

TITLE OF THE INVENTION

HEAT-TRANSFER-MEDIUM HEATING AND COOLING APPARATUS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a heat-transfer-medium heating and cooling apparatus, and, more particularly, to a heat-transfer-medium heating and cooling apparatus which performs temperature control of a low-temperature reactor which is used in a chemical reaction process or the like.

DESCRIPTION OF THE RELATED ART

A chemical reaction process, such as organic synthesis or crystallization, requires high-precision temperature control. The chemical reaction process therefore uses a double-structure container having an independent jacket which permits communication of a heat transfer medium with outside a reactor. As disclosed in Japanese Unexamined Patent Publication No. H11-37623, for example, the interior of the reactor is indirectly kept in a predetermined low temperature state by providing a heat transfer medium feeder for recirculating a heat transfer medium cooled down to a predetermined temperature to the jacket side of the reactor.

Such a heat transfer medium feeder generally has an expansion vessel provided in series to the heat-transfer-medium-suction side of the heat transfer medium pump to prevent bubbles from entering the heat transfer medium pump

and absorb a change in volume originating from a change in temperature of heat transfer medium. To keep the suction pressure of the heat transfer medium pump constant, the expansion vessel is provided with pressure control means, such as a pressure control valve or a pressure reducing valve, which makes compressed gas enter the expansion vessel when the volume of the heat transfer medium decreases due to a reduction in temperature of heat transfer medium and drains the compressed gas from the expansion vessel when the volume of the heat transfer medium increases due to a rise in temperature of heat transfer medium.

In cleaning the reactor, it is necessary to perform an operation of cyclically supplying a high-temperature heat transfer medium to the jacket to heat a detergent in the reactor. This requires provision of some means for feeding the heat transfer medium in addition to the heat transfer medium feeder. The heat-transfer-medium feeding means, if configured to drain the heat transfer medium from inside the jacket and feed the heat transfer medium thereto, makes the device configuration including pipings complex, and needs to switch the heat transfer medium and the heat transfer medium to be supplied to the jacket from one to the other, thereby making the process complex.

As a solution to this problem, means for heating a heat transfer medium may be provided in the recirculation system of the heat transfer medium feeder, so that the heat transfer medium is heated to a predetermined temperature and

recirculated to the jacket to heat the reactor. In the foregoing case where the expansion vessel is provided in series to the heat-transfer-medium-suction side of the pump, however, the heat transfer medium in the expansion vessel as well as the heat transfer medium in the pipings in the recirculation system and the jacket should be heated. This results in a huge energy cost required for heating and cooling. Because a large-scale system, in particular, uses a large expansion vessel, the response drops considerably, thus increasing the energy loss.

Further, an increase in volume which originates from a rise in temperature of heat transfer medium and vaporization of the heat transfer medium may cause expensive heat transfer medium vapor to be discharged outside when the pressure control means is actuated to discharge the gas in the expansion vessel.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a heat-transfer-medium heating and cooling apparatus capable of reducing the energy cost and effecting efficient heating and cooling of a reactor by minimizing the amount of a heat transfer medium (coolant) to be heated and cooled, thereby avoiding complication and enlargement of the configuration of the apparatus.

To achieve the object, a heat-transfer-medium heating and cooling apparatus according to the present invention

comprises a pump which pumps out a heat transfer medium; a cooling unit which cools the heat transfer medium discharged from the pump; a reactor whose temperature is controlled by the heat transfer medium output from the cooling unit; and a heating unit which heats the heat transfer medium output from the reactor, wherein a recirculation path for recirculating the heat transfer medium to the pump via the pump, the cooling unit, the reactor, and the heating unit, a reserve path being provided in a pump-suction-side path extending from the heating unit to the pump, and branching from the pump-suction-side path to connect to a liquid phase portion of an expansion vessel.

In the heat-transfer-medium heating and cooling apparatus according to the invention, the reserve path may branch upward from the pump-suction-side path, or the expansion vessel may have a condenser communicating with a gas phase portion of the expansion vessel, and having a cooling unit which cools a heat transfer medium vapor for liquification thereof, a path for returning the heat transfer medium liquefied by cooling in the cooling unit, and a gas relief valve which discharges a gas from the gas phase portion of the condenser according to a pressure in the condenser.

As the expansion vessel is so disposed as to branch from the recirculation path in the heat-transfer-medium heating and cooling apparatus of the invention, the heat transfer medium to be heated or cooled can be restricted to

the heat transfer medium that recirculates in the recirculation path at the time of switching heating of the reactor to cooling, or vice versa, thus eliminating the need to heat or cool the heat transfer medium in the expansion vessel. This leads to a reduction in energy cost and an improved response and allows the reactor to be reliably heated or cooled to a predetermined temperature.

As the reserve path which connects to the expansion vessel is branched upward from the pump-suction-side path, bubbles present in the heat transfer medium flowing in the pump-suction-side path can be discharged to the expansion vessel efficiently, thus preventing the bubbles from entering the pump. Further, the provision of the condenser at the expansion vessel can prevent a heat transfer medium vapor in the expansion vessel from being discharged outside through the gas relief valve due to a pressure rise in the recirculation system.

What is more, because a heat transfer medium can be heated and cooled by a single closed cycle system, the apparatus configuration is prevented from becoming complex or larger, thereby leading to reductions in equipment cost and running cost.

BRIEF DESCRIPTION OF THE DRAWINGS

The figure is a system diagram showing a heat-transfer-medium heating and cooling apparatus according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A heat-transfer-medium heating and cooling apparatus shown in the figure has a pump 11 which pumps out a heat transfer medium, a heat exchanger 12 or a cooling unit which cools down the heat transfer medium pumped out from the pump 11, a reactor 13 whose temperature is controlled by the heat transfer medium output from the heat exchanger 12, a heating unit 14 which heats the heat transfer medium output from the reactor 13, and pipings which connect those components. The pipings form a recirculation path 15 of a closed cycle which recirculates a heat transfer medium to the pump 11 via the pump 11, the heat exchanger 12, the reactor 13 and the heating unit 14.

The heat exchanger 12 cools the recirculating heat transfer medium to a predetermined temperature by indirectly exchanging heat with a low-temperature fluid, such as a low-temperature liquefied gas, which is supplied to the heat exchanger 12 from a low-temperature fluid inlet path 16 and discharged to a discharge gas path 17. The heating unit 14 heats the recirculating heat transfer medium to a predetermined temperature with a heater 14a.

The reactor 13 has a jacket 13b provided on the outer surface of a reaction container 13a. The heat transfer medium flows through the jacket 13b. The temperature of the heat transfer medium to be supplied to the jacket 13b is adjusted by controlling the opening/closing of a flow

regulator 20 provided in the low-temperature fluid inlet path 16 and the performance of the heater 14a using a temperature indicator and controller (TIC) 19 provided in an inlet-side path 18 of the jacket 13b.

A reserve path 23 which branches upward from a pump-suction-side path 21 and connects to a liquid phase portion 22a of an expansion vessel 22, is provided in the pump-suction-side path 21 extending from the heating unit 14 to the pump 11. The expansion vessel 22 is provided branching from the recirculation path 15 via the reserve path 23, and, unlike the conventional type, is separated from the recirculation flow of the heat transfer medium, not in series to the recirculation flow from the viewpoint of flow. The expansion vessel 22 is configured so that the expansion vessel 22 and the recirculation path 15 exchange the heat transfer medium according to a change in the volume of the heat transfer medium flowing in the recirculation path 15, and the recirculation path 15 is set in a liquid sealing state to inhibit a gas from entering the recirculation path 15 from the expansion vessel 22.

A gas phase portion 22b of the expansion vessel 22 is connected with a gas inlet valve 24, which is actuated according to the pressure in the expansion vessel 22, and a condenser 25. The condenser 25 is provided with a gas relief valve 26 which is actuated according to the pressure in the condenser 25.

The condenser 25 has a cooling unit 27 for cooling a

heat transfer medium vapor for liquification thereof, a mist separator 28 that separates the heat transfer medium liquefied by the cooling unit 27 and a gas which is not liquefied from each other, a heat transfer medium return path 29 for returning the heat transfer medium separated by the mist separator 28 to the expansion vessel 22, and a float valve 30 which is opened and closed according to the amount of the heat transfer medium (the amount of the fluid) remaining in the mist separator 28 and a differential pressure.

The gas inlet valve 24 and the gas relief valve 26 are actuated according to a change in pressure originating from a change in the volume of the heat transfer medium recirculating in the recirculation path 15 which communicates with the valves 24 and 26 by means of pressure. When the heat transfer medium is heated to increase the volume, raising the pressure in the system, the gas relief valve 26 is actuated to release the gas in the system to the outside thereof, thereby keeping the pressure in the system to or lower a set upper limit pressure. When the heat transfer medium is cooled to decrease the volume, lowering the pressure in the system, the gas inlet valve 24 is opened to supply a gas which does not affect the heat transfer medium, e.g., a nitrogen gas, from outside the system as a compressed gas, thereby keeping the pressure in the system to or higher a set lower limit pressure.

At the time of discharging the gas from the gas relief

valve 26, the heat transfer medium vapor contained in the gas can be condensed for liquification by cooling the gas which is drained from the gas phase portion 22b of the expansion vessel 22 with the cooling unit 27 of the condenser 25. This can prevent the heat transfer medium vapor as well as the gas to be released through the gas relief valve 26 from being discharged to the outside. When the amount of the heat transfer medium retaining in the mist separator 28 becomes a certain level or greater, the float valve 30 is opened to return the heat transfer medium to the expansion vessel 22 for recycle from the mist separator 28 via the heat transfer medium return path 29.

In the thus configured heat-transfer-medium heating and cooling apparatus, with a predetermined cooling temperature set in the temperature indicator and controller 19 at the time of cooling the reactor 13, the temperature indicator and controller 19 is actuated according to the temperature of the heat transfer medium flowing in the inlet-side path 18, so that at the time of cooling, the cooling state of the heat transfer medium in the heat exchanger 12 is regulated by mainly controlling the degree of opening of the flow regulator 20.

At the time of cooling, the heat transfer medium in the expansion vessel 22 flows into the recirculation path 15 due to a reduction in the volume of the heat transfer medium originating from a temperature drop, and the gas inlet valve 24 is opened or closed according to a pressure drop

originating from a reduction in the amount of the heat transfer medium in the expansion vessel 22, permitting supply of the compressed gas into the system to keep the pressure in the system at a predetermined pressure. At this time, the heat transfer medium which has a relatively high temperature flows into the recirculation path 15 from the expansion vessel 22. As the flow amount of the heat transfer medium is a slight amount according to the amount of the volume of the heat transfer medium reduced by cooling, however, it does not cause a large change in the temperature of the heat transfer medium recirculating the recirculation path 15.

Because the expansion vessel 22 is separated from the recirculation path 15, it is unnecessary to cool the heat transfer medium in the expansion vessel 22, making the amount of the heat transfer medium to be cooled smaller than the conventional apparatus in which all the heat transfer mediums are to be cooled. Therefore, the heat-transfer-medium heating and cooling apparatus of the invention can reduce the energy cost for cooling the heat transfer medium significantly as compared with the conventional apparatus, and is excellent in response characteristic.

With a predetermined heating temperature set in the temperature indicator and controller 19 at the time of heating the reactor 13, the temperature indicator and controller 19 is actuated according to the temperature of the heat transfer medium flowing in the inlet-side path 18,

so that at the time of heating, the heating state of the heat transfer medium in the heating unit 14 is regulated by mainly controlling the performance of the heating unit 14.

At the time of heating, an increase in the volume of the heat transfer medium originating from an increase in the temperature of the heat transfer medium causes a part of the heat transfer medium recirculating in the recirculation path 15 to flow into the expansion vessel 22, thus raising the pressure in the condenser 25. The gas relief valve 26 is opened or closed according to the pressure rise to discharge the gas outside the system, thereby keeping the pressure in the system at a predetermined level. Bubbles of the heat transfer medium vapor generated by heating float in the heating unit 14 in the reserve path 23 branching upward from the pump-suction-side path 21, thus preventing the pump 11 from sucking the bubbles. The bubbles of the heat transfer medium vapor floating in the expansion vessel 22 from the reserve path 23 flow into the liquid phase portion 22a of the expansion vessel 22, and contacts a heat transfer medium lower in temperature than the heat transfer medium that recirculates in the recirculation path 15 for reliquification or is reliquified at the cooling unit 27 of the condenser 25.

Bubbles in the heat transfer medium can be efficiently floated toward the reserve path 23 to be separated by branching the reserve path 23 upward from the pump-suction-side path 21 in the vertical direction, and using thick

pipes for the pump-suction-side path 21 and the reserve path 23 or bending the pump (11) side portion of the pump-suction-side path 21 downward.

Because the heat transfer medium to be heated is just the heat transfer medium that recirculates in the recirculation path 15 as mentioned above, it is possible to considerably reduce the energy cost required for heating the heat transfer medium and improve the response characteristic. In addition, while the heat transfer medium that is heated by the heating unit 14 according to an increase in the volume of the heat transfer medium flows into the expansion vessel 22, the flow amount of the heat transfer medium is small and the heat transfer medium is not heated further. Accordingly, a heat transfer medium vapor is hardly generated in the expansion vessel 22, so that even if the heat transfer medium vapor is evaporated, the vapor can be trapped by the condenser 25 for recycle, thereby minimizing the loss of the heat transfer medium.

The heating unit and the cooling unit in use, which are provided in the recirculation path 15, can be selected adequately according to the conditions, such as the heating temperature, the cooling temperature and the process amount. Any heating source and any cooling source can be used. The cooling temperature in the cooling unit 27 can be set arbitrarily according to the boiling point of the heat transfer medium, the expected amount of vapor, and the vapor temperature. An ordinary cooling system, such as air

cooling or water cooling, can be employed, and the cooling system can take any structure and shape. Further, the heat transfer medium in use can be selected adequately according to the cooling temperature and the heating temperature. For example, silicone oil or alcohols, hydrofluoroether can be used as the heat transfer medium.

What is claimed is:

1. A heat-transfer-medium heating and cooling apparatus comprising:

a pump which pumps out a heat transfer medium;

a cooling unit which cools the heat transfer medium discharged from the pump;

a reactor whose temperature is controlled by the heat transfer medium output from the cooling unit; and

a heating unit which heats the heat transfer medium output from the reactor, wherein

a recirculation path for recirculating the heat transfer medium to the pump via the pump, the cooling unit, the reactor, and the heating unit,

a reserve path being provided in a pump-suction-side path extending from the heating unit to the pump, and branching from the pump-suction-side path to connect to a liquid phase portion of an expansion vessel,

the expansion vessel which has a condenser communicating with a gas phase portion of the expansion vessel, and having a cooling unit which cools a heat transfer medium vapor for liquification thereof, a path for returning the heat transfer medium liquefied by cooling in the cooling unit, and a gas relief valve which discharges a gas from the gas phase portion of the condenser according to a pressure in the condenser.

2. The heat-transfer-medium heating and cooling apparatus according to claim 1, wherein the reserve path branches upward from the pump-suction-side path.