

Reduced Pressure Steam Heat Treating Device

This invention relates to a heat-treating device for safely and efficiently heat-treating product to be treated at relatively low temperature such as lower than 100°C with reduced pressure steam as heat medium.

In the field of chemical and food industries, materials are frequently treated at relatively low temperature lower than 100°C, for example, in order to maintain safe operation and product quality. For such heat-treatment, such a device as disclosed, for example, in the Japanese patent opening Gazette No. 60-64108, which uses reduced pressure steam as heat medium, has been used. In this device, steam is supplied from a steam source through a pressure reducing valve to a heat exchanger chamber having an outlet connected to a conventional vacuum pump through a steam trap which is bypassed for enabling flow-rate control of the fluid path. However, the conventional vacuum pump is operated always to attain its ultimate vacuum pressure, so that the steam is excessively sucked by the pump to give an undesirably high degree of vacuum to the heat exchanger chamber. In order to prevent such trouble, the flow-rate of the above-mentioned bypass may be increased for maintaining the pressure within the heat exchanger chamber. As a result, however, a lot of steam is exhausted through the bypass to result not only in an excessive loss of steam but

also in an unstable pressure within the heat exchanger chamber.

Accordingly, the invention seeks to provide an improved reduced pressure steam heat treating device which exhibits a steady steam pressure in the heat exchanger chamber and a high thermal efficiency.

Another aim of this invention is to provide a convenient heat-treating device which can effect alternating heating and cooling operations as occasion demands.

According to this invention, there is provided a reduced pressure steam heat treating device comprising a pressure reducing valve having an inlet connected to a steam source and an outlet, a heat exchanger chamber having an inlet connected to the outlet of said pressure reducing valve, and a pressure reducing ejector having a suction chamber connected to the outlet of said heat exchanger chamber, means for feeding operation fluid to said ejector, and means for controlling the temperature of said operation fluid to control the suction pressure of said ejector.

According to one embodiment of this invention, the reduced pressure steam heat-treating device further comprises a pump for feeding the fluid to the ejector, a tank for supplying the fluid to the pump and receiving the fluid discharged from the defuser of the ejector and means for selectively connecting the outlet of the pump to the inlet of the heat exchanger chamber, and at the same time, disconnecting the steam supply from the heat exchanger chamber to enabling cooling operation with the same fluid.

These and other features of this invention will be described in detail below about its embodiments with reference to the accompanying drawings.

In the drawings:

Figure 1 is a schematic diagram representing a

configuration of a first embodiment of the heat-treating device according to this invention;

Figure 2 is a block diagram representing a variation of the embodiment of Figure 1;

Figure 3 is a sectional view representing a main portion of a header used in the variation of Figure 2;

Figure 4 is a schematic diagram, partly in block form, representing a configuration of a second embodiment of the heat-treating device according to this invention;

Figure 5 is a schematic sectional view representing a structure of the pressure reducing valve used in the device of this invention; and

Figure 6 is a sectional view representing a partial structure of the heat exchanger chamber used in the embodiment of Figure 4.

Throughout the drawings, same reference numerals are given to corresponding structural components which will not be described separately.

Referring to Figure 1, steam supplied from a suitable steam generator (not shown) passes a pressure reducing valve 1 and enters a heat exchanger chamber 2 which will be described later. The heat exchanger chamber 2 is connected to an ejector device 3. The ejector device 3 includes an ejector 4 having a suction chamber connected to the heat exchanger chamber 2, a storage tank 5 of operation fluid (e.g., water) for the ejector, and a conventional volute pump 6 for feeding the fluid in the tank to the nozzle of the ejector 4 and returning it through its defuser to the tank 5. The tank 5 is provided with a water feeding pipe 8 having an electrically driven valve 7 and a valve control unit 9 for driving the valve 7 is adapted to respond to a temperature signal from a temperature sensor 10 disposed in the piping between the tank 5 and the pump 6.

Another electrically driven valve 11 connected to the exterior is disposed between the pump 6 and the ejector 4 and a valve control unit 12 for driving this valve is adapted to respond to a detection signal from a level detector 13 disposed in the tank 5.

In operation, the water in the tank 5 is forcibly fed to the ejector 4 by the pump 6 and returns again to the tank 5 to repeat circulation. Then, a saturation pressure corresponding to the current water temperature is produced in the ejector 4 and the pressure within the heat exchanger 2 is reduced thereby. The water temperature is constantly monitored by the temperature sensor 10 and, if it exceeds a predetermined value, the electrically driven valve 7 is opened by the valve control unit 9 to replenish cool water from the feeding pipe 8 for reducing the water temperature. Accordingly, the pressure within the heat exchanger chamber 2 is automatically maintained at a predetermined value by suitably presetting the actuation temperature of the valve control unit 9. While the water level within the tank 5 is raised by the replenishment of water, it is constantly monitored by the level detector 13 and, if it exceeds a predetermined upper limit, the electrically controlled valve 11 is opened by the valve control unit 12 to discharge the excessive water to the exterior. The valve 11 is closed when the level reaches a predetermined lower limit. Thus, the steam pressure within the heat exchanger chamber 2 is maintained at a predetermined reduced value in the device of this invention and never becomes an excessive vacuum as in the prior art devices.

As described above, the pressure within the heat exchanger chamber 2 is expected to become a saturation vapour pressure of the operation fluid and the temperature

of the heating steam fed through the pressure reducing valve 1 is expected to become a saturation temperature corresponding to this pressure. However, a high pressure steam has a general tendency of becoming a superheated steam when reduced in pressure by a pressure reducing valve and the temperature within the heat exchanger chamber 2 may become higher than an expected temperature. In order to suppress such superheating, as shown in Figure 2, a header chamber 14 is disposed between the pressure reducing valve 1 and the heat exchanger chamber 2, the bottom of the header chamber 14 is connected through a steam trap 15 to the suction chamber of the ejector 4 and the inlet side of the electrically driven valve 11 is connected through a valve 16 to a temperature dumper 17 attached to the side wall of the header chamber 14. As shown in Figure 3, the temperature dumper 17 includes a hollow head portion 18 screwed into the side wall of the header chamber 14 and a pipe joint 19 coupled thereto and the head portion 18 has a through-hole 20 opening in the header chamber 14 at the top and a rear portion connected to the interior of the pipe coupling 19 through side openings 21 and a screen 22. With this arrangement, drain collected by the steam trap 15 from the header chamber 14 is sucked by the ejector device 3 and, when the valve 16 is opened, the water at its saturation temperature is forcedly fed by the pump 6 to the temperature dumper 17 and sprayed from the through-hole 20 into the header chamber 14. Thus, the superheated steam is reduced in temperature and the sprayed water becomes a saturated water vapour. The vapour pressure within the head exchanger chamber 2 can be maintained constantly at a saturated vapour pressure by controlling the valve 16 to adjust the amount of spray.

---

Referring next to Figure 4, the ejector device of this embodiment also includes an ejector 4, a tank 5, a pump 6, a feed valve 7, a feed pipe 8 and a discharge valve 11 and the tank 5 is provided with a temperature sensor 10 and a level detector 13, as in the embodiment of Figure 1. In this embodiment, however, an electrically driven valve 23 is disposed before the pressure reducing valve 1 and the outlet side of the pump 6 is connected through an electrically driven valve 24 to the outlet side of the pressure reducing valve 1, namely, the inlet of the heat exchanger chamber 2. Motors or electromagnets 25 and 26 for driving the valves 23 and 24 are connected to a central control device 27 to open and close the valves 23 and 24 in mutually opposing fashion under control thereof. Motors or electromagnets 28 and 29 for driving the valves 7 and 11 are also connected to the central control device 27 and adapted to effect the same operation as in the embodiment of Figure 1 based upon

the signals from the temperature sensor 10 and the level detector 13. As shown, the heat exchanger chamber 2 of this embodiment has a U-shaped vertical section and is put in contact with a cylindrical reaction chamber 30 which is provided with a material inlet 31, a product outlet 32 and a stirrer 33. A condenser 34 is inserted between the outlet of the heat exchanger chamber 2 and the ejector 4 and the cooling water for the condenser 34 is fed from the feed pipe 8 through an electrically driven valve 35 and discharged to the exterior. A driving motor or electromagnet 36 for this valve is also connected to the central control device 27.

When the valve 24 is closed and the valve 23 is opened in this arrangement, steam from a steam source (not shown) enters the heat exchanger chamber 2 through the pressure reducing valve 1 and, after heating the reaction chamber 30 which is in contact with the heat exchanger chamber 2 and causing a desired reaction as in the embodiment of Figure 1, it is condensed by the condenser 34 and sucked by the ejector 4 to enter the tank 5, thereby raising the water temperature therein. However, the condenser 34 need not be used in such a heating operation as in the embodiment of Figure 1.

If the valve 23 is then closed and the valve 24 is opened, the steam supply to the heat exchanger chamber 2 stops and, at the same time, the warm water in the tank 5 is forcedly fed to the heat exchanger chamber 2 by the pump 6. This water and the residual steam are sucked by the ejector 4 to return to the tank 5. At the same time, the feed valve 7 is opened to replenish the tank 5 with water to gradually lower the water temperature of the tank 5. While the water fed into the heat exchanger chamber 2 is evaporated by the heat of the reaction chamber 30 to cool the reaction chamber 30 by its heat of evaporation, a lot of vapor produced at this time is condensed by the condenser 34 and sucked by the ejector 4. Thus, the condenser 34 serves to suppress the overload upon the sucking operation

of the ejector 4. If cool water is fed in the heat exchanger chamber 2 as in the prior art devices, the residual steam therein is quickly condensed to cause sudden change of the pressure and so-called hammer effect which may induce vibration and destruction of the device. In the device of this invention, however, there is no quick condensation of the residual steam and, therefore, no hammer effect is induced since the water temperature of the tank 5 just after the heating operation is substantially high. The temperature of the heat exchanger chamber 2 lowers gradually with reduction of the water temperature of the tank 5. If this water temperature is suitably preset in the control device 27, the negative pressure of the ejector 4 is accordingly controlled and the cooling speed is thereby controlled to enable a desired cooling treatment.

When the heating operation is resumed after the cooling operation, the feed valve 7 is closed first. Then, the water in the tank 5 circulates through the pump 6, valve 24, heat exchanger chamber 2, condenser 34 and ejector 4 and absorbs heat from the reaction chamber 30 to gradually raise its temperature. When it reaches a suitable temperature, the valve 26 is closed and the valve 23 is opened at the same time to introduce the steam. In this manner, the heating operation can be resumed without the hammer effect attributable to sudden change of the temperature.

The above-mentioned adjustment of the water temperature and control of the valves can be stored previously as a predetermined program in the control device 27, thereby enabling complete automation of the heating and cooling operations.

While the heat-treating device of this invention is particularly effective when used in the case of normal heating temperature below 100°C such as in various reaction chambers and food distilling, condensing and sterilising devices, a structure of the pressure reducing valve 1 used in this case is schematically shown in Figure 5. As shown,

the pressure reducing valve 1 has a steam inlet 37 and a steam outlet 38 and includes a main valve 39 therebetween. The main valve 39 is coupled to a pressure responsive diaphragm 41 through a connecting rod 40 and pulled up with the diaphragm 41 by a spring 42 to close the steam path, contrary to the conventional pressure reducing valve. The lower cavity of the diaphragm 41 is connected to the outlet side through an opening 43 to have the secondary pressure. Accordingly, when the secondary pressure, namely, the pressure of the heat exchanger chamber 2 lowers to some extent, the diaphragm 41 is pulled down against the spring 42 to open the main valve 39 to feed the steam to the heat exchanger chamber 2. When the secondary pressure is restored, the diaphragm 41 is pulled up to close the main valve 39. The tension of the spring 42 can be adjusted by a tension control 44. The tension control 44 may include, for example, an adjusting motor and operate in response to a signal from the control device 27 as shown in Figure 4. When the above-mentioned heating temperature is above 100°C, a pressure reducing valve of the conventional structure is used since the secondary saturated vapor pressure becomes above the atmospheric pressure. In this case, the main valve 39 is pushed down by the spring 42 and normally opens, while it is closed when the secondary pressure becomes above a predetermined value.

The heat exchanger chamber 2 of the embodiment of Figure 4 has such a trouble in that, when the cooling water is introduced therein from the valve 24 through the path which is common to the steam after heating operation as described above, much thereof is insufficiently contacted with the surface of the reaction chamber 30 and sucked by the ejector 4 before evaporation, thereby resulting in a low cooling efficiency. Figure 6 shows an improved structure for removing this trouble. As shown, the reaction chamber 30 is surrounded by the heat exchanger chamber 2 having an outer wall 45. The heat ex-

changer chamber 2 has an annular cover 46 which is coupled by bolts 48 with an annular rubber plate 47 intervening therebetween. The inner diameter of the rubber plate 47 is a little smaller than the outer diameter of the reaction chamber 30, and therefore, its inner peripheral portion is bent downwards along the outer wall of the reaction chamber 30 as shown. When the cooling water is introduced from the valve 24 into the cavity above the rubber plate 47 as schematically shown by an arrow 49, it deforms the rubber plate 47 by its pressure and flows down through the gap between the outer wall of the reaction chamber 30 and the rubber plate 47 along that outer wall and, finally, it is sucked and discharged from the lower outlet 50. Thus, the feed cooling water is effectively evaporated by the heat of the reaction chamber 30 and the reaction chamber 30 can be efficiently cooled by the resultant heat of evaporation. In the case of this structure, the heating steam is introduced from the pressure reducing valve 1 through another piping separate from the cooling water into the underside of the rubber plate 47 as schematically shown by an arrow 51. The rubber plate 47 may be made of a suitable resilient material other than rubber.

As described above, this invention provides a reduced pressure steam heat treating device having high stability and high thermal efficiency. The above-mentioned embodiments have been proposed for illustrative purposes only and never mean any limitation of the invention. It should be understood by those skilled in the art that various modifications and changes of these embodiments can be made without leaving the scope of the invention as defined in the appended claims. For example, while a U-shaped section of the heat exchanger chamber 2 surrounding the reaction chamber 30 is shown in the above embodiment, the structure and shape of the heat exchanger chamber 2 is freely selectable and, if necessary, the material to be treated may be inserted di-

---

rectly in the heat exchanger chamber 2. While all valves are illustrated as controlled automatically in Figure 4, it is free to manually control any one or more of them. If the pressure reducing valve 1 of Figure 4 is adapted to enable its complete closure, the preceding valve 23 may be removed. Moreover, some of those components other than the pressure reducing valve, heat exchanger chamber and ejector device may be optionally removed in accordance with the use and operational condition of the device.



-12-

CLAIMS:-

1. A reduced pressure steam heat treating device comprising a pressure reducing valve having an inlet connected to a steam source and an outlet, a heat exchanger chamber having an inlet connected to the outlet of said pressure reducing valve, and a pressure reducing ejector having a suction chamber connected to the outlet of said heat exchanger chamber, means for feeding operation fluid to said ejector, and means for controlling the temperature of said operation fluid to control the suction pressure of said ejector.
2. A device as set forth in claim 1, further comprising means for introducing said operation fluid to the inlet of said heat exchanger chamber, and means for switching feed of said steam and said operation fluid to said heat exchanger chamber.
3. A device as set forth in claim 1 or 2, wherein said operation fluid feeding means includes a fluid storage tank, pumping means for forcedly feeding the operation fluid in said storage tank to a jetting nozzle of said ejector, means for returning the operation fluid from said ejector to said storage tank, and means for replenishing said storage tank with operation fluid of relatively low temperature.
4. A device as set forth in claim 3, wherein said means for controlling the temperature of the operation fluid includes a temperature sensor for sensing the temperature of said operation fluid to provide a sense signal, and means



responsive to said sense signal for controlling the amount of replenishment of said replenishing means.

5. A device as set forth in claim 3, further comprising means for detecting the level of said fluid storage tank to provide a detection signal, and means responsive to said detection signal for discharging said operation fluid to the exterior.

6. A device as set forth in claim 1, further comprising means for suppressing superheating of the steam inserted between said pressure reducing valve and said heat exchanger chamber, said means including a chamber and means for spraying said operation fluid into said chamber.

7. A device as set forth in claim 1, 2, 3, 4 or 5, wherein said pressure reducing valve includes a main valve normally urged to the direction of closure, and pressure responsive means for responding to reduction of the pressure of the outlet side to open said main valve.

8. A device as set forth in claim 1, 2, 3, 4, 5 or 7, wherein a condenser device is provided in the piping between said heat exchanger chamber and said ejector.

9. A device as set forth in claim 1, 2, 3, 4, 5, 7 or 8, wherein said heat exchanger chamber has a U-shaped section surrounding a cylindrical reaction chamber, and an inner cavity divided by an annular partition plate into an upper cavity having a relatively small volume and a lower cavity having a relatively large volume, said partition plate being composed of a resilient material having an inner



-14-

diameter less than the outer diameter of said reaction chamber, the inner peripheral portion of said partition plate being bent along the outer wall of said reaction chamber, said upper cavity having an inlet for said operation fluid, and said lower cavity having an inlet for said steam and an outlet for both said steam and fluid.

10. A reduced pressure steam heat treating device substantially as herein described with reference to the accompanying drawings.

---