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(11)

EP 1 722 070 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

15.11.2006 Bulletin 2006/46

(51) Int Cl.:

F01D 9/02 (2006.01)

F01D 9/04 (2006.01)

(21) Application number: **06252184.4**

(22) Date of filing: **22.04.2006**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

Designated Extension States:

AL BA HR MK YU

(30) Priority: **27.04.2005 US 115371**

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(54) **Method of manufacturing segmented stators for a steam turbine**

(57) A method of manufacturing reaction nozzles for a turbine comprising (a) providing a piece of flat plate stock (38) of predetermined size and thickness; and (b)

machining the piece of flat plate stock to form a unitary, arcuate reaction nozzle segment (24) including at least two adjacent nozzle airfoils (26).

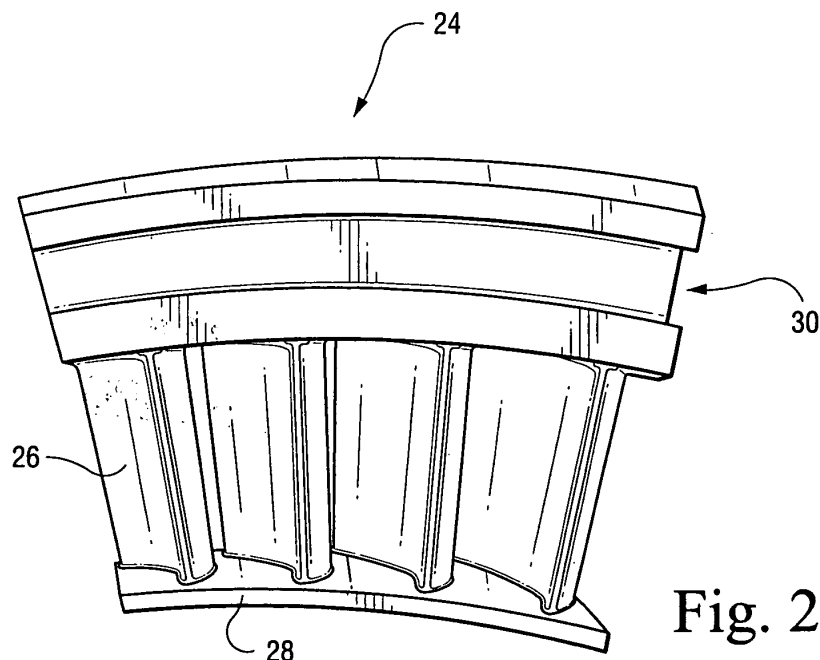


Fig. 2

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Description

[0001] This invention relates to a method of producing steam turbine components and, specifically, dovetailed reaction nozzle segments.

[0002] Current fixed reaction nozzle stages that are located between rotating turbine stages (or wheels) are made up of individual nozzles that are individually inserted within a dovetail slot in a fixed nozzle carrier or turbine casing. The nozzles are formed with integral dovetails at their radially outer ends and integral tip shrouds at their radially inner ends. These nozzles are designed to maintain tip shroud contact throughout operation by incorporating appropriate cover or tip shroud interference along with a pre-twisted cold airfoil portions. During assembly of such nozzles, it has been difficult to confirm that the required cover or tip shroud interference has been obtained. In addition, the process of pre-twisting the nozzle airfoils at assembly causes the airfoils to deviate from the "design" airfoil shape. This can potentially reduce the efficiency of the airfoil.

[0003] Various embodiments of the present invention substantially eliminate many issues relating to individually formed nozzle airfoils. In accordance with an exemplary embodiment, a plurality of nozzles are manufactured by machining from a single piece of flat plate stock. For example, in one exemplary embodiment, a single solid donut-shaped ring is cut from flat plate stock and then cut into two 180° segments. The cut ends of the segments may then be configured for temporary attachment to a machining jig or the like, or the segments may be temporarily joined together (by, e.g., bolts) on a jig and subsequently machined to include integral shroud covers, airfoils and dovetails. After machining, the two 180° segments are loaded into the nozzle carrier or casing dovetail in the usual manner.

[0004] In another arrangement, four 90° segments may be cut from the solid ring and subsequently machined to each include 25% of the required nozzles.

[0005] Alternatively, arcuately shorter segments may be machined to include as few as two integral nozzle airfoils, thus still reducing the nozzle components by half.

[0006] In all cases, proper spacing between arcuate nozzle segments can be maintained through the utilization of shims of appropriate thickness placed between the segments and the carrier or casing dovetail.

[0007] Accordingly, in one aspect, the invention relates to a method of manufacturing reaction nozzles for a turbine comprising (a) providing a piece of flat plate stock of predetermined size and thickness; and (b) machining the piece of flat plate stock to form a unitary, arcuate reaction nozzle segment including at least two adjacent nozzle airfoils.

[0008] In another aspect, the invention relates to a method of manufacturing reaction nozzles for a turbine comprising (a) providing a single piece of flat plate stock of predetermined size and thickness; and (b) cutting the flat plate stock to form a 360° ring; (c) cutting the 360°

ring into two or more arcuate segments; and (d) machining each of the segments to include a plurality of nozzle airfoils.

[0009] In still another aspect, the invention relates to a reaction nozzle component for a steam turbine comprising a unitary arcuate segment formed to include a plurality of adjacent nozzle airfoils.

[0010] The invention will now be described in connection with the drawings identified below, in which:

FIGURE 1 is a perspective view of a known steam turbine reaction nozzle;

FIGURE 2 is a perspective view of a unitary arcuate reaction nozzle segment in accordance with an exemplary embodiment of this invention;

FIGURE 3 is a plan view of a piece of flat plate stock marked for cutting a 360° ring from the stock;

FIGURE 4 is a plan view of the ring removed from the plate stock of Figure 3 and cut to form two 180° arcuate segments;

FIGURE 5 is an exploded view of the two 180° arcuate segments of Figure 4 modified for temporary attachment to a jig or to each other for machining; and

FIGURE 6 is a plan view of a solid ring cut into four 90° segments for subsequent machining in accordance with another embodiment of the invention.

[0011] With reference initially to Figure 1, a conventional steam turbine reaction nozzle 10 includes an airfoil 12 and an integral radially inner tip shroud or cover 14. The radially outer end of the nozzle is formed with a base 16 having a dovetail configuration. Specifically, the base or dovetail 16 is provided with a pair of flanges 18 and 20 projecting in both axially upstream and downstream directions, defining recesses 22 therebetween. It will be appreciated that the nozzle casing or carrier (not shown) is provided with generally correspondingly shaped dovetail grooves which allow the nozzles 10 to be individually loaded into the carrier or casing at a conventional notched cut-out. Thus, each nozzle can be loaded into the dovetail slot in the carrier until the entire row of nozzles has been assembled. It will also be appreciated that the dovetail arrangement may be reversed, with the dovetail groove component formed in the nozzle and the dovetail hook component formed on the carrier or casing.

[0012] Figure 2 illustrates a unitary arcuate dovetail reaction nozzle component or segment manufactured in accordance with an exemplary embodiment of the invention. The segment 24 is machined from a single piece of flat metal plate stock and includes a plurality of adjacent airfoil portions (or simply "airfoils") 26 with an integral, common tip shroud or cover 28 at the radially inner ends

of the airfoils, and an integral, common dovetail hook 30 at the radially inner ends of the airfoils. As will be described further below, the arcuate length of the segments may be varied as desired to include as few as two airfoils or as many as 50% of the airfoils required for a full 360° reaction nozzle ring. In one embodiment, the common dovetail comprises a centerline support mechanism for a 180° segment.

[0013] Turning to Figure 3, a donut-shaped ring 36 is initially cut from a single piece of flat plate stock 38, using any conventional cutting technique, for example, wire electrical discharge machining (EDM). With the ring 36 removed from the plate stock as shown in Figure 4, the ring is cut into two 180° segments 40 and 42, again using conventional cutting processes. The separated segments 40 and 42 may be provided with any suitable end flanges as shown at 44, 46 that permit the segments to be bolted to a machining jig in alignment with each other, similar to their alignment when assembled in upper and lower carrier or casing components. Alternatively, the segments 38, 40 may be temporarily bolted together and otherwise secured to the jig for machining. The segments 38 and 40 are then machined to include the airfoils 26, integral tip shrouds or tip covers 28, and dovetail hooks 30 as shown in Figure 2, but noting that Figure 2 illustrates an arcuately shorter segment. After machining, the segments 38 and 40 are disassembled or removed from the jig and are ready for insertion into the carrier or casing dovetail groove.

[0014] In an alternative arrangement as shown in Figure 6, a solid ring 48 may be cut from the flat plate stock into four individual 90° segments 50, 52, 54 and 56 and machined to each include 25% of the required airfoils. In other embodiments, the arcuate length of the airfoil segments may be altered as desired with each segment including at least two airfoils.

[0015] In the exemplary embodiment, the flat plate stock 38 may be high grade 400 Series stainless steel with 12% chromium, or other suitable material.

[0016] In order to maintain proper circumferential spacing of the airfoils, shims of appropriate thickness may be placed between the segments at the dovetail. The segments may be held in place in the dovetail via conventional radial end or axial shims which eliminate the radial end or axial gap between the segment dovetail and the dovetail groove in the casing or carrier.

[0017] By machining airfoils in this fashion, a number of issues associated with the current individual reaction nozzle design can be substantially eliminated or at least minimized including:

tip shroud interference and associated manufacturing and assembly difficulties;

untwist of shrouds and airfoils during operation;

axial clearance issues related to the piece-part twist variation at assembly and during operation;

assembling individual nozzle/pins for each stage;

the need to perform in-process assembly checks such as twist, shingling and throat area measurements;

the need for standing assembled modal tests and associated costs and scheduling impacts of each test;

ergonomic concerns related to assembling individual loading pins for individual nozzles.

[0018] In addition to eliminating the issues above, the machined segment concept in accordance with aspects of this invention also improves the ability to service/repair rows relative to current practice; creates a known/repeatable/unvarying boundary condition; reduces the number of parts per stage; and insures that segments are assembled in the correct location/direction.

[0019] 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.

Claims

1. A method of manufacturing reaction nozzles for a turbine comprising:

- (a) providing a piece of flat plate stock (38) of predetermined size and thickness; and
- (b) machining said piece of flat plate stock (38) to form a unitary, arcuate reaction nozzle segment (24) including at least two adjacent nozzle airfoils (26).

2. The method of claim 1 wherein said reaction nozzle segment (24) also includes a common tip shroud cover (28) and a common dovetail hook (30) at opposite ends of, and spanning, said at least two adjacent nozzle airfoils (26).

3. The method of claim 1 or claim 2 wherein said flat plate stock (38) is comprised of a stainless steel alloy.

4. The method of claim 3 wherein said stainless steel alloy comprises a 400 Series stainless steel with 12% chromium.

5. The method of any preceding claim wherein each of said arcuate segments (24) spans substantially 180°.

6. The method of any one of claims 1 to 4 wherein each of said arcuate segments (24) spans substantially 90°.
7. A method of manufacturing reaction nozzles for a turbine comprising:
- (a) providing a single piece of flat plate stock (38) of predetermined size and thickness; and
 - (b) cutting said flat plate stock (38) to form a 360° ring (36);
 - (c) cutting said 360° ring (36) into two or more arcuate segments (40, 42); and
 - (d) machining each of said segments to include a plurality of nozzle airfoils (26).
8. The method of claim 7 wherein, during step (d), each segment also includes an integral, common tip shroud cover (28) and an integral, common dovetail component (30).
9. The method of claim 7 or claim 8 wherein steps (b) and (c) are carried out with wire EDM.
10. The method of any one of claims 7 to 9 wherein, during step (c), said ring is cut into four 90° segments (50, 52, 54, 56).

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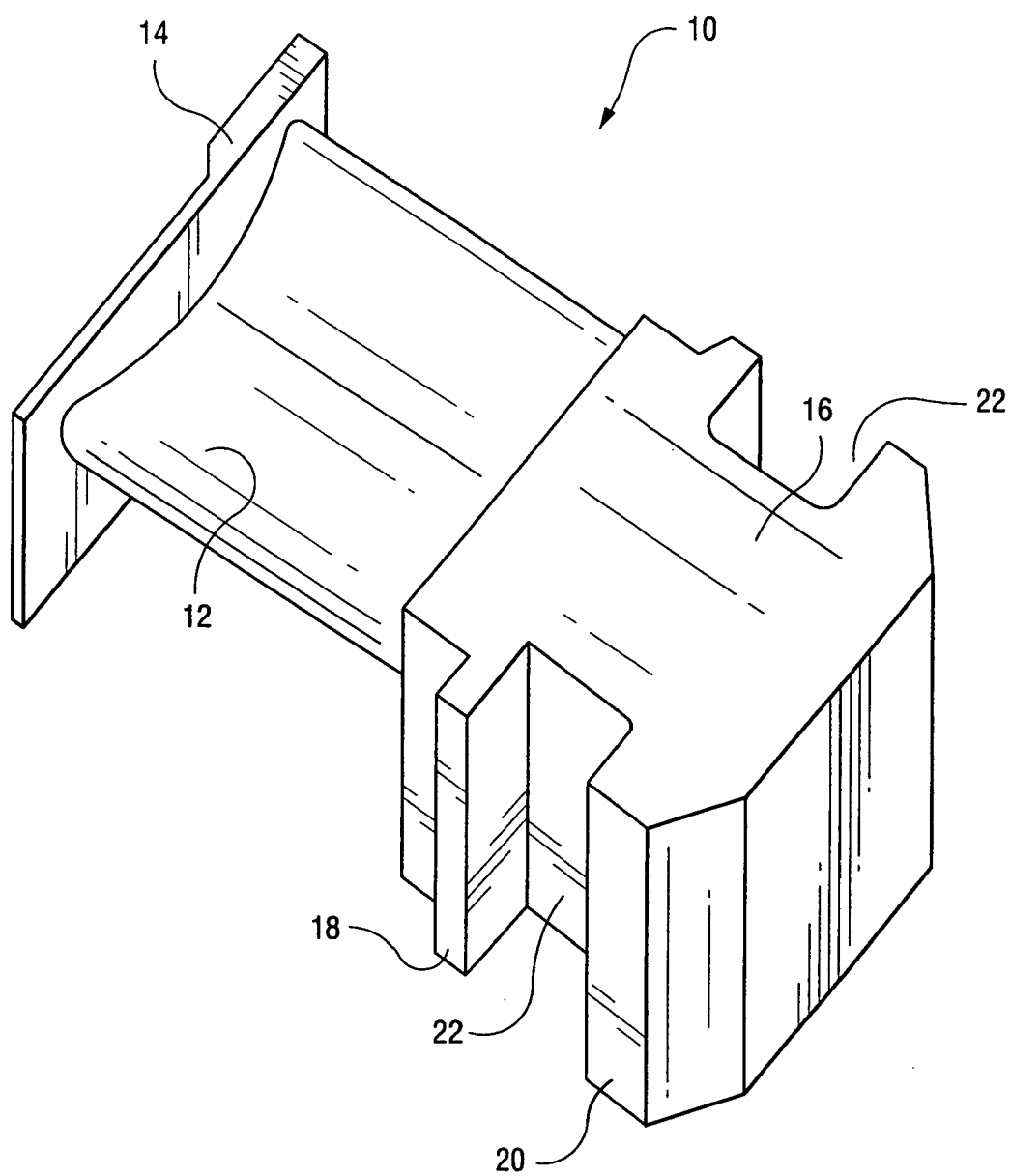


Fig. 1
(PRIOR ART)

