NEW HAVEN, CT 06510 (US) A turbomachine has a number of interspersed stages of rotor blades and stator vanes. A split case has first and second case sections meeting along a junction extending essentially along a longitudinal first plane. The metallic spring seal extends along the junction. The spring seal may be installed in a remanufacturing of an existing turbomachine.
SPLIT CASE SEALS AND METHODS
CROSS-REFERENCE TO RELATED APPLICATION

[0001] Benefit is claimed of U.S. patent application Ser. No. 60/647,080, filed Jan. 25, 2005, and entitled “Split Case Seals and Methods”, the disclosure of which is incorporated by reference herein as if set forth at length.

BACKGROUND OF THE INVENTION

[0002] The invention relates to turbomachinery. More particularly, the invention relates to the sealing of split cases of steam turbines and industrial gas turbines.

[0003] Stationary turbine installations include steam turbines and industrial gas turbines. A principal use is for power generation. Common configurations for such turbines include horizontally-split cases with upper and lower case sections joined along a pair of diametrically opposed mating flanges. The flanges may be sealed such as with a gasket material.

[0004] Some stationary turbines are subject to particularly stressful use patterns. So-called peaker turbines are used intermittently and often relatively briefly. For example, a peaker turbine in a power generation facility may be used to address peak loads whereas the other turbines are more constantly used. Use may also be temporary to replace the capacity of another turbine which has been temporarily dropped from service. The peaker turbine may be of like kind or dissimilar to other units in a facility. For example, a power plant with a number of steam turbines may use an industrial gas turbine to both address peak loads and address steam system failures. Peaker use often involves rapid starting from a shutdown condition to a high power condition. The stressful use pattern of peaker turbines may cause case deformation and sealing failure.

SUMMARY OF THE INVENTION

[0005] Accordingly, one aspect of the invention involves a method for modifying a turbomachine split case. First and second case sections are separated along their junction. A channel is machined into the first case section along the junction. A metallic spring seal segment is inserted in the channel. The first and second case sections are reassembled to compress the spring seal segment. The method may be performed during regular maintenance or more comprehensive remanufacturing of the turbomachine.

[0006] The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic side view of a stationary turbomachine.

[0008] FIG. 2 is a schematic transverse sectional view of the turbomachine of FIG. 1.

[0009] FIG. 3 is a view of a sealing face of a case section flange of the engine of FIG. 1.

[0010] FIG. 4 is a view of a seal.

[0011] FIG. 5 is a transverse sectional view of the seal of FIG. 4, taken along line 5-5.

[0012] FIG. 6 is a transverse sectional view of the flange of FIG. 3, taken along line 6-6.

[0013] Dimensions shown in the drawings are merely exemplary for one particular implementation.

[0014] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0015] FIG. 1 shows a turbomachine 20 having a central longitudinal axis 500 which forms an axis of rotation of the turbomachine rotors. The axis 500 falls along a transverse horizontal centerplane 502. The turbomachine has a case assembly including an exemplary front (upstream) case 22, intermediate case 24, and rear case 26. The intermediate case 24 is shown having ends fore and aft 28 and 30 at junctions with the front and rear cases.

[0016] FIG. 2 shows the intermediate case 24 as including upper and lower halves 32 and 34. In the exemplary turbomachine, these halves are symmetric across a vertical centerplane 504. The halves 32 and 34 are joined along respective pairs of flanges 40A, 42A and 40B, 42B having faces 50 at junctions along the horizontal centerplane 502. The flanges of each pair may be secured together such as via bolting. FIG. 3 shows the face 50 of the flange 42A, the flange 42B being a mirror image. Along the intermediate case 24, its interior surface 52 varies in diameter relative to the centerline 500 to accommodate the diameters of the various rotating components. The flange generally follows such change in radius.

[0017] The surface 50 may initially be essentially flat and uninterrupted. A channel 60 may then be machined through the surface 50 to accommodate a seal. FIG. 3 shows the channel 60 closely spaced apart from the interior surface 52 along a majority of and essentially the entirety of the intermediate case length (e.g., in excess of 99%). An exemplary channel 60 is essentially a right channel with a pair of sidewalls and a base.

[0018] FIGS. 4 and 5 show further details of an exemplary seal 62. The exemplary seal is a spring compression seal having a C-sectioned outer jacket 64 and a coiled energizing spring 66 concentrically within the jacket (e.g., along a seal centerline 510). The exemplary spring 66 has an outer diameter labeled as Ds. The exemplary jacket 64 has a diameter Dw which forms a relaxed thickness of the seal and jacket normal to a plane 512 discussed below. The jacket extends more than 180° around the axis 510 to form two sealing faces. The exemplary jacket extends approximately 270° around the axis 510 in a relaxed condition.

[0019] The seal 62 and its centerline 502 extend from a first end 68 to a second end 70 which, when installed, fall close to the intermediate case ends 28 and 30. The exemplary seal and its centerline include several straight portions 72, 74, 76, and 78 interspersed with curved portions or bends 80, 82, and 84. The exemplary channel 60 also extends between first and second ends 98 and 100. In the exemplary embodiment, these ends are recessed from the intermediate case ends 28 and 30 by lengths L1 and L2 (measured parallel to the axis 500). The channel has straight portions 102, 104,
106 and 108 and bends 110, 112, and 114 corresponding to the straight portions and bends of the seal. FIG. 4 shows sections corresponding to the seal straight portions as having lengths L_{13}, L_{14}, L_{15}, and L_{16} (measured along the seal and to the middle of each adjacent bend). The corresponding channel sections have lengths L'_{13}, L'_{14}, L'_{15}, and L'_{16}. In the exemplary embodiment, L_{14} and L_{15} may respectively very closely correspond to L_{13} and L_{16} whereas L_{13} and L_{15} may be slightly greater than L_{15} and L_{16} to provide room for longitudinal expansion (e.g., thermal expansion) of the seal.

[0020] The exemplary seal bends are parallel to each other so that the seal centerline falls along a plane 512. When the seal is installed, the plane 512 may be parallel to and spaced apart from the plane 502 (e.g., by half the depth of the channel 60 as shown in FIG. 6). In the installed condition, the seal is compressed (e.g., to the channel height H) below the relaxed thickness D. The compression may close an initial gap (if any) between the jacket and spring and further compress the jacket and spring to an out-of-round condition. The compression may thus also narrow the gap between longitudinal edges of the jacket. In the exemplary installed condition of FIG. 6, the flanges are fully mated to each other (with contact of their faces 50) compressing the seal within the channel 60. However, stress may cause local or general separation of the flanges either transiently or more permanently. When these separations occur, advantageously, the seal compliance maintains the seal in engagement with both flanges, preventing escape of hot gases. The present seals may be supplemented or complemented by additional sealing means. For example, a ceramic fiber-filled RTV silicone may be used to seal at the ends of the seals 62.

[0021] Exemplary jacket material is UNS N07718 (SAE AMS 5596) sheet, a (gamma) precipitation-hardenable nickel-chromium alloy containing significant amounts of iron, niobium, and molybdenum along with lesser amounts of aluminum and titanium. Its microstructure consists principally of a Ni—Cr—Fe—Mo solid-solution matrix. Exemplary spring material is UNS N07960 (SAE AMS 5829) wire, a nickel-chromium-cobalt alloy being precipitation hardenable, having high stress-rupture strength and creep resistance at high temperatures (up to about 950°C). A stationary industrial gas turbine (IGT) for electrical power generation. Implementations of the invention may involve: (1) remanufacture/retrofit of an existing IGT; and/or (2) a reengineering of an existing IGT configuration prior to manufacture of further units. An exemplary remanufacture/retrofit implementation is performed on-site with the IGT shut down. The upper and lower case halves are unbolted and separated along their junction. The channels 60 are then machined (e.g., via conventional milling) in the associated flanges. The seals 62 may then be inserted in the respective channels. The case halves may be reassembled and the bolts tightened to compress the seals. In one example, the channels are machined in the flanges of the upper case half. This permits machining to be performed away from the rest of the IGT so that there is better access to the flanges and less chance of introducing debris to the IGT. Although machining may be performed with the upper case half inverted, reassembly involves facing the channels downward. Accordingly, the seals may be retained by wax, adhesive, or the like during replacement of the upper case half. This material may be sacrificed (e.g., melted/vaporized) upon IGT operation.

[0023] One or more embodiments of the present invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, when implemented as a remanufacturing of an existing engine or a reengineering of an existing engine configuration, details of the existing configuration may influence or dictate details of any particular implementation. Accordingly, other embodiments are within the scope of the following claims.

What is claimed is:
1. A turbomachine comprising:
   a plurality of stages of rotor blades;
   a plurality of stages of stator vanes interspersed with the stages of rotor blades;
   a split case having first and second case sections meeting along a junction extending essentially along a longitudinal first plane; and
   a metallic spring seal extending along the junction.
2. The turbomachine of claim 1 being a steam turbine.
3. The turbomachine of claim 1 being a stationary gas turbine.
4. The turbomachine of claim 1 driving an electrical generator.
5. The turbomachine of claim 1 wherein:
   the metallic spring seal is a coil spring-energized c-seal segment.
6. The turbomachine of claim 1 wherein:
   the first plane is horizontal;
   the junction includes first and second junction sections respectively along opposite sides of a vertical longitudinal centerplane of the turbomachine; and
   the metallic spring seal comprises first and second seal segments accommodated in an upward-facing channel in the first case section, respectively along the first and second junction sections.
7. The turbomachine of claim 1 wherein:
   the metallic spring seal has an essentially uniform cross-section along a seal centerline; and
   the seal centerline extends essentially in a second plane, parallel to the first plane, the seal centerline being non-straight to accommodate a change in stage diameter along the case.
8. The turbomachine of claim 1 wherein:
   the first plane intersects a turbomachine central longitudinal axis.
9. A turbomachine case seal comprising:
   a c-sectioned jacket extending from a first end to a second end; and
   an energizing spring within the jacket.
10. The turbomachine case seal of claim 9 wherein:
    the energizing spring is a coil spring essentially sharing a centerline with the jacket;
    the centerline has a at least one curve; and
    the jacket consist essentially of a single metallic piece of a nickel-based superalloy.
11. The turbomachine case seal of claim 10 wherein:
the centerline has a plurality of straight portions.
12. The turbomachine case seal of claim 10 wherein:
the centerline has a plurality of straight portions joined at bends.
13. The turbomachine case seal of claim 10 compressed between mated flanges of a split turbine case.
14. A method for modifying a turbomachine split case, the case comprising first and second case sections meeting along a junction extending essentially along a longitudinal first plane, the method comprising:
separating the first and second case sections along the junction;
machining a channel in the first case section along the junction;
inserting a metallic spring seal segment in the channel; and
reassembling the first and second case sections to compress the spring seal segment.
15. The method of claim 14 performed on the turbomachine after use of the turbomachine.
16. The method of claim 14 leaving the second case section essentially unaltered.
17. The method of claim 14 further comprising shaping the metallic spring seal segment to fit the channel.
18. The method of claim 14 performed on an industrial gas turbine.
19. The method of claim 14 wherein the reassembling causes contact between flanges of the first and second case sections.
20. The method of claim 14 wherein:
the channel is a first channel along a face of a first flange of the first case section;
the metallic spring seal segment is a first metallic spring seal segment; and
the method further includes:
machining a second channel in the first case section along the junction along a face of a second flange of the first case section;
inserting a second metallic spring seal segment in the second channel.
21. A method for reengineering the configuration of a turbomachine split case, the case comprising first and second case sections meeting along a junction extending essentially along a longitudinal first plane, the method comprising:
adding a channel in the first case section along the junction; and
adding a metallic spring seal segment in the channel.