

DESCRIPTION

GAS PRESSURE REGULATING DEVICE

TECHNICAL FIELD

[0001] This invention is related to the governor (gas pressure regulating device) which uses pilot governors to reduce the primary pressure of gas etc. transported from upstream side, to secondary pressure for downstream supply in gas supplying systems.

BACKGROUND ART

[0002] For example, in gas supplying systems such as town gas, a gas pressure regulating device (gas governor) is set up to supply gas with primary pressure (high/medium pressure) from the upstream side transportation pipe (hereinafter referred to as "upstream pipe") to the downstream side transportation pipe (hereinafter referred to as "downstream pipe") with reduced secondary pressure set preliminarily.

[0003] Conventional gas governors, as shown in Fig. 10, are generally connected to the main valve (governor body) 11 that adjusts the gas amount from upstream to downstream, and downstream pipe 13, where pilot governor 21 is equipped to control governor body 11 to cope with the change of pressure at the downstream side (hereinafter

referred to as "secondary pressure") P2. Pilot governor 21 is set to operate the main valve (governor body) 11 so as to supply gas to the downstream side when secondary pressure P2 is less than P_s , the predetermined standard operation control pressure.

Gas pressure regulating device that uses such kind of pilot governor 21 has the contradictory property of tilting occurring easier if it is made more responsive to downstream pressure changes; and if tilting is suppressed, the responsiveness drops.

[0004] Tilting is not allowed to occur in governors set up in gas supplying lines etc. Therefore, in order to ensure the flow rate without tilting, sufficiently closing the aperture of air bleed valve 22 of pilot governor 21 can be considered. However, this method will respond to the decrease of secondary pressure P2, leading to the response of opening the governor body drops significantly.

Especially when the usage of gas pressure regulating device increases from a totally closed state to gas being used at downstream pipe 13 side, waiting time is necessary for the start of usage from the status of low secondary pressure P2 to when governor body 11 actually operates. Therefore, the relationship of usage at downstream side and pipe volume might lead to the secondary pressure dropping too much.

[0005] To avoid the situation of slow response leading to significant drop of secondary pressure P2 as

mentioned above, the prior art that suppresses tilting from happening while improving the responsiveness is suggested in Patent Reference 1 as shown in Fig. 11.

[0006] The technology specified in Patent Reference 1 has sub pilot governor SC set up in addition to main pilot governor SB. At the side of downstream pipe 13 of sub pilot governor SC, main pilot line S26 connects main pilot governor SB to downstream pipe 13, and is connected to main pilot line S26 through sub pilot line S28. Also, the operating pressure of sub pilot governor SC is set to be lower than that of main pilot governor SB. By applying this configuration, tilting of main pilot governor SB can be suppressed, while responsiveness is improved by the quicker response of sub pilot governor SC when there is a drop of secondary pressure P2.

CITATION LIST

PATENT DOCUMENT

[0007] Patent Document 1: JP(UM) 1978-78637 A

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0008] Though the governor as stated in Patent Reference 1 had better responsiveness, when sub pilot governor SC operates, gas flows from sub pilot governor SC through sub pilot line S28 and main pilot line S26 to

downstream pipe 13. This gas flow affects the secondary pressure P2 that is supplied to main pilot line S26.

Therefore, when sub pilot governor SC starts operating, the secondary pressure P2 of the downstream pipe cannot be correctly transmitted to main pilot governor SB, leading to the problem of unstable operation of main pilot governor SB.

[0009] This invention is made in view of the above-mentioned problem. It is aimed to provide a gas pressure regulating device (gas governor) that suppresses the occurrence of tilting while having quick responsiveness, yet capable of ensuring a stable and sufficient flow rate of gas.

MEANS FOR SOLVING PROBLEM

[0010] The gas pressure regulating device according to this invention is made in view of the problems in the above conventional technology and, is characterized in that,

A gas pressure regulating device comprising:

the main valve installed in the middle of a pipe line, which reduces a pressure of the gas transported from the upstream side at primary pressure to the downstream side at secondary pressure;

a main pilot loop connecting the upstream pipe of the main valve and downstream pipe via a restrictor;

a main pilot governor installed at the downstream of the restrictor inside the main pilot loop, which controls

the gas flow that passes through the main pilot loop, and controls the operation of the main valve so that the secondary pressure is stabilized when the secondary pressure drops below a preset standard operation control pressure;

a sub pilot loop connected in between the restrictor of the main pilot loop and the main pilot governor at one end, while the other end is connected to the downstream pipe using another route different from the main pilot loop; and

a sub pilot governor installed in the sub pilot loop, which controls the operation of the main valve when the secondary pressure becomes a second standard pressure which is higher than the preset standard operation control pressure by controlling the gas amount passing through the sub pilot loop.

[0011] Also, by installing a Venturi tube at the downstream pipe side, and connecting the sub pilot loop to the small pipe of the Venturi, the responsiveness can be further improved.

EFFECT OF THE INVENTION

[0012] The location of the connection point from sub pilot loop to downstream pipe is different from that of the main pilot loop. By setting a different independent path from the main pilot loop, the sub pilot loop will not

affect main pilot governor while operating, contributing to operation stability.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Fig. 1 is a schematic diagram showing one of the embodiments of the gas pressure regulating device related to this invention.

Fig. 2 is a schematic diagram showing an example of a main valve (gas governor body) used for the gas pressure regulating device related to this invention.

Fig. 3 are graphs schematically showing the changes in secondary pressure as the dynamic characteristic of the gas pressure regulating device in the case the secondary pressure is going to drop when the main valve is in an occluded state. Graph (a) shows the change in secondary pressure when sub pilot governor does not exist. Graph (b) shows the change in secondary pressure when sub pilot governor is installed.

Fig. 4 is a schematic diagram showing another embodiment of the gas pressure regulating device related to this invention.

Fig. 5 is a schematic diagram showing the connection between sub pilot loop and downstream pipe in the second and other embodiments.

Fig. 6 are graphs showing the dynamic characteristics P2-Q of the gas pressure regulating device

in this invention and conventional technology when the primary pressure is 0.2MPa and flow rate is 50m³/h at upstream pipe side.

Fig. 7 are graphs showing the dynamic characteristics P2-Q of the gas pressure regulating device in this invention and conventional technology when the primary pressure is 0.25MPa and flow rate is 50m³/h at upstream pipe side.

Fig. 8 are graphs showing the dynamic characteristics P2-Q of the gas pressure regulating device in this invention and conventional technology when the primary pressure is 0.3MPa and flow rate is 50m³/h at upstream pipe side.

Fig. 9 are graphs showing the dynamic characteristics when the primary pressure are varied respectively to 0.2MPa, 0.25MPa and 0.3MPa in each graph, and the flow rate is increased to 100m³/h in each graph.

Fig. 10 is a schematic diagram showing the configuration of gas pressure regulating device according to conventional technology.

Fig. 11 is a schematic diagram showing the configuration of gas pressure regulating device according to Patent Reference 1.

MODE(S) FOR CARRYING OUT THE INVENTION

[0014] With reference to the drawings, the explanation regarding gas pressure regulating device 10 in this invention is as follows.

Fig. 1 shows an example of the configuration of gas pressure regulating device 10. Fig. 2 schematically shows an example of main valve 11 (governor body).

Regarding the gas pressure regulating device 10 in Fig. 1, the same numbering as in Fig. 10 is used for parts with the same functionality as conventional technology.

[0015] Gas pressure regulating device 10 has main valve 11 installed midstream of the piping, which reduces the pressure of gas transported from upstream at primary pressure P1 to downstream at secondary pressure P2.

In this embodiment, the axial flow type governor that is adapted as main valve 10 is widely used currently. As shown in Fig. 2, the brief structure is constituted by a pair of drum-shape closure 16 with multiple slits at the surface,

a rubber sleeve 17 that closes the slit of closure 16, together with the cylindrical valve body 18 that stores all these. By applying control pressure Pc to the space between valve body 18 and sleeve 17, sleeve 17 can be used to open and close the slit of the pair of drum-shape closure 16.

[0016] In this invention, gas pressure regulating device 10 bypasses main valve 11 by installing a pilot loop that connects upstream pipe 12 and downstream pipe 13. The

pilot loop is constituted by main pilot loop 20 and sub pilot loop 30.

[0017] Both main pilot loop 20 and sub pilot loop 30 are connected to upstream pipe 12 by connection point C1, and restrictor 14 is installed at the side of upstream pipe. By installing restrictor 14, control pressure P_c is generated to control the operation of main valve 11. The output of restrictor 14 is separated into 2 routes: to Main Pilot 20 which is connected to downstream pipe 13 at connection point C_2 of downstream pipe 13, and to sub pilot loop 30 which is connected to downstream pipe 13 at connection point C_3 .

[0018] For main pilot loop 20, main pilot governor 21 is installed between restrictor 14 and connection point C_2 . For sub pilot loop 30, sub pilot governor 31 is installed between restrictor 14 and connection point C_3 .

[0019] Moreover, the output of restrictor 14 is connected to main valve 11 via Pipe 40, supplying control pressure P_c to main valve 11. When secondary pressure P_2 drops, sub pilot governor 31 and main pilot governor 21 operates thus lowering the control pressure P_c . main valve 1 opens up in proportion to the decrease of control pressure P_c . As main valve 11 opens, gas is supplied from upstream pipe 12 to downstream pipe 13.

[0020] As for main pilot governor 21, secondary pressure P_2 of downstream side is supplied through main

pilot line 20. For main pilot governor 21, when secondary pressure P2 drops below the standard operation control pressure Ps, the spring pressure and atmospheric pressure is used to adjust the valve connected to the internal diaphragm to open. Air bleed aperture 22 is an aperture used to change the size of the opening to atmospheric pressure. This can adjust the responsiveness of main pilot governor 21.

[0021] When the responsiveness of main pilot governor 21 is enhanced, main valve 11 will open at once, leading to a rapid rise in secondary pressure P2. Therefore, main pilot governor 21 is repeatedly opened and closed, increasing the occurrence of tilting. From the perspective of stableness control, tilting is highly unfavorable for gas pressure regulating devices. Therefore, air bleed aperture 22 of main pilot governor 21 is adjusted so that tilting is suppressed, even if the responsiveness is slightly slower.

[0022] Sub pilot governor 31 also has substantially the same structure and functionality as main pilot governor 21. However, the function of air bleed aperture is not crucial to sub pilot governor 31. Also, since the aim of sub pilot governor 31 is to assist the startup responsiveness of main pilot governor 21, the flow rate can be smaller than main pilot governor 21. For example, the

flow rate of sub pilot governor 31 can be approximately 1/3 of main governor 21.

[0023] Sub pilot governor 31 is adjusted to have a higher operating pressure P_{ss} than the standard operation control pressure P_s of main pilot governor, and has good responsiveness. Moreover, sub pilot governor 31 has a small flow rate, therefore control pressure P_c drops less and tilting is less likely to occur.

For example, the operation control pressure P_s for main pilot governor can be set to 2.2kPa, and the operation control pressure P_{ss} for sub pilot governor can be set to approximately 2.5kPa.

[0024] According to the above configuration of gas pressure regulating device 10, when secondary pressure P_2 at downstream side drops below the operation control pressure P_{ss} of sub pilot governor, first sub pilot governor 31 opens, so gas flows from upstream pipe 12, pass through sub pilot loop 30, and arrives downstream pipe 13. Then, the control pressure P_c of the downstream pipe 40 of restrictor 14 drops. When the control pressure P_c of main valve 11 drops, main valve 11 opens, and gas is supplied from upstream pipe 12 to downstream pipe 13. It should be noted that when tilting needs to be suppressed, such as in cases like when a governor of large flow rate is used such as sub pilot governor 31, adjustable aperture 23 can be installed at downstream pipe 13 of sub pilot loop 30, as

shown in Fig. 1. The installation of adjustable aperture 23 is optional.

[0025] After sub pilot governor 31 is opened for a while, the valve of main pilot governor 21 opens, with suppressed responsiveness made possible by air bleed aperture 22. As a result, the control pressure P_c of main valve 11 drops further, and a large amount of gas is supplied from main valve 11 to downstream side, with secondary pressure P_2 adjusted to the preset pressure (standard operation control pressure P_s).

[0026] Fig. 3 is used for the following explanation. Fig. 3 is a schematic graph showing the change of secondary pressure from the state where main valve 11 is closed to the operation of gas pressure regulating device. (A) shows the adjustment of gas pressure regulating device in the configuration with only main pilot loop 20 exists and sub pilot loop 30 does not exist. (B) shows the adjustment of gas pressure regulating device in the configuration of this invention - with both main pilot loop 20 and sub pilot loop 30.

[0027] At the state where main valve is closed and flow equals 0, due to lock up, it is slightly high than standard operation control pressure P_s .

As seen in Fig. 3(a), when sub pilot loop does not exist, tilting is suppressed by closing air bleed aperture 22, leading to slow response. Also, when the usage at

downstream is large, it is possible that secondary pressure P2 drops till 0.

[0028] On the other hand, if sub pilot loop 30 exists, when secondary pressure drops to the operation control pressure Pss of sub pilot governor 31, sub pilot governor 31 immediately operates, and control pressure Pc of main valve 11 drops. As a result, since main valve 11 opens, even if main pilot governor 21 does not immediately respond, gas is supplied from upstream pipe 12 to downstream pipe 13. Therefore, secondary pressure p2 will not drop excessively. Moreover, after sub pilot governor 31 starts operating for a while, main pilot governor 21 also operates after a time lag. Therefore, secondary pressure P2 is immediately adjusted to the preset pressure (operation control pressure Ps), so tilting will not occur.

[0029] As a result, by installing sub pilot loop 30, even the responsiveness of main pilot governor 21 is lowered to suppress tilting, it is possible to enhance the responsiveness of the gas pressure adjusting device as a whole system.

Moreover, in this configuration for main pilot loop 20 and sub pilot loop 30, main pilot governor 21 and sub pilot governor 31 have a different independent connection route to downstream pipe 13. Therefore, the operation of sub pilot governor 31 does not affect secondary pressure P2 that is supplied to main pilot loop 20.

Thus, main pilot governor 21 can be stably controlled by the actual secondary pressure P_2 of downstream pipe 13.

[0030] Fig. 4 shows the second embodiment of this invention, where Fig. 5 shows the schematic diagram of how sub pilot loop 30 is connected to downstream pipe 13 using the second or other embodiments.

[0031] Regarding the second embodiment, the downstream side pipe 13 of sub pilot loop 30 leads to connection point C_3' is connected to the small pipe of Venturi 53 installed at the downstream pipe. When main valve 11 opens and gas is supplied, although gas will pass into downstream pipe 13, since the pressure at the small pipe 53 of Venturi 51 is lower than secondary pressure P_2 , the responsiveness of sub pilot governor 31 at the moment right after main valve 11 opens is improved.

[0032] Moreover, as another form of embodiment, the connection point to downstream pipe 13 of sub pilot loop 30 can be set at C_3'' , where the pipe from main valve to nearby the entrance of downstream pipe is drastically wider. By using this configuration, when gas flows from the small pipe at the output side of main valve 11.

The negative pressure generated acts to the operation control pressure P_s of sub pilot governor 31, and thus the responsiveness of sub pilot governor 31 can be improved.

[0033] Figs. 6-8 are graphs showing the comparison between the dynamic characteristics of secondary pressure

P2 and flow rate Q during pressure regulation of the gas pressure regulating device in this invention and conventional pressure regulating device.

Figs. 6-8(a) shows the measurement result of dynamic characteristic of P2-Q using the configuration of this invention, as shown in Fig. 1 (referred to as "embodiment 1" as follows): the downstream pipe of main pilot loop 30 is connected to the pressure regulator branched from C₂ where secondary pressure P2 is stabilized, and the downstream pipe side of sub pilot loop 30 is connected to C₃ located nearby the exit of downstream pipe 13, not the same as connection point C₂ for main pilot loop 30. Figs. 6-8(b) shows the measurement result of dynamic characteristic of P2-Q using this configuration (referred to as "comparative example 1" as follows): the downstream pipe side of main pilot loop 20 in gas pressure regulating device of Fig. 1 is connected to the pressure regulator as in embodiment 1, where the downstream pipe side of sub pilot loop 30 is connected to the pressure regulator at the same position C₂ as main pilot loop 20. Figs. 6-8(c) shows the measurement result of dynamic characteristics of P2-Q using a gas pressure regulating device where sub pilot loop 30 is not installed, and only main pilot loop is used to control the regulation of secondary pressure P2 (referred to as "comparative example 2" as follows).

[0034] Each Drawing of Figs. 6 - 8 shows the status when primary pressure P1 is changed to 0.2MPa, 0.25MPa and 0.3MPa respectively. Moreover, flow rate Q is 50m³/h in all cases of Figs. 6 - 8,

[0035] As seen in Figs. 6 - 8, gas pressure regulating device 10 (embodiment 1) in this invention and comparative example 1 are both comparatively faster for secondary pressure P2 to be stabilized when compared to comparative example 2. This effect is achieved by installing sub pilot loop.

[0036] Moreover, as seen in graph (a) of Figs. 6 - 9, in embodiment 1, after the transitional vibration of secondary pressure P2 is settled, the stability of secondary pressure P2 is maintained regardless of primary pressure P1. On the other hand, especially for configurations without sub pilot loop 30 (comparative example 2), from the result of P2-Q dynamic characteristic test (c), even after settling down of the transitional vibration at the start of adjustment, secondary pressure P2 has a comparatively larger ups and downs (vibration) (refer to Figs. 6 - 8 (c)).

[0037] Though not as significant when compared to the configuration of comparative example 2 (refer to Figs. 6-8(c)), the dynamic characteristic (refer to Figs. 6-8(b)) of this configuration (comparative example 1) where the downstream of the sub pilot loop is connected to the

downstream of main loop, has a larger vertical vibration of secondary pressure P2 after P2 has settled down when compared to that of embodiment 1 of this invention (refer to Figs. 6-8(a)), showing its lack of stability when compared to embodiment 1.

After the initial transition vibration is settled, stabilization is preferred. This vertical vibration range (amplitude) has a tolerance limit of around 0.1kPa, so the dynamic characteristic of comparative example 1 has a marginal amplitude value (refer to Figs. 7 and 8(b) in particular).

[0038] Moreover, as seen from the dynamic characteristics from Fig. 7, when primary pressure P1 increases, for comparative example 1 and 2, secondary pressure P2 right after the main valve is closed has a much larger increase when compared to the dynamic characteristics of the embodiment of this invention (a). The smaller the increase of secondary pressure P2, the better it is. From Fig. 7 that shows the dynamic characteristics, the pressure increase of comparative example 1 and 2 is around 2 times that of embodiment 1. Thus, the time needed for secondary pressure P2 to stable is 2 times more than embodiment, showing the unstableness.

[0039] This phenomenon (dynamic characteristic) is less noticeable when the flow is low as around 50m³/h. However, when flow rate Q increases, or when primary

pressure P1 increases, it becomes significantly noticeable. As a reference, the dynamic characteristic of the increased flow rate $100\text{m}^3/\text{h}$ is shown in Fig. 9. Fig. 9(a) - (c) show the dynamic characteristics of primary pressure P1 is increased to 0.2MPa, 0.25MPa and 0.3MPa respectively when flow rate Q is increased to $100\text{m}^3/\text{h}$. All Figs. 9(a)-9(c) show the dynamic characteristics using the configuration of embodiment 1 in this invention. The dynamic characteristics of comparative example 1 is shown on the right. On the other hand, though comparative example 2 is not shown in Fig. 9, when main valve 11 is closed, the sharp increase of secondary pressure P2 in comparative example 2 is equal or greater than that of comparative example 1.

[0040] As shown in Fig. 9, when flow Q is increased to $100\text{m}^3/\text{h}$, either when primary pressure P1 equals 0.2MPa, 0.25MPa or 0.3MPa, the pressure increase of secondary pressure P2 right after main valve 11 is closed is more than 2 times than that of the embodiment 1 of this invention. The time needed for stabilization for secondary pressure P2 is around 2 times.

[0041] On the other hand, for the configuration of comparative example 1 with sub pilot loop 30 being connected to main pilot loop 20 at the downstream side, even when main valve 11 is not opened, secondary pressure constantly changes from time to time. This phenomenon is significantly noticeable in Fig. 7(b). This shows the

unstable status with fluctuation of secondary pressure P2 when main valve 11 is nearly closed, with a slight gas flow of only about $1\text{m}^3/\text{h}$ from upstream pipe 12 to downstream pipe 13.

* This fluctuation can be totally eliminated by using the configuration in this invention: use a different separate route for the downstream side of sub pilot loop 30 and for the downstream side of main pilot loop 20 (Refer to Figs. 6-8(a) and Fig. 9.

[0042] As shown above, by applying this invention and using a different independent route for the connection point C₂ and C₃ to the downstream of main pilot loop 20 and sub pilot loop 30 respectively, the responsiveness is improved. Also, this gas pressure regulating device can maintain a certain amount of secondary pressure P2 at a stable state with tilting suppressed.

[0043] Also, by installing Venturi 51 at the downstream pipe, and connecting the small pipe of Venturi 51 to the downstream side of sub pilot loop 30, it is possible to further enhance the responsiveness of main valve 11 once it is opened.

[0044] Furthermore, by connecting the downstream side of sub pilot loop 30 to nearby the output of main pilot valve 11 of downstream pipe, it is also possible to further enhance the responsiveness of main valve 11 once it is opened.

EXPLANATIONS OF LETTERS OR NUMERALS

[0045]

- 10 Gas pressure regulating device in this invention
- 11 Main valve (governor body)
- 12 Upstream side transportation pipe (upstream pipe)
- 13 Downstream side transportation pipe (downstream
pipe)
- 14 Restrictor
- 16 Closure
- 17 Sleeve
- 18 Valve body
- 19 Connection pipe of upstream side
- 20 Main pilot loop
- 21 Main pilot governor
- 22 Aperture for air bleed
- 23 Adjustable aperture
- 30 Sub pilot loop
- 31 Sub pilot governor
- 50 Gas pressure regulating device in the second
embodiment
- 51 Venturi
- 53 Small pipes
- P1 Primary pressure
- P2 Secondary pressure
- Pc Control pressure

Ps Standard operation control pressure

Pss Operating control pressure of sub pilot governor

Q Flow rate

CLAIMS

1. A gas pressure regulating device comprising:
 - a main valve installed in the middle of a pipe line, which reduces a pressure of the gas transported from the upstream side at primary pressure to the downstream side at secondary pressure;
 - a main pilot loop connecting the upstream pipe of the main valve and downstream pipe via a restrictor;
 - a main pilot governor installed at the downstream of the restrictor inside the main pilot loop, which controls the gas flow that passes through the main pilot loop, and controls the operation of the main valve so that the secondary pressure is stabilized when the secondary pressure drops below a preset standard operation control pressure;
 - a sub pilot loop connected in between the restrictor of the main pilot loop and the main pilot governor at one end, while the other end is connected to the downstream pipe using another route different from the main pilot loop; and
 - a sub pilot governor installed in the sub pilot loop, which controls the operation of the main valve when the secondary pressure becomes a second standard pressure which is higher than the preset standard operation control

pressure by controlling the gas amount passing through the sub pilot loop.

2. The gas pressure regulating device according to claim 1, wherein the sub pilot loop has the characteristic of the downstream pipe line connected to the other end, connects to the small pipe of Venturi installed at the pipes of downstream side.

3. The gas pressure regulating device according to claim 1, wherein the sub pilot loop has the characteristic of the downstream side connected to the other end, connects near to the main valve output of the downside pipe line.