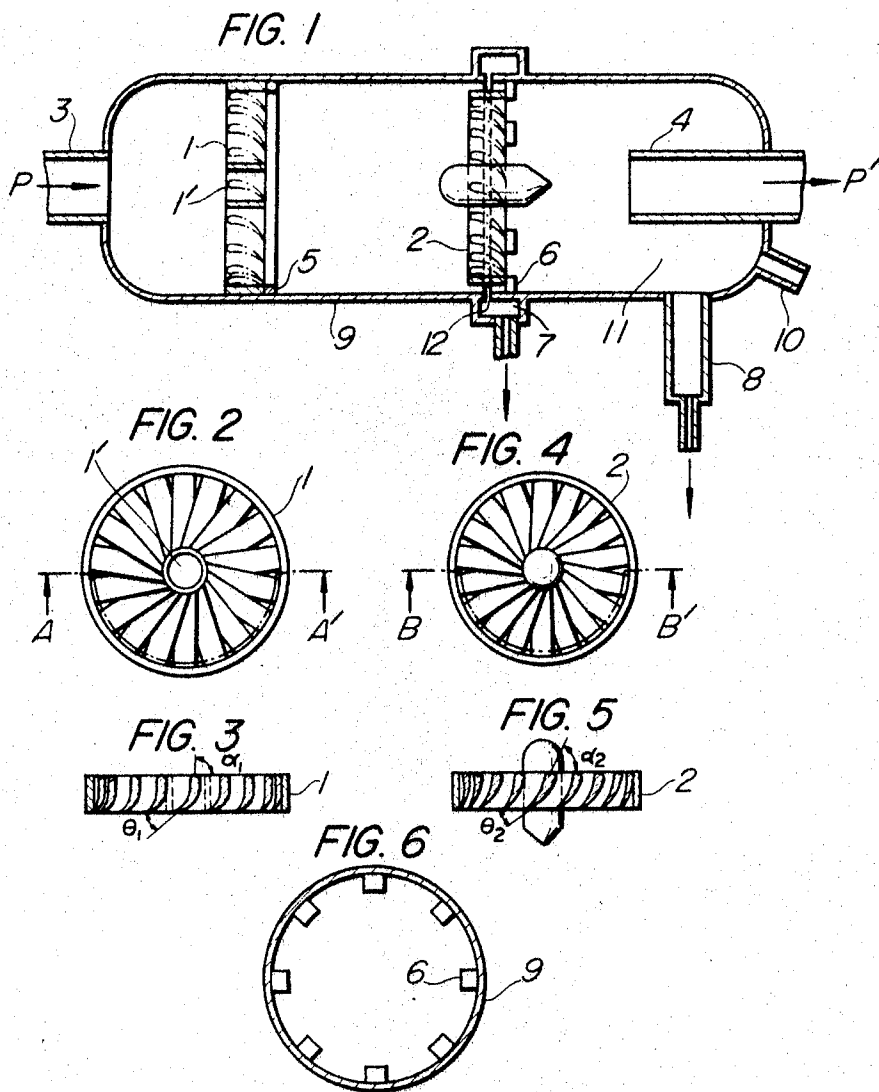


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STEAM SEPARATOR OF AXIAL FLOW AND CENTRIFUGAL
SEPARATION TYPE
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STEAM SEPARATOR OF AXIAL FLOW AND CENTRIFUGAL SEPARATION TYPE

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9 Claims

ABSTRACT OF THE DISCLOSURE

An axial flow and centrifugal separation steam separator having a cylindrical steam passage body with a steam inlet at one end and a substantially identical cross section steam outlet at the other end. A first set of radially extending guide vanes produces a gyratory motion in the axially moving steam and is provided with a central axial aperture of substantially one half the diameter of the inlet conduit. A second set of radially extending guide vanes are disposed axially downstream from the first set with an inlet angle substantially equal to the outlet angle of the first set for increasing the gyratory motion of the steam. A first annular drain slit is disposed radially outside of the second set of guide vanes and a second drain is provided downstream with a small steam outlet to prevent reverse flow.

Background of the invention

Steam turbines installed in nuclear power plants are generally designed to operate with a large amount of low pressure, low temperature steam, that is, saturated steam. With such manner of turbine operation, the proportion of liquid-state water in the steam becomes extremely great at the low pressure stage of the turbine. Presence of such large amount of liquid-state water is detrimental to the satisfactory turbine operation because various parts of the turbine may thereby be corroded in addition to lowering of turbine efficiency. In order to protect the turbine from the troubles as described above, there arises a necessity that steam having its liquid-state water content increased beyond an allowable limit is taken outwardly of the turbine for the sake of separation of water particles therefrom so as to be recirculated into the turbine as dry saturated steam.

Summary

It is therefore the primary object of the present invention to provide an effective separator means which meets the above-described demand.

Another object of the present invention is to provide an axial-flow type steam separator of simple structure in which means are provided to impart a gyrating flow to steam for convenient and efficient centrifugal separation of water particles from the steam.

According to the present invention, there is provided a steam separator of axial flow and centrifugal separation type comprising a generally cylindrical body defining a steam passage therein, a steam inlet conduit and a steam outlet conduit connected to opposite ends of said body in axially aligned relation with each other, and a plurality of spaced guide vane assemblies disposed in said steam passage for separating water particles from the steam, each of said guide vane assemblies being composed of a plurality of radially arranged vanes.

Or more precisely, the present invention contemplates the provision of a steam separator of axial flow and centrifugal separation type which is characterized by the provision of a generally cylindrical body defining a steam passage therein, a steam inlet conduit and a steam

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outlet conduit connected to opposite ends of said body in axially aligned relation with each other, a first guide vane assembly disposed in said steam passage for causing a gyrating flow of steam, said first guide vane assembly having an axial central aperture and being composed of a plurality of radially arranged vanes, a second guide vane assembly disposed in said steam passage in suitably spaced relation from said first guide vane assembly for causing a gyrating flow of steam, said second guide vane assembly being also composed of a plurality of radially arranged vanes, a slit extending over the entire inner periphery of said body at a position substantially downstream of said first guide vane assembly, a first drain port communicating with said slit, a stabilizing chamber defined in said body on the downstream side of said second guide vane assembly, and a second drain port provided in said stabilizing chamber.

Description

The above and other objects, advantages and features of the present invention will become apparent from the following description with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of a preferred embodiment of the steam separator according to the present invention;

FIG. 2 is a front elevational view of a first guide vane assembly provided in the steam separator;

FIG. 3 is a section taken on the line A-A' in FIG. 2;

FIG. 4 is a front elevational view of a second guide vane assembly provided in the steam separator;

FIG. 5 is a section taken on the line B-B' in FIG. 4; and

FIG. 6 is a section of the steam separator to show the manner of disposition of mounting lugs for the second guide vane assembly, the section being taken at right angles with respect to the axis of the steam separator.

Referring to FIG. 1, there is shown, in longitudinal section, a steam separator embodying the present invention, which includes a generally cylindrical body 9 defining a steam passage therein. An inlet conduit 3 and an outlet conduit 4 of substantially same diameter are connected in axially aligned relation to opposite end openings of the body 9. The outlet conduit 4 protrudes a substantial length into the body 9. The body 9 has a diameter which is about three times the diameter of the inlet and outlet conduits 3 and 4. In suitably spaced relation from the inlet end opening, there is disposed a first guide vane assembly 1 of the structure as shown in FIGS. 2 and 3, which is composed of a plurality of radial vanes each having an inlet angle α_1 of 90° and an exit angle θ_1 of 20° to 35°. The first guide vane assembly 1 is provided with an axial central aperture 1' of a diameter which is about the half of the diameter of the inlet and outlet conduits 3 and 4. A mounting ring 5 firmly fixes the first guide vane assembly 1 in position. In suitably spaced relation from the first guide vane assembly 1, there is provided a second guide vane assembly 2 of the structure as shown in FIGS. 4 and 5, which is also composed of a plurality of radial vanes each having an angle α_2 of 20° to 35° and an exit angle θ_2 of 15° to 25°. The second guide vane assembly 2 is firmly supported in the body 9 by a plurality of spaced mounting lugs 6 as best shown in FIG. 6 so as to be spaced a certain gap from the inner wall of the body 9. At a position substantially downstream of the first guide vane assembly 1, a slit 12 of a width of the order of 10 to 20 millimeters extends over the entire inner periphery of the body 9 so as to guide steam drains into a drain collecting chamber 7 to which a conduit is connected. A stabilizing chamber 11 is defined between the second guide vane assembly 2 and the outlet end of the body 9, and a drain collecting conduit 8

is connected to the bottom of this stabilizing chamber 11 to discharge drains therethrough. A discharge conduit 10 is provided at a position adjacent the junction between the body 9 and the outlet conduit 4 to allow for escape of a small amount of steam therethrough for the reason as will be described later.

The steam separator of the present invention operates in the following manner. Wet saturated steam containing liquid-state water or water particles therein is led through the inlet conduit 3 into the separator body 9 to reach the first guide vane assembly 1. The radial vanes forming the first guide vane assembly 1 convert the axial flow of wet saturated steam into a gyrating flow. Due to the centrifugal force caused by the gyrating flow of steam imparted by the first guide vane assembly 1, water particles with a greater specific gravity than the steam are urged to directions at right angles with respect to the axis $p-p'$ of the body 9 to deposit on the inner wall of the body 9. Those water particles which are deposited on the inner wall of the body 9 are forced towards the downstream side while still continuing gyration and are finally led through the slit 12 into the drain collecting chamber 7 to be drained outwardly of the steam separator through the conduit connected to the drain collecting chamber.

The central aperture 1' of the first guide vane assembly 1 is operative to prevent the gyrating flow of steam from being intensified solely at the central portion and to impart to the steam a radial flow so that the steam flow can be gyrated at a position remote from the axis $p-p'$ of the body 9. By the provision of the central aperture 1', the centrifugal separation effect can be increased and at the same time pressure loss can be minimized.

The steam leaving the first guide vane assembly 1 is then led into the second guide vane assembly 2 where the steam is further subjected to gyratory movement so that those water particles which have not been separated by the first guide vane assembly 1 can be removed from the steam. The angular disposition of the radial vanes forming the second guide vane assembly 2 is such that each vane has an inlet angle which is the same as the exit angle of the vanes of the first guide vane assembly 1 in order that the gyrating flow of steam imparted by the first guide vane assembly 1 can be admitted into the second guide vane assembly 2 at a minimum loss, while each vane of the second guide vane assembly 2 has an exit angle slightly smaller than the exit angle of the first guide vane so that the gyrating flow of steam can thereby be intensified. The steam leaving the second guide vane assembly 2 is again subjected to the water particle separation due to the centrifugal force, and the central portion of steam flow having little liquid-state water content flows into the outlet conduit 4. Meanwhile, those water particles which are deposited on the inner wall of the body 9 by the action of the first guide vane assembly 1 but can not be collected through the slit 12 into the drain collecting chamber 7 are led through the annular gap between the second guide vane assembly 2 and the inner wall of the body 9 and through the spaces between the mounting lugs 6 into the stabilizing chamber 11 to be guided together with those water particles separated by the action of the second guide vane assembly 2 into the drain collecting conduit 8 connected to the bottom of the stabilizing chamber 11. The provision of the discharge conduit 10 is quite useful to prevent such a trouble that those water particles once separated from the steam in the stabilizing chamber 11 may flow backwardly along the inwardly projected portion of the outlet conduit 4 by the gyrating action caused by the second guide vane assembly 2 and may be drawn into the outlet conduit 4.

It is found by our experimental experiences that the overall dimensions of a separator of this invention can be preferably determined in the following conditions:

d =inside diameter of conduit 3

D =inside diameter of body 9 $>3d$

d_0 =inside diameter of conduit 4= d

d_1 =diameter of aperture 1'= $\frac{1}{2}d$

S =width of slit 12=10-20 mm.

$\alpha_1=90^\circ$

$\theta_1=20-35^\circ$

$\alpha_2=\theta_1$

$\theta_2=15-25^\circ$.

From the foregoing description, it will be appreciated that the steam separator according to this invention provides various advantages including an efficient separating action, extremely simple structure and ease of repair and replacement.

What is claimed is:

1. A steam separator of axial flow and centrifugal separation type comprising a generally cylindrical body defining a steam passage therein, a steam inlet conduit and a steam outlet conduit connected to opposite ends of said body in axially aligned relation with each other, a first guide vane means disposed in said steam passage for causing a gyrating flow of steam, said first guide vane means having an axial central aperture generally one half the diameter of said inlet conduit and being composed of a plurality of radially arranged vanes, a second guide vane means disposed in said steam passage in suitably spaced relation from said first guide vane means for causing a gyrating flow of steam, said second guide vane means being also composed of a plurality of radially arranged vanes, and drain means for removing the separated liquid.

2. The steam separator of claim 1, wherein said outlet conduit has substantially the same diameter as said inlet conduit and said body has a diameter substantially three times the diameter of said inlet conduit.

3. The steam separator of claim 1, wherein said outlet conduit extends axially forwardly into said body for a substantial distance to a terminal end, and including steam discharge conduit means downstream of said outlet conduit terminal end closely beneath said outlet conduit for preventing movement of separated liquid on the exterior of said outlet conduit toward its terminal end, said discharge conduit means having a steam carrying capacity substantially less than said outlet conduit.

4. A steam separator according to claim 1, wherein said first guide vane means vanes each have an inlet angle of 90° and an exit angle of $20^\circ-35^\circ$, and each vane of said second guide vane means has an inlet angle of $20^\circ-35^\circ$ and an exit angle of $15^\circ-25^\circ$.

5. A steam separator according to claim 4, wherein said drain means includes an annular slit in said body downstream of said first guide vane means and a drain port communicating with said slit.

6. The steam separator of claim 5, wherein said slit is radially opposite from the vanes of said second guide vane means.

7. A steam separator according to claim 5, wherein said body includes a stabilizing chamber downstream of said second guide vane means, and said drain means includes a second drain port communicating with said stabilizing chamber.

8. The steam separator according to claim 7, wherein said outlet conduit is substantially the same diameter as said inlet conduit, said body has a diameter substantially three times the diameter of said inlet conduit, and said slit has an axial width of 10-20 mm.

9. The steam separator according to claim 8, wherein said outlet conduit extends axially into said stabilizing chamber for a substantial length, said second drain port being located downstream of the forwardmost end of said outlet conduit, and including a steam discharge conduit substantially smaller than and closely adjacent said outlet conduit downstream from the forwardmost end of said outlet conduit constituting means for preventing forward movement of separated liquid on the exterior of said outlet conduit.

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