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PRESSURE REDUCING CONTROL VALVE

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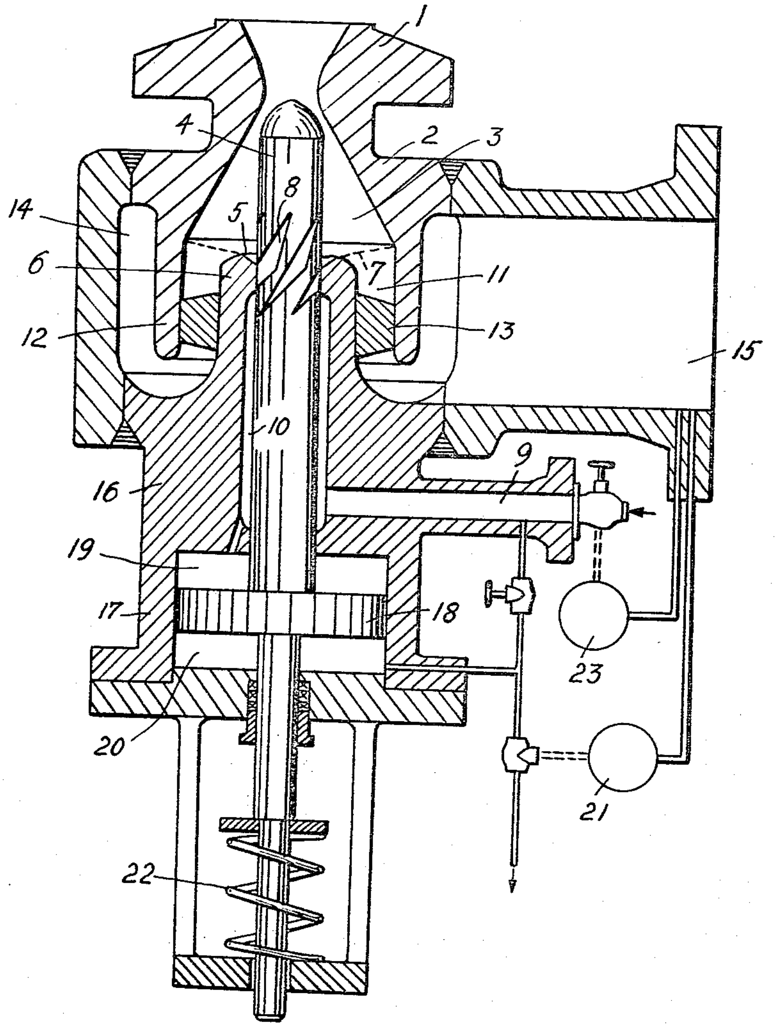

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PRESSURE REDUCING CONTROL VALVE

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This invention relates to a pressure reducing control valve for steam conduits, which on its discharge side is provided with means for injecting cooling water into the steam flow. Pressure reducing control valves are already known as steam conversion valves.

In a known valve, the cooling water is admitted near the valve seat in the place where the steam is subjected to the greatest constriction so that the water is entrained and finely dispersed by the high steam velocity prevailing in this place, and evaporated by the temperature gradient between the steam and the water. If a determined percentage of water thus added is not exceeded, the water can be absorbed by the steam within the valve. Due to the fact that the spraying orifice is in the form of an annular slot the percentage of added water reaches higher values. A disadvantage is the high cooling water pressure required for reducing high pressure superheated steam to low pressure steam. The cooling water either has to be taken from the boiler feed pump so that this latter must be designed correspondingly larger, which results in higher costs for the plant, or a special high pressure injection pump has to be installed which with the high pressures required and the small quantities to be injected would operate inefficiently and uneconomically. In existent steam boiler plants in which the desuperheater is to be replaced by a steam conversion valve, the boiler feed pumps lacks the reserve necessary for delivering also the injection water. The discharge pressure of the available cooling water pumps of the desuperheater to be replaced is, however, insufficient for the water supply of the known steam conversion valve so that special high pressure injection pumps must be provided. A further disadvantage consists in that desuperheating to a point close to the state of saturated steam is impossible because the temperature difference between the steam and the water and thus the heat exchange disappear before the evaporation is completed.

It is known to improve the control behaviour of the known steam conversion valve by coupling the cooling water valve with the steam valve or by permitting pressure-dependent regulating means to act simultaneously on the steam valve and the water valve, whereas a temperature control means is only permitted to act on the water valve. Further, it is known to provide an abrupt widening of the flow passage on the downstream side of the mixing zone of steam and water, thereby to intensify the vorticity and evaporation effects. The disarranged flow, however, may cause intolerable noises and dangerous vibrations.

When the cooling water is injected near the valve seat, damage to the valve and troubles in the operation thereof are the possible consequences of the thermic stress. In a known steam conversion valve, therefore, the cooling water injection is provided in the valve portion located on the discharge or outlet side of the valve, which portion is preferably designed as a Venturi tube to achieve pressure recuperation. But this valve is only intended for use with subcritical pressure gradients. In another steam conversion valve, a second constriction is provided on the discharge side and the water is injected at this second constriction. This measure eliminates any danger for the valve seat but the steam velocity which determines the size of the drops is greatly reduced.

In a known steam conversion valve with discharge side water injection, the water is injected at a suitable rate into the steam flow through a self-controlling annular gap even in the case of partial load. Because of the intense noises which are due to the uneven flow, this valve is followed by a very effective labyrinth-type throttle path to keep the pressure level at such a height that the tapering tube between the steam valve and the throttle path acts as a Venturi tube.

Moreover, a throttle valve is known which has a discharge pipe arranged behind the position of the passage of the steam and a throttling member protruding into the discharge pipe, the throttling member being adjustable by means of the valve spindle and so shaped that in any position of the throttling member the steam will be guided in the same way as in a Laval nozzle. This valve has for its object to maintain the flow of steam constant with a fixed valve adjustment and variable back-pressure but it is not suitable to control the back-pressure and to cool, at the same time, the steam by means of injected water.

The known steam conversion valves have the common feature that the atomization of the introduced water is effected by the relative velocity while the evaporation is brought about by the temperature drop between the water and the steam. The uneven flow resulting from such throttling and mixing actions is accompanied by intolerably intense noises and frequently also by dangerous vibrations. These valves must, therefore, be followed by labyrinth type throttle paths which destroy the major part of the pressure head at full throughput and, moreover, act as filling bodies which cause the residual drops to evaporate subsequently. Due to the square dependence of the labyrinth throttling loss on the steam throughput there occur control difficulties and intense expansion noises with small steam throughput.

To avoid the disadvantages of known valves the present invention provides apparatus for reducing the pressure and temperature of superheated steam by first producing a supersonic flow of steam, injecting cooling water into the supersonic flow, and transforming the supersonic flow into subsonic flow by creating a pressure wave front in the water-injected supersonic flow.

More particularly, a valve mechanism for carrying out the above-described method includes a casing having a steam inlet and a steam outlet, a pressure reducing valve in the casing, a flow chamber situated in the casing downstream of the pressure reducing valve and having a cross-section which increases in the direction of flow, means at the outlet end of the flow chamber reducing the cross-section to cause the creation of a pressure wave front in the flow through the chamber, and outlet duct means for the injection of cooling water opening into the flow chamber adjacent to and upstream of the means reducing the cross-section of the flow chamber.

The pressure reducing valve may include a valve stem disposed through the flow chamber, and preferably includes throttling ports for the supply of cooling water as, for example, in the shape of helically contoured slots or chambers.

The valve stem is advantageously mounted for reciprocal movement relative to the valve and the flow chamber whereby the cross-section of the cold water supply ports and the passage of the steam pressure reducing valve are varied in proportion to the valve stem movement. The flow chamber opens downstream into the passage in which the media flows at subsonic velocities, the flow being guided by radially disposed guide ribs in the passage.

The valve stem of the steam pressure reducing valve is also preferably coupled to a hydraulic actuator into which is introduced the cooling water for subsequent conduction into the flow chamber through the throttling ports, and the hydraulic actuator is preferably responsive to a pressure differential produced by a control valve responsive to the steam outlet pressure.

In this arrangement, the steam flow is accelerated to high supersonic velocity by orderly expansion and then receives the necessary cooling water addition immediately prior to be subjected to an abrupt rise in pressure and attended shock waves.

Temperature and pressure of the superheated steam flowing into the valve are considerably decreased by the large expansion. The steam may even get wet when this takes place. Under these conditions, the admission of hot cooling water does not cause any significant flow disturbance, it merely increases the moisture of the steam. When the temperature of the cooling water is above the evaporation temperature corresponding to the decreased steam pressure, the injected water will be instantaneously divided into fine drops by internal evaporation. The wet steam penetrates into the pressure wave from having a thickness of much less than 0.001 mm. Within the pressure wave front the fine drops are subjected to high pressure from the front and to low pressure from the rear so that they are retained and smashed. When the shock waves and/or pressure rise occurs, the entropy of the stream of wet steam is considerably increased. This causes the flow energy to be converted into heat in a very restricted space, whereby the steam is instantaneously dried. By the fact that all the fine drops penetrate into the pressure wave front it is ensured that the steam is completely dried.

The evaporation within the pressure wave front even enables the steam to be cooled down to the saturated state because any moisture is retained by the pressure wave front for the small water drops are prevented from entering the zone of higher pressure by the pressure rise.

The great expansion of the steam and the resulting temperature drop enable a servomotor or a comparable hydraulic actuator for operating the valve to be provided immediately on the low pressure side of the valve casing, which servomotor is operated by hot water from the water supply tank. In this arrangement the cylinder space of the servomotor on the valve side may communicate with the cooling water supply of the steam converting valve so that a stuffing box can be dispensed with on the steam side, especially in cases where the cooling water is injected along the valve stem. The steam converting valve proposed by the present invention operates only with the cooling water and its relatively low pressure and requires no further means so that it is particularly reliable in operation.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawing, the only figure of which is a longitudinal sectional view of a pressure reducing control valve according to the invention.

The figure shows a valve casing **2** with an inlet **1** and the superheated steam to be expanded and cooled enters the valve casing **2** through the inlet **1**. A flow chamber **3** surrounding a valve stem **4** is designed so as to accelerate the steam flow by expansion to a supersonic velocity and acts like a Laval nozzle. A generally concave upwardly opening end face **5** of a guide hub **6** provides an abrupt narrowing of the flow chamber **3** so that a pressure wave front **7** will form in which the supersonic flow is converted unevenly into a subsonic flow of increased pressure. The valve stem **4** is preferably provided with helically disposed throttling ports **8** for the cooling water supply. The cooling water entering the flow chamber **3** through a connecting piece **9**, an annular space **10** and the throttling ports **8** is fed immediately before the compression front **7**, where the pressure and temperature of the steam are greatly reduced and where, in some instances, the steam is already wet. Due to its helical introduction, the water is radially spread. When hot water, e.g., boiler supply water, is used the evaporation pressure of the cooling water is higher than the steam pressure in front of the pressure wave front **7**, with the result that the small water drops are caused to burst due to internal steam generation and only thereafter will get into the pressure wave front **7** where they are completely smashed and evaporated. In a flow chamber **11** adjacent the pressure wave front **7** subsonic velocity prevails. For orienting the flow in one direction and for supporting a bell-shaped wall **12** the guide hub **6** is provided with ribs **13** which direct the flow into a low pressure chamber **14** from where the steam flows to an outlet **15**. A servo-cylinder **17** is arranged on a junction cover **16** and serves for movably guiding therein a piston **18**. The servo-cylinder **17** includes a cylinder space **19**, in which the same pressure as in the annular space **10** prevails, and a cylinder spacer **20** in which a pressure modified by a governor **21** prevails, this governor causing the piston **18** to move against the action of a spring **22** when the steam pressure to be regulated drops. The throttling ports **8** are so shaped that the water-to-steam ratio remains constant during the lifting movement of the valve stem **4** to ensure low-inertia regulation of the steam temperature. The steam temperature is regulated by a governor **23** which varies the cooling water pressure prevailing at the connecting piece **9**.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

We claim:

1. A valve mechanism for the pressure-reduction and cooling of superheated steam comprising a casing having a steam inlet and a steam outlet, a pressure reducing valve in said casing, a flow chamber disposed in said casing downstream of said pressure reducing valve, said flow chamber having a cross-section which increases in the direction of flow through which flows supersonic steam, means centrally located at a downstream end portion of said flow chamber reducing the cross-section thereof, said last-mentioned means including a concave surface portion opening in opposition to the steam flow for creating a pressure wave front thereby transforming the supersonic flow to subsonic flow, and outlet duct means for injecting a cooling medium into the flow chamber adjacent to and upstream of said cross-section reducing means.

2. The valve mechanism as defined in claim 1 wherein said valve includes a valve stem and said outlet duct means are formed in said valve stem.

3. The valve mechanism as defined in claim 1 wherein said valve includes a valve stem having an end portion opening into said chamber, said outlet duct means are formed in said valve stem end portion, said cross-section reducing means surround said valve stem end portion, and means are provided for reciprocating said valve stem for selectively varying the portion of said outlet duct means exposed to the interior of the flow chamber thereby varying the quantity of cooling medium introduced into the flow chamber.

4. The valve mechanism as defined in claim 1 wherein said valve includes a valve stem having an end portion opening into said chamber, said outlet duct means are formed in said valve stem end portion, and said outlet duct means are a plurality of helically extending throttling ports.

5. The valve mechanism as defined in claim 1 wherein the casing includes a subsonic flow chamber downstream of said first-mentioned chamber, and flow orienting ribs downstream of said subsonic flow chamber.

6. The valve mechanism as defined in claim 1 including hydraulic actuator means for operating said valve and

means placing said actuator means in fluid communication with the cooling medium.

7. The valve mechanism as defined in claim **6** including pressure governor means coupled to said actuator means for throttling the flow of the cooling medium to reduce pressure in a fluid chamber of the actuator means whereby the latter becomes operative.

8. The valve mechanism as defined in claim **1** including means for operating said valve to at all times maintain a constant cooling medium-to-steam ratio irrespective of the position of the valve.

9. The valve mechanism as defined in claim **8** wherein said outlet duct means are carried by said valve and said operating means are operative for selectively regulating and varying the effective size of said duct means to regulate the flow of the cooling medium into the flow chamber.

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