United States Patent [19]

Onoda et al.

[11] **3,904,722**

[45] **Sept. 9, 1975**

[54] **STEAM REFORMING DEVICE**

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[22] Filed: **July 30, 1973**

[21] Appl. No.: **383,515**

[30] **Foreign Application Priority Data**

July 31, 1972 Japan 47-76661

[52] **U.S. Cl.** .... **261/64 R**; 261/76; 261/118; 261/DIG. 13

[51] **Int. Cl.** **B01f 3/04**

[58] **Field of Search** ...... 261/DIG. 13, 118, 76, 64 R

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[57] **ABSTRACT**

A steam reforming valve device comprising a casing structure having a steam inlet and outlet and further having steam consecutive passageways between the steam inlet and outlet, pressure reducing valve means provided within the steam passageways in the upstream part thereof, and temperature reducing means provided within the steam passageways in the downstream part thereof and as a separate structure from the pressure reducing valve means. The pressure reducing valve means and the temperature reducing means, while being assembled unitarilly with and within the casing structure, are mutually separated by a suitable distance. The constituent parts of the pressure reducing valve means can be replaced individually and independently of other parts.

8 Claims, 2 Drawing Figures

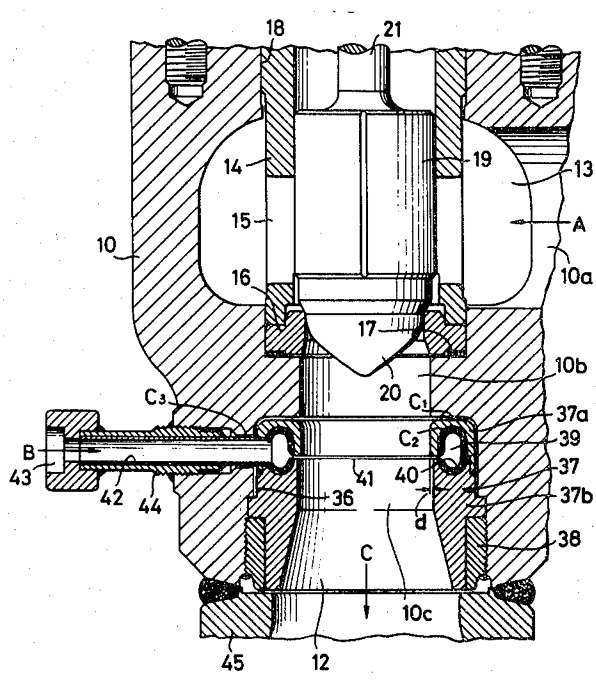
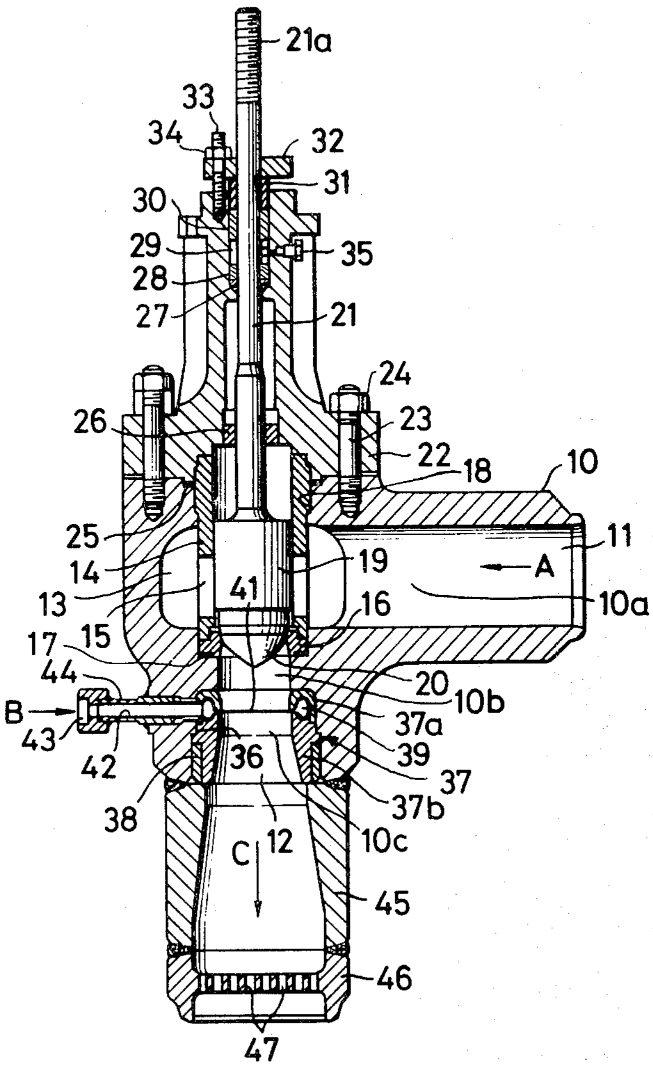


FIG.1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37b
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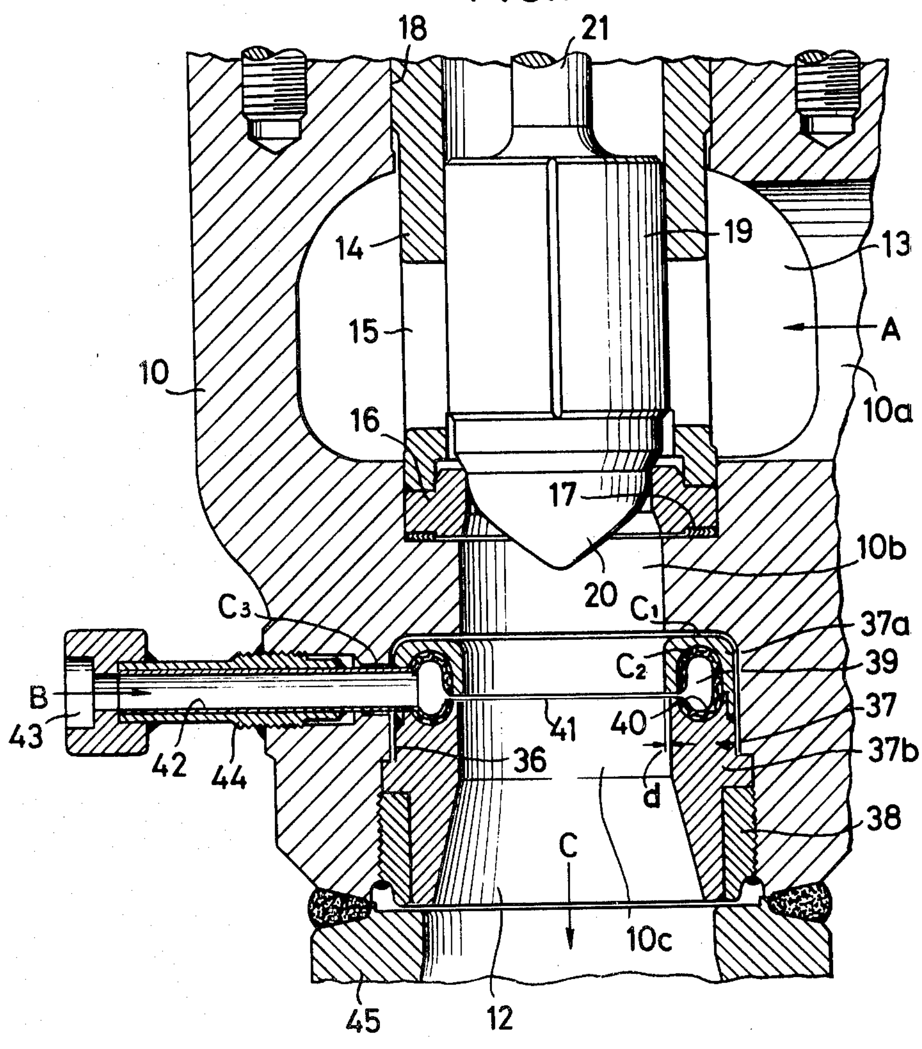
FIG. 2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STEAM REFORMING DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a steam reforming valve device and more particularly to a device for converting steam at high temperature and high pressure into steam at low temperature and low pressure.

Heretofore, as means for converting superheated steam at high temperature and high pressure into low-temperature, low-pressure steam, a device comprising, within a steam flowpath, a pressure reducing device disposed at an upstream position and a temperature reducing device disposed apart and downstream from the pressure reducing device. However, since the pressure reducing device and the temperature reducing device are respectively provided separately and, moreover, at separated positions in this known device, the space required for the installation of these devices is large, and a large number of accessory equipment items are required, whereby high costs are entailed. A further drawback is that, since the pressure reducing action and the temperature reducing actions with respect to the steam are carried out at relatively separated places, accurate control of both actions is difficult.

In endeavoring to overcome the above described drawbacks of the known device, a steam reforming valve wherein a pressure reducing valve and a temperature reducing means are integrated into a single unit has been proposed. In this proposed steam reforming valve, the pressure reducing valve part is provided with one or more cooling water injection nozzles for temperature reduction, and pressure reduction and temperature reduction are carried out with the same part and at the same time.

In general, the wear rate of the valve body and the valve seat of a pressure reducing valve is high. Consequently, the serviceable life of these parts is short, whereby it is necessary to replace these parts after a certain short period of use. Furthermore, since the above described steam reforming valve proposed heretofore has a construction wherein the openings of water injection nozzles are formed in the valve seat part, replacement of the valve seat could not be carried out easily, whereby it was necessary to change the whole steam reforming valve.

Another problem arises from the direct contacting of water for cooling to the valve plug and valve seat which are being exposed to high-temperature steam, whereby so-called thermal cracks or fracturing due to thermal stress in the valve parts occur. As a result of this damage, also, the serviceable life of the valve is further shortened.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful steam reforming device wherein the above described difficulties heretofore encountered in the art are overcome.

More particularly, an object of the invention is to provide a steam reforming device which is integrally constructed as a single device yet has a temperature reducing part which is provided in a position spaced apart by a suitable distance from a pressure reducing valve. In the device according to the invention, parts such as the valve body and the valve seat can be changed or replaced irrespectively of the temperature reducing part. Furthermore, since the water for cooling does not directly contact valve parts such as the pressure reducing valve, there is little possibility of shortening of the valve life.

Another object of the invention is to provide a steam reforming valve in which, by providing a stepped configuration in a water injection orifice part, the steam flow past this part is effectively utilized to attain effective injection of cooling water in the form a fine spray into a temperature reducing section.

Other objects and further features of the invention will be apparent from the following detailed description with respect to a preferred embodiment of the invention when read in conjunction with the accompanying drawings, in which like parts are designated by like reference numerals.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is side view, in longitudinal section, of one embodiment of a steam reforming device according to the present invention; and

FIG. 2 is an enlarged side view, in longitudinal section, of one important part of the steam reforming valve illustrated in FIG. 1.

DETAILED DESCRIPTION

Referring to FIGS. 1 and 2, the steam reforming device shown therein has a device casing structure **10** having a steam passageway **10***a* provided with a steam inlet **11** for introducing superheated steam at high temperature and high pressure from a lateral direction and steam passageways **10***b* and **10***c* extending in a direction perpendicular to the steam flowpath **10***a*. The passageway **10***c* is coaxially and contiguously connected to the passageway **10***b* and has a steam outlet **12** for conducting out steam which has been reformed, i.e., reduced in temperature and pressure, as described hereinafter. Between the passageways **10***a* and **10***b*, there is provided a chamber **13**.

A sleeve-like cage **14** passing through the chamber **13** is tightly fitted in a hollow cavity **18** of the valve casing structure **10** and, in its part passing through the chamber **13**, has through holes **15**. Below the cage **14**, a seat ring **16** consituting a valve seat is inserted into the casing structure **10** over a gasket **17** interposed therebetween. The axial centerline of the cage **14** coincides with the axial centerline of the steam passageways **10***b* and **10***c*.

Within the cage **14**, there is inserted a valve plug **19** in a fluid-proof manner and in a manner to slide freely in the axial direction. At the lower end of the valve plug **19**, there is formed integrally and coaxially therewith a valve body **20** adapted to seat against and separate from the abovementioned seat ring **16**. A valve stem **21** is fixed coaxially to the upper part of the valve plug **19** and extends upward and out of the valve casing structure to an upper stem end **21***a*, which is coupled to an actuating device (not shown) such as a diaphragm actuator.

A cover structure **22** is fixedly but detachably secured to the upper part of the valve casing structure **10** over a gasket **25** interposed therebetween by stud bolts **23** and nuts **24**. When the cover structure **22** is thus secured in place, it presses down on the upper end of the cage **14**, whereby the lower end of the cage **14** presses the seat ring **16** down on the gasket **17**.

The cover structure **22** has a hollow interior, through which the above mentioned valve stem **21** is passed. A stem guide **26** for slidably guiding the valve stem **21** is fixed to the cover structure **22** near the lower part thereof. The cover structure **22** is further provided at its upper part with a sealing device comprising a packing retaining ring **27**, a packing **28**, a lantern ring **29**, a packing ring **31**, a retaining disk **32** for retaining the retaining ring **31**, stud bolts **33** and nuts **34** for securing the retaining disk **32** to the cover structure **22**, a lubricator plug **35** for lubricating the lantern ring **29**, and other parts. The valve stem **21** passes through this sealing device.

In a part of the casing structure **10** contiguous to the steam passageway **10***b*, there is formed a recess **36**, in which an orifice forming member **37** of cylindrical shape is inserted and fixed by a locking member **38**. The orifice forming member **37**, in this particular embodiment, comprises two orifice forming half members **37***a* and **37***b*, which upon being assembled form the stem passageway **10***c*. A clearance C_1 is provided between the upper surface of the orifice forming member **37** and the upper wall surface of the recess **36** in the casing structure **10**. Furthermore, the area of the member **37** in contact of with the total wall surface of the recess **36** is designed to be a minimum.

Between the orifice forming half members **37***a* and **37***b*, an annular hollow space **39** is formed, and an annular sleeve **40** of thin wall thickness is inserted in this hollow space **39**. A slit is provided in sleeve **40** corresponding to a slit (orifice) **41** between the orifice forming half members **37***a* and **37***b*. Accordingly, the internal space of the sleeve **40** is communicative by way of the slit of the sleeve **40** and the slit **41** with the passageway **10***c*. The gap between the slit **41** and the seat ring **16** is selected in the instant embodiment to be approximately 100mm. Concavities and convexities are formed on the outer surface of the sleeve **40**. A clearance C_2 is provided between the sleeve **40** and the orifice forming half members **37***a* and **37***b* thereby to reduce to a minimum the area of contact with these parts.

The inner diameter of the nozzle forming half member **37***b* is made slightly greater than the inner diameter of the orifice forming half member **37***a*. Consequently, in the part of the slit **41**, a stepped part *d* (for example, of the order of 1mm.) is formed between the inner wall surfaces of the half member **37***a* and the half member **37***b*.

A water supply pipe **42** is passed transversely through the casing structure **10** to communicate at its inner end with the interior of the sleeve **40**. In outer end of this pipe **42** is provided with a fitting **43** through which water for temperature reduction is supplied to flow in the arrow direction B through the pipe **42** and into the interior of the sleeve **40**. The water supply pipe **42** is held by a pipe holding structure **44**, which is supported by the casing structure **10** but is also adapted to contact this structure with minimum contact area. Furthermore, a clearance C_3 is provided also between the water supply pipe **42** and the casing structure **10**.

As mentioned above, the area of contact between the orifice forming half members **37***a* and **37***b*, the area of contact between the sleeve **40** and the orifice forming half members **37***a* and **37***b*, the area of contact between the water supply pipe **43** and the casing structure **10**, and the area of contact between the pipe holding structure **44** and the casing structure **10** are made as minimal as possible. For this reason, it is possible to maintain a great temperature different between the water for temperature reduction, which passes through the sleeve **40** and is ejected as a fine spray through the slit **41** as described hereinafter, and superheated steam at high tempeature to be reduced in temperature.

To the lower end of the casing structure **10**, there is fixedly connected a reducer **45** having an interior communicating coaxially with steam outlet **12** and diverging with an inner diameter increasing with distance from the outlet **12**. A perforated plate **46** provided with a large number of holes **47** is fixed to the downstream end of the reducer **45**.

The steam reforming device of the above described structural organization according to the invention operates as follows.

Primary-side superheated steam at a high temperature of, for example, from 400° to 530°C, and a high pressure of, for example, from 40 to 130 kg/cm^2, is supplied from a superheated steam source (not shown) and enters the steam reforming device through the inlet **11** to enter the passageway **10***a* and flow in the arrow direction A to the chamber **13**.

Then, when the valve stem **21** is pulled upward, as viewed in the drawing, by the aforementioned actuating device activated by some means or a control signal, the valve plug **19** also is lifted unitarily with the stem **21**, and the valve body **20** separates from the seat ring **16**. Consequently, the primary-side steam which has entered the chamber **13** from the passageway **10***a* flows through the through holes **15** and between the valve body **20** and the seat ring **16** and, being here throttled and reduced in pressure to a pressure of from 2 to 40 kg/cm^2., for example, flows at high velocity into the passageway **10***b*. Therefore, in the pressure reducing part formed by the valve body **20** and the seat ring **16**, only pressure reduction of the primary-side steam is carried out.

The pressure reduced steam which has flowed into the passageway **10***b* flows further at high velocity into the passageway **10***c*. Here, the inner diameter of the orifice half member **37***a* has been made smaller than that of the orifice half member **37***b*, whereby, in the orifice member **37**, the orifice half member **37***a* forms a kind of Venturi tube construction or throat. As a consequence, the water within the sleeve **40** is sucked through the slit (orifice) **41** formed between the orifice half members **37***a* and **37***b* by the negative pressure produced by the steam flowing from the passageway **10***b* to the passageway **10***c* and past this Venturi throat at high velocity. The water is thus ejected as a fine spray by the resulting atomization action.

The above mentioned pressure reduced stream is mixed with the fine spray of water ejected through the slit (orifice) **41** and thereby reduced in temperature as it flows through the interior of the reducer **45** in the arrow direction C. This steam is further agitated in a positive manner by the perforated plate **46** and thereby uniformly reduced in temperature to from 150° to 300°C, for example.

In this manner, secondary-side steam at low pressure and low temperature which has been uniformly reduced in pressure and temperature to specific values is obtained on the downstream side of the perforated plate **46** after it has passed through the holes **47** thereof.

In the operation of this steam reforming device, while pressure reduction of the steam is accomplished to a slight extent in the perforated plate **46**, the greater part thereof is carried out in the aforementioned pressure reduction part formed by the valve body **20** and the seat ring **16**. On the other hand, the steam temperature reduction is effectively carried out between the temperature reduction part including the slit **41** and the perforated plate **46**.

In the case where this steam reforming valve is used in an automatic apparatus or device, pressure detecting means and temperature detecting means are installed downstream from the perforated plate **46** at positions near the downstream side thereof. Then, in accordance with the detection outputs of these detecting or monitoring means, the axial displacement of the stem **21** and the flowrate of the water supplied through the water supply inlet fitting **43** and into the sleeve **40** are automatically controlled.

When it becomes necessary to replace a constituent part of the pressure reducing section of this device, such as the seat ring **16**, this can be accomplished easily, unrelatedly to the temperature reduction section, by loosening and removing the nuts **24**, lifting the cover structure **22** off the casing structure **10**, and lifting out cage **14**.

Further, this invention is not limited to these embodiments but various variations and modifications may be made without departing from the scope and spirit of the invention.

We claim:

1. A steam reforming device comprising: a casing structure having a steam inlet, a steam outlet and consecutive passageways therebetween; pressure reducing valve means in an intermediate part of said steam passageways and operating to reduce the pressure of superheated steam flowing at high temperature and high pressure into said passageways through said steam inlet to a predetermined pressure value; and temperature reducing means within the steam passageways downstream from said pressure reducing valve means and constituted as a separate structure therefrom and operating to discharge water as a spray into the high-temperature, low-pressure steam thus reduced in pressure by the pressure reducing valve means and thereby to reduce the temperature of this steam to a predetermined temperature value, said temperature reducing means comprising an orifice-forming member forming said passageway through which the steam reduced in pressure by said pressure reducing valve means flows and, moreover, forming an annular hollow space and an annular orifice of slit-form in the wall surface of the orifice-forming member, a hollow sleeve disposed within said annular hollow space in the orifice-forming member and having a slit communicating with said orifice, said sleeve having an outer perpheral shape conforming to said annular hollow space and being supported all around the periphery therein and projection and groove means between said sleeve and said annular hollow space for minimizing the area of contact therebetween and for maintaining temperature differential therebetween, and a water supply pipe extending through said casing structure into communication with the interior of the sleeve, said orifice and said passageway being so constructed that the flow of the steam through the passageway causes water to be ejected as a spray through the orifice and into the passageway.

2. A steam reforming device according to claim **1** further comprising a cover structure detachably fixed to the casing structure and covering said pressure reducing valve means inserted in the casing structure, such that constituent parts of the pressure reducing valve means can be disassembled and taken out of the casing structure for replacement by detaching the covering structure.

3. A steam reforming device according to claim **1** in which said orifice-forming member is so formed that, with the position of said orifice as a reference line, the inner diameter of the passageway upstream of said reference line is small, and that downstream of said reference line is large, whereby said passageway has a stepped configuration at said orifice.

4. A steam reforming device according to claim **3** wherein said stepped configuration of said passageway provides a Venturi throat serving for introduction of the water as a spray into said passageway.

5. A steam reforming device according to claim **1** in which said orifice-forming member comprises two orifice forming half members forming therebetween said orifice, the orifice forming half member upstream of the orifice having a smaller inner diameter than the other orifice forming half member downstream of the orifice.

6. A steam reforming device according to claim **1** in which clearances are provided respectively between the orifice forming member and the casing structure, between the sleeve and the orifice forming member, and between the water supply pipe and the casing structure.

7. A steam reforming device according to claim **1** which further comprises an exit passageway for conducting steam flowing out of said steam outlet, and perforated plate means installed within said exit passageway, said perforated plate means having a large number of holes for passage therethrough of steam already sprayed with water.

8. A steam reforming device according to claim **1**, wherein said projection and groove means comprises convexities and concavities on the periphery of said sleeve.

* * * * *