

## DESCRIPTION

### THERMOSENSITIVE VALVE AND SPRINKLER SYSTEM USING SAME

#### Technical Field

[0001]

The present invention relates to a thermosensitive valve and a sprinkler system using the same.

#### Background Art

[0002]

Water spray is performed using a sprinkler system such as a sprinkler for cooling, watering, or the like in various facilities including a solar power panel, a roof, a wall, a park, a work site, and the like. For automatic control of the start and stop of water sprinkling using a sprinkler system, a temperature sensor such as a thermostat and a solenoid valve are generally used.

[0003]

A solenoid valve is electrically driven; however, automatic control requiring no electricity is desired, and there is proposed automatic control by a thermosensitive valve, for example (for example, Patent Literature 1). The thermosensitive valve controls the start and stop of water sprinkling by using thermal expansion of a thermal expansion member such as wax.

## Citation List

### Patent Literature

[0004]

Patent Literature 1: JP 2012-256823 A

### Summary of Invention

#### Technical Problem

[0005]

In a thermosensitive valve disclosed in Patent Literature 1, water to be sprayed flows through the thermosensitive valve body; therefore, the following issue may occur. If much water flows while a valve is open, the thermal expansion member is cooled by the flowing water, and the valve is thus be closed, whereby water is not be sufficiently sprinkled. Further, the pressure of the flowing water may cause a vibration (chattering) of a movable part of the valve, and the water may not be sprinkled uniformly.

[0006]

The present invention has been made in view of the above issues, and the present invention is to provide a thermosensitive valve in which it can be inhibited that the valve is cooled by water flowing while the valve is open and is thus closed and in which chattering can be inhibited from occurring; and the present invention is to provide a sprinkler system using the thermosensitive valve.

## Solution to Problem

[0007]

A thermosensitive valve according to a first aspect of the present invention includes:

a main water passage passing from an inlet port to a main outlet port, wherein water flows in through the inlet port;

a sub water passage branching off from the main water passage and passing to a sub outlet port;

a master valve which opens and closes the main water passage; and

a slave valve which opens and closes the main water passage, wherein the master valve includes a master-valve opening/closing member which opens and closes the main water passage in association with the opening and the closing of the sub water passage,

the slave valve includes:

a heat receiving member which receives heat from a heat source;

a thermal expansion member whose volume can be increased and decreased by heat transferred from the heat receiving member; and

a slave-valve opening/closing member which is driven by the increase and the decrease of the volume of the

thermal expansion member and thus opens and closes the sub water passage,

the master-valve opening/closing member closes the main water passage, following the closing of the sub water passage by the slave valve, so as to stop water from being discharged from the main outlet port, and

the master-valve opening/closing member opens the main water passage, following the opening of the sub water passage by the slave valve, so as to allow the water to be discharged from the main outlet port.

[0008]

Further, it is desirable that the master valve includes a pressure chamber provided on the sub water passage,

the slave valve closes the sub water passage so as to increase a pressure in the pressure chamber, and thus the master-valve opening/closing member closes the main water passage, and

the slave valve opens the sub water passage so as to decrease the pressure in the pressure chamber, and thus the master-valve opening/closing member opens the main water passage.

[0009]

Furthermore, it is desirable that the slave valve is disposed, through a connection tube, at a position a long distance away from the master valve.

[0010]

Further, the thermosensitive valve may include a slave-valve cooling member connected to the sub outlet port to supply the water discharged from the sub outlet port to the slave valve so as to cool the slave valve.

[0011]

In addition, the thermosensitive valve according to a second aspect of the present invention includes:

a thermosensitive valve according to the first aspect of the present invention;

a water supply unit connected to the inlet port of the thermosensitive valve so as to supply water to the inlet port; and

a water sprinkling unit which sprinkles water discharged from the main outlet port of the thermosensitive valve to an object to be watered.

#### Advantageous Effects of Invention

[0012]

In the thermosensitive valve according to the present invention, a slave valve controls the movability of the master valve which performs the opening and closing of the main water passage. While the slave valve is open, the amount of the water flowing through the slave valve is small; therefore, it is possible to reduce cooling, by the flowing water, of the thermal expansion member which performs opening and closing of the slave

valve. This arrangement inhibits the slave valve from being unintentionally closed. Further, since the amount of the flowing water is small, chattering is not likely to occur.

#### Brief Description of Drawings

[0013]

Fig. 1 is an internal structural view of a thermosensitive valve and shows an embodiment of the present invention.

Fig. 2 is an internal structural view of the thermosensitive valve viewed in A-A' direction of Fig. 1.

Fig. 3 is an internal structural view of the thermosensitive valve in an open state, and shows an embodiment of the present invention.

Fig. 4 is an internal structural view of the thermosensitive valve in a closed state, and shows an embodiment of the present invention.

Fig. 5 is an explanatory diagram of a cooling structure of the slave valve, and shows an embodiment of the present invention.

Fig. 6 is a structural diagram of a sprinkler system and shows an embodiment of the present invention.

#### Description of Embodiment

[0014]

##### Thermosensitive Valve

Hereinafter, a thermosensitive valve according to an embodiment of the present invention will be described based on the drawings, and the thermosensitive valve has, in a sprinkler system, a function to automatically start water sprinkling by a heat source such as a temperature of the air. The thermosensitive valve 1 is equipped with a master valve 10 and a slave valve 20 as shown in Fig. 1 and Fig. 2. The master valve 10 and the slave valve 20 are connected to each other through a connection tube 40. Further, in the thermosensitive valve 1, there are formed a main water passage MW and a sub water passage SW.

[0015]

The main water passage MW is a water passage which passes from an inlet port IP opened in the master valve 10, through the inside of the master valve 10, to a main outlet port MOP opened in the master valve 10. To the inlet port IP, there is connected a water supply unit. Further, to the main outlet port MOP, there is connected a water sprinkling unit which sprinkles water on an object to be watered.

[0016]

On the other hand, the sub water passage SW is a water passage which branches off from the main water passage MW, then passes through the inside of the master valve 10, the connection tube 40, and inside of the slave valve 20, to a sub outlet port SOP opened in the slave valve 20.

[0017]

A part of the sub water passage SW functions as a pressure chamber PR.

The pressure chamber PR is a space which is surrounded by a master-valve main-body upper part 11 and a master-valve opening member 14.

[0018]

The master valve 10 is equipped with the master-valve main-body upper part 11, a master-valve main-body lower part 12, a bulkhead 13, a master-valve opening/closing member 14, a spring 15, and a flow rate adjustment member 16.

[0019]

The master-valve opening/closing member 14 is disposed between the bulkhead 13 and the pressure chamber PR and has a function to open and close the main water passage MW together with the bulkhead 13. Further, an edge part of the master-valve opening/closing member 14 is held between the master-valve main-body upper part 11 and the master-valve main-body lower part 12, and the master-valve opening/closing member 14 has a function to separate the main water passage MW and the sub water passage SW.

[0020]

The master-valve opening/closing member 14 is a member configured to be movable between the pressure chamber PR side and the bulkhead 13 side, depending on the relationship among

a water power of the water flowing through the main water passage MW, a pressure in the pressure chamber PR disposed in the sub water passage SW, and a biasing force of the spring 15. It is preferable that the master-valve opening/closing member 14 be configured of elastic material such as rubber so that the master-valve opening/closing member 14 is closely contacted with the bulkhead 13 to inhibit the water from flowing in the bulkhead 13 while closing the main water passage MW.

[0021]

Further, the spring 15 biases the master-valve opening/closing member 14 to the bulkhead 13. The flow rate adjustment member 16 is a member which moves in the longitudinal direction when turned and adjusts the biasing force of the spring 15, thereby adjusting the amount of the water flowing through the main water passage MW.

[0022]

The slave valve 20 is configured with a slave-valve main body 21, a slave-valve opening/closing member 22, a spring 23, a hole 24 formed in the slave-valve opening/closing member 21, a thermal expansion member 25, a diaphragm 26, fluid 27, a sealing member 28, a piston 29, and a heat receiving member 30. Further, the slave valve 20 may be housed in an outer casing such as a thermometer screen which blocks the sunlight and rain but through which wind easily passes.

[0023]

Through the slave-valve main body 21, there is formed a flow passage 31, and the flow passage 31 functions as a part of the sub water passage SW. To the upstream side of this flow passage, the connection tube 40 is connected, and the connection tube 40 is connected to the master valve 10.

[0024]

The slave-valve opening/closing member 22, which is capable of opening and closing a part of the flow passage 31, is disposed. The slave-valve opening/closing member 22 is disposed to be reciprocally movable by an action of the spring 23 and the piston 29. Through the slave-valve opening/closing member 22, there is formed the hole 24 which functions as a part of the flow passage 31, and when the hole 24 is overlapped by the flow passage 31, the sub water passage SW is open, and when the hole 24 is not overlapped by the flow passage 31, the sub water passage SW is closed.

[0025]

Examples of the heat receiving member 30 include a heat receiving tube which doubles as a casing and a member receiving the temperature of the air or the like. The heat received by the heat receiving tube is transferred to the thermal expansion member 25 through an inner wall of the heat receiving tube, which receives the heat.

It is preferable that the heat receiving tube, which is an example of the heat receiving member 30, be made of material

such as copper, which has a large heat capacity, so as to effectively receive heat from the temperature of the air or the like.

Further, the heat receiving tube may be made of a material such as copper, aluminum, or brass, which has an excellent thermal conductivity and easily absorbs heat of the temperature of the air or the like. Further, the heat receiving tube may be in the shape of a lidded tubular body and may have a plurality of fins formed around the heat receiving tube.

Still further, the heat receiving member 30 may be a tubular body in various shapes such as the cylindrical shape or a polygonal tubular body, which is the shape of a lidded tubular body, and the heat receiving member 30 is preferably a heat receiving tube having a large surface area.

Further, it is desirable that the material of the heat receiving tube be a material which has a higher thermal conductivity than the material (brass) of the Wax Thermo-Element (made by Asey Industry Co., Ltd.) so that residual heat of the valve body does not affect.

[0026]

As the thermal expansion member 25, there is used a member whose volume increases at high temperatures compared with low temperatures. For example, examples of the thermal expansion member 25 include wax, where the wax is solid at low temperatures

and where the wax becomes liquid and the volume of the wax increases at high temperatures.

[0027]

Subsequently, the operation of the thermosensitive valve 1 will be described based on Figs. 3 and 4. Note that the following description will be given assuming that a pipe or the like is connected to each of the inlet port IP and the main outlet port MOP and that water is constantly supplied through the inlet port IP.

[0028]

Fig. 3 shows the state that the main water passage MW is closed and the discharge of water from the main outlet port MOP is thus stopped. In this state, the thermal expansion member 25 is not in the state that the thermal expansion member 25 is melted due to the heat transferred through the inner wall of the heat receiving tube, which is the heat receiving member 30, but the thermal expansion member 25 is in a solid state. In this case, the piston 29 is not pushed out, but the slave-valve opening/closing member 22 is pushed to the piston 29 side by the stretching force of the spring 23. The hole 24 formed in the slave-valve opening/closing member 22 does not overlap the flow passage 31 of the slave-valve main body 21, and the slave-valve opening/closing member 22 thus closes the flow passage 31.

[0029]

The water flowing through the sub water passage SW is stopped by the slave-valve opening/closing member 22; thus, the water pressure in the pressure chamber PR formed on the sub water passage SW increases. The pressure in the pressure chamber PR presses the master-valve opening/closing member 14 against the bulkhead 13. Thus, the main water passage MW is closed to stop the water from the main outlet port MOP.

[0030]

Then, when the heat receiving member 30 becomes hot due to the heat received from the temperature of the air, the main water passage MW is opened, as described below, and the water is discharged from the main outlet port MOP. Fig. 4 shows the state that the main water passage MW is opened.

[0031]

The heat receiving member 30 receives heat from the temperature of the air, and the received heat is transferred through the inner wall of the heat receiving tube to the thermal expansion member 25; and when the volume of the thermal expansion member 25 is thus increased, the thermal expansion member 25 pushes out the piston 29 through the diaphragm 26, the fluid 27, and the sealing member 28. By the piston 29 being pushed out, the slave-valve opening/closing member 22 is pushed against the force of the spring 23. When the slave-valve opening/closing member 22 is pushed, the hole 24 formed in the slave-valve opening/closing member 22 overlaps the flow passage 31 formed

in the slave-valve main body 21. The water blocked by the slave-valve opening/closing member 22 flows to the sub outlet port SOP, the sub water passage SW is opened. As a result, the water flows through the sub water passage SW as indicated by the void arrow.

[0032]

In the state that the sub water passage SW is opened and the water flows through the sub water passage SW as described above, the water pressure in the pressure chamber PR decreases. The water pressure in the main water passage MW becomes higher than the water pressure in the pressure chamber PR and the biasing force of the spring 15, and the master-valve opening/closing member 14 is thus moved to the pressure chamber PR side. With this operation, the master-valve opening/closing member 14 becomes apart from the bulkhead 13; thus, the water blocked by the master-valve opening/closing member 14 and the bulkhead 13 passes through between the master-valve opening/closing member 14 and the bulkhead 13. As a result, the water flows through the main water passage MW as indicated by the black arrow and is then discharged from the main outlet port MOP.

[0033]

As described above, the master valve 10 is opened and closed following the opening and closing of the slave valve 20, and the water is thus controlled to be discharged from the main outlet port MOP and to be stopped.

[0034]

Because the flow passage diameter of the sub water passage SW is formed smaller than the flow passage diameter of the main water passage MW, in the state that the main water passage MW and the sub water passage SW are opened, the amount of the water flowing through the sub water passage SW is much smaller than the amount of the water flowing through the main water passage MW. Therefore, the cooling of the thermal expansion member 25 by the water flowing through the sub water passage SW is kept weak. Therefore, the slave valve 20 is inhibited from being unintentionally closed, thereby inhibiting the water from flowing through the main water passage MW and inhibiting the water from being discharged through the main outlet port MOP.

[0035]

Further, because the amount of the water flowing through the sub water passage SW is very small as described above, chattering of the slave valve 20 is also inhibited.

[0036]

Note that any mechanism may be used as the master valve 10 if the mechanism is a valve mechanism which can close and open the main water passage MW in association with the closing and opening of the sub water passage SW by the slave valve 20. For example, it is possible to use as the master valve 10 a constant water level valve, an air-operated bi-directional valve for water,

or an air-driven poppet valve which is commercially available. Further, as the slave valve 20, a commercially available thermosensitive valve may be used.

[0037]

Further, as a material for the connection tube 40, a resin tube may be used to improve heat insulation to the master valve. Regarding the place of installation of the thermosensitive valve 1, the master valve and the slave valve may be separately disposed indoor and outdoor, respectively, for example; and further, the connection tube 40 may be made long depending on the purpose of use or the like.

[0038]

Further, after a predetermined time has elapsed, the slave valve 20 may be closed, and the sub water passage SW and the main water passage MW may be in a closed state. For example, as shown in Fig. 5, the slave valve 20 may be in a state of being cooled by the water discharge from the sub outlet port SOP. To the sub outlet port SOP, a slave-valve cooling pipe 32 is connected, and the end of the slave-valve cooling pipe 32 is disposed such that the water passing through the slave-valve cooling pipe 32 drops on the heat receiving member 30 of the slave valve 20.

[0039]

After the slave valve 20 is opened and the sub water passage SW is opened, the water is discharged from the sub outlet port SOP, and the discharged water drops on the heat receiving member

30, thereby cooling the heat receiving member 30. The water keeps dropping on the heat receiving member 30 for a predetermined time, the thermal expansion member 25 is cooled, whereby the volume of the thermal expansion member 25 decreases. The decrease of the volume of the thermal expansion member 25 closes the slave valve 20, and the master valve 10 is also closed along with the close of the sub water passage SW; thus, the main water passage MW is closed, and the discharge of water from the main outlet port MOP is stopped.

[0040]

With this configuration, after a predetermined time has elapsed, the water sprinkling is automatically stopped, and the consumption of used water can be reduced. For example, if used to cool a solar power panel, it is possible to sprinkle water only while the temperature of the solar power panel is higher than a predetermined temperature, whereby cooling cost is reduced.

[0041]

Note that the slave-valve cooling pipe 32 may be disposed so as to supply water to a casing 24 which encloses the thermal expansion member 25. Further, at the end of the slave-valve cooling pipe 32, there may be provided a spray nozzle or the like which sprays water in mist form.

[0042]

Further, a part of the water discharged from the main outlet port MOP may be supplied to the slave valve 20 to cool the slave valve 20.

[0043]

#### Sprinkler System

Subsequently, a sprinkler system equipped with the above thermosensitive valve will be described. In the following, a description will be given taking a cooling device for a solar power panel as an example of the sprinkler system.

[0044]

As shown in Fig. 6, a cooling device 50 is equipped with spray nozzles 53 which spray water on solar power panels 60, a water supply device 51 which supply water to the spray nozzles 53 through a pipe 52, a thermosensitive valve 1 which controls the water spray, and pipes 52 each of which connects between the water supply device 51 and the thermosensitive valve 1 and between the thermosensitive valve 1 and the spray nozzles 53.

[0045]

The water supply device 51 is not particularly limited if water can be supplied to the spray nozzles 53 through the pipe 52. For example, a faucet may be used as the water supply device 51, and alternatively, a device may be used which supplies water stored in a water storage tank by using a lifting pump or the like.

[0046]

The thermosensitive valve 1 is connected to an arbitrary position on the pipe 52. The inlet port IP and the main outlet port MOP of the thermosensitive valve 1 are each connected to the pipes 52.

[0047]

From the water supply device 51, water is constantly supplied. When the temperature is low, the slave valve 20 of the thermosensitive valve 1 is closed as described above, and also the master valve 10 is thus closed, whereby the discharge of the water from the main outlet port MOP is stopped. As a result, the spray nozzles 53 do not spray water.

[0048]

On the other hand, when the temperature is raised by the temperature of the air, the slave valve 20 of the thermosensitive valve 1 is opened, and the master valve 10 is subsequently opened, whereby water is discharged from the main outlet port MOP. Therefore, the water is sprayed on the solar power panels 60 from the spray nozzles 53. The power generation efficiency of the solar power panels 60 are low when the temperature is too high; therefore, if the solar power panels 60 are cooled by the water sprayed by the cooling device 50, the power generation efficiency can be maintained.

[0049]

Further, with the above arrangement in which the slave valve 20 is cooled by the water discharged from the sub outlet

port SOP, after the water is sprayed on the solar power panels 60 for a predetermined time, the spraying is stopped. Then, if the temperature rises again, spray is performed again for a predetermined time. By repeating the water spray intermittently as described above, it is possible to maintain the power generation efficiency of the solar power panels 60, and at the same time it is possible to reduce the consumption of water.

[0050]

In the above, the description is given taking the cooling device for the solar power panel as an example; however, examples of the object to be watered include various things such as a roof, a park, a rooftop garden, a rooftop vegetable garden, a science tank, and a commercial facility. Further, the present invention can be used not only for the object to be cooled but also for various purposes such as watering a lawn.

[0051]

Various embodiments and deformation of the present invention are possible without departing from the broad spirit and scope of the present invention. Further, the above embodiment is for describing the present invention, and does not limit the scope of the present invention. That is, the scope of the present invention is defined not by the embodiment but by the claims. Further, it is considered that the scope of the present invention includes the deformations made in the scope

of the claims and in the scope of the purposes of the equivalent invention.

#### Industrial Applicability

[0052]

The present invention is industrially applicable by establishing and practicing the technology of the thermosensitive valve of the present invention and the sprinkler system using the same.

#### Reference Signs List

[0053]

- |    |                                     |
|----|-------------------------------------|
| 1  | Thermosensitive valve               |
| 10 | Master valve                        |
| 11 | Master-valve main-body upper part   |
| 12 | Master-valve main-body lower part   |
| 13 | Bulkhead                            |
| 14 | Master-valve opening/closing member |
| 15 | Spring                              |
| 16 | Flow rate adjustment member         |
| 20 | Slave valve                         |
| 21 | Slave-valve main body               |
| 22 | Slave-valve opening/closing member  |
| 23 | Spring                              |
| 24 | Hole                                |

|     |                          |
|-----|--------------------------|
| 25  | Thermal expansion member |
| 26  | Diaphragm                |
| 27  | Fluid                    |
| 28  | Sealing member           |
| 29  | Piston                   |
| 30  | Heat receiving member    |
| 31  | Flow passage             |
| 32  | Slave-valve cooling pipe |
| 40  | Connection tube          |
| 50  | Cooling device           |
| 51  | Water supply device      |
| 52  | Pipe                     |
| 53  | Spray nozzle             |
| 60  | Solar power panel        |
| MW  | Main water passage       |
| SW  | Sub water passage        |
| IP  | Inlet port               |
| MOP | Main outlet port         |
| SOP | Sub outlet port          |
| PR  | Pressure chamber         |

## CLAIMS

1. A thermosensitive valve comprising:
  - a main water passage passing from an inlet port to a main outlet port, wherein water flows in through the inlet port;
  - a sub water passage branching off from the main water passage and passing to a sub outlet port;
  - a master valve which opens and closes the main water passage; and
  - a slave valve which opens and closes the main water passage, wherein the master valve includes a master-valve opening/closing member which opens and closes the main water passage in association with the opening and the closing of the sub water passage,
- the slave valve includes:
  - a heat receiving member which receives heat from a heat source;
  - a thermal expansion member whose volume can be increased and decreased by heat transferred from the heat receiving member; and
  - a slave-valve opening/closing member which is driven by the increase and the decrease of the volume of the thermal expansion member and thus opens and closes the sub water passage,
- the master-valve opening/closing member closes the main water passage, following the closing of the sub water passage

by the slave valve, so as to stop water from being discharged from the main outlet port, and

the master-valve opening/closing member opens the main water passage, following the opening of the sub water passage by the slave valve, so as to allow the water to be discharged from the main outlet port.

2. The thermosensitive valve according to claim 1, wherein the master valve includes a pressure chamber provided on the sub water passage,

the slave valve closes the sub water passage so as to increase a pressure in the pressure chamber, and thus the master-valve opening/closing member closes the main water passage, and

the slave valve opens the sub water passage so as to decrease the pressure in the pressure chamber, and thus the master-valve opening/closing member opens the main water passage.

3. The thermosensitive valve according to claim 1 or 2, wherein the slave valve is disposed, through a connection tube, at a position a long distance away from the master valve.

4. The thermosensitive valve according to claim 1 or 2, comprising a slave-valve cooling member connected to the sub

outlet port to supply the water discharged from the sub outlet port to the slave valve so as to cool the slave valve.

5. A sprinkler system comprising:

a thermosensitive valve according to any one of claims 1 to 3;

a water supply unit connected to the inlet port of the thermosensitive valve so as to supply water to the inlet port; and

a water sprinkling unit which sprinkles water discharged from the main outlet port of the thermosensitive valve to an object to be watered.

6. The thermosensitive valve according to claim 1 or 2, comprising a slave-valve cooling member connected to the sub outlet port to supply the water discharged from the sub outlet port to the slave valve so as to cool the slave valve.

7. The thermosensitive valve according to claim 1, wherein the heat receiving member is a lidded tubular body.

8. The thermosensitive valve according to claim 1 or 7, wherein the heat receiving member is a lidded tubular body having a fin on a circumference of the lidded tubular body.