the smaller volume (which may be ½ of the total time elapsed during the calibration period (a calibration time) where other operating conditions for the pump are the same). (A "calibration time" like an operation time, may be any suitable measure for a duration of operation for the pump, not just actual time, e.g., in seconds, but may be an integrated voltage, for example.)

[0029] **FIG. 2** shows one example of a lookup table approach that may be used by the controller to determine the operation index. The lookup table may list a series of calibration times, e.g., 50 different calibration entries. (As discussed in more detail below, the lookup table in **FIG. 2** includes "volt-tics" which is a measure of the voltage provided to the pump over time. It will be understood that other measurements may be used, such as seconds, etc.) Once the calibration period is completed, the controller **51** may compare the calibration value obtained during calibration to the entries in the lookup table, and identify that entry that is closest to the calibration time. The position of the closest time in the list may be assigned to the pump as its operation index, e.g., if the 10^{th} entry in the lookup table is the closest to the calibration time, the pump may be assigned an operation index of 10 for subsequent control of the pump.

[0030] In one aspect of the invention, the controller may determine the operation index for the pump based on a power supply characteristic of power supplied to the pump during the calibration period. The use of the power supply characteristic may be used in lieu of other pump performance characteristics, such as volume flow rate. For example, a linear or other curve **3** may be known for the pump that relates a volume flow rate for the pump to voltage supplied to the pump such as that shown in **FIG. 3**. During calibration, the controller **51** may determine the voltage applied to the pump during its operation, and use the voltage to determine an operation index (e.g., relating to a volume flow rate that corresponds to the voltage in the curve **3**) for subsequent operation of the pump. Such an approach may be useful where voltage supplied to the pump varies due to operation of other portions of the beverage forming system or for other reasons. For example, a beverage forming system may be sold in two different countries which each have different electrical standards with different line voltages. The controller **51** may determine the voltage supplied to the system, and use this voltage to control pump operation.

[0031] In another aspect of the invention, the controller may use two (or more) pump performance characteristics to determine an operation index for the pump. For example, the controller may use both a volume flow rate provided by the pump and a voltage supplied to the pump to determine an operation index. Referring again to **FIG. 3**, the slope of the curve **3** may be known to be the same for all pumps, but pump-to-pump variations may cause the curve to be shifted (e.g., up or down as shown) for some pumps relative to others. Additionally, the curve may not be linear across all voltages. Thus, during calibration, the controller **51** may determine the voltage provided to the pump as well as the volume flow rate during the calibration period and determine the "shifted" location of the curve **3** for the pump. The shifted curve may be used to determine the pump's operation index for subsequent operation of the pump. In this embodiment, the operation index may relate to the shifted position of the curve **3** (e.g., define the "zero crossing" on the voltage axis where a hypothetical zero volume flow rate is provided) and be used to determine an operation time for the pump in subsequent operation based on a desired volume to be delivered and an expected voltage to be supplied to the pump during the operation time.

[0032] In another embodiment, the controller **51** may use a lookup table such as that in **FIG. 2** to determine an operation index based on a volume flow rate and voltage provided to the pump. As mentioned above, the lookup table in **FIG. 2** includes calibration times in "volt-tics" which is a measure of integrated voltage provided to the pump during the calibration period. For example, in one embodiment, the controller **51** may measure a current voltage being applied to the pump at regular time intervals (such as every "zero crossing" of a 60 Hz power supply, or every 8.3 milliseconds), and sum the voltage measurements until the desired volume has been delivered to conclude the calibration period. As a result, the "volt-tic" measurement may provide a composite indication of time and voltage applied to the pump. The controller **51** may use the "volt-tic" measurement and compare it to the volt-tic values in the lookup table to determine the operation index, e.g., a position of a volt-tic value in the lookup table nearest that of the calibration period may be assigned as an operation index for the pump. In this embodiment, the pump may be assigned an operation index from 0 to 49, but larger or smaller index ranges may be used. As an example, the number of entries in the lookup table and the range of those entries can be widened or narrowed depending upon the amount of variation in pump rates, across pumps and/or voltages.

[0033] In another aspect of the invention, the controller may determine an operation time for the pump to deliver a predetermined volume of liquid based on an operation index that represents an ability of the pump to provide a volume flow rate for a given voltage supplied to the pump and/or based on voltage supplied to the pump during the operation time. In one embodiment, the source of the operation index need not be from a calibration operation performed under the control of the controller, but instead the operation index may be supplied to the controller in any suitable way, such as by programming the controller with the operation index at the time of manufacture of the system. The controller may use the operation index and/or voltage supplied to access a lookup table to identify a suitable operation time for the pump to deliver a desired predetermined volume, or may use the operation index and one or more algorithms to calculate the operation time. In one embodiment, a lookup table may include a two dimensional data set in which the controller may identify a suitable operation time (e.g., a volt-tic value) as one that corresponds to the pump's operation index and a voltage to be supplied to the pump during the operation time.

[0034] In a further embodiment, the controller may monitor the voltage provided to the pump during operation and adjust or set the operation time as necessary depending on the voltage. For example, the controller may integrate the voltage provided to the pump, and based on the integrated voltage determine a total volume provided by the pump. (Voltage provided to some pumps is directly proportional to the volume flow rate of the pump, and thus an integrated voltage over time may be indicative of a total volume provided by the pump.) One or more correction factors may be used in the calculation, including the operation index.

[0035] In another embodiment, the controller may access a lookup table and based on the operation index, select a "volt-tic" value or other operation time value. For example, the controller may access the lookup table in **FIG. 2** and select the volt-tic value that corresponds to the pump's operation index. The volt-tic value in the lookup table may correspond to a different volume than that desired for the pump to provide. For example, in one embodiment in which the pump completely fills the chamber **53** during a calibration period (e.g., a total volume of 24 ounces), the controller may multiply the volt-tic value from the lookup table by a factor to determine a volt-tic value that corresponds to a different volume (e.g., if the pump is to provide a volume of 6 ounces to the chamber **53**, the controller may multiply the volt-tic value obtained from the lookup table by 6/24). Alternately, the controller may maintain another lookup table that is specific to the volume to be delivered by the pump, such that the controller may access and use the volt-tic value corresponding to the pump's operation index without using a volume correction factor or other operation. This volt-tic value may then be used to operate the pump, e.g., the controller may sample the voltage provided to the pump during the operation time in much the same way as described above for a calibration operation, and decrement the operation time volt-tic value by the voltage measurement made at each interval. When the volt-tic value is decremented to "0", the pump may be stopped.

[0036] While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, embodiments of the invention as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A method for calibrating the operation of a pump used in a beverage forming machine, comprising:

providing a beverage forming machine including at least one pump adapted to cause liquid to flow from a first location to a second location;

operating the pump for calibration purposes;

measuring a performance characteristic of the pump during operation; and

assigning an operation index to the pump based on the performance characteristic, the operation index being usable to control subsequent operation of the pump.

2. The method of claim 1, wherein the step of measuring a performance characteristic includes determining at least one power supply characteristic of power supplied to the pump to cause the pump to operate for calibration purposes.

3. The method of claim 2, wherein the at least one power supply characteristic includes an integrated voltage supplied to the pump during operation of the pump.

4. The method of claim 1, wherein the step of measuring a performance characteristic includes determining a volume flow rate for the pump during operation for calibration purposes.

5. The method of claim 1, wherein the performance characteristic includes an integrated voltage supplied to the pump and a total volume provided by the pump during operation of the pump for calibration purposes.

6. The method of claim 5, further comprising:

determining an operation time for the pump to deliver a desired volume of liquid based on the operation index; and

causing the pump to operate for the operation time.

7. The method of claim 6, further comprising:

determining a power supply characteristic of power supplied to the pump to cause the pump to operate during the operation time; and

wherein the step of determining an operation time comprises determining the operation time based on the operation index and the power supply characteristic of power supplied during the operation time.

8. The method of claim 1, further comprising:

determining an operation time for the pump to deliver a desired volume of liquid based on the operation index; and

causing the pump to operate for the operation time.

9. The method of claim 8, further comprising:

determining a power supply characteristic of power supplied to the pump to cause the pump to operate during the operation time; and

wherein the step of determining an operation time comprises determining the operation time based on the operation index and the power supply characteristic of power supplied to the pump during the operation time.

10. The method of claim 1, further comprising:

using the operation index to identify within a lookup table a pump operation time to cause the pump to deliver a predetermined volume;

wherein the step of determining a power supply characteristic comprises determining a value representing an integrated voltage applied to the pump; and

the step of causing the pump to operate comprises stopping operation of the pump when the value equals the pump operation time.

11. A method for controlling the operation of a pump used in a beverage forming machine, comprising:

providing a beverage forming machine including at least one pump adapted to cause liquid to flow from a first location to a second location;

determining a power supply characteristic of power supplied to the pump to cause the pump to operate to deliver a predetermined volume of liquid;

determining an operation time for the pump based on the power supply characteristic to deliver the predetermined volume of liquid; and

operating the pump according to the determined operation time.

12. The method of claim 11, wherein the step of determining the operation time comprises determining the operation time based on an operation index for the pump.

13. The method of claim 12, wherein the power supply characteristic includes a voltage supplied to the pump during the operation time.

14. The method of claim 12, further comprising:

operating the pump for calibration purposes;

measuring a performance characteristic of the pump during operation for calibration purposes; and

assigning the operation index to the pump based on the performance characteristic.

15. The method of claim 14, wherein the performance characteristic includes a total volume delivered by the pump.

16. The method of claim 14, wherein the step of assigning an operation index comprises assigning the operation index based on a power supply characteristic of power supplied to the pump during operation of the pump for calibration purposes.

17. The method of claim 12, further comprising:

using the operation index to identify within a lookup table a pump operation time to cause the pump to deliver a predetermined volume.

18. The method of claim 12, further comprising:

determining a value representing an integrated voltage applied to the pump during the operation time; and

stopping operation of the pump when the value equals the pump operation time.

19. A beverage forming system comprising:

a beverage forming apparatus adapted to form a beverage at least in part from a liquid, the beverage forming apparatus including a pump adapted to cause liquid to flow from a first location to a second location; and

a controller adapted to control the pump to operate for an operation time to deliver a predetermined volume of liquid from the first location to the second location, the controller determining the operation time for the pump based on voltage supplied to the pump during the operation time, and/or based on an operation index that represents an ability of the pump to provide a volume for given voltage supplied to the pump.

20. The system of claim 19, wherein the controller is adapted to cause the pump to operate during a calibration period, the controller determining a calibration time taken for the pump to deliver a measured volume of liquid during the calibration period and determining the operation index based on the calibration time.

21. The system of claim 19, wherein the controller is adapted to determine a value representing an integrated voltage provided to the pump during the calibration period, and determines the operation index based on the value.

22. The system of claim 19, wherein the controller determines the operation time based on the operation index and voltage supplied to the pump during the operation time.

23. The system of claim 22, wherein the controller is adapted to use a lookup table to determine the operation time.

24. The system of claim 23, wherein the beverage forming apparatus includes a storage tank and a metering tank, and wherein the pump provides a predetermined volume of water from the storage tank to the metering tank.

25. A beverage forming system comprising:

a beverage forming apparatus adapted to form a beverage at least in part from a liquid, the beverage forming apparatus including a pump adapted to cause liquid to flow from a first location to a second location; and

a controller adapted to control the pump to operate based on an operation index to deliver a predetermined volume of liquid from the first location to the second location, the controller adapted to cause the pump to operate during a calibration period, the controller determining the operation index based on a performance characteristic of the pump during the calibration period, the operation index being usable to control subsequent operation of the pump.

26. The system of claim 25, wherein the performance characteristic includes a calibration time taken for the pump to deliver a measured volume of liquid during the calibration period.

27. The system of claim 25, wherein the performance characteristic includes a calibration voltage provided to the pump during the calibration period, the calibration voltage representing an integrated voltage provided to the pump during the calibration period.

28. The system of claim 25, wherein the controller is adapted to determine an operation time to operate the pump to deliver a predetermined volume from the first location to the second location, the controller being adapted to determine the operation time based on the operation index.

29. The system of claim 28, wherein the controller is adapted to use a lookup table to determine the operation time.

30. The system of claim 28, wherein the controller is adapted to determine a value representing an integrated voltage applied to the pump during the operation time, and is adapted to stop operation of the pump when the value equals the operation time.

31. The system of claim 25, wherein a volume of liquid delivered by the pump during the calibration period is different from the predetermined volume of liquid delivered by the pump during subsequent operation of the pump.

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