METHODS FOR PERFORMING GAS TURBINE ENGINE CASING REPAIRS AND REPAIRED CASES

BACKGROUND

Technical Field

The disclosure generally relates to gas turbine engines.

Description of the Related Art

Gas turbine engine components typically experience harsh operating conditions such as high temperature cycling, which can result in thermal fatigue and other types of distress modes such as cracking or wear. Additionally, some engines are exposed to harsh environment conditions such as salt ingestion that can occur during transoceanic flights, for example. Due to these and other factors, gas turbine engine components can wear and/or become damaged. In this regard, repair of gas turbine engine components oftentimes involves dimensionally restoring the components.

SUMMARY

Methods for repairing gas turbine engine casings and repaired casings are provided. In this regard, an exemplary embodiment of a method for repairing a gas turbine engine casing comprises: removing an annular portion of the engine casing; and attaching an annular replacement portion to the engine casing.

Another exemplary embodiment of a method comprises: providing a salvaged engine casing; removing an annular portion of the engine casing; providing a

replacement component comprising excess material; trimming the excess material of the replacement component to form a replacement portion; and attaching the replacement portion to the engine casing.

An exemplary embodiment of a repaired gas turbine engine casing comprises an annular replacement portion attached to the casing.

Other systems, methods, features and/or advantages of this disclosure will be or may become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features and/or advantages be included within this description and be within the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. 1 is a schematic diagram depicting a portion of a representative repaired engine casing.

FIG. 2 is a schematic diagram depicting a step of an exemplary embodiment of a method for repairing a gas turbine engine casing.

FIG. 3 is a schematic diagram depicting another step of an exemplary embodiment of method.

FIG. 4 is a flowchart depicting an embodiment of a method for repairing a gas turbine engine casing.

FIG. 5 is a schematic diagram depicting another embodiment of a method for repairing a gas turbine engine casing.

DETAILED DESCRIPTION

Methods for repairing gas turbine engine casings and repaired casings are provided, several exemplary embodiments of which will be described in detail. In some embodiments, an annular portion of an engine casing is removed and replaced. In some embodiments, attachment of the replacement is facilitated by welding, after which a heat treatment can be performed in order to reduce stresses in the vicinity of the repair site.

An exemplary embodiment of a repaired engine casing is depicted schematically in FIG. 1. As shown in FIG. 1, engine casing 100 includes non-containment zones (e.g., non-containment zone 102) and containment zones (e.g., a containment zone 104). Specifically, each containment zone is located in a vicinity of corresponding rotating blades (e.g., blade 105) of a turbine that are positioned within the casing. In this embodiment, the non-containment zone 102 is associated with a replacement portion 106 that includes a front flange 108 of the casing. The front flange is used to attach the casing to an adjacent casing. Notably, a front flange (flange 110 of FIG. 2) that was previously attached to the case was considered unsuitable for continued use, such as by exhibiting severe cracking or wear, and was removed.

As shown in FIG. 2, removal of front flange 110 from case is accomplished by cutting the case along the cut plane 120. The cut plane is oriented perpendicular to the longitudinal axis 122 of the casing although other cut plane orientations can be used in other embodiments. Cutting can be accomplished in various manners, such as by machining, turning, milling, sawing, or laser cutting. Notably, the cut plane is located outside of a containment zone of the casing in this embodiment. However, in other embodiments, the cut plane may be associated with a containment zone.

In FIG. 3, annular replacement component 130 is provided that includes replacement portion 106 and an optional trim portion 132. The trim portion is formed of excess material that can be trimmed to form an appropriate mating surface for engaging a corresponding surface of the casing 100. In this regard, the trim portion can be suitably dimensioned for attachment to the casing using various techniques, such as using a technique similar to that use in removing the front flange (shown in FIG. 2). After the replacement component is trimmed, attachment to the casing 100 can be accomplished by using various techniques.

As shown in FIG. 4 an exemplary embodiment of a method for repairing a gas turbine engine casing includes providing an engine casing (block 150). In block 152, an annular portion of the engine case is removed, and a replacement portion is provided (block 154). In some embodiments, the portion removed is restricted to non-containment portion of the casing. Thereafter, such as depicted in block 156, the replacement portion is attached to the engine casing.

Another exemplary embodiment of a method for repairing a gas turbine engine casing is depicted in the flowchart of FIG. 5. As shown in FIG. 5, the method may be

construed as beginning at block 200, in which an annular portion of a gas turbine engine casing is removed. By way of example, the portion can be a front flange portion of a turbine casing. In block 202, the remaining casing can be cleaned.

In block 204, a replacement component (e.g., a forged replacement flange with a trim portion) is provided and a hardness check is performed. In some embodiments, such as when the casing is a precipitation-hardened nickel alloy turbine casing, the hardness should be at least approximately HRC36 (or equivalent). If it is determined that the hardness is adequate, the process may proceed to block 206, in which the replacement component is trimmed. For instance, the replacement component can be machined (and optionally cleaned) in order to provide appropriate mating tolerance for the attachment technique that is to be used for attaching the replacement portion to the casing. In block 208, an inspection can be performed such as a fluorescent penetrant inspection, x-ray inspection and/or hardness inspection in order to identify any defects.

In block 210, material in a vicinity of the attachment can be prepared (such as by cleaning with a silicon carbide rag wheel or a stainless steel wire brush, for example) in order to prepare the mating surfaces for attachment. In some embodiments, this can involve preparing an approximately one inch wide (25.4 mm) area adjacent to the cut line at the front face of the case and the corresponding mating surface of the replacement portion. Preparation also can include additional cleaning steps in some embodiments, such as by cleaning the surfaces with a solvent wipe method.

In block 212, the replacement portion is positioned for attachment. Notably, this can involve inspection to confirm that any gaps between the replacement portion and the casing do not exceed acceptable tolerances. If tolerances are met, the process may

proceed to block 214, in which the replacement portion is attached to the casing, such as by welding, for example. In this regard, various welding techniques, such as electron beam welding (EBW), machine TiG welding and plasma arc welding can be used. Inspection and optional re-welding then can be performed such as depicted in block 216. Thereafter, such as depicted in block 218, stress relief/heat treatment can be performed in order to relieve internal stresses. In block 220, various inspections, such as a hardness check, fluorescent penetrant inspection and/or x-ray inspection can be performed to insure completeness of the weld. Finishing then can be performed in block 222. By way of example, the weld can be machine finished to ensure a smooth continuous surface with no undercuts. Final cleaning and inspection then can be performed.

In some embodiments, the replacement component and salvaged casing can be heat treated (e.g., solution heat treated) prior to welding in order to soften the materials for ease of welding and to potentially prevent rework. However, there is a risk of component/casing distortion during such heat treatment that may require appropriate fixturing to prevent distortion.

It should be emphasized that the above-described embodiments are merely possible examples of implementations set forth for a clear understanding of the principles of this disclosure. Many variations and modifications may be made to the above-described embodiments without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the accompanying claims.

CLAIMS

1. A method for repairing gas turbine engine casing comprising:

removing an annular portion of the engine casing; and

attaching an annular replacement portion to the engine casing.

2. The method of claim 1, wherein the casing is a turbine casing.

3. The method of claim 1, wherein the portion removed is a non-containment portion of the casing.

4. The method of claim 1, wherein removing comprises cutting the casing along a plane perpendicular to a longitudinal axis of the casing.

5. The method of claim 1, wherein attaching comprises:

providing a replacement portion with a trim portion that is dimensioned to be trimmed prior to attachment; and

trimming the trim portion such that gap tolerances between the replacement portion and the casing are provided.

6. The method of claim 1, wherein attaching comprises welding the annular replacement portion to the engine casing.

7. The method of claim 6, wherein welding the annular replacement portion to the engine casing is performed using at least one of: electron beam welding, machine TiG welding, and plasma arc welding.

8. The method of claim 1, further comprising performing at least one of the following:

a stress relief/heat treatment before attaching the replacement portion to the engine casing; and

a stress relief/heat treatment after attaching the replacement portion to the engine casing.

9. The method of claim 8, further comprising finishing the casing.

10. A method for repairing gas turbine engine casing comprising:

providing a salvaged engine casing;

removing an annular portion of the engine casing;

providing a replacement component comprising excess material;

trimming the excess material of the replacement component to form a replacement portion; and

attaching the replacement portion to the engine casing.

11. The method of claim 10, wherein removing comprises cutting the casing along a plane perpendicular to a longitudinal axis of the casing.

12. The method of claim 11, wherein the portion removed is a non-containment portion of the casing.

13. The method of claim 10, wherein attaching comprises welding the replacement portion to the engine casing.

14. The method of claim 13, wherein welding the replacement portion to the engine casing is performed using at least one of: electron beam welding, machine TiG welding and plasma arc welding.

15. The method of claim 13, further comprising performing at least one of the following:

a stress relief/heat treatment before attaching the replacement portion to the engine casing; and

a stress relief/heat treatment after attaching the replacement portion to the engine casing.

16. The method of claim 10, wherein the casing is a turbine casing.

17. A repaired gas turbine engine casing comprising:

an annular replacement portion attached to the casing.

18. The casing of claim 17, wherein the casing is a turbine casing.

19. The casing of claim 17, wherein:

the casing has a front portion and an aft portion; and

the front portion comprises the replacement portion.

20. The casing of claim 19, wherein the replacement portion includes a front flange.