

SEPARATION TOOL AND METHOD FOR NOZZLE SEGMENTS OF GAS TURBINES

TECHNICAL FIELD

[0001] The present application and the resultant patent relate generally to gas turbine
5 engines and more particularly relate to a separation tool used to separate adjacent nozzle
segments in preparation for removing the nozzles from a casing of the turbine for repair or
replacement.

BACKGROUND

[0002] A gas turbine engine conventionally includes a compressor for compressing
10 ambient air and a combustor for mixing the flow of air with a flow of fuel to generate hot
combustion gases. A turbine receives the flow of hot combustion gases and extracts energy
therefrom for powering the compressor and for producing output power for an external load
such as an electrical generator and the like. The turbine components such as the turbine
nozzles and blades positioned along the hot gas path are subject to high combustion
15 temperatures and pressures as well as different types of dynamic forces. Given such, these
hot gas path components may be replaced and/or refurbished on a periodic basis to ensure
efficient and safe performance.

[0003] Removal of a hot gas component such as a nozzle and the like may be difficult
and time consuming. Each stage of the nozzles typically may be formed in segments and
20 placed circumferentially end-to-end to form a continuous ring about the casing of the turbine
section. The high temperature and high pressure environment may cause the nozzles to stick
together and/or to be seized together in the supporting structure. Moreover, the small
clearances in the turbine section provide very little space to access the nozzles and the other
components therein much less sufficient space to apply any type of force to separate the
25 nozzles prior to removal.

SUMMARY

[0004] The present application and the resultant patent thus provide a nozzle segment
separation tool for use with a pair of airfoils of adjacent nozzle segments in a turbine. The
nozzle segment separation tool includes a pair of separation brackets, a movable separation
30 bracket and a stationary separation bracket, and a hydraulic cylinder positioned between the
pair of separation brackets. The movable separation bracket is positioned about a first airfoil
of the pair of airfoils and the stationary separation bracket is positioned about a second airfoil

of the pair of airfoils. The hydraulic cylinder pushes the movable separation bracket against the first airfoil until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.

5 [0005] The present application and the resultant patent further provide a method of separating a pair of adjacent nozzles in a casing of a turbine. The method may include the steps of sliding a nozzle segment separation tool about the pair of airfoils, positioning a movable separation bracket of the nozzle segment separation tool about a first airfoil of the pair of airfoils, positioning a stationary separation bracket of the nozzle segment separation tool about a second airfoil of the pair of airfoils, and pushing the movable separation bracket
10 against the first airfoil by a hydraulic cylinder until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.

[0006] The present application and the resultant patent further may provide a nozzle segment separation tool for use with a pair of airfoils of adjacent nozzle segments in a turbine. The nozzle segment separation tool includes a pair of separation brackets, a movable
15 separation bracket and a stationary separation bracket, and a hydraulic cylinder positioned between the pair of separation brackets. The stationary separation bracket is attached to the hydraulic cylinder and includes a contoured shape. The movable separation bracket is positioned about a first airfoil of the pair of airfoils and the stationary separation bracket is positioned about a second airfoil of the pair of airfoils. The hydraulic cylinder pushes the
20 movable separation bracket against the first airfoil until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.

[0007] These and other features and improvements of this application and the resultant patent will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended
25 claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a schematic diagram of a gas turbine engine including a compressor, a combustor, a turbine, and an external load.

30 [0009] Fig. 2 is a schematic diagram of a number of stages positioned within a casing of a turbine.

[0010] Fig. 3 is a front perspective view of a nozzle segment separation tool as may be described herein.

[0011] Fig. 4 is a rear perspective view of the nozzle segment separation tool of Fig. 3

[0012] Fig. 5 is a partial front sectional view of the nozzle segment separation tool of Fig. 3 positioned between a pair of airfoils.

[0013] Fig. 6 is a partial rear sectional view of the nozzle segment separation tool of Fig. 3 positioned between a pair of airfoils.

[0014] Fig. 7 is a perspective view of the nozzle segment separation tool of Fig. 3 positioned between nozzle segments.

[0015] Fig. 8 is a top plan view of the nozzle segment separation tool of Fig. 3 positioned between a pair of airfoils.

10 [0016] Fig. 9 is a side plan view of the nozzle segment separation tool of Fig. 3 positioned about a nozzle segment.

DETAILED DESCRIPTION

[0017] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, Fig. 1 shows a schematic diagram of a gas turbine engine 10 as may be used herein. The gas turbine engine 10 may include a compressor 15. The compressor 15 compresses an incoming flow of air 20. The compressor 15 delivers the compressed flow of air 20 to a number of combustor cans 25. The combustor cans 25 mix the compressed flow of air 20 with a pressurized flow of fuel 30 and ignite the mixture to create a flow of hot combustion gases 35. Although only a single combustor can 25 is shown, the gas turbine engine 10 may include any number of combustor cans 25 positioned in a circumferential array and the like. Alternatively, the combustor 25 may be an annular combustor. The flow of combustion gases 35 is in turn delivered to a turbine 40. The flow of combustion gases 35 drives the turbine 40 to produce mechanical work. The mechanical work produced in the turbine 40 drives the compressor 15 and an external load 50 such as an electrical generator and the like via a rotor shaft 45.

[0018] The gas turbine engine 10 may use natural gas, various types of syngas, liquid fuels, and/or other types of fuels and blends thereof. The gas turbine engine 10 may be any one of a number of different gas turbine engines offered by General Electric Company of Schenectady, New York, including, but not limited to, those such as a 7-series or a 9-series heavy duty gas turbine engine and the like. The gas turbine engine 10 may be part of a simple cycle or a combined cycle power generation system or other types of generation systems.

The gas turbine engine 10 may have different configurations and may use other types of components. Other types of gas turbine engines also may be used herein. Multiple gas turbine engines, other types of turbines, and other types of power generation equipment also may be used herein together.

5 **[0019]** Fig. 2 is a partial sectional view of the turbine 40. The turbine 40 includes a number of stages 52. Generally described, each stage 52 of the turbine 40 includes a stationary row 54 of nozzles 56 and a rotating row 58 of turbine blades 60. In this example, three stages 52 are shown, a first stage, a second stage, and a third stage. Any number of stages 52 may be used herein. The turbine blades 60 in each row 58 are spaced
10 circumferentially about, and extend radially outward from, a rotor disk 62. Each rotor disk 62 is coupled to the rotor shaft 45. A turbine casing 64 extends circumferentially about the nozzles 56. The nozzles 56 are each coupled to the turbine casing 64 and each nozzle 56 extends radially inward from the turbine casing 64 towards the rotor shaft 45. Specifically, as will be described in more detail below, the nozzles 56 may be arranged in a number of
15 segments 66 and may be attached to the turbine casing 64 via a number of shroud grooves in a number of shrouds. A hot combustion gas path 72 may be defined between the turbine casing 64 and each rotor disk 62.

[0020] Figs. 3-5 show an example of a nozzle segment separation tool 100 as may be described herein. The nozzle segment separation tool 100 may include a pair of separation
20 brackets 110. In this case, a movable separation bracket 120 and a stationary separation bracket 130. The separation brackets 110 may be made out of any substantially rigid material such as stainless steel and the like. Positioned between the separation brackets 110 and attached thereto may be a hydraulic cylinder 140. The hydraulic cylinder 140 may be of conventional design. Specifically, the hydraulic cylinder 140 may include a hydraulic fluid
25 port 150 positioned within a hydraulic swivel hoist 160 and an internal piston 170. The hydraulic cylinder 140 may have a single stroke or a double stroke design. An exemplary hydraulic cylinder may be a five-ton capacity hydraulic cylinder sold by ENERPAC of Milwaukee, Wisconsin. Other type of hydraulic cylinders, other types of capacities, and other types of push or pull mechanisms may be used herein. For example, different types of jacks,
30 screws, and the like may be used herein. The hydraulic swivel hoist 160 may rotate through any desired angle of rotation. Other components and other configurations may be used herein.

[0021] At least the stationary separation bracket 130 of the nozzle segment separation tool 100 may have a contoured shape 180. The contoured shape 180 of the stationary

separation bracket 130 may be complimentary to the shape of an intended airfoil 190. The movable separation bracket 120 may be similarly contoured. Separation brackets 110 with different types of contoured shapes 180 may be used herein to accommodate different types and shapes of airfoils 190. Each of the separation brackets 110 may have a shock absorbing layer 200 thereon. The shock absorbing layer 200 may be any type of viscoelastic materials such as rubber, polymeric, and the like. Each of the separation brackets 110 also may have a bumper 210 extending laterally therefrom. The bumpers 210 may be any type of substantially rigid material and also may have a shock absorbing layer 200 thereon. The bumpers 210 assist in guiding the separation brackets 110 into place about the airfoils 190 and maintain the separation brackets 110 in place once operation has begun. Other components and other configurations may be used herein.

[0022] The stationary separation bracket 130 of the nozzle segment separation tool 100 may be bolted or otherwise attached to the hydraulic cylinder 140. The separation brackets 110 also may be attached to each other by a pair of safety slides 220. In this case, a top safety slide 230 and a front safety slide 240. Each safety slide 220 may be fixedly attached to the movable separation bracket 120 and slidably attached to the stationary separation bracket 130 via a roller 250 positioned within a slot 260. The safety slides 220 limit the length of travel of the separation brackets 110 if the nozzle segment separation tool 100 becomes disengaged from the airfoils 190. Brackets, cable, and the like also may be used. Other components and other configurations may be used herein.

[0023] The nozzle segment separation tool 100 may have a tool maneuvering rod 270 attached thereto. Specifically, the tool maneuvering rod 270 may be attached to the stationary separation bracket 130 or elsewhere via a quick release coupling 280 with a quick release pin 290. Other types of attachment mechanisms may be used herein. The tool maneuvering rod 270 may have any suitable size, shape, and length. Other types of maneuvering devices and connection devices may be used herein. Other components and other configurations may be used herein.

[0024] In use as is shown in Figs. 5-9, the nozzle segment separation tool 100 may be inserted between the airfoils 190 of adjacent nozzle segments 66. Specifically, the nozzle segments separation tool 100 may be maneuvered into place via the tool maneuvering rod 270 or otherwise between a first airfoil 300 and a second airfoil 310. The movable separation bracket 120 comes into contact with the first airfoil 300 and the stationary separation bracket 130 comes into contact with the second airfoil 310. The bumpers 210 assist in correctly orienting the separation brackets 110 into position. The hydraulic cylinder 140 may be

activated and may push the movable separation bracket 120 against the first airfoil 300. The hydraulic cylinder 140 continues pushing such that the stationary separation bracket 130 comes into contact with the second airfoil 310. The nozzle segment separation tool 100 thus pushes the second airfoil 310 in the direction of travel 320 until the airfoils 190 and the
5 nozzle segments 66 are separated. The hydraulic cylinder 140 then may be disengaged. The nozzle segment separation tool 100 then may be removed and/or repositioned. Once separated, the nozzle segments 66 may be removed in the ordinary fashion.

[0025] The nozzle segment separation tool 100 thus allows quick and easy separation of the nozzle segments 66. Significantly, the nozzle segment separation tool 100 may separate
10 the nozzle segments 66 without requiring time-consuming disassembly of the turbine 40 as a whole, i.e., without requiring the removal of the rotor 45 and the like. The nozzle segment separation tool 100 thus reduces the required labor time and reduces the overall outage time of the gas turbine engine 10.

[0026] It should be apparent that the foregoing relates only to certain embodiments of this
15 application and resultant patent. Numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

[0027] Further aspects of the invention are provided by the subject matter of the following clauses:

[0028] 1. A nozzle segment separation tool for use with a pair of airfoils of adjacent
20 nozzle segments in a turbine, comprising: a pair of separation brackets; wherein the pair of separation brackets comprises a movable separation bracket and a stationary separation bracket; and a hydraulic cylinder positioned between the pair of separation brackets; wherein the movable separation bracket is positioned about a first airfoil of the pair of airfoils and
25 the stationary separation bracket is positioned about a second airfoil of the pair of airfoils; and wherein the hydraulic cylinder pushes the movable separation bracket against the first airfoil until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.

[0029] 2. The nozzle segment separation tool of any preceding clause, wherein the
30 hydraulic cylinder comprises an internal piston.

- [0030] 3. The nozzle segment separation tool of any preceding clause, wherein the hydraulic cylinder comprises a hydraulic fluid port positioned within a hydraulic swivel hoist.
- [0031] 4. The nozzle segment separation tool of any preceding clause, wherein one or
5 both of the pair of separation brackets comprise a contoured shape.
- [0032] 5. The nozzle segment separation tool of any preceding clause, wherein each of the pair of separation brackets comprises a shock absorbing layer.
- [0033] 6. The nozzle segment separation tool of any preceding clause, wherein each of the pair of separation brackets comprises a bumper.
- 10 [0034] 7. The nozzle segment separation tool of any preceding clause, wherein the bumper comprises a shock absorbing layer.
- [0035] 8. The nozzle segment separation tool of any preceding clause, further comprising a safety slide positioned between the pair of separation brackets.
- [0036] 9. The nozzle segment separation tool of any preceding clause, wherein the
15 safety slide is fixedly attached to the movable separation bracket.
- [0037] 10. The nozzle segment separation tool of any preceding clause, wherein the safety slide is slidably attached to the stationary separation bracket via a roller and a slot.
- [0038] 11. The nozzle segment separation tool of any preceding clause, further comprising a plurality of safety slides.
- 20 [0039] 12. The nozzle segment separation tool of any preceding clause, further comprising a tool maneuvering rod.
- [0040] 13. The nozzle segment separation tool of any preceding clause, wherein the tool maneuvering rod is attached to the stationary separation bracket via a quick release coupling.
- [0041] 14. The nozzle segment separation tool of any preceding clause, wherein the
25 stationary separation bracket is bolted to the hydraulic cylinder.
- [0042] 15. A method of separating a pair of airfoils of adjacent nozzle segments in a turbine, comprising: sliding a nozzle segment separation tool about the pair of airfoils; positioning a movable separation bracket of the nozzle segment separation tool about a first airfoil of the pair of airfoils; positioning a stationary separation bracket of the nozzle segment

separation tool about a second airfoil of the pair of airfoils; and pushing the movable separation bracket against the first airfoil by a hydraulic cylinder until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.

[0043] 16. A nozzle segment separation tool for use with a pair of airfoils of adjacent
5 nozzle segments in a turbine, comprising: a pair of separation brackets; wherein the pair of
separation brackets comprises a movable separation bracket and a stationary separation
bracket; and a hydraulic cylinder positioned between the pair of separation brackets; wherein
the stationary separation bracket is attached to the hydraulic cylinder and comprises a
contoured shape; wherein the movable separation bracket is positioned about a first airfoil
10 of the pair of airfoils and the stationary separation bracket is positioned about a second airfoil
of the pair of airfoils; and wherein the hydraulic cylinder pushes the movable separation
bracket against the first airfoil until the stationary separation bracket pushes the second
airfoil to separate from the first airfoil.

[0044] 17. The nozzle segment separation tool of any preceding clause, wherein the
15 hydraulic cylinder comprises a hydraulic swivel hoist.

[0045] 18. The nozzle segment separation tool of any preceding clause, wherein each of
the pair of separation brackets comprises a shock absorbing layer and a bumper.

[0046] 19. The nozzle segment separation tool of any preceding clause, further
comprising a safety slide positioned between the pair of separation brackets.

20 **[0047]** 20. The nozzle segment separation tool of any preceding clause, further
comprising a tool maneuvering rod attached to the stationary separation bracket.

[0048] List of references:

10 gas turbine engine
15 compressor
25 20 flow of air
25 combustor
30 flow of fuel
35 flow of combustion gases
40 turbine
30 45 shaft
50 generator
52 stages

	54	stationary row
	56	nozzles
	58	rotating row
	60	turbine blades
5	62	rotor disc
	64	casing
	66	segments
	68	grooves
	70	shrouds
10	72	combustion path
	100	nozzle segment separation tool
	110	separation brackets
	120	movable separation bracket
	130	stationary separation bracket
15	140	hydraulic cylinder
	150	hydraulic fluid port
	160	hydraulic swivel hoist
	170	piston
	180	contoured shape
20	190	airfoil
	200	shock absorbing layer
	210	bumper
	220	safety slides
	230	top safety slide
25	240	front safety slide
	250	roller
	260	slot
	270	tool maneuvering rod
	280	quick release coupling
30	290	quick release pin
	300	first airfoil
	310	second airfoil
	320	direction of travel

CLAIMS

1. A nozzle segment separation tool for use with a pair of airfoils of adjacent nozzle segments in a turbine, comprising:

a pair of separation brackets;

5 wherein the pair of separation brackets comprises a movable separation bracket and a stationary separation bracket; and

a hydraulic cylinder positioned between the pair of separation brackets;

wherein the movable separation bracket is positioned about a first airfoil of the pair of airfoils and the stationary separation bracket is positioned about a second airfoil of the pair of
10 airfoils; and

wherein the hydraulic cylinder pushes the movable separation bracket against the first airfoil until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.
- 15 2. The nozzle segment separation tool of claim 1, wherein the hydraulic cylinder comprises an internal piston.
3. The nozzle segment separation tool of claim 1, wherein the hydraulic cylinder comprises a hydraulic fluid port positioned within a hydraulic swivel hoist.
4. The nozzle segment separation tool of claim 1, wherein one or both of the pair of separation brackets comprise a contoured shape.
- 20 5. The nozzle segment separation tool of claim 1, wherein each of the pair of separation brackets comprises a shock absorbing layer.
6. The nozzle segment separation tool of claim 1, wherein each of the pair of separation brackets comprises a bumper.
7. The nozzle segment separation tool of claim 6, wherein the bumper comprises a shock
25 absorbing layer.
8. The nozzle segment separation tool of claim 1, further comprising a safety slide positioned between the pair of separation brackets.

9. The nozzle segment separation tool of claim 8, wherein the safety slide is fixedly attached to the movable separation bracket.
10. The nozzle segment separation tool of claim 9, wherein the safety slide is slidably attached to the stationary separation bracket via a roller and a slot.
- 5 11. The nozzle segment separation tool of claim 8, further comprising a plurality of safety slides.
12. The nozzle segment separation tool of claim 1, further comprising a tool maneuvering rod.
13. The nozzle segment separation tool of claim 12, wherein the tool maneuvering rod is
10 attached to the stationary separation bracket via a quick release coupling.
14. The nozzle segment separation tool of claim 1, wherein the stationary separation bracket is bolted to the hydraulic cylinder.
15. A method of separating a pair of airfoils of adjacent nozzle segments in a turbine, comprising:
- 15 sliding a nozzle segment separation tool about the pair of airfoils;
- positioning a movable separation bracket of the nozzle segment separation tool about a first airfoil of the pair of airfoils;
- positioning a stationary separation bracket of the nozzle segment separation tool about a second airfoil of the pair of airfoils; and
- 20 pushing the movable separation bracket against the first airfoil by a hydraulic cylinder until the stationary separation bracket pushes the second airfoil to separate from the first airfoil.