system or a hydronic heating system, the thermal valve may regulate (e.g., passively regulate) the flow of fluid flow through the path based on the temperature of the fluid. As such, a hot water supply system or a hydronic heating system may maintain a substantially constant temperature by utilizing one or more thermal valves to passively control the flow of circulating fluid. Further, by utilizing one or more thermal valves in a hot water supply system or a hydronic heating system having a number of fluid circulation loops and/or zones, the system may automatically and passively maintain balance over time. The passive balancing of the system may occur in lieu of or in the presence of manual balancing adjustments to the system. Additionally, the use of the thermal valve(s) to restrict the flow of hot water at appropriate points during the operation of the hot water supply or hydronic heating system may lead to substantial energy and cost savings.

[0007] According to some embodiments of the invention, there is provided a thermal valve for controlling a flow of fluid, the thermal valve including: a housing having an inlet and an outlet configured to permit the flow of fluid through an interior of the housing; an actuator including heat-sensitive material configured to contract or expand based on a temperature of the fluid; a rod fixedly coupled to the housing and partially inside the actuator, the rod being configured to move relative to the actuator as the heat-sensitive material contracts or expands; a chamber inside the housing and fixedly coupled to the housing, the chamber being configured to accommodate the actuator and defining one or more flow openings; a first compressive resilient element configured to movably couple the actuator to the chamber; and a disc movably coupled to the chamber via a second compression element, and configured to permit flow of the fluid from the inlet to the outlet and to reduce flow of water from the outlet to the inlet, wherein the actuator is configured to move toward the one or more flow openings in the chamber and fully seat against the one or more flow openings to reduce fluid flow through the inlet as the heat-sensitive material expands.

[0008] In an embodiment, the actuator is configured to reduce a flow of the fluid through the thermal valve when the temperature of the fluid exceeds a closing temperature.

[0009] In an embodiment, the actuator includes a body extending along a lengthwise direction of a housing and a fin extending laterally from the body.

[0010] In an embodiment, the chamber includes a widened portion and a stem, the widened portion having a diameter greater than that of the stem.

[0011] In an embodiment, the stem is configured to receive the body of the actuator, and wherein the widened portion is configured to accommodate the fin of the actuator.

[0012] In an embodiment, the chamber has perforated walls

[0013] In an embodiment, the chamber has a flow opening, and the actuator is configured to close a gap between a fin of the actuator and the chamber at the flow opening when the temperature of the fluid exceeds a closing temperature.

[0014] In an embodiment, the first compressive resilient element is configured to maintain the fin of the actuator at a distance from the inlet when the temperature of the fluid does not exceed the closing temperature.

[0015] In an embodiment, the heat-sensitive material includes wax.

[0016] In an embodiment, the disc has a diameter greater than that of the inlet, the disc being configured to press against a seating surface of the housing and to reduce current flow when the fluid flows from the outlet to the inlet.

[0017] In an embodiment, the second compressive resilient element is configured to apply a force to the disc to press the disc against the seating surface of the housing.

[0018] In an embodiment, the disc includes a bypass hole configured to permit reduced fluid flow through the housing.

[0019] In an embodiment, the thermal valve further includes a valve flange at an outer periphery of the housing and extending substantially perpendicular to a lengthwise direction of the housing.

[0020] In an embodiment, the valve flange is coupled between a flange of a pipe and an input or an output of a pump.

[0021] In an embodiment, the housing is configured to fit within a pipe at an interface of the pipe and a pump.

[0022] In an embodiment, a lengthwise periphery of the housing is separated from an inner surface of the pipe by a gap.

[0023] According to some embodiments of the invention, there is provided a thermal valve for controlling a flow of fluid, the thermal valve including: a housing having an inlet and an outlet configured to permit the flow of fluid through an interior of the housing; a stopper inside the housing and fixedly coupled to the housing and defining a valve opening; an actuator including heat-sensitive material configured to contract or expand and to engage the stopper based on a temperature of the fluid, the actuator being further configured to reduce a flow of the fluid through the thermal valve as the temperature of the fluid decreases, the actuator comprising a body extending along a lengthwise direction of the housing and a fin extending laterally from the body; a rod fixedly coupled to the housing and partially inside the actuator, the rod being configured to move relative to the actuator as the heat-sensitive material contracts or expands; a chamber inside the housing and fixedly coupled to the housing, the chamber being configured to accommodate the actuator, the chamber comprising a tapered widened portion configured to receive the fin of the actuator, a stem configured to receive the body of the actuator and allow the actuator to move in the lengthwise direction of the housing, and one or more flow openings in the tapered widened portion; a first compressive resilient element configured to movably couple the actuator to the chamber; and a disc movably coupled to the chamber via a second

compression element, and configured to permit flow of the fluid from the inlet to the outlet and to reduce flow of water from the outlet to the inlet.

[0024] In an embodiment, the actuator is configured to increase a gap between a fin of the actuator and the stopper at the valve opening when the temperature of the fluid exceeds an opening temperature.

[0025] In an embodiment, the first compressive resilient element is configured to maintain the fin of the actuator pressed against the stopper when the temperature of the fluid does not exceed the opening temperature.

WHAT IS CLAIMED IS:

1. A thermal valve for controlling a flow of fluid, the thermal valve comprising:

a housing having an inlet and an outlet configured to permit the flow of fluid through an interior of the housing;

an actuator comprising heat-sensitive material configured to contract or expand based on a temperature of the fluid;

a rod fixedly coupled to the housing and partially inside the actuator, the rod being configured to move relative to the actuator as the heat-sensitive material contracts or expands;

a chamber inside the housing and fixedly coupled to the housing, the chamber being configured to accommodate the actuator and defining one or more flow openings;

a first compressive resilient element configured to movably couple the actuator to the chamber; and

a disc movably coupled to the chamber via a second compressive resilient element, and configured to permit flow of the fluid from the inlet to the outlet and to reduce flow of water from the outlet to the inlet,

wherein the actuator is configured to move toward the one or more flow openings in the chamber and fully seat against the one or more flow openings to reduce fluid flow through the inlet as the heat-sensitive material expands.

2. The thermal valve according to claim 1, wherein the actuator is configured to reduce a flow of the fluid through the thermal valve when the temperature of the fluid exceeds a closing temperature.

3. The thermal valve according to any one of claims 1-2, wherein the actuator comprises a body extending along a lengthwise direction of a housing and a fin extending laterally from the body.

4. The thermal valve of according to any one of claims 1-3, wherein the chamber comprises a widened portion and a stem, the widened portion having a diameter greater than that of the stem.

5. The thermal valve of claim 4, wherein the stem is configured to receive the body of the actuator, and wherein the widened portion is configured to accommodate the fin of the actuator.

6. The thermal valve according to any one of claims 1-5, wherein the chamber has perforated walls.

7. The thermal valve according to any one of claims 1-6, wherein the actuator is configured to close a gap between a fin of the actuator and the chamber at the flow opening when the temperature of the fluid exceeds a closing temperature.

8. The thermal valve according to any one of claims 1-7, wherein the first compressive resilient element is configured to maintain a fin of the actuator at a distance from the inlet when the temperature of the fluid does not exceed the closing temperature.

9. The thermal valve according to any one of claims 1-8, wherein the heat-sensitive material includes wax.

10. The thermal valve according to any one of claims 1-9, wherein the disc has a diameter greater than that of the inlet, the disc being configured to press against a seating surface of the housing and to reduce current flow when the fluid flows from the outlet to the inlet.

11. The thermal valve according to any one of claims 1-10, wherein the second compressive resilient element is configured to apply a force to the disc to press the disc against the seating surface of the housing.

12. The thermal valve according to any one of claims 1-11, wherein the disc comprises a bypass hole configured to permit reduced fluid flow through the housing.

13. The thermal valve according to any one of claims 1-12, further comprising a valve flange at an outer periphery of the housing and extending substantially perpendicular to a lengthwise direction of the housing.

14. The thermal valve of claim 13, wherein the valve flange is coupled between a flange of a pipe and an input or an output of a pump.

15. The thermal valve of claim 13, wherein the housing is configured to fit within a pipe at an interface of the pipe and a pump.

16. The thermal valve of claim 15, wherein a lengthwise periphery of the housing is separated from an inner surface of the pipe by a gap.

17. A thermal valve for controlling a flow of fluid, the thermal valve comprising:

a housing having an inlet and an outlet configured to permit the flow of fluid through an interior of the housing;

a stopper inside the housing and fixedly coupled to the housing and defining a valve opening;

an actuator comprising heat-sensitive material configured to contract or expand and to engage the stopper based on a temperature of the fluid, the actuator being further configured to reduce a flow of the fluid through the thermal valve as the temperature of the fluid decreases, the actuator comprising a body extending along a lengthwise direction of the housing and a fin extending laterally from the body;

a rod fixedly coupled to the housing and partially inside the actuator, the rod being configured to move relative to the actuator as the heat-sensitive material contracts or expands;

a chamber inside the housing and fixedly coupled to the housing, the chamber being configured to accommodate the actuator, the chamber comprising a tapered widened portion configured to receive the fin of the actuator, a stem configured to receive the body of the actuator and allow the actuator to move in the lengthwise direction of the housing, and one or more flow openings in the tapered widened portion;

a first compressive resilient element configured to movably couple the actuator to the chamber; and

a disc movably coupled to the chamber via a second compressive resilient element, and configured to permit flow of the fluid from the inlet to the outlet and to reduce flow of water from the outlet to the inlet.

18. The thermal valve according to claim 17, wherein the actuator is configured to increase a gap between a fin of the actuator and the stopper at the valve opening when the temperature of the fluid exceeds an opening temperature.

19. The thermal valve according to any one of claims 17-18, wherein the first compressive resilient element is configured to maintain the fin of the actuator pressed against the stopper when the temperature of the fluid does not exceed the opening temperature.