(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 548 652 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
23.01.2013 Bulletin 2013/04

(21) Application number: **10847960.1**

(22) Date of filing: **10.09.2010**

(51) Int Cl.:
B05B 7/26 *(2006.01)* ***B05B 1/12*** *(2006.01)*
B05D 1/02 *(2006.01)* ***B22D 11/124*** *(2006.01)*

(86) International application number:
PCT/JP2010/065586

(87) International publication number:
WO 2011/114552 (22.09.2011 Gazette 2011/38)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **18.03.2010 JP 2010063340**

(71) Applicant: **H. Ikeuchi & Co., Ltd.**
Osaka-shi
Osaka 550-0011 (JP)

(72) Inventors:
- **NAKANO, Hisatsugu**
  Osaka 5500011 (JP)
- **IIMURA, Tomokata**
  Osaka 5500011 (JP)

(74) Representative: **Pluckrose, Anthony William**
Boult Wade Tennant
Verulam Gardens
70 Gray's Inn Road
London WC1X 8BT (GB)

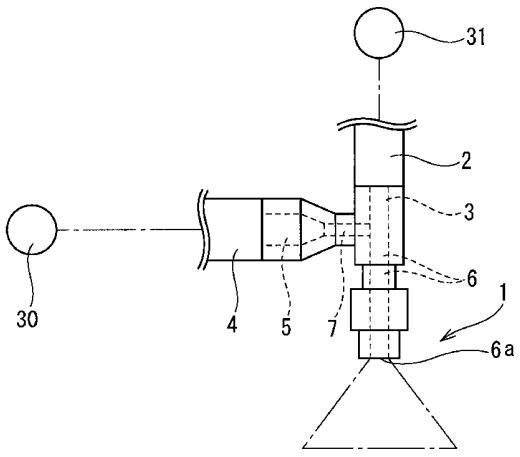
(54) **METHOD FOR SPRAYING WITH NOZZLE AND NOZZLE**

(57) Disclosed is a method for spraying with a nozzle which enables to properly switch between one-fluid spray of spraying only a liquid and two-fluid spray of spraying a mixture of a liquid and air without varying a spraying angle etc. using a single nozzle.

The nozzle is connected to a liquid feeding tube and an air feeding tube so as to combine the one-fluid spray of spraying only a liquid and the two-fluid spray of spraying a mixture of a liquid and air.

The one-fluid spray of spraying only a liquid is performed when a fluid pressure is high, that is when the amount of a supplied liquid is large, and two-fluid spray of spraying a mixture of a liquid and air is performed when the fluid pressure is low, that is when the amount of the supplied liquid is small.

Fig. 2



EP 2 548 652 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a spray method to be carried out by a nozzle and the nozzle and more particularly to a spray method and a nozzle preferably used to cool slab, bloom, billet, and a roller having high temperatures.

BACKGROUND ART

[0002] Continuous casting equipment produces a wide variety of steel plates. It is necessary to adjust the amount of spray jetted from the nozzle according to the kind of a steel plate. Either single fluid nozzle which sprays only water or a binary fluid nozzle which sprays a mixture of water and air is hitherto used.
Of these nozzles, it is often the case that a binary fluid consisting of the mixture of water and air is sprayed from the nozzle because the binary fluid spray allows the amount of spray to be easily adjusted by changing the balance between the pressure of the liquid and that of the air to be supplied to the nozzle.

[0003] For example, a nozzle 100 shown in Fig. 12 is conventionally used. In the nozzle 100, an orifice 103 is formed at the front end of an independent hole 102 formed along the axis of the nozzle 100, and a cutout portion 104 communicating with the orifice 103 is formed at a jetting side to form a jet port.
The nozzle 100 has a problem that with a change of the spray amount of the nozzle 100, a spray angle and a flow rate distribution change and as a result, a uniform cooling cannot be performed. More specifically, in spraying the mixture of water and air from the nozzle 100, when the ratio of the flow rate of air to that of water is decreased and finally only water is jetted to lower the flow rate of the water, the spray angle in the spray width direction and that in the spray thickness direction become small. That is, the spray angle is liable to become unstable.

[0004] The binary fluid nozzle 105 which sprays the mixture of the liquid (water) and the air is disclosed in Japanese Examined Patent Application Publication No. 3-15493 shown in Fig. 13. In the nozzle 105, the nozzle tip 106 is mounted at the front end of the adaptor 109 into which the mixture of the liquid and the gas flows. At the nozzle tip 106, the sectionally circular stirring chamber 107 is formed. A front portion 106a of side wall of the stirring chamber 107 is inclined to an opposite direction. Two inlets 108 opposed to each other are formed on the side wall of the stirring chamber 107.

[0005] In the binary fluid nozzle 105, the spray amount is changed by adjusting the balance between the pressure of the liquid and that of the air to make the spray angle and the flow rate distribution constant. But the nozzle 105 has a problem that with a change in the flow rate of the liquid, the spray angle in the spray width direction fluctuates and thus nonuniform cooling is liable to occur. In the case where the ratio of the flow rate of a gas to that of the liquid is lowered to spray only the liquid, there occurs a problem that the configuration of the flow rate distribution in the spray width direction becomes unstable. For example, when a binary fluid consisting of the mixture of the water and the air is sprayed, as shown in Fig. 14(A), the spray angle is large. When a single fluid consisting of the water is sprayed, as shown in Fig. 14 (B), the spray angle becomes small. Thus the nozzle 105 has another problem that when the ratio of the flow rate of the gas to that of the liquid is greatly fluctuated, a stable spray pattern cannot be obtained.

[0006] When the mixture of the liquid (water) and the gas (air) is always sprayed, a large amount of the air is consumed. With an increase of the consumption amount of the air, the power consumption of an air supply compressor increases. Thus there is an increase in the cost. Therefore upon request of cost reduction, to save energy by decreasing the power consumption of the air supply compressor, a decrease (or only liquid is sprayed) in the ratio of the flow rate of the air to that of the liquid is demanded. To this end, it is necessary to obtain a stable spray pattern, even though the ratio of the flow rate of the air to that of the liquid is lowered. But the above-described nozzle cannot comply with the need to a sufficient extent.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0007] Patent document 1: Japanese Examined Patent Application Publication No. 3-15493

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0008] It is an object of the present invention to provide a method, to be carried out by a nozzle, which is capable of stabilizing the pattern of spray jetted from the nozzle without greatly fluctuating a spray angle and a flow rate distribution, even though the nozzle is used by timely switching spray of a binary fluid to spray of a single fluid and vice versa and is capable of decreasing the consumption amount of air by lowering air-to-water ratio which specifies the ratio of the amount of a gas (air) to that of a liquid.

MEANS FOR SOLVING THE PROBLEM

[0009] To solve the above-described problems, the present invention provides a spray method to be carried out by a nozzle, connected to a liquid supply tube and an air supply tube, which sprays a single fluid consisting of a liquid and a binary fluid consisting of a mixture of the liquid and air in combination with each other. When a pressure of the liquid is high when a supply amount of

the liquid is large, the nozzle sprays only the liquid, whereas when the pressure of the liquid is low when the supply amount of the liquid is small, the nozzle sprays the binary fluid consisting of the mixture of the liquid and the air.

[0010] In the present invention, when the pressure of the liquid is high, and thus when the flow rate of the liquid increases, i.e., at the time of a high flow rate, a spray angle is comparatively wide and a flow rate distribution is stable. When the pressure of the liquid becomes high, i.e., at the time of the high flow rate, the nozzle sprays only the liquid, namely, a single fluid. As described above, at the time of the high flow rate, the spray angle and the flow rate distribution are stable. Therefore even though the nozzle sprays only the liquid, namely, the single fluid, it is possible to stably maintain the spray angle and the flow rate distribution.

On the other hand, when the liquid pressure decreases and thus the flow rate thereof becomes low, the spray angle and the flow rate distribution become unstable if the spray of the single fluid, namely, the spray of only the liquid is continued. Therefore the spray of the single fluid is switched to the spray of the binary fluid consisting of the mixture of the liquid and the air. As described above, when the liquid pressure decreases and thus the flow rate thereof becomes low, by adding the air to the liquid, it is possible to stably spray the binary fluid at a spray angle and a flow rate distribution similar to those to be obtained when only the liquid is sprayed at a high flow rate.

[0011] The present invention provides a nozzle to be used in carrying out the spray method. The nozzle has a liquid inflow path connected to a liquid supply tube, an air inflow path connected to an air supply tube, and a main fluid flow path having a jet port at a front end thereof. A liquid inlet and an air inlet communicating with the liquid inflow path and the air inflow path respectively are disposed in confrontation each other or at inside and outside positions in such a way that the liquid inflow path and the air inflow path are in parallel with each other, the liquid inlet is always open, the air inlet is opened and closed by a switching valve, and when the pressure of a liquid supplied from the liquid supply tube decreases, the switching valve is opened so that the nozzle sprays a binary fluid.

[0012] Specifically, a valve body of the switching valve of the air inlet is urged by a spring, a pressure of air supplied from the air supply pipe is set to a constant pressure of P2, and a pressure of the spring is set to P3. When the pressure of the liquid supplied from the liquid supply tube is high and P1+P3>P2, the nozzle sprays only the liquid. When the liquid pressure P1 is low and P1+P3<P2, the switching valve is opened by the air pressure to introduce air into the main fluid flow path according to a decrease rate of the liquid pressure so that the nozzle sprays a binary fluid.

[0013] In the above-described construction, the pressure P3 of the spring for urging the valve body of the switching valve which closes the air inlet does not fluctuate, and the air pressure P2 is constant. Therefore when the liquid pressure P1 is high, the liquid pressure P1 acts on the valve body in addition to the spring pressure P3. As a result, the valve body securely closes the air inlet. Thus it is possible to prevent the air from flowing into the flow path of the switching valve.

On the other hand, when the air pressure P2 becomes higher than the pressure obtained by the addition of the liquid pressure P1 and the spring pressure P3 as a result of a decrease of the liquid pressure P1, the air inlet is automatically opened by the air pressure and the air flows into the flow path of the switching valve. As a result, the air mixes with the liquid. Thus the nozzle sprays the binary fluid. The inflow amount of the air automatically fluctuates according to the pressure of the liquid. When the flow rate of the liquid becomes low as a result of a decrease in the pressure of the liquid, the flow rate of the air increases.

As described above, as a result of the automatic addition of the air to the liquid according to the fluctuation of the liquid pressure, it is possible to stably spray the binary fluid at a spray angle and a flow rate distribution similar to those to be obtained when only the liquid is sprayed at a high flow rate.

It is possible to provide the air inlet with the valve body to be urged by the spring to differentiate the spring pressure and the pressure of the spring mounted at the air inlet from each other.

[0014] It is possible that an electromagnetic valve is used as the switching valve of the air inlet and that when the pressure of the liquid supplied from the liquid supply tube becomes less than a set value, the switching valve is controlled so that the switching valve is opened to spray the binary fluid.

[0015] It is preferable that the above-described set value of the liquid pressure is in a range of 0.005MPa to 0.9MPa and that a ratio of an amount of air to a maximum amount of a liquid when the binary fluid is sprayed is set to a range of 0.5 to 5.0.

By using the electromagnetic valve as the switching valve and automatically opening and closing the switching valve according to the liquid pressure, it is possible to simplify the construction of the nozzle. It is preferable to adjust the open angle of the switching valve according to the liquid pressure.

[0016] The construction of the nozzle is not limited to a specific one, provided that the nozzle is capable of spraying the single fluid consisting of the liquid and the binary fluid consisting of the mixture of the liquid and the air. It is possible to preferably use a nozzle so constructed as to allow fluids to collide with each other in the neighborhood of the jet port and the spray angle to be specified owing to the collision.

[0017] As a nozzle to be used, it is preferable to form a large-diameter main fluid flow path along the axis of a nozzle body, form a plurality of independent holes at the front end of the main fluid flow path, and gradually de-

crease the area of a flow path at a spray side of each of the independent holes to close the front end of each of the independent holes.

It is preferable to diametrically form a notched portion on an end surface of a spray side of the nozzle body in such a way that the bottom surface of the notched portion is circular arc-shaped or tapered and has a required width and that both lateral surfaces sandwiching the bottom surface thereof therebetween are parallel with the axis of the nozzle body or the front end of an opening thereof is so inclined as to become wider in an opposite direction.

It is preferable to cut out the lateral surface of the notched portion at the side of the axis of the nozzle body disposed apart from a front-end closed portion of each independent hole to form L-shaped jet ports on the lateral surface of the notched portion and on the bottom surface thereof perpendicular thereto so that the fluid returns from the front-end closed portion of each independent hole to the jet ports.

It is preferable to increase the spray thickness owing to the collision between fluids jetted from the opposed jet ports formed at both sides of the notched portion and guide the fluids sprayed from the jet ports inside the notched portion to control the spray width.

[0018] As described above, according to the spray method of the present invention to be carried out by the nozzle, by adjusting the liquid pressure to adjust the spray amount of the liquid, the spray angle and the flow rate distribution are not fluctuated. Thus a steel plate or the like can be uniformly cooled in a required range. Therefore the spray method of the present invention is most favorably used as a means for cooling the steel plate disposed in the secondary cooling zone of the continuous casting equipment. The spray method of the present invention is effective at a step of performing controlled cooling of a rolled thick plate and a step of changing the cooling speed of the steel plate such as a run-out table.

In addition to the above-described uses, the spray method and the nozzle of the present invention can be preferably used for other purposes.

EFFECT OF THE INVENTION

[0019] According to the present invention, by changing the liquid pressure according to a condition in which an object is cooled by spray, it is possible to easily and automatically switch the spray of the fluid consisting of the liquid to the spray of the binary fluid consisting of the mixture of the liquid and the air and vice versa. In addition, the flow rate of the liquid is so fluctuated that when the flow rate of the liquid is high, the nozzle sprays the single fluid consisting of the liquid and that when the flow rate of the liquid is low, the nozzle sprays the binary fluid consisting of the mixture of the liquid and the air. Even though the spray method is switched from the spray of the single fluid to the spray of the binary fluid and vice versa, the angle of the spray jetted from the nozzle and the flow rate distribution are not fluctuated between the spray of the single fluid when the flow rate of the liquid is high and the spray of the binary fluid when the flow rate of the liquid is low. Thus it is possible to stably maintain the spray angle and the flow rate distribution.

Further because it is possible to lower the ratio of the flow rate of the gas to that of the liquid (air-to-water ratio) while maintaining a stable spray pattern, it is possible to save the power consumption of the gas supply compressor and save energy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is an overall view of a nozzle of a first embodiment of the present invention.

Fig. 2 is a front view showing mixing step of the first embodiment.

Fig. 3 is a sectional view in which main parts of Fig. 2 are enlarged.

Fig. 4(A) shows a spray angle when a single fluid is sprayed in the case where the flow rate of a liquid is high; and 4(B) shows a spray angle when a binary fluid is sprayed in the case where the flow rate thereof is low.

Fig. 5 is a sectional view of a nozzle of a second embodiment.

Fig. 6 is a sectional view orthogonal to Fig. 5.

Fig. 7 is a front view of a jetting side of the nozzle of the second embodiment.

Fig. 8 is a rear view of an inlet side of the nozzle of the second embodiment.

Fig. 9(A) is a sectional view in which main parts of Fig. 5 are enlarged; and Fig. 9(B) is a sectional view in which main parts of Fig. 6 are enlarged.

Fig. 10 is a front view of a nozzle of a third embodiment.

Fig. 11 is a sectional view in which main parts of a nozzle of a fourth embodiment are enlarged.

Fig. 12 is a sectional view of a conventional nozzle.

Fig. 13 is a sectional view of another conventional nozzle.

Figs. 14(A) and 14(B) show problems of the conventional nozzles.

MODE FOR CARRYING OUT THE INVENTION

[0021] The embodiments of the present invention are described below with reference to the drawings.

Figs. 1 through 4 show a first embodiment. A nozzle 1 of the first embodiment is disposed at a secondary cooling zone of a continuous casting equipment to cool slab having a high temperature.

[0022] As shown in Figs. 1 and 2, the nozzle 1 has a liquid inflow path 3 connected to a liquid supply tube 2, an air inflow path 5 connected to an air supply tube 4, and a main fluid flow path 6 having a jet port 6a at its front end.

[0023] As shown in Fig. 2, the nozzle 1 has an automatic switching valve 7 adopting a spray method (hereinafter referred to as a switching valve 7). The switching valve 7 is mounted at a boundary position between the liquid inflow path 3 and the main fluid flow path 6 and between the liquid inflow path 3 and the air inflow path 5.

[0024] The switching valve 7 has a flow path 7a orthogonal to the main fluid flow path 6. One end of the flow path 7a is set as a liquid inlet 7b communicating with the liquid inflow path 3. The other end of the flow path 7a is set as an air inlet 7c communicating with the air inflow path 5 in such a way that the air inlet 7c confronts the liquid inlet 7b. A spring 8 is accommodated inside the flow path 7a of the switching valve 7. A valve body 9 for closing the air inlet 7c is disposed at a front end of the spring 8. The air inlet 7c is opened and closed by the valve body 9.

A valve body is not disposed at the liquid inlet 7b to always open the liquid inlet 7b so that a liquid is always flowed into the flow path 7a. Thus a liquid pressure P1 of the liquid and a spring pressure P3 of the spring 8 are always applied to the valve body 9.

[0025] The air supply tube 4 is connected to a compressor 30 to set an air pressure to be always supplied to the air inflow path 5 through the air supply tube 4 to a constant pressure P2.

Therefore when the liquid pressure P1 of the liquid supplied from the liquid supply tube 2 is high and thus P1+P3>P2, the valve body 9 is in a closed state. Therefore air does not flow into the flow path 7a of the switching valve 7, but only the liquid is supplied to the main fluid flow path 6.

On the other hand, when the liquid pressure P1 is low and thus P1+P3<P2, the valve body 9 is opened by the air pressure to flow the air into the flow path 7a of the switching valve 7.

Thus a mixture of the liquid and the air is supplied to the main fluid flow path 6.

[0026] The liquid pressure P1 of the liquid is set by a discharge pressure of a pump 31 connected with the liquid supply tube 2. The discharge pressure is set according to the kind or temperature of a steel plate cooled by the nozzle to set the flow rate of the liquid.

[0027] As described above, in the nozzle 1 of the present invention, when the liquid pressure P1 is high and P1+P3>P2, the valve body 9 is in the closed state. Thus only the liquid is supplied to the main fluid flow path 6. Therefore spray from the jet port is single fluid spray of spraying only the liquid.

As shown in Fig. 4(A), when single fluid is sprayed, a spray angle θ in a width direction is comparatively wide and has an angle $\theta 1$.

On the other hand, when the liquid pressure P1 is low and P1+P3<P2, the valve body 9 is opened by the air pressure. As a result, the air flows into the flow path 7a of the switching valve 7. Thus a mixture of the liquid and the air is supplied to the main fluid flow path 6. Thus spray from the jet port is binary fluid spray of spraying the mixture of the liquid and the air.

When the flow rate of the liquid is low, the spray angle becomes narrow. But the air is added to the liquid to form a binary fluid. Thus the spray angle increases. Therefore as shown in Fig. 4(B), the spray angle $\theta 2$ is similar to that in the single fluid spray ($\theta 2 \fallingdotseq \theta 1$), and the flow rate distribution in the thickness direction is uniformly maintained. When the flow rate of the liquid lowers, the air is added to the liquid to form the binary fluid. Thereby it is possible to restrain the spray angle and the flow rate distribution from fluctuating.

[0028] Let it be supposed that there is a variation in the configuration of the main fluid flow path 6 of the nozzle 1 and the configuration of the jet port of the nozzle 1 at its front end. In the case where the flow rate of the liquid to be sprayed is high, the spray angle becomes comparatively large. In the case where the flow rate of the liquid to be sprayed is low, the spray angle becomes comparatively small. According to the present invention, when the flow rate of the liquid is low, the air is automatically added to the liquid. As a result, the total of the flow rate of the liquid and that of the air can be set almost equally to that of only the liquid. Thereby it is possible to restrain a decrease of the spray angle and set the spray angle equivalently to that when the flow rate of the liquid is high.

[0029] Figs. 5 through 9 show the second embodiment. The construction of a nozzle 10 to be used in the second embodiment is different from the nozzle 1 to be used in the first embodiment in the construction of the main fluid flow path 6 at its jet port side. Similarly to the nozzle 1 of the first embodiment, in the nozzle 10, the main fluid flow path 6 communicates with the liquid inflow path 3 connected to the liquid supply tube 2 through the switching valve 7 and the air inflow path 5 connected to the air supply tube 4 to switchingly spray single fluid consisting of the liquid and a binary fluid consisting of the mixture of the liquid and the air from the jet port.

[0030] A partitioning wall 19 is formed at a front end of the cylindrical main fluid flow path 6 formed along the center line of a nozzle body 15, namely, along the axis of the nozzle 10. Independent holes 17 and 18 are formed at both sides of the partitioning wall 19.

Front-end closed portions 17a and 18a each having a gradually decreased flow path area are formed at front end portions of the independent holes 17 and 18 respectively. A notched portion 22 is concavely formed from the front end of a spray side of the nozzle body 15 to communicate the notched portion 22 with one lateral portion of the front-end closed portion 17a opposed to one lateral portion of the front-end closed portion 18a. Openings of the front-end closed portions 17a and 18a communicating with each other through the notched portion 22 serve as jet ports 20 and 21.

[0031] A bottom surface 22a of the notched portion 22 is formed concavely in the shape of a circular arc in such a way that the bottom surface 22a becomes wider toward the spray side. A lateral surface 22b of the notched portion 22 is parallel with the axial direction of the nozzle 10.

The radius of curvature of the circular arc of the bottom surface 22a is in a range of 4 to 50mm and is determined according to the size of the nozzle body and a requested spray width.

[0032] The bottom surface 22a of the notched portion 22 and the lateral surface 22b thereof are orthogonal to each other in such a way that the jet ports 20 and 21 are sectionally L-shaped. As shown in Fig. 9(A), at the front-end closed portions 17a and 18a, there are formed U-shaped portions 17b and 18b so configured as to U-turn the fluid to the partitioning wall 19 from the front ends of the independent holes 17 and 18 through the jet ports 20 and 21. A tapered portion 23 which becomes wider in an opposite direction is formed continuously with the front end of the spray side of the lateral surface 22b of the notched portion 22.

[0033] In the nozzle 10 of the second embodiment, the step of spraying the single fluid and the step of spraying the binary fluid when the single fluid consisting of the liquid or the binary fluid consisting of the mixture of the liquid and the air flows into the main fluid flow path 6 are identical to each other and are described below.

[0034] As shown in Figs. 9(A) and 9(B), the fluid which has flowed into the main fluid flow path 6 flows into the independent holes 17 and 18 separately. With the fluid which has flowed into the independent holes 17 and 18 increasing its flow speed with a decrease of the area of the flow paths at the front-end closed portions 17a and 18a, fluids which have flowed out from the opposed jet ports 20 and 21 collide with each other inside the notched portion 22.

[0035] The collision accelerates the diffusion of the fluids in a spray thickness direction T and a spray width direction W. The U-shaped portions 17b and 18b so configured as to U-turn the fluid to the partitioning wall 19 from the front ends of the independent holes 17 and 18 through the jet ports 20 and 21. Thus at that time, a small amount of the fluids jetted from the jet ports 20 and 21 flow in a return direction. Owing to this flow, the fluids are stirred, and the collision between the two flows can be enhanced. Therefore even when the flow rate is low, it is possible to sufficiently secure a spray angle θn in the spray thickness direction T and a spray angle θw in the spray width direction W.

[0036] The fluids which have collided with each other are guided by the lateral surface 22b of the notched portion 22 in the spray thickness direction T and smoothly guided by the circular arc-shaped bottom surface 22a of the notched portion 22 in the spray width direction W. Therefore even though the flow rate of the liquid fluctuates, it is possible to provide the stable spray angle θn in the spray thickness direction T and the stable spray angle θw in the spray width direction W.

Because the bottom surface 22a of the notched portion 22 constituting a guide wall is circular arc-shaped, the fluids can be sprayed at a small energy loss in the spray width direction W.

[0037] At the final stage of the spray step, the spray in the spray thickness direction T which has been stabilized by the lateral surface 22b of the notched portion 22 is guided by the tapered portion 23 formed continuously with the front end of the spray side of the lateral surface 22b of the notched portion 22 to enlarge the spray angle θn.

[0038] As described above, because the spray is sufficiently diffused, it is possible to uniformly keep the flow rate distribution in the spray width direction, even though the flow rate of the liquid fluctuates. The bottom surface 22a of the notched portion 22 and the lateral surface 22b thereof are orthogonal to each other in such a way that the jet ports 20 and 21 are sectionally L-shaped. Therefore it is possible to make the openings of the jet ports 20 and 21 large, raise the upper limit value of the flow rate, and make the jet ports 20 and 21 large without changing the size of the nozzle body 15. Therefore it is possible to make the nozzle 10 compact.

[0039] The spray pattern is stable. Thus when the flow rate of the liquid fluctuates, it is possible to lower the ratio of the flow rate of the gas to that of the liquid (air-to-water ratio), restrain the power consumption of the gas supply compressor, and thus save energy.

The spray pattern is stable. Thus even though the ratio of the flow rate of the gas to that of the liquid (air-to-water ratio) is lowered, it is possible to stably hold the spray angle without fluctuating the spray angle when the nozzle 10 sprays the single fluid consisting of the liquid.

[0040] According to the nozzle 10, the fluids which have flowed out from the opposed jet ports of the independent holes collide with each other and diffuse. Thereby it is possible to increase the spray thickness and the spray width. Because the fluids are sprayed under the guidance of the lateral surface of the notched portion and the circular arc-shaped bottom surface thereof, it is possible to obtain a stable spray thickness and spray width and uniformly maintain the flow rate distribution, even though the flow rate fluctuates. Further in the independent holes, the front-end closed portion having the gradually decreased flow path area is formed at the front side of each of the jet ports. Therefore the fluids collide with each other at a high speed and a high pressure, and thus the diffusion effect of the spray can be enhanced. Furthermore by providing the U-shaped portion in the range from the front end of each of the independent holes to each of the jet ports, a small amount of the fluids sprayed from the opposed jet ports flow in the return direction and thus the fluids are stirred, and further the collision between the two flows can be enhanced. Therefore even when the flow rate is small, it is possible to secure a sufficient spray area.

[0041] As described above, the spray pattern is stable. Thus even though the flow rate of the liquid fluctuates and the ratio of the flow rate of the gas to that of the liquid (air-to-water ratio) is lowered, it is possible to use the nozzle 10 without replacing it by switching the spray of the single fluid consisting of the liquid to the spray of the binary fluid consisting of the mixture of the liquid and the

air and vice versa. In addition, because the air-to-water ratio can be decreased, it is possible to save the power consumption of the gas supply compressor and save energy.

[0042] Fig. 10 shows the third embodiment.

In the nozzle of the third embodiment, instead of the switching valve of the first embodiment which opens and closes the air inlet by urging the valve body with the spring, an electromagnetic switching valve 50 is mounted at the air inlet. When an air pressure supplied by the liquid supply tube becomes below a set value, the electromagnetic switching valve 50 opens so that the nozzle sprays the binary fluid by mixing the air with the liquid.

Because the construction of the nozzle is similar to that of the second embodiment, the description thereof is omitted herein.

[0043] The above-described set value of the liquid pressure at which the spray of the single fluid consisting of the liquid is switched to the spray of the binary fluid is in the range of 0.005MPa to 0.9MPa. The air-to-water ratio which is the ratio of the amount of the air to a maximum amount of the liquid when the nozzle sprays the binary fluid is set to the range of 0.5 to 5.0.

[0044] Fig. 11 shows the fourth embodiment.

In the first through third embodiments, the air supply tube is laterally confluent with the liquid supply tube provided along the axis of the nozzle. But in the fourth embodiment, a double tube construction is adopted. More specifically, air flows in a central flow path inside an inner tube 40. A mixing adaptor 43 accommodating the switching valve 7c having a spring and a valve body is mounted at a front end of the inner tube 40.

An outer tube 41 is disposed on the outer periphery of the inner tube 40 by interposing a liquid flow path 42 between the outer tube 41 and the inner tube 40. A nozzle body 45 is coupled to the front end of the outer tube 41. An adaptor (not shown) coupled to an air supply source and a liquid supply source through pipes is coupled to the proximal side of each of the inner tube 40 and the outer tube 41.

[0045] In the fourth embodiment, when the pressure of a liquid flowing through the liquid flow path 42 disposed on the outer periphery of the inner tube 40 decreases and the pressure of air supplied into the inner tube 40 becomes higher than the pressure of the liquid, the switching valve 7c is opened to jet the air from an opening 43a disposed at the front end of the mixing adaptor 43 so that the air is mixed in the liquid. The mixture of the liquid and the air is sprayed from a jet port 45a disposed at the front end of the nozzle body 45.

When the pressure of the liquid is high, the switching valve 7c remains closed so that the nozzle sprays the single fluid consisting of the liquid.

EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

[0046]

1: 10 nozzle
2: liquid supply tube
3: liquid inflow path
4: air supply tube
5: air inflow path
6: main fluid flow path
7: switching valve
8: spring
9: valve body
50: electromagnetic switching valve

Claims

1. A spray method to be carried out by a nozzle, connected to a liquid supply tube and an air supply tube, which sprays a single fluid consisting of a liquid and binary fluid consisting of a mixture of said liquid and air in combination with each other,
wherein when a pressure of said liquid is high when a supply amount of said liquid is large, said nozzle sprays only said liquid, whereas when said pressure of said liquid is low when said supply amount of said liquid is small, said nozzle sprays a mixture of said liquid and said air.

2. A nozzle to be used in carrying out a spray method according to claim 1, comprising a liquid inflow path connected to a liquid supply tube, an air inflow path connected to an air supply tube, and a main fluid flow path having a jet port at a front end thereof;
wherein a liquid inlet and an air inlet communicating with said liquid inflow path and said air inflow path respectively are disposed in confrontation each other or at inside and outside positions in such a way that said liquid inflow path and said air inflow path are in parallel with each other, said liquid inlet is always open, said air inlet is opened and closed by a switching valve, and when a pressure of a liquid supplied from said liquid supply tube decreases, said switching valve is opened so that said nozzle sprays a binary fluid.

3. A nozzle according to claim 2, wherein a valve body of said switching valve of said air inlet is urged by a spring, a pressure of air supplied from said air supply pipe is set to a constant pressure of P2, and a pressure of said spring is set to P3;
when said pressure of said liquid supplied from said liquid supply tube is high and P1+P3>P2, said nozzle sprays only said liquid; and when said liquid pressure P1 is low and P1+P3<P2, said switching valve is opened by said air pressure to introduce air into said main fluid flow path according to a decrease rate of said liquid pressure so that said nozzle sprays a binary fluid.

4. A nozzle according to claim 2, wherein an electro-

magnetic valve is used as said switching valve of said air inlet, and when said pressure of said liquid supplied from said liquid supply tube becomes less than a set value, said switching valve is controlled so that said switching valve is opened to spray said binary fluid.

5. A nozzle according to claim 4, wherein said set value of said liquid pressure is in a range of 0.005MPa to 0.9MPa; and a ratio of an amount of air to a maximum amount of a liquid when said binary fluid is sprayed is set to a range of 0.5 to 5.0.

Fig. 1

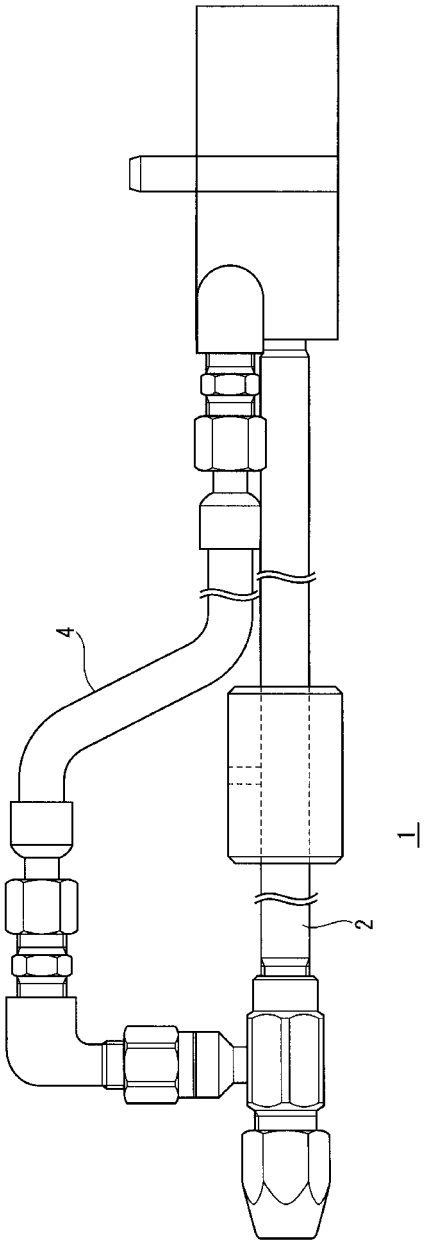


Fig. 2

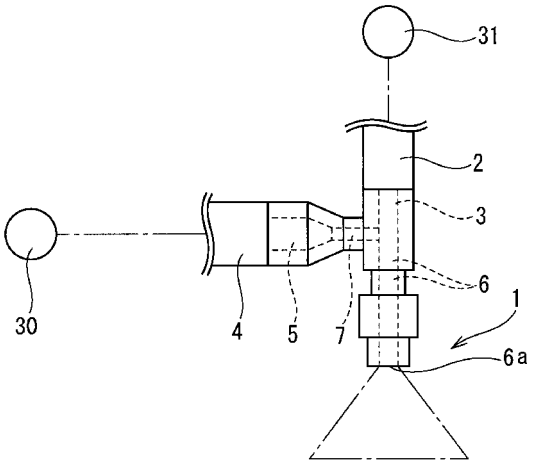


Fig. 3

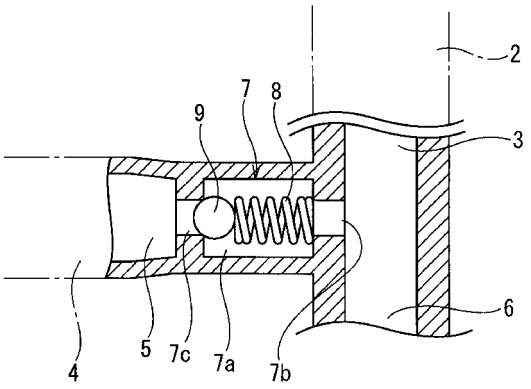


Fig. 4A

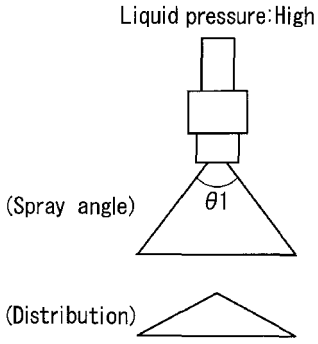


Fig. 4B

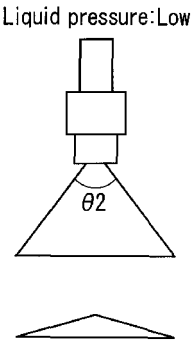


Fig. 5

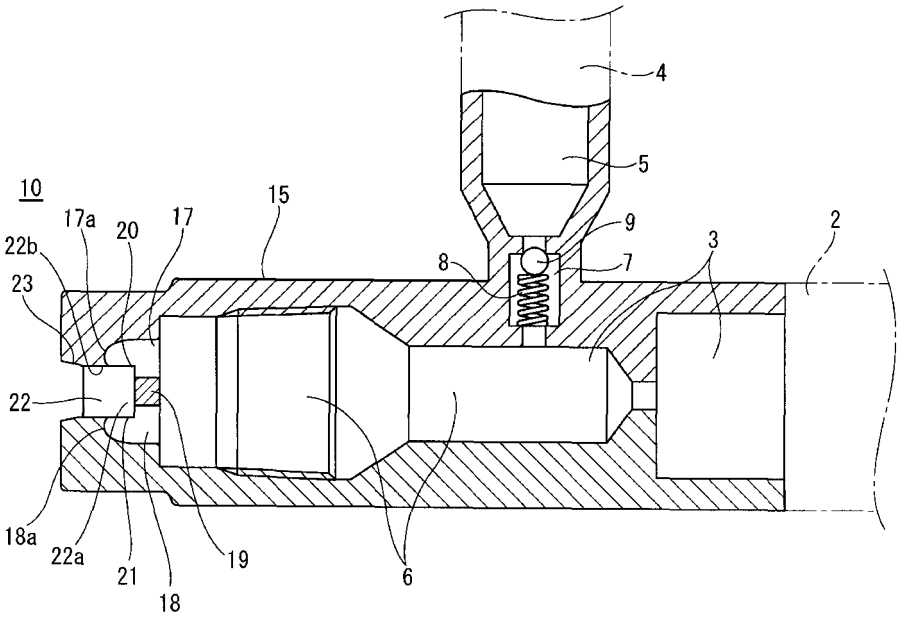


Fig. 6

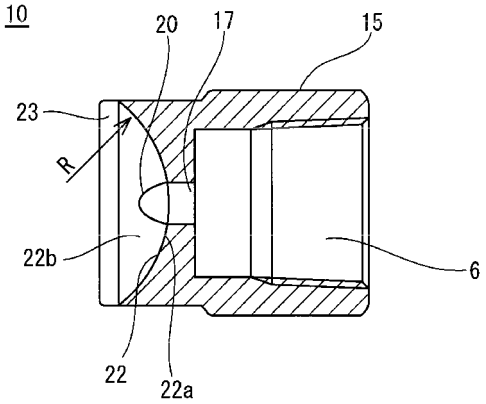


Fig. 7

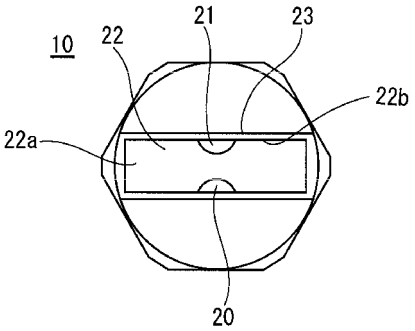


Fig. 8

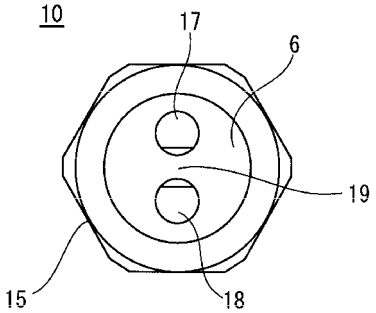


Fig. 9A

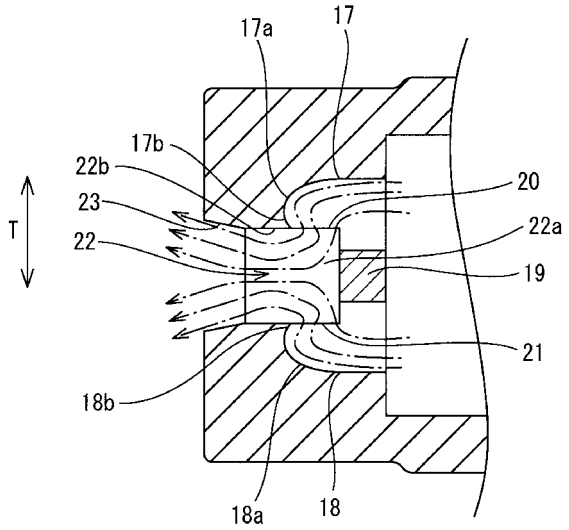


Fig. 9B

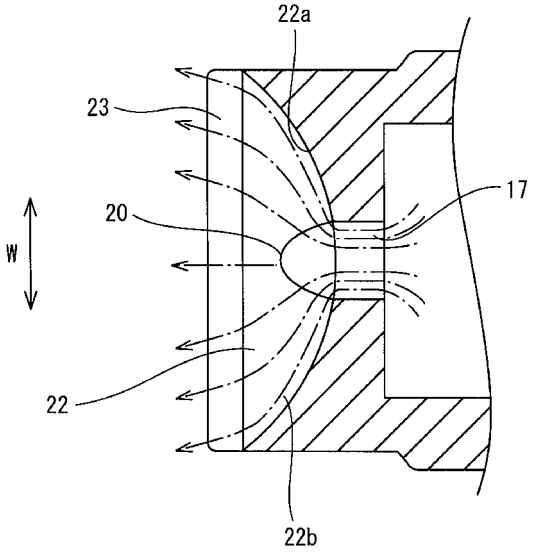


Fig. 10

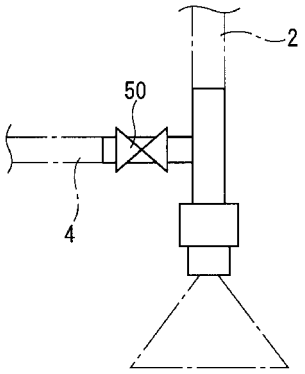


Fig. 11

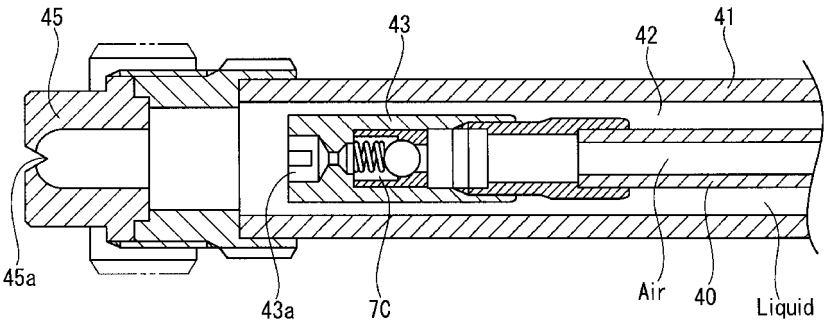
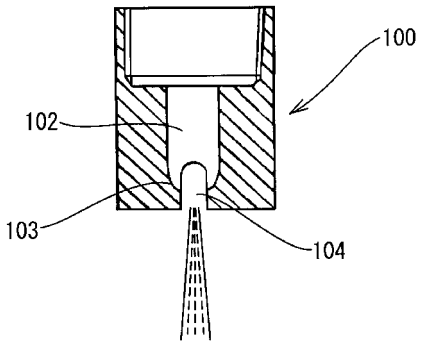
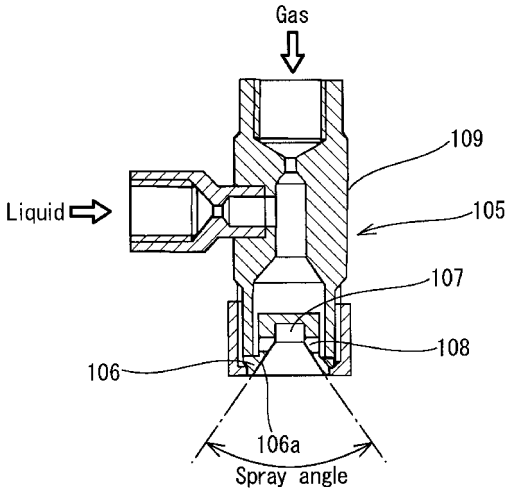


Fig. 12



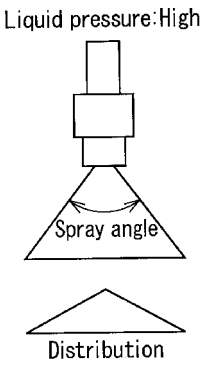
[Prior Art]

Fig. 13



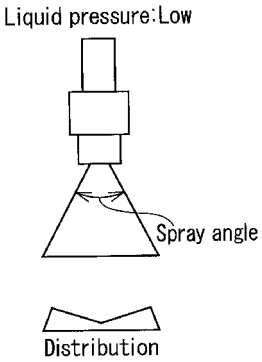
[Prior Art]

Fig. 14A



[Prior Art]

Fig. 14B



[Prior Art]

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/065586

A. CLASSIFICATION OF SUBJECT MATTER
B05B7/26(2006.01)i, *B05B1/12*(2006.01)i, *B05D1/02*(2006.01)i, *B22D11/124*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B05B7/26, B05B1/12, B05D1/02, B22D11/124, B08B3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2000-312865 A (Toyota Auto Body Co., Ltd.), 14 November 2000 (14.11.2000), paragraphs [0002] to [0003]; fig. 4 (Family: none)	1 2-5
Y	JP 10-230229 A (Maruyama Mfg. Co., Inc.), 02 September 1998 (02.09.1998), paragraphs [0003] to [0005]; fig. 6 to 7 (Family: none)	2-5
Y	JP 2005-270870 A (Kabushiki Kaisha Fuji Clean), 06 October 2005 (06.10.2005), entire text; fig. 1 to 2 (Family: none)	4-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 December, 2010 (09.12.10)	21 December, 2010 (21.12.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 3015493 A **[0004] [0007]**