STEAM TURBINE NOZZLE PLATE HAVING 360 DISCHARGE

Inventors: Michael Thomas Hamlin, Schoharie, NY (US); Dennis Roger Ahi, Sprakers, NY (US); James Harvey Vogan, Schenectady, NY (US); Tai Joung Kim, Schenectady, NY (US); Jeffrey Louis Palmer, Schenectady, NY (US); Thomas Joseph Farineau, Schoharie, NY (US); Richard Jon Chevrette, Troy, NY (US); George Edward Hilt JR., Schenectady, NY (US)

Correspondence Address:
NIXON & VANDERHYE P.C.
8th Floor
1100 North Glebe Road
Arlington, VA 22201 (US)

Application No.: 09/997,235
Filed: Nov. 30, 2001

Publication Date: Jun. 5, 2003

Publication Classification
Int. Cl. F01D 9/04
U.S. Cl. 415/191; 415/202; 415/209.2

ABSTRACT
An inner shell of a steam turbine has discrete arcuate steam outlet ports through an axial face. In axial opposition is a nozzle ring including a pair of nozzle ring segments joined at a horizontal midline. At the midline joint, split partitions are employed to provide a full 360° discharge through the nozzle ring. The split partitions are split in an axial direction to define discrete partition portions in each of the nozzle ring segments adjacent the midline joint.
STEAM TURBINE NOZZLE PLATE HAVING 360 DISCHARGE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a steam turbine nozzle plate for discharging steam received from discrete supply ports of the turbine inner shell in a continuous uninterrupted 360° arc and particularly relates to a steam turbine nozzle plate having split partitions at the horizontal midline of the turbine for eliminating flow restrictions or blockages typical of prior nozzle designs at the horizontal midline.

[0002] In a typical steam turbine, an inner shell is provided having, e.g., four inlet ports for receiving steam in directions generally normal to the axis of the turbine. Conventionally, a pair of valved inlet ports are provided on the upper half of the inner shell and a similar pair of valved inlet ports are provided on the lower half of the inner shell. These discrete steam flow passages turn the steam from a flow direction generally normal to the axis of the turbine into a unidirectional axial flow for flow through associated discrete steam outlet ports in an end axial face of the inner shell. These discrete outlet ports are arcuate and are spaced one from the other by bridging portions. For example, at the horizontal midline of the steam turbine, the bridging portions define the extreme ends of the outlet ports. Similarly, bridging portions are also provided in the inner shell along the vertical centerline of the turbine and define the opposite extreme ends of the outlet ports. It will thus be appreciated that the steam outlet flow through the discrete ports of the inner shell enables partial arc admissions into the nozzles of the steam turbine depending upon the valved inlet flows and precludes a full 360° arc admission. Typically, and with all inlet valves open, a steam admission of about 340° arc maximum is obtained.

[0003] The nozzles for the turbine typically include inner and outer bands with stator vanes or partitions extending in generally radial directions between the inner and outer bands. The nozzle ring is provided in 180° segments which are joined to one another along the horizontal midline of the turbine. The axial inlet side of the nozzle ring bears against the axial face of the inner shell such that the nozzles receive the steam flowing through the discrete outlet ports of the inner shell as partial arc steam admissions. Typically, the nozzle segments, for design and other reasons, have end blocks adjacent the horizontal midline. These end blocks have a circumferential extent which blocks part of the admission from the axially adjoining outlet port of the inner shell. The nozzle segments also included port bridges which are aligned with the vertical bridging portions of the inner shell upon assembly. As a consequence of this construction, particularly the large end blocks at the horizontal midline of the turbine, the steam flow from the outlet ports of the inner shell is interrupted by the discontinuity of the end blocks. The resulting partial arc admission of steam to and through the nozzles has limited efforts to upgrade flow rates through the turbine and, hence, inhibits desired increases in efficiency.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In accordance with a preferred embodiment of the present invention, there is provided a nozzle plate which affords increased full load efficiency in the steam turbine through employment of a continuous uninterrupted 360° inlet nozzle design. Particularly, the nozzle plate is fabricated similarly as prior nozzle plates, preferably in 180° segments. However, the end blocks which previously occupied a substantial circumferential extent of the nozzle plate are entirely eliminated and partitions are provided which extend 360° about the rotor axis without interruption from ancillary structure. More particularly, a split partition is provided at each of the horizontal midline joints between the nozzle ring segments such that steam from the outlet ports of the inner shell on opposite sides of the horizontal midline flows along opposite sides of the split partition. Each nozzle segment has, at the midline joint, a partition portion which mates with another partition portion of the adjacent segment upon assembly of the segments to form a split partition whereby steam flows from adjacent outlet ports of the inner shell along opposite sides, respectively, of the split partition. The partition is thus split in the axial direction of the turbine.

[0005] Additionally, a port bridge is disposed in the nozzle in front of each of the split partitions at the horizontal midline. The port bridges axially register with the bridging portions between the pairs of adjacent outlet ports of the inner shell at opposite sides of the horizontal midline. A weld buildup is provided between each split partition and its associated port bridge to form a continuous surface for guiding the steam flow from the inlet ports along respective opposite sides of the split partition. As a consequence, full 360° steam admission is provided.

[0006] In a preferred embodiment according to the present invention, there is provided a nozzle plate for a turbine comprising nozzle plate segments forming an annular array of nozzles, each segment including inner and outer band portions and circumferentially spaced partitions extending between the inner and outer band portions, adjacent ends of the segments forming a joint therebetween, at least one of the joints including a split partition with at least one of the split partition forming part of an end of one segment and a second portion of the split partition forming part of an adjacent end of another segment.

[0007] In a further preferred embodiment according to the present invention, there is provided a steam turbine comprising an inner shell having an axial face and a plurality of axially opening arcuate shaped steam outlet ports about the face with bridging portions between the outlet ports, a pair of the bridging portions being located at a horizontal midline of the turbine, a plurality of nozzle segments forming an annular array of nozzles in axial registration with the axial faces of the inner shell, each segment including inner and outer band portions and circumferentially spaced partitions extending between the inner and outer band portions, adjacent ends of the segments forming joints therebetween with a pair of the joints lying along the horizontal midline of the turbine, the joints between the segments along the horizontal midline lying in axial registration with bridging portions of the inner shell at the horizontal midline, each joint including a split partition with a first portion of the split partition forming part of an end of one segment and a second portion of the split partition forming part of an end of the adjacent segment, whereby enabling steam flow through adjacent outlet ports on opposite sides of the horizontal midline to in part flow along opposite sides of the split partition.
BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a fragmentary perspective view illustrating upper and lower nozzle segments constructed in accordance with a preferred embodiment of the present invention;

[0009] FIG. 2 is an enlarged fragmentary side elevation view illustrating the nozzle ring and inner shell;

[0010] FIG. 3 is an axial end view of the axial face of the inner shell which registers with the inlet side of the nozzle ring with portions of the nozzle plate superimposed;

[0011] FIG. 4 is a schematic fragmentary cross-sectional view of one of the horizontal joints of the nozzle segments in conjunction with the inlet ports, the view being folded out in plan;

[0012] FIG. 5 is a schematic illustration of the upper and lower nozzle ring segments folded in plan illustrating the split partitions at the horizontal midline; and

[0013] FIG. 6 is a fragmentary view of a nozzle segment at its horizontal joint folded out in plan view according to the prior art illustrating the end blockage.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Referring now to the drawings, particularly to FIGS. 1 and 2, there is schematically illustrated a portion of a diaphragm, generally designated 10, for use in steam turbines and includes a nozzle plate or ring 12 having inner and outer bands 14 and 16, respectively. A plurality of stator vanes or partitions 18 are spaced circumferentially one from the other about the nozzle ring 12 and extend generally in radial directions between the inner and outer bands 14 and 16. As illustrated in FIG. 1, the nozzle ring 12 is separated into preferably a pair of upper and lower nozzle ring segments 20 and 22 which are joined one to the other along the horizontal midline of the steam turbine at installation. As illustrated in FIG. 2, the nozzle ring 10 forms part of the diaphragm for receiving steam from an inner shell 24. As illustrated in FIG. 2, the partitions 18 receive steam from outlet ports, described below, and discharge the steam to drive the buckets 26 of the first stage of the steam turbine rotor 28.

[0015] Referring to FIGS. 2 and 3, the inner shell 24 includes a plurality of valved steam admission ports. In the illustrated form, a pair of steam inlet ports 30 are formed along the upper side of the inner shell 24, while a similar pair of valved inlet ports 30 are disposed along the lower half of the inner shell 24. The inner shell 24 includes passages 32 associated with each of the inlet ports 30 for turning the steam from an inlet direction generally normal to the axis of rotation of the turbine to an axial direction for flow through steam outlet ports 34 in the axial face 36 in axial registration with the nozzle ring 12. From a review of FIG. 3, it will be appreciated that each steam outlet port 34 is associated with a valved steam inlet port 30 and is generally arcuate in configuration, each outlet port 34 subtending an arc less than 90°. Bridging portions 39 are provided adjacent steam outlet ports 34 along opposite sides of the horizontal midline 37 and bridging portions 38 are provided along the vertical centerline to maintain the outlet ports 34 segregated one from the other. Valved steam admission through the segregated steam outlet ports 34 is useful when one or more of the valved inlet ports 30 are used to supply steam while the other valved inlet port(s) do not supply steam. Consequently, it will be appreciated that in the illustrative embodiment, the steam inlet ports 34 are arcuate about the rotor axis, lie in quadrants less than 90° and are separated one from the other by bridging portions 39 and 38 along the axial face of the inner shell 24. Also illustrated in FIG. 3 is a superimposition in schematic form of the nozzle ring 12 and partitions 18 illustrating their location relative to the steam inlet ports 34.

[0016] Referring to FIG. 6, there is illustrated a portion of a prior art nozzle ring segment laid out in plan to illustrate an end block portion 50 along the horizontal midline. Particularly as illustrated, the nozzle ring 52 includes a plurality of partitions 54 which extend generally radially and an end block portion 50 which extends a discrete circumferential extent. The end block 50, in combination with the end block 50 of the opposing nozzle ring segment, as well as end blocks along the diametrically opposite side of the nozzle ring occupy circumferential extents which otherwise could receive a number of partitions, e.g., five or six partitions each. It will be appreciated, however, that because of the end block portions 50, a full 360° discharge through the nozzle ring 52 cannot be achieved.

[0017] In accordance with a preferred embodiment of the present invention and with reference to FIGS. 4 and 5, a full 360° uninterrupted flow of steam through the nozzle ring 12 hereof is provided. To accomplish this, the end block typically provided on each of the upper and lower nozzle segments adjacent each of the midline joints is entirely eliminated and replaced by a number of additional partitions and a split partition. Particularly, the partitions 18 are provided in the areas adjacent the midline joints of the nozzle segments, a split partition 60 being provided at each of the midline joints. More particularly, the split partition 60 includes along one midline joint of one of the nozzle ring segments a suction side partition portion 62. The adjacent segment of the nozzle ring segment includes a pressure side partition portion 64 of the split partition 60. The split partition portions, upon assembly, are joined one to the other along an axially extending split line 66, e.g., by welding. It will be appreciated that the number of partitions 18 illustrated in FIGS. 4 and 5 are reduced from the actual number of partitions for clarity.

[0018] For example, as illustrated in FIG. 4, the upper nozzle ring segment 20 includes a suction side partition portion 62 along one end thereof and a pressure side partition portion 64 along its opposite end. The lower nozzle ring segment 22 includes a suction side partition portion 62 and a pressure side partition portion 64 adjacent opposite ends. When the upper and lower segments 20 and 22 are assembled, the suction and pressure side portions 62 and 64, respectively, mate with one another to form a single complete partition 60. The partition 60 is spaced from and configured similarly as the adjacent partitions 18 about the nozzle ring.

[0019] As illustrated in FIGS. 4 and 5, the leading edges of the partitions 18 are axially inset from the leading edge of the nozzle diaphragm. Additionally, strength bridges 68 are disposed between the inner and outer rings at periodic circumferentially spaced positions forwardly of the partitions 18. As best illustrated in FIG. 4, it will be appreciated that each of the horizontal joints between the upper and lower nozzle ring segments 20 and 22, respectively, lie in
axial registration with the bridging portions 36 of the inner shell 24 at the horizontal midline 37. To provide strength to the nozzle ring and continuous flow of steam along opposite sides of each split partition 60 from the adjacent steam outlet ports 34, a port bridge 70 extends between the inner and outer rings forwardly of the leading edge of the split partition 60. Additionally, a weld buildup 72 is provided between the port bridge 70 and the split partition 60 to form the continuous surface along opposite sides of the split partition. Similarly, at the vertical centerlines of the nozzle segments in axial opposition to the bridging portions 38 between the steam outlet ports 34 of the inner shell, port bridges 74 are provided (FIG. 5). By providing the port bridges 70 and 74, partial arc admissions of steam may be provided from one or more of the valved inlet ports 30. It will be appreciated, however, that when steam is provided through each of the valved inlet ports 30 for flow through the outlet ports 34, the nozzle ring provides a full 360° discharge of steam onto the buckets of that stage.

[0020] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A nozzle plate for a turbine comprising:
   nozzle plate segments forming an annular array of nozzles, each segment including inner and outer band portions and circumferentially spaced partitions extending between said inner and outer band portions, adjacent ends of said segments forming a joint therebetween;
   at least one of said joints including a split partition with a first portion of the split partition forming part of an end of one segment and a second portion of the split partition forming part of an adjacent end of another segment.

2. A nozzle plate according to claim 1 including a port bridge disposed in front of said split partition.

3. A nozzle plate according to claim 1 wherein each of said segments subtends an arc of 180°, another of said joints between said segments including a second split partition with a first portion thereof forming part of an end of said one segment and a second portion thereof forming part of an adjacent end of said another segment.

4. A nozzle plate according to claim 3 including a port bridge disposed between said inner and outer bands in an upstream direction relative to said split partitions.

5. A nozzle plate according to claim 1 wherein the split partition is split in an axial direction.

6. A nozzle plate according to claim 1 wherein each of said segments subtends an arc of 180°, another of said joints between said segments including a second partition split in an axial direction with a first portion thereof forming part of an end of said one segment and a second portion thereof forming part of an adjacent end of said another segment, said split partitions being split in axial directions.

7. A nozzle plate according to claim 1 wherein each of said segments subtends an arc of 180°, another of said joints between said segments including a second partition split in an axial direction with a first portion thereof forming part of an end of said one segment and a second partition thereof forming part of an adjacent end of said another segment, including a port bridge disposed in front of each said split partition, and a weld buildup between a leading edge of each split partition and the port bridge.

8. A steam turbine comprising:
   an inner shell having an axial face and a plurality of axially opening arcuate shaped steam outlet ports about said face with bridging portions between said outlet ports, a pair of said bridging portions being located at a horizontal midline of the turbine;
   a plurality of nozzle segments forming an annular array of nozzles in axial registration with said axial faces of said inner shell, each segment including inner and outer band portions and circumferentially spaced partitions extending between said inner and outer band portions, adjacent ends of said segments forming joints therebetween with a pair of said joints lying along said horizontal midline of the turbine;
   the joints between said segments along said horizontal midline lying in axial registration with bridging portions of the inner shell at said horizontal midline, each joint including a split partition with a first portion of the split partition forming part of an end of one segment and a second portion of the split partition forming part of an end of the adjacent segment, thereby enabling steam flow through adjacent outlet ports on opposite sides of the horizontal midline to in part flow along opposite sides of said split partition.

9. A turbine according to claim 8 including a port bridge disposed in front of each said split partition.

10. A turbine according to claim 8 wherein each of said segments subtends an arc of 180°.

11. A turbine according to claim 8 including a port bridge disposed in front of each said split partition, and a weld buildup between a leading edge of each split partition and the port bridge.

12. A turbine according to claim 8 wherein each of said split partitions are split in an axial direction.

13. A turbine according to claim 12 including a port bridge disposed in front of each said split partition, and a weld buildup between a leading edge of each split partition and the port bridge.