DESCRIPTION

Title of Invention

HEAT-MEDIUM SUPPLY APPARATUS

Technical Field

[0001] The present invention relates to a heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, such as an etching apparatus, a CVD apparatus, or a PVD apparatus.

Background Art

[0002] A semiconductor manufacturing apparatus (for example, an etching apparatus, a CVD apparatus, or a PVD apparatus) for manufacturing a semiconductor device is configured to perform a manufacturing process while controlling a processing temperature. For example, in the etching apparatus, a processing temperature for a wafer is regulated by causing a liquid as a temperature-regulated heat medium to flow through a flow path formed in a susceptor supporting the wafer.

[0003] A temperature of the heat medium to be supplied to the semiconductor manufacturing apparatus is regulated directly or indirectly by a cooling device and a heating device. For example, a temperature-regulated heat medium is generated by mixing the heat medium cooled by the cooling device and the heat medium heated by the heating device, and the processing temperature in the semiconductor manufacturing apparatus is regulated by the heat medium supplied to the semiconductor manufacturing apparatus. In another example, as shown in Patent document 1, a first heat medium and a second heat medium are cooled and heated by the cooling device and the heating device, respectively, a temperature of a third heat medium is regulated by heat exchange between the cooled first heat medium and heated second heat medium and the third heat medium. A processing temperature in the semiconductor manufacturing apparatus is then regulated by the third heat medium supplied to the semiconductor manufacturing apparatus.

Citation List

Patent Literature

[0004] Patent document 1: Japanese laid-open patent publication No. 2021-77086

Patent document 2: Japanese laid-open patent publication No. 2023-98068

Patent document 3: Japanese Patent No. 7014988

Summary of Invention

Technical Problem

[0005] During processing of a wafer in the semiconductor manufacturing apparatus, a target processing temperature for the wafer changes depending on a processing step. For example, when the target processing temperature in the semiconductor manufacturing apparatus drops during the processing of the wafer, it is necessary to rapidly drop the temperature of the heat medium to be supplied to the semiconductor manufacturing apparatus. As a result, a thermal load on the cooling device temporarily increases. Similarly, when the target processing temperature in the semiconductor manufacturing apparatus rises during the processing of the wafer, it is necessary to rapidly raise the temperature of the heat medium to be supplied to the semiconductor manufacturing apparatus. As a result, a thermal load on the heating device temporarily increases.

[0006] However, if a cooling capacity of the cooling device and a heating capacity of the heating device are increased in preparation for a temporary load fluctuation, disadvantages, such as an increase in size and an increase in cost of the cooling device and the heating device, arise.

[0007] Therefore, the present invention provides a heat-medium supply apparatus capable of rapidly responding to a change in a target processing temperature in a semiconductor manufacturing apparatus without changing a rated capacity of a cooling device or a heating device.

Solution to Problem

[0008] In an embodiment, there is provided a heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a

temperature of a semiconductor manufacturing apparatus, comprising: a cooling device configured to cool a first heat medium; a heating device configured to heat a second heat medium; a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus; a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus; a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device; a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and an operation controller configured to control an operation of the cooling device, wherein the operation controller is configured to, when a thermal load on the cooling device exceeds a cooling-load threshold value, instruct the cooling device to switch the operation of the cooling device from a rated cooling operation to an overload cooling operation.

[0009] The rated cooling operation is an operation of operating the cooling device within a range equal to or lower than an upper limit of a rated cooling capacity of the cooling device. The overload cooling operation is an operation of operating the cooling device within a range exceeding the upper limit of the rated cooling capacity of the cooling device. An excessive increase in the thermal load on the cooling device occurs when the temperature of the heat medium returning from the temperature control apparatus to the cooling device excessively rises. Such an excessive temperature rise of the heat medium normally occurs temporarily during an operation of the semiconductor manufacturing apparatus, and its duration is relatively short, from several tens of seconds to one hundred and several tens of seconds. Therefore, by temporarily causing the cooling device to perform the overload cooling operation, the cooling capacity of the cooling device is enhanced, so that the cooling device can rapidly cool the first heat medium to a target cooling temperature.

[0010] In an embodiment, the operation controller is configured to, when a predetermined overload cooling operation allowable time has elapsed after the operation of the cooling

device is switched from the rated cooling operation to the overload cooling operation, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation.

Since the increase in the thermal load on the cooling device is temporary, there is no need to continue the overload cooling operation for a long time. Therefore, when the predetermined overload cooling operation allowable time has elapsed, the operation of the cooling device is switched from the overload cooling operation to the rated cooling operation, so that a failure of the cooling device caused by the overload cooling operation can be prevented.

[0011] In an embodiment, the operation controller is configured to, when an abnormality of the cooling device is detected during the overload cooling operation of the cooling device, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation.

According to the present invention, the failure of the cooling device can be prevented. The abnormality of the cooling device is detected by, for example, an abnormality detection device included in the cooling device itself.

[0012] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

When the same heat medium is used for the first heat medium and the second heat medium, they can be used by being mixed. Therefore, the first heat medium and the second heat medium can be directly supplied to the temperature control apparatus. However, the first heat medium, the second heat medium, and a third heat medium can be used as independent systems by interposing a heat exchanger.

[0013] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.

Since the different heat media are used for the first heat medium and the second heat medium, they cannot be used by being mixed, and thus, it is necessary to provide heat exchange between the first heat medium and a third heat medium on the temperature control

apparatus side, and between the second heat medium and the third heat medium on the temperature control apparatus side. Instead, there are effects that adjustment of liquid levels of the first heat medium and the second heat medium is unnecessary, and even if flow rates of the first heat medium and the second heat medium are controlled, a flow rate on the temperature control apparatus side is not affected.

[0014] In an embodiment, there is provided a heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, comprising: a cooling device configured to cool a first heat medium; a heating device configured to heat a second heat medium; a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus; a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus; a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device; a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and an operation controller configured to control an operation of the heating device, wherein the operation controller is configured to, when a thermal load on the heating device exceeds a heating-load threshold value, instruct the heating device to switch the operation of the heating device from a rated heating operation to an overload heating operation.

[0015] The rated heating operation is an operation of operating the heating device within a range equal to or lower than an upper limit of a rated heating capacity of the heating device. The overload heating operation is an operation of operating the heating device within a range exceeding the upper limit of the rated heating capacity of the heating device. An excessive increase in the thermal load on the heating device occurs when the temperature of the heat medium returning from the temperature control apparatus to the heating device excessively drops. Such an excessive temperature drop of the heat medium normally occurs temporarily during the operation of the semiconductor manufacturing

apparatus, and its duration is relatively short, from several tens of seconds to one hundred and several tens of seconds. Therefore, by temporarily allowing the heating device to perform the overload heating operation, the heating capacity of the heating device is enhanced, so that the heating device can rapidly heat the second heat medium to a target heating temperature.

[0016] In an embodiment, the operation controller is configured to, when a predetermined overload heating operation allowable time has elapsed after the operation of the heating device is switched from the rated heating operation to the overload heating operation, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

Since the increase in the thermal load on the heating device is temporary, there is no need to continue the overload heating operation for a long time. Therefore, when the predetermined overload heating operation allowable time has elapsed, the operation of the heating device is switched from the overload heating operation to the rated heating operation, so that a failure of the heating device caused by the overload heating operation can be prevented.

[0017] In an embodiment, the operation controller is configured to, when an abnormality of the heating device is detected during the overload heating operation of the heating device, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

According to the present invention, the failure of the heating device can be prevented. The abnormality of the heating device is detected by, for example, an abnormality detection device included in the heating device itself.

[0018] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

When the same heat medium is used for the first heat medium and the second heat medium, they can be used by being mixed. Therefore, the first heat medium and the second heat medium can be directly supplied to the temperature control apparatus.

However, the first heat medium, the second heat medium, and a third heat medium can be used as independent systems by interposing a heat exchanger.

[0019] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.

Since the different heat media are used for the first heat medium and the second heat medium, they cannot be used by being mixed, and thus, it is necessary to provide heat exchange between the first heat medium and a third heat medium on the temperature control apparatus side, and between the second heat medium and the third heat medium on the temperature control apparatus side. Instead, there are effects that adjustment of liquid levels of the first heat medium and the second heat medium is unnecessary, and even if flow rates of the first heat medium and the second heat medium are controlled, a flow rate on the temperature control apparatus side is not affected.

[0020] In an embodiment, there is provided a heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, comprising: a cooling device configured to cool a first heat medium; a heating device configured to heat a second heat medium; a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus; a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus; a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device; a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and an operation controller configured to control operations of the cooling device and the heating device, wherein the operation controller is configured to: when a thermal load on the cooling device exceeds a cooling-load threshold value, instruct the cooling device to switch the operation of the cooling device from a rated cooling operation to an overload cooling operation; and when a thermal load on the heating device exceeds a heating-load threshold value, instruct the heating device to switch the operation

of the heating device from a rated heating operation to an overload heating operation.

[0021] In an embodiment, the operation controller is configured to: when a predetermined overload cooling operation allowable time has elapsed after the operation of the cooling device is switched from the rated cooling operation to the overload cooling operation, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation; and when a predetermined overload heating operation allowable time has elapsed after the operation of the heating device is switched from the rated heating operation to the overload heating operation, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[0022] In an embodiment, the operation controller is configured to: when an abnormality of the cooling device is detected during the overload cooling operation of the cooling device, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation; and when an abnormality of the heating device is detected during the overload heating operation of the heating device, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[0023] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

When the same heat medium is used for the first heat medium and the second heat medium, they can be used by being mixed. Therefore, the first heat medium and the second heat medium can be directly supplied to the temperature control apparatus. However, the first heat medium, the second heat medium, and a third heat medium can be used as independent systems by interposing a heat exchanger.

[0024] In an embodiment, the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.

Since the different heat media are used for the first heat medium and the second heat medium, they cannot be used by being mixed, and thus, it is necessary to provide heat

exchange between the first heat medium and a third heat medium on the temperature control apparatus side, and between the second heat medium and the third heat medium on the temperature control apparatus side. Instead, there are effects that adjustment of liquid levels of the first heat medium and the second heat medium is unnecessary, and even if flow rates of the first heat medium and the second heat medium are controlled, a flow rate on the temperature control apparatus side is not affected.

Advantageous Effects of Invention

[0025] According to the present invention, when a temporary increase in the thermal load occurs, the cooling device or the heating device is temporarily allowed to perform the overload operation, so that the heat medium can be rapidly cooled or heated to the target temperature.

Brief Description of Drawings

[0026]

[FIG. 1] FIG. 1 is a schematic diagram showing an embodiment of a semiconductor manufacturing system including a semiconductor manufacturing apparatus, a temperature control apparatus, and a heat-medium supply apparatus.

[FIG. 2] FIG. 2 is a graph showing an example of temporal changes in a temperature of a first heat medium cooled by a cooling device.

[FIG. 3] FIG. 3 is a schematic diagram showing another embodiment of the heat-medium supply apparatus.

[FIG. 4] FIG. 4 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus.

[FIG. 5] FIG. 5 is a graph showing an example of temporal changes in a temperature of a second heat medium heated by a heating device.

[FIG. 6] FIG. 6 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus.

[FIG. 7] FIG. 7 is a diagram showing an embodiment in which the embodiment described with reference to FIG. 1 and the embodiment described with reference to FIG. 4 are

combined.

[FIG. 8] FIG. 8 is a diagram showing an embodiment in which the embodiment described with reference to FIG. 3 and the embodiment described with reference to FIG. 6 are combined.

Description of Embodiments

[0027] Hereinafter, embodiments of the present invention will be described with reference to the drawings. FIG. 1 is a schematic diagram showing an embodiment of a semiconductor manufacturing system including a semiconductor manufacturing apparatus, a temperature control apparatus, and a heat-medium supply apparatus. The semiconductor manufacturing system includes a semiconductor manufacturing apparatus 1 (for example, an etching apparatus, a CVD apparatus, a PVD apparatus, etc.), a temperature control apparatus 2 configured to regulate a temperature of a heat medium to be supplied to the semiconductor manufacturing apparatus 1, and a heat-medium supply apparatus 3 configured to supply a cooled first heat medium and a heated second heat medium to the temperature control apparatus 2. The temperature control apparatus 2 is coupled to the semiconductor manufacturing apparatus 1, and the heat-medium supply apparatus 3 is coupled to the temperature control apparatus 2. In the embodiment shown in FIG. 1, an etching apparatus configured to perform a dry etching process on a wafer is used as the semiconductor manufacturing apparatus 1, but the semiconductor manufacturing apparatus 1 is not limited to this embodiment.

[0028] The heat-medium supply apparatus 3 includes a cooling device 7 configured to cool the first heat medium, a heating device 8 configured to heat the second heat medium, a cooling-medium delivery pipe 11 configured to deliver the cooled first heat medium to the temperature control apparatus 2, a heating-medium delivery pipe 12 configured to deliver the heated second heat medium to the temperature control apparatus 2, a cooling-side return pipe 18 configured to return the first heat medium that has passed through the temperature control apparatus 2 to the cooling device 7, a heating-side return pipe 19

configured to return the second heat medium that has passed through the temperature control apparatus 2 to the heating device 8, and an operation controller 35 configured to control operations of the cooling device 7 and the heating device 8.

[0029] The operation controller 35 includes at least one computer. The operation controller 35 includes a memory 35a in which a program and the like is stored, and an arithmetic device 35b configured to execute arithmetic operations according to instructions included in the program. The memory 35a includes a main memory, such as a random access memory (RAM), and an auxiliary memory, such as a hard disk drive (HDD) or a solid state drive (SSD). Examples of the arithmetic device 35b include a CPU (central processing unit) and a GPU (graphic processing unit). However, a specific configuration of the operation controller 35 is not limited to these examples.

[0030] The cooling-medium delivery pipe 11 and the heating-medium delivery pipe 12 are coupled to the temperature control apparatus 2. The temperature control apparatus 2 has a first heat-medium bypass pipe 42 configured to return the cooled first heat medium to the cooling device 7 without delivering the cooled first heat medium to the temperature control apparatus 2, and a second heat-medium bypass pipe 43 configured to return the heated second heat medium to the heating device 8 without delivering the heated second heat medium to the temperature control apparatus 2. Furthermore, the temperature control apparatus 2 includes a first bypass flow-rate regulating valve 44 provided in the first heat-medium bypass pipe 42, a cooling-side delivery flow-rate regulating valve 45 communicating with the cooling-medium delivery pipe 11, a cooling-side return flow-rate regulating valve 46 communicating with the cooling-side return pipe 18, a second bypass flow-rate regulating valve 47 provided in the second heat-medium bypass pipe 43, a heating-side delivery flow-rate regulating valve 48 communicating with the heating-medium delivery pipe 12, and a heating-side return flow-rate regulating valve 49 communicating with the heating-side return pipe 19.

[0031] The temperature control apparatus 2 can regulate a flow rate of the first heat medium to be delivered to the semiconductor manufacturing apparatus 1 by controlling

operations of the first bypass flow-rate regulating valve 44, the cooling-side delivery flow-rate regulating valve 45, and the cooling-side return flow-rate regulating valve 46. Similarly, the temperature control apparatus 2 can regulate a flow rate of the second heat medium to be delivered to the semiconductor manufacturing apparatus 1 by controlling operations of the second bypass flow-rate regulating valve 47, the heating-side delivery flow-rate regulating valve 48, and the heating-side return flow-rate regulating valve 49. In this manner, the temperature control apparatus 2 is configured to regulate the temperature required for the semiconductor manufacturing apparatus 1 by mixing the cooled first heat medium and the heated second heat medium while regulating the flow rate of the cooled first heat medium and the flow rate of the heated second heat medium.

[0032] The plurality of flow-rate regulating valves 44, 45, 46, 47, 48, and 49 are two-way valves, but are not limited to the two-way valves as long as the same effects can be obtained. For example, the plurality of flow-rate regulating valves 44, 45, 46, 47, 48, and 49 may be three-way valves, or combinations of two-way valves and three-way valves.

[0033] In the present embodiment, the same heat medium is used for the first heat medium and the second heat medium. When the same heat medium is used for the first heat medium and the second heat medium, they can be used by being mixed. Therefore, the first heat medium and the second heat medium can be directly supplied to the temperature control apparatus 2. In one embodiment, a fluorine-based inert liquid is used as the first heat medium and the second heat medium. An example of the cooling device 7 includes a vapor compression refrigeration machine. The vapor compression refrigeration machine includes a turbo refrigeration machine, a screw refrigeration machine, a rotary refrigeration machine, a scroll refrigeration machine, etc., and these can be used. Examples of the heating device 8 include a heat pump, a boiler, an electric heater, etc. Configurations of the cooling device 7 and the heating device 8 are not particularly limited as long as the first heat medium and the second heat medium can be cooled and heated.

[0034] The heat-medium supply apparatus 3 includes a first buffer tank 25 configured to hold the first heat medium therein, a second buffer tank 26 configured to hold the second

heat medium therein, a tank communication pipe 30 providing fluid communication between the first buffer tank 25 and the second buffer tank 26, and a communication valve 31 provided in the tank communication pipe 30. The first buffer tank 25 is coupled to the cooling-side return pipe 18. The cooling-side return pipe 18 extends from the temperature control apparatus 2 to the cooling device 7 via the first buffer tank 25.

[0035] The cooling-medium delivery pipe 11 configured to deliver the first heat medium cooled by the cooling device 7 extends from the cooling device 7 to the temperature control apparatus 2. The heating-medium delivery pipe 12 configured to deliver the second heat medium heated by the heating device 8 extends from the heating device 8 via the second buffer tank 26 to the temperature control apparatus 2. The second buffer tank 26 is coupled to the heating-medium delivery pipe 12. The heating-side return pipe 19 extends from the temperature control apparatus 2 to the heating device 8.

[0036] The heat-medium supply apparatus 3 includes a first pump 33 coupled to the cooling-side return pipe 18. When the first pump 33 is operated, the first heat medium is delivered from the first buffer tank 25 through the cooling-side return pipe 18 to the cooling device 7. The cooling device 7 is coupled to the cooling-medium delivery pipe 11 and the cooling-side return pipe 18. The cooling device 7 is configured to cool the first heat medium delivered through the cooling-side return pipe 18. The cooled first heat medium is delivered to the temperature control apparatus 2 through the cooling-medium delivery pipe 11.

[0037] The heat-medium supply apparatus 3 includes a second pump 34 coupled to the heating-medium delivery pipe 12. When the second pump 34 is operated, the second heat medium (heated second heat medium) in the second buffer tank 26 is delivered to the temperature control apparatus 2 through the heating-medium delivery pipe 12. The heating device 8 is coupled to the heating-medium delivery pipe 12 and the heating-side return pipe 19. The heating device 8 is configured to heat the second heat medium delivered through the heating-side return pipe 19. The heat medium heated by the heating device 8 passes through the heating-medium delivery pipe 12 and is delivered to the

temperature control apparatus 2 via the second buffer tank 26.

[0038] The cooled first heat medium and the heated second heat medium are mixed by the temperature control apparatus 2, so that a third heat medium having a preset temperature is generated. The third heat medium having the preset temperature is delivered from the temperature control apparatus 2 to the semiconductor manufacturing apparatus 1, and cools or heats a wafer (not shown in the drawing) in the semiconductor manufacturing apparatus 1 while passing through the semiconductor manufacturing apparatus 1. The third heat medium that has passed through the semiconductor manufacturing apparatus 1 is returned to the temperature control apparatus 2, and is divided into two flows within the temperature control apparatus 2. One of the two flows flows as the first heat medium into the cooling-side return pipe 18, and the other flows as the second heat medium into the heating-side return pipe 19. The first heat medium that has flowed into the cooling-side return pipe 18 is delivered to the cooling device 7 through the cooling-side return pipe 18 and the first buffer tank 25. The second heat medium that has flowed into the heating-side return pipe 19 is delivered to the heating device 8 through the heating-side return pipe 19.

[0039] In this manner, the first heat medium circulates through the cooling device 7, the cooling-medium delivery pipe 11, the first heat-medium bypass pipe 42, the cooling-side return pipe 18, and the first buffer tank 25, and simultaneously the second heat medium circulates through the heating device 8, the heating-medium delivery pipe 12, the second heat-medium bypass pipe 43, the second buffer tank 26, and the heating-side return pipe 19. As the first heat medium and the second heat medium circulate, a difference occurs between a liquid level of the first heat medium in the first buffer tank 25 and a liquid level of the second heat medium in the second buffer tank 26. The operation controller 35 reduces the difference between the liquid level of the first heat medium in the first buffer tank 25 and the liquid level of the second heat medium in the second buffer tank 26 by operating the communication valve 31.

[0040] Next, operation control of the cooling device 7 by the operation controller 35 will be described. In the present embodiment, the operation controller 35 is configured to,

when a thermal load on the cooling device 7 exceeds a cooling-load threshold value, instruct the cooling device 7 to switch the operation of the cooling device 7 from a rated cooling operation to an overload cooling operation. When the cooling device 7 is a vapor compression refrigeration machine, such as a turbo refrigeration machine, the operation controller 35 switches the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation by increasing a rotational speed of a compressor of the vapor compression refrigeration machine.

[0041] The rated cooling operation is an operation of operating the cooling device 7 within a range equal to or lower than an upper limit of a rated cooling capacity of the cooling device 7, and the overload cooling operation is an operation of operating the cooling device 7 within a range exceeding the upper limit of the rated cooling capacity of the cooling device 7. An excessive increase in the thermal load on the cooling device 7 occurs when the temperature of the heat medium returning from the temperature control apparatus 2 to the cooling device 7 rises excessively. Such an excessive temperature rise of the heat medium normally occurs temporarily during the operation of the semiconductor manufacturing apparatus 1, and its duration is relatively short, from several tens of seconds to one hundred and several tens of seconds. Therefore, by temporarily allowing the cooling device 7 to perform the overload cooling operation, the cooling capacity of the cooling device 7 is enhanced, so that the cooling device 7 can rapidly cool the first heat medium to the target cooling temperature.

[0042] The operation controller 35 monitors the temperature of the first heat medium in order to determine whether or not the thermal load on the cooling device 7 has exceeded the cooling-load threshold value. More specifically, the heat-medium supply apparatus 3 includes a first heat-medium temperature measuring device 41 configured to measure the temperature of the first heat medium flowing through the cooling-side return pipe 18. The first heat-medium temperature measuring device 41 is coupled to the cooling-side return pipe 18. The first heat-medium temperature measuring device 41 is electrically coupled to the operation controller 35, and a measured value of the temperature of the first heat

medium is transmitted to the operation controller 35. During operation of the heat-medium supply apparatus 3, the operation controller 35 monitors the measured value of the temperature of the first heat medium transmitted from the first heat-medium temperature measuring device 41, and determines whether or not the thermal load on the cooling device 7 has exceeded the cooling-load threshold value.

[0043] In the present embodiment, the operation controller 35 is configured to, when the temperature of the first heat medium flowing through the cooling-side return pipe 18 exceeds a cooling-temperature threshold value, instruct the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation. The temperature of the first heat medium measured by the first heat-medium temperature measuring device 41 reflects the thermal load on the cooling device 7. The cooling-temperature threshold value related to the temperature of the first heat medium corresponds to the cooling-load threshold value related to the thermal load on the cooling device 7. The operation controller 35 determines whether or not the thermal load on the cooling device 7 has exceeded the cooling-load threshold value based on a comparison between the temperature of the first heat medium and the cooling-temperature threshold value. Therefore, based on the measured value of the temperature of the first heat medium, the operation controller 35 can instruct the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation.

[0044] The determination of the increase in the thermal load on the cooling device 7 may be based on a signal from the semiconductor manufacturing apparatus 1, or a signal from the temperature control apparatus 2, other than the temperature of the first heat medium. For example, the operation controller 35 receives a signal indicating a target processing temperature in the semiconductor manufacturing apparatus 1 from the semiconductor manufacturing apparatus 1. When the target processing temperature in the semiconductor manufacturing apparatus 1 exceeds a predetermined processing cooling-temperature threshold value, the operation controller 35 instructs the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling

operation.

[0045] FIG. 2 is a graph showing an example of temporal changes in the temperature of the first heat medium cooled by the cooling device 7. In FIG. 2, a thin solid line represents the temperature of the first heat medium sent from the cooling device 7 to the temperature control apparatus 2 during the rated cooling operation, a thick broken line represents the temperature of the first heat medium sent from the cooling device 7 to the temperature control apparatus 2 during the overload cooling operation, and a dash-dot line represents the temperature of the first heat medium returning from the temperature control apparatus 2 to the cooling device 7.

[0046] When the thermal load on the cooling device 7 excessively increases, as shown in FIG. 2, the temperature of the first heat medium coming out of the cooling device 7 and the temperature of the first heat medium returning from the temperature control apparatus 2 temporarily rise. When the thermal load on the cooling device 7 exceeds the cooling-load threshold value (for example, the temperature of the first heat medium flowing through the cooling-side return pipe 18 exceeds the cooling-temperature threshold value), the cooling device 7 performs the overload cooling operation. As a result, the temperature of the first heat medium coming out of the cooling device 7 drops more rapidly than in the rated cooling operation, and reaches the target cooling temperature. In one example, the temperature of the first heat medium when the cooling device 7 is performing the overload cooling operation can reach the target cooling temperature about 30% faster than when the cooling device 7 is performing the rated cooling operation.

[0047] The operation controller 35 is configured to, when a predetermined overload cooling operation allowable time has elapsed after the operation of the cooling device 7 is switched from the rated cooling operation to the overload cooling operation, instruct the cooling device 7 to switch the operation of the cooling device 7 from the overload cooling operation to the rated cooling operation. Since the increase in the thermal load on the cooling device 7 is temporary, there is no need to continue the overload cooling operation for a long time. Therefore, when the predetermined overload cooling operation allowable

time has elapsed, the operation of the cooling device 7 is switched from the overload cooling operation to the rated cooling operation, so that the failure of the cooling device 7 caused by the overload cooling operation can be prevented.

[0048] The operation controller 35 is configured to, when an abnormality of the cooling device 7 is detected during the overload cooling operation of the cooling device 7, instruct the cooling device 7 to switch the operation of the cooling device 7 from the overload cooling operation to the rated cooling operation. Such an operation can prevent the failure of the cooling device 7. The abnormality of the cooling device 7 is detected by, for example, an abnormality detection device included in the cooling device 7 itself. Examples of the abnormality of the cooling device 7 include an excessive rise in a temperature of a refrigerant gas discharged from the compressor, a drop in an oil level in the compressor, a high temperature of the compressor, etc.

[0049] The operation control of the cooling device 7 described above can be applied to the heat-medium supply apparatus 3 described below. FIG. 3 is a schematic diagram showing another embodiment of the heat-medium supply apparatus 3. Configurations and operations that are not particularly described are the same as those of the above embodiment described with reference to FIGS. 1 and 2, and overlapping descriptions thereof will be omitted.

[0050] The cooling-medium delivery pipe 11 configured to deliver the first heat medium cooled by the cooling device 7 to the temperature control apparatus 2 and the cooling-side return pipe 18 configured to return the first heat medium that has passed through the temperature control apparatus 2 to the cooling device 7 constitute a first circulation circuit 51 in which the first heat medium circulates. The heating-medium delivery pipe 12 configured to deliver the second heat medium heated by the heating device 8 to the temperature control apparatus 2 and the heating-side return pipe 19 configured to return the second heat medium that has passed through the temperature control apparatus 2 to the heating device 8 constitute a second circulation circuit 52 in which the second heat medium circulates. The first heat medium circulates in the first circulation circuit 51 by the first

pump 33, and the second heat medium circulates in the second circulation circuit 52 by the second pump 34.

[0051] The temperature control apparatus 2 includes a third circulation circuit 53 in which the third heat medium circulates. The third circulation circuit 53 is coupled to the semiconductor manufacturing apparatus 1. The third heat medium circulates through the third circulation circuit 53 and the semiconductor manufacturing apparatus 1. The processing temperature in the semiconductor manufacturing apparatus 1 is regulated by the third heat medium. The temperature of the third heat medium is regulated by the first heat medium and the second heat medium as will be described later.

[0052] The second circulation circuit 52 is independent of the first circulation circuit 51, and the third circulation circuit 53 is independent of the first circulation circuit 51 and the second circulation circuit 52. Specifically, the first circulation circuit 51, the second circulation circuit 52, and the third circulation circuit 53 form closed circuits that are independent of each other, so that the first heat medium, the second heat medium, and the third heat medium are not mixed.

[0053] Different heat media are used for the first heat medium, the second heat medium, and the third heat medium. For example, a common brine is used as the first heat medium for cooling. Examples of the brine include ethylene glycol, propylene glycol, calcium chloride, etc. An example of the second heat medium for heating includes silicone oil, etc. An example of the third heat medium includes a fluorine-based inert liquid. The third heat medium is an insulator that is chemically stable from a low temperature to a high temperature in order to directly regulate the processing temperature in the semiconductor manufacturing apparatus 1.

[0054] A usable lower limit temperature of the third heat medium is lower than usable lower limit temperatures of the first heat medium and the second heat medium. A usable upper limit temperature of the third heat medium is higher than usable upper limit temperatures of the first heat medium and the second heat medium. Specifically, a usable temperature range of the third heat medium is wider than usable temperature ranges of the

first heat medium and the second heat medium. The usable temperature is a temperature at which a viscosity (fluidity) of the heat medium can be maintained, and a phase of the heat medium does not change (does not boil and does not solidify).

[0055] The temperature control apparatus 2 includes a first heat exchanger 56 configured to perform heat exchange between the first heat medium cooled by the cooling device 7 and the third heat medium, and a second heat exchanger 57 configured to perform heat exchange between the second heat medium heated by the heating device 8 and the third heat medium. The first heat exchanger 56 is coupled to the first circulation circuit 51 and the third circulation circuit 53. The first heat medium flowing through the first circulation circuit 51 and the third heat medium flowing through the third circulation circuit 53 perform heat exchange in the first heat exchanger 56. The second heat exchanger 57 is coupled to the second circulation circuit 52 and the third circulation circuit 53. The second heat medium flowing through the second circulation circuit 52 and the third heat medium flowing through the third circulation circuit 53 perform heat exchange in the second heat exchanger 57.

[0056] The first heat exchanger 56 and the second heat exchanger 57 are coupled in parallel by the third circulation circuit 53. The third circulation circuit 53 includes a first outlet flow passage 61 coupled to a heat-medium outlet of the first heat exchanger 56, a first inlet flow passage 62 coupled to a heat-medium inlet of the first heat exchanger 56, a second outlet flow passage 63 coupled to a heat-medium outlet of the second heat exchanger 57, a second inlet flow passage 64 coupled to a heat-medium inlet of the second heat exchanger 57, a merge flow passage 67 coupled to both the first outlet flow passage 61 and the second outlet flow passage 63, and a distribution flow passage 68 coupled to both the first inlet flow passage 62 and the second inlet flow passage 64. The merge flow passage 67 and the distribution flow passage 68 are coupled to the semiconductor manufacturing apparatus 1.

[0057] The temperature control apparatus 2 includes a three-way valve 70, a first check valve 71, and a second check valve 72. The three-way valve 70 is coupled to the first inlet

flow passage 62, the second inlet flow passage 64, and the distribution flow passage 68. The third heat medium flowing through the distribution flow passage 68 is distributed to the first inlet flow passage 62 and the second inlet flow passage 64 via the three-way valve 70. Flow rates of the third heat medium distributed to the first inlet flow passage 62 and the second inlet flow passage 64 are regulated by the three-way valve 70. The first check valve 71 is provided in the first inlet flow passage 62, and the second check valve 72 is provided in the second inlet flow passage 64.

[0058] The third heat medium cooled by the first heat medium in the first heat exchanger 56 flows through the first outlet flow passage 61. The third heat medium heated by the second heat medium in the second heat exchanger 57 flows through the second outlet flow passage 63. The third heat medium that has flowed through the first outlet flow passage 61 and the third heat medium that has flowed through the second outlet flow passage 63 merge in the merge flow passage 67, are delivered to the semiconductor manufacturing apparatus 1, and cool or heat a wafer in the semiconductor manufacturing apparatus 1. The third heat medium that has passed through the semiconductor manufacturing apparatus 1 flows through the distribution flow passage 68, and is distributed to the first inlet flow passage 62 and the second inlet flow passage 64 by the three-way valve 70. In this manner, the third heat medium circulates through the first heat exchanger 56, the second heat exchanger 57, and the semiconductor manufacturing apparatus 1.

[0059] The first heat exchanger 56 is configured to cause the heat exchange between the first heat medium cooled by the cooling device 7 and the third heat medium before being delivered to the semiconductor manufacturing apparatus 1. The second heat exchanger 57 is configured to cause the heat exchange between the second heat medium heated by the heating device 8 and the third heat medium before being delivered to the semiconductor manufacturing apparatus 1. The third heat medium is cooled by the first heat medium, and is heated by the second heat medium.

[0060] The first heat-medium temperature measuring device 41 measures the temperature of the first heat medium flowing through the cooling-side return pipe 18 constituting the

first circulation circuit 51. The measured value of the temperature of the first heat medium is transmitted to the operation controller 35. During the operation of the heat-medium supply apparatus 3, the operation controller 35 monitors the measured value of the temperature of the first heat medium transmitted from the first heat-medium temperature measuring device 41, and determines whether or not the thermal load on the cooling device 7 has exceeded the cooling-load threshold value.

[0061] In the present embodiment, the operation controller 35 is configured to, when the temperature of the first heat medium flowing through the cooling-side return pipe 18 exceeds the cooling-temperature threshold value, instruct the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation. The temperature of the first heat medium measured by the first heat-medium temperature measuring device 41 reflects the thermal load on the cooling device 7. The cooling-temperature threshold value related to the temperature of the first heat medium corresponds to the cooling-load threshold value related to the thermal load on the cooling device 7.

[0062] The operation controller 35 determines whether or not the thermal load on the cooling device 7 has exceeded the cooling-load threshold value based on the comparison between the temperature of the first heat medium and the cooling-temperature threshold value. Therefore, based on the measured value of the temperature of the first heat medium, the operation controller 35 can instruct the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation. As the cooling device 7 performs the overload cooling operation, the temperature of the first heat medium drops more rapidly than in the rated cooling operation, and can reach the target cooling temperature.

[0063] The determination of the increase in the thermal load on the cooling device 7 may be based on a signal from the semiconductor manufacturing apparatus 1, or a signal from the temperature control apparatus 2, other than the temperature of the first heat medium. For example, the operation controller 35 receives a signal indicating a target processing

temperature in the semiconductor manufacturing apparatus 1 from the semiconductor manufacturing apparatus 1. When the target processing temperature in the semiconductor manufacturing apparatus 1 exceeds a predetermined processing cooling-temperature threshold value, the operation controller 35 instructs the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation.

[0064] FIG. 4 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus 3. Configurations and operations that are not particularly described are the same as those of the above embodiment described with reference to FIG. 1, and overlapping descriptions thereof will be omitted.

[0065] In the present embodiment, as described below, operation control of the heating device 8 is performed by the operation controller 35. The operation controller 35 is configured to, when the thermal load on the heating device 8 exceeds a heating-load threshold value, instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation. When the heating device 8 is a heat pump, the operation controller 35 switches the operation of the heating device 8 from the rated heating operation to the overload heating operation by increasing a rotational speed of a compressor of the heat pump.

[0066] The rated heating operation is an operation of operating the heating device 8 within a range equal to or lower than an upper limit of a rated heating capacity of the heating device 8, and the overload heating operation is an operation of operating the heating device 8 within a range exceeding the upper limit of the rated heating capacity of the heating device 8. The excessive increase in the thermal load on the heating device 8 occurs when the temperature of the heat medium returning from the temperature control apparatus 2 to the heating device 8 drops excessively. Such an excessive temperature drop of the heat medium normally occurs temporarily during the operation of the semiconductor manufacturing apparatus 1, and its duration is relatively short, from several tens of seconds to one hundred and several tens of seconds. Therefore, by temporarily allowing the

heating device 8 to perform the overload heating operation, the heating capacity of the heating device 8 is enhanced, so that the heating device 8 can rapidly heat the second heat medium to the target heating temperature.

[0067] The operation controller 35 monitors the temperature of the second heat medium in order to determine whether or not the thermal load on the heating device 8 has exceeded the heating-load threshold value. More specifically, the heat-medium supply apparatus 3 includes a second heat-medium temperature measuring device 80 configured to measure the temperature of the second heat medium flowing through the heating-side return pipe 19. The second heat-medium temperature measuring device 80 is coupled to the heating-side return pipe 19. The second heat-medium temperature measuring device 80 is electrically coupled to the operation controller 35, and a measured value of the temperature of the second heat medium is transmitted to the operation controller 35. During the operation of the heat-medium supply apparatus 3, the operation controller 35 monitors the measured value of the temperature of the second heat medium transmitted from the second heat-medium temperature measuring device 80, and determines whether or not the thermal load on the heating device 8 has exceeded the heating-load threshold value.

[0068] In the present embodiment, the operation controller 35 is configured to, when the temperature of the second heat medium flowing through the heating-side return pipe 19 falls below a heating-temperature threshold value, instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation. The temperature of the second heat medium measured by the second heat-medium temperature measuring device 80 reflects the thermal load on the heating device 8. The heating-temperature threshold value related to the temperature of the second heat medium corresponds to the heating-load threshold value related to the thermal load on the heating device 8. The operation controller 35 determines whether or not the thermal load on the heating device 8 has exceeded the heating-load threshold value based on a comparison between the temperature of the second heat medium and the heating-temperature threshold value. Therefore, based on the measured value of the temperature

of the second heat medium, the operation controller 35 can instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation.

[0069] The determination of the increase in the thermal load on the heating device 8 may be based on a signal from the semiconductor manufacturing apparatus 1, or a signal from the temperature control apparatus 2, other than the temperature of the second heat medium. For example, the operation controller 35 receives a signal indicating a target processing temperature in the semiconductor manufacturing apparatus 1 from the semiconductor manufacturing apparatus 1. When the target processing temperature in the semiconductor manufacturing apparatus 1 falls below a predetermined processing heating-temperature threshold value, instructs the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation.

[0070] FIG. 5 is a graph showing an example of temporal changes in the temperature of the second heat medium heated by the heating device 8. In FIG. 5, a thin solid line represents the temperature of the second heat medium sent from the heating device 8 to the temperature control apparatus 2 during the rated heating operation, a thick broken line represents the temperature of the second heat medium sent from the heating device 8 to the temperature control apparatus 2 during the overload heating operation, and a dash-dot line represents the temperature of the second heat medium returning from the temperature control apparatus 2 to the heating device 8.

[0071] When the thermal load on the heating device 8 excessively increases, as shown in FIG. 5, the temperature of the second heat medium coming out of the heating device 8 and the temperature of the second heat medium returning from the temperature control apparatus 2 temporarily drop. When the thermal load on the heating device 8 exceeds the heating-load threshold value (for example, the temperature of the second heat medium flowing through the heating-side return pipe 19 falls below the heating-temperature threshold value), the heating device 8 performs the overload heating operation. As a result, the temperature of the second heat medium coming out of the heating device 8 rises more

rapidly than in the rated heating operation, and reaches the target heating temperature. In one example, the temperature of the second heat medium when the heating device 8 is performing the overload heating operation can reach the target heating temperature about 15% faster than when the heating device 8 is performing the rated heating operation.

[0072] The operation controller 35 is configured to, when a predetermined overload heating operation allowable time has elapsed after the operation of the heating device 8 is switched from the rated heating operation to the overload heating operation, instruct the heating device 8 to switch the operation of the heating device 8 from the overload heating operation to the rated heating operation. Since the increase in the thermal load on the heating device 8 is temporary, there is no need to continue the overload heating operation for a long time. Therefore, when the predetermined overload heating operation allowable time has elapsed, the operation of the heating device 8 is switched from the overload heating operation to the rated heating operation, so that the failure of the heating device 8 caused by the overload heating operation can be prevented.

[0073] The operation controller 35 is configured to, when the abnormality of the heating device 8 is detected during the overload heating operation of the heating device 8, instruct the heating device 8 to switch the operation of the heating device 8 from the overload heating operation to the rated heating operation. Such an operation can prevent the failure of the heating device 8. The abnormality of the heating device 8 is detected by, for example, an abnormality detection device included in the heating device 8 itself. Examples of the abnormality of the heating device 8 include an excessive rise in a temperature of a refrigerant gas discharged from the compressor, a drop in an oil level of the compressor, a high temperature of the compressor, etc.

[0074] The operation control of the heating device 8 described above can also applied to the embodiment of the heat-medium supply apparatus 3 described with reference to FIG. 3. FIG. 6 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus 3. Configurations and operations that are not particularly described are the same as those of the above embodiment described with reference to FIGS. 3 to 5, and

overlapping descriptions thereof will be omitted.

[0075] The second heat-medium temperature measuring device 80 measures the temperature of the second heat medium flowing through the heating-side return pipe 19 constituting the second circulation circuit 52. The measured value of the temperature of the second heat medium is transmitted to the operation controller 35. During the operation of the heat-medium supply apparatus 3, the operation controller 35 monitors the measured value of the temperature of the second heat medium transmitted from the second heat-medium temperature measuring device 80, and determines whether or not the thermal load on the heating device 8 has exceeded the heating-load threshold value.

[0076] In the present embodiment, the operation controller 35 is configured to, when the temperature of the second heat medium flowing through the heating-side return pipe 19 falls below the heating-temperature threshold value, instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation. The temperature of the second heat medium measured by the second heat-medium temperature measuring device 80 reflects the thermal load on the heating device 8. The heating-temperature threshold value related to the temperature of the second heat medium corresponds to the heating-load threshold value related to the thermal load on the heating device 8.

[0077] The operation controller 35 determines whether or not the thermal load on the heating device 8 has exceeded the heating-load threshold value based on the comparison between the temperature of the second heat medium and the heating-temperature threshold value. Therefore, based on the measured value of the temperature of the second heat medium, the operation controller 35 can instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation. As the heating device 8 performs the overload heating operation, the temperature of the second heat medium rises more rapidly than in the rated heating operation, and can reach the target heating temperature.

[0078] The determination of the increase in the thermal load on the heating device 8 may

be based on a signal from the semiconductor manufacturing apparatus 1, or a signal from the temperature control apparatus 2, other than the temperature of the second heat medium. For example, the operation controller 35 receives a signal indicating a target processing temperature in the semiconductor manufacturing apparatus 1 from the semiconductor manufacturing apparatus 1. When the target processing temperature in the semiconductor manufacturing apparatus 1 falls below a predetermined processing heating-temperature threshold value, instructs the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation.

[0079] FIG. 7 is a diagram showing an embodiment in which the embodiment described with reference to FIG. 1 and the embodiment described with reference to FIG. 4 are combined. FIG. 8 is a diagram showing an embodiment in which the embodiment described with reference to FIG. 3 and the embodiment described with reference to FIG. 6 are combined. Detailed configurations and operations shown in FIG. 7 are the same as those of the embodiments described with reference to FIGS. 1 and 4, and thus overlapping descriptions thereof will be omitted. Detailed configurations and operations shown in FIG. 8 are the same as those of the embodiments described with reference to FIGS. 3 and 6, and thus overlapping descriptions thereof will be omitted.

[0080] In the embodiments shown in FIGS. 7 and 8, the operation controller 35 is configured to, when the thermal load on the cooling device 7 exceeds the cooling-load threshold value, instruct the cooling device 7 to switch the operation of the cooling device 7 from the rated cooling operation to the overload cooling operation, and when the thermal load on the heating device 8 exceeds the heating-load threshold value, instruct the heating device 8 to switch the operation of the heating device 8 from the rated heating operation to the overload heating operation.

[0081] According to the embodiments shown in FIGS. 7 and 8, when a temporary increase in the thermal load occurs, the cooling device 7 or the heating device 8 performs the overload cooling operation or the overload heating operation, so that the first heat medium or the second heat medium can rapidly reach the target cooling temperature or the target

heating temperature.

[0082] The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

Industrial Applicability

[0083] The present invention is applicable to a heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, such as an etching apparatus, a CVD apparatus, or a PVD apparatus.

Reference Signs List

[0084]

1 semiconductor manufacturing apparatus
2 temperature control apparatus
3 heat-medium supply apparatus
7 cooling device
8 heating device
11 cooling-medium delivery pipe
12 heating-medium delivery pipe
18 cooling-side return pipe
19 heating-side return pipe
25 first buffer tank
26 second buffer tank
30 tank communication pipe
31 communication valve
33 first pump

34 second pump

35 operation controller

41 first heat-medium temperature measuring device

42 first heat-medium bypass pipe

43 second heat-medium bypass pipe

44 first bypass flow-rate regulating valve

45 cooling-side delivery flow-rate regulating valve

46 cooling-side return flow-rate regulating valve

47 second bypass flow-rate regulating valve

48 heating-side delivery flow-rate regulating valve

49 heating-side return flow-rate regulating valve

51 first circulation circuit

52 second circulation circuit

53 third circulation circuit

56 first heat exchanger

57 second heat exchanger

61 first outlet flow passage

62 first inlet flow passage

63 second outlet flow passage

64 second inlet flow passage

67 merge flow passage

68 distribution flow passage

70 three-way valve

71 first check valve

72 second check valve

80 second heat-medium temperature measuring device

CLAIMS

[Claim 1] A heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, comprising:

a cooling device configured to cool a first heat medium;

a heating device configured to heat a second heat medium;

a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus;

a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus;

a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device;

a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and

an operation controller configured to control an operation of the cooling device,

wherein the operation controller is configured to, when a thermal load on the cooling device exceeds a cooling-load threshold value, instruct the cooling device to switch the operation of the cooling device from a rated cooling operation to an overload cooling operation.

[Claim 2] The heat-medium supply apparatus according to claim 1, wherein the operation controller is configured to, when a predetermined overload cooling operation allowable time has elapsed after the operation of the cooling device is switched from the rated cooling operation to the overload cooling operation, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation.

[Claim 3] The heat-medium supply apparatus according to claim 1, wherein the

operation controller is configured to, when an abnormality of the cooling device is detected during the overload cooling operation of the cooling device, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation.

[Claim 4] The heat-medium supply apparatus according to claim 1, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

[Claim 5] The heat-medium supply apparatus according to claim 1, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.

[Claim 6] A heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, comprising:

a cooling device configured to cool a first heat medium;

a heating device configured to heat a second heat medium;

a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus;

a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus;

a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device;

a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and

an operation controller configured to control an operation of the heating device,

wherein the operation controller is configured to, when a thermal load on the

heating device exceeds a heating-load threshold value, instruct the heating device to switch the operation of the heating device from a rated heating operation to an overload heating operation.

[Claim 7] The heat-medium supply apparatus according to claim 6, wherein the operation controller is configured to, when a predetermined overload heating operation allowable time has elapsed after the operation of the heating device is switched from the rated heating operation to the overload heating operation, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[Claim 8] The heat-medium supply apparatus according to claim 6, wherein the operation controller is configured to, when an abnormality of the heating device is detected during the overload heating operation of the heating device, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[Claim 9] The heat-medium supply apparatus according to claim 6, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

[Claim 10] The heat-medium supply apparatus according to claim 6, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.

[Claim 11] A heat-medium supply apparatus for supplying a heat medium to a temperature control apparatus configured to regulate a temperature of a semiconductor manufacturing apparatus, comprising:

a cooling device configured to cool a first heat medium;

a heating device configured to heat a second heat medium;

a cooling-medium delivery pipe configured to deliver the cooled first heat medium to the temperature control apparatus;

a heating-medium delivery pipe configured to deliver the heated second heat medium to the temperature control apparatus;

a cooling-side return pipe configured to return the first heat medium that has passed through the temperature control apparatus to the cooling device;

a heating-side return pipe configured to return the second heat medium that has passed through the temperature control apparatus to the heating device; and

an operation controller configured to control operations of the cooling device and the heating device,

wherein the operation controller is configured to:

when a thermal load on the cooling device exceeds a cooling-load threshold value, instruct the cooling device to switch the operation of the cooling device from a rated cooling operation to an overload cooling operation; and

when a thermal load on the heating device exceeds a heating-load threshold value, instruct the heating device to switch the operation of the heating device from a rated heating operation to an overload heating operation.

[Claim 12] The heat-medium supply apparatus according to claim 11, wherein the operation controller is configured to:

when a predetermined overload cooling operation allowable time has elapsed after the operation of the cooling device is switched from the rated cooling operation to the overload cooling operation, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation; and

when a predetermined overload heating operation allowable time has elapsed after the operation of the heating device is switched from the rated heating operation to the

overload heating operation, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[Claim 13] The heat-medium supply apparatus according to claim 11, wherein the operation controller is configured to:

when an abnormality of the cooling device is detected during the overload cooling operation of the cooling device, instruct the cooling device to switch the operation of the cooling device from the overload cooling operation to the rated cooling operation; and

when an abnormality of the heating device is detected during the overload heating operation of the heating device, instruct the heating device to switch the operation of the heating device from the overload heating operation to the rated heating operation.

[Claim 14] The heat-medium supply apparatus according to claim 11, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are the same heat medium.

[Claim 15] The heat-medium supply apparatus according to claim 11, wherein the first heat medium cooled by the cooling device and the second heat medium heated by the heating device are different heat media.