METHODS OF PREPARING, CLEANING AND REPAIRING ARTICLE AND ARTICLE REPAIRED

BACKGROUND OF THE INVENTION

[0001] This invention relates to methods of preparing, cleaning and repairing an article and the repaired article.

BRIEF SUMMARY OF THE INVENTION

[0002] It is an object of the present invention to provide a method of preparing an article for cleaning.

[0003] It is a further object of the present invention to provide a method of cleaning an article.

[0004] It is a further object of the present invention to provide a method of repairing an article.

[0005] It is a further object of the present invention to provide a repaired article.

[0006] These and other objects of the present invention are achieved in one aspect by a method of preparing a part for cleaning, comprising the steps of: providing a part with an internal cavity, at least one opening in communication with the cavity, and foreign material within the cavity: and creating an additional opening in the part at a location adjacent the foreign material.

[0007] These and other objects of the present invention are achieved in another aspect by method of cleaning a part, comprising the steps of: providing a part with an internal cavity, at least one

opening in communication with the cavity; creating an additional opening in the part; and flushing the cavity with a fluid. The additional opening acts as an exit or entrance for the fluid.

[0008] These and other objects of the present invention are achieved in another aspect by a method of repairing a part, comprising the steps of: providing a part with an internal cavity, at least one opening in communication with the cavity, and foreign material within the cavity; creating an additional opening in the part; and removing the foreign material. The removing step occurs through the additional opening.

[0009] These and other objects of the present invention are achieved in another aspect a part, comprising: an exterior surface; an internal cavity; at least one opening through the surface and in communication with the cavity; and a repaired section of the surface. The repaired section was an additional opening that provided a temporary exit or entrance to the cavity for removing foreign material from the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Other uses and advantages of the present invention will become apparent to those skilled in the art upon reference to the specification and the drawings, in which:

[0011] Figure 1 is a cross-sectional view of a gas turbine engine;

[0012] Figure 2 is an elevational view of a turbine blade used in the engine of Figure 1;

[0013] Figure 3 is a cross-sectional view of the turbine blade of Figure 2;

[0014] Figure 4 is the turbine blade of Figure 3 showing the presence of foreign material therein;

[0015] Figure 5 is the turbine blade of Figure 3 after a step in one possible method of removing the foreign material;

[0016] Figure 6 is the turbine blade of Figure 3 during another step of one possible method of removing the foreign material; and

[0017] Figure 7 is the turbine blade of Figure 3 after being refurbished by one possible method of removing the foreign material.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Figure 1 displays a gas turbine engine 10 used, for example, for propulsion or power generation. Along an axial centerline 12 in the downstream direction, the engine 10 includes a fan section 14, a compressor section 16, a burner section 18 and a turbine section 20.

[0019] The fan section 14 draws air 22 into the engine 10. A portion of the air 22 drawn in by the fan section 14 travels into the compressor 16 (*i.e.* "core engine flow"), while the remainder (*i.e.* "bypass flow") does not. The core engine flow becomes compressed traveling through the compressor section 16, then mixes with fuel supplied by fuel injectors in the burner section 18. Within the burner section 18, the air/fuel mixture combusts. The combustion gases exit the

burner section 18 and enter the turbine section 20. The combustion gases drive the turbine section 18.

[0020] Figure 2 displays a portion of the turbine section 20. Specifically, the figure displays a turbine blade 22 with a root section 26 and an airfoil section 28 separated by a platform 30. The root section 26 secures to a correspondingly shaped feature on a rotor 32 (shown in phantom). Since the platform 30, in combination with other features of the engine 10, defines the radially inner boundary of the core gas path, the airfoil section 28 resides within the core gas path. The engine case 34 (shown in phantom) defines the radially outer boundary of the core gas path. During operation, the rotor 32 and turbine blades 22 spin as a result of the combustion gases CG exiting the burner section 18.

[0021] So the turbine section 20, particularly the airfoil section 28 of the turbine blades 28, can endure prolonged exposure to the high temperature of the combustion gases CG, the engine 10 introduces cooling air to the turbine section 20. Typically, the engine 10 draws such cooling air from the compressor section 16. One path for introducing cooling air to the turbine section 20 is through the turbine blades 22. As explained in more detail below, the turbine blade 22 is hollow so as to receive cooling air CA.

[0022] Figure 3 displays a cross-sectional view of the turbine blade 22. The turbine blade 22 has an internal cavity 36. The cavity 36 includes one or more openings, such as one or more inlets 38 and one or more outlets 40. In addition to the exterior surface 42, the turbine blade 22 could include one or more internal walls 44 arranged to form a serpentine passageway 46 between the

inlets 38 and outlets 40. The cooling air CA can enter the internal cavity 36 through the inlets 38, travel along the passageway 46, then exit the outlets 40. Although shown in the figure as disposed along the trailing edge, the outlets 40 could reside anywhere on the airfoil section 28 and in any desired arrangement.

[0023] As seen in Figure 4, foreign material F can become trapped within the cavity 36. Various causes can introduce the foreign material F to the cavity 36. For instance, harsh operating conditions can introduce the foreign material F (*e.g.* sand) into the engine 10. In addition, maintenance operations (*e.g.* coating removal) can introduce the foreign material F to the cavity 36. In fact, the manufacturing process that produces the turbine blade 22 could introduce the foreign material F. Although shown at one specific location within the cavity 36, the foreign material F could reside at any location within the cavity 36.

[0024] The presence of the foreign material F within the cavity 36 can reduce the effectiveness of the cooling air CA. Unless successful removal of the foreign material F occurs, the turbine blade 22 will likely not return to service (*i.e.* scrapped). Scrapping a turbine blade 22 can be costly. Removal of the foreign material F from the cavity 36 can prove difficult for several reasons. First, the operation of the engine 22 with the foreign material F present, the performance of maintenance operations and the manufacturing processes tend to sinter the foreign material F in place. Second, the typical size of the inlets 38 and outlets 40 and the shape of the serpentine passageway 46 make access to the foreign material F difficult.

[0025] The following describes the steps in one possible method of refurbishing the turbine blade 22 by removing the foreign material F. Although described with specific reference to a turbine blade, the methods described herein have applicability with any part having an internal cavity that may contain foreign material F. These parts could be other parts of the engine 10, such as turbine vanes, or parts unrelated to gas turbine engines.

[0026] One step in a possible method of removing the foreign material F is to locate the foreign material F within the cavity 36. Depending on the position of the foreign material F within the serpentine passageway 46, various techniques are available to locate the foreign material. For example, the technician may visually identify the location of the foreign material F. Most likely, however, the technician would need to rely on suitable machines to locate the foreign material F. For instance, the technician could use x-ray, neutron radiography, ultrasound and thermal imaging to locate the foreign material F.

[0027] Another step in a possible method of removing the foreign material F is to create another opening in the turbine blade 22. Figure 5 shows the turbine blade 22 with an additional opening 48 in communication with the cavity 36. The technician could rely on any suitable technique to create the additional opening 48 in the turbine blade 22. For example, a technician could utilize a router, milling machines, electrical discharge machining (EDM) or laser drilling to create the additional opening 48. As seen in the figure, the additional opening 48 could have the shape of a channel on the tip of the turbine blade 22, transversing the turbine blade 22 from a concave side to a convex side of the airfoil section 28, but other shapes are possible. The figure also shows the

opening 48 extending in the radial direction, but other orientations (*e.g.* angled relative to the radial direction) are possible.

[0028] Furthermore, the additional opening 48 could have any suitable position on the turbine blade 22. The position of the additional opening 48 could be selected relative to the location of the foreign material F and to the specific techniques used in later method steps. Generally speaking, one suitable location for the additional opening 48 is radially outboard of the foreign material F and as close to the foreign material F as possible. As seen in the figure, the additional opening 48 is downstream of the foreign material F.

[0029] Performing the locating step is not mandatory. Without the locating step, the technician does not know the exact location of foreign material or if foreign material even resides within the cavity 36. In this instance, one suitable location for the additional opening 48 is adjacent an expected location of the foreign material F, determined either by prior experience or estimation. After adding the additional opening 48, preparation of the turbine blade 22 has occurred. The turbine blade 22 can proceed to another step in a possible method, the removal of the foreign material F.

[0030] Figure 6 shows another step in a possible method of removing the foreign material F. The figure displays a cleaning device for the cavity 36, such as a high-pressure washer 50. The washer includes a fluid source 52, a manifold 54 for receiving fluid W from the fluid source 52 and one or more probes 56 for discharging the fluid into the cavity 36. The shape of the serpentine passageway 46 can determine the length and positioning of the probes 56 within the

cavity 36. As an example, the location of the probes 56 helps direct the fluid through the serpentine passageway 46 and out of the cavity 36. While water appears the most economical and environmentally friendly choice to flush out the foreign material F, the washer 50 could operate with other fluids, or even with water having additives therein.

[0031] The washer 50 could operate, for example, at pressures of between approximately 1000 and 20,000 psi. In addition, the washer 50 could have an automatic wash cycle or the technician could manually operate the washer 50. As an example, the washer 50 could be a HDP52 Power Flush unit available from Hammelmann Corporation of Dayton, Ohio.

[0032] Although shown in Figure 6 as entering the cavity 36 through the inlets 38, the probes 56 could enter the cavity 36 through any suitable opening. In other words, the probes 56 could enter the cavity 36 through the outlets 40 or the additional opening 48. That allows the additional opening 48 to either serve as an entrance for the fluid into the cavity 36 or, as seen in Figure 6, as an exit for the fluid W from the cavity 36. The technician may need to repeat the aforementioned method any number of times to remove the foreign material F entirely.

[0033] Rather than using the washer 50, the present invention could use alternate steps to dislodge the foreign material F. As one example, a technician could use an implement, such as a pick, to enter the cavity 36 and to physically contact the foreign material F. The technician could insert the implement through the additional opening 48, although the other openings are also available. Entering the cavity 36 through the additional opening 48 may require the additional opening 48 to have a different location or shape than that described above. For example, the

additional opening could be directed towards the foreign material F to assist insertion of the implement.

[0034] After dislodging the foreign material, another step in a possible method is to close the additional opening 48. The technician could use any suitable technique to close the additional opening 48. Depending on the material used for the turbine blade 22, suitable techniques include, for example, weld build-up, a weld plug, transient liquid phase bonding and brazing a filler material therein.

[0035] Figure 7 displays the turbine blade 22 after closing the additional opening 48. The turbine blade 22 now has a repaired section 58 that was once the additional opening 48. In other words, the additional opening was a temporary feature on the turbine blade 22. Preferably, the repaired turbine blade 22 mirrors the turbine blade before the repair, except for the foreign material F. The present invention allows for the salvage of turbine blades 22 that, due to the presence of the foreign material F in the cavity 36, would typically require scrapping.

[0036] The present invention has been described in connection with the preferred embodiments of the various figures. It is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

CLAIMS

1. A method of preparing a part for cleaning, comprising the steps of:

providing a part with an internal cavity, at least one opening in communication with said cavity, and foreign material within said cavity; and

creating an additional opening in said part at a location adjacent said foreign material.

2. The method of claim 1, further comprising the step of locating said foreign material within said cavity, wherein said creating step is responsive to said locating step.

3. The method of claim 2, wherein said locating step comprises visual recognition.

4. The method of claim 2, wherein said locating step comprises x-ray, n-ray, ultrasonic or thermal imaging analysis.

5. The method of claim 1, wherein said cavity has a passageway from an inlet to an outlet, and said location of said additional opening is downstream of said foreign material.

6. The method of claim 1, wherein said part is a blade or vane.

7. A method of cleaning a part, comprising the steps of:

providing a part with an internal cavity, at least one opening in communication with said cavity;

creating an additional opening in said part; and

flushing said cavity with a fluid;

wherein said additional opening acts as an exit or entrance for said fluid.

8. The method of claim 7, wherein said part has foreign material within said cavity, and said creating step includes the step of locating said foreign material within said cavity

9. The method of claim 8, wherein said creating step is responsive to said locating step.

10. The method of claim 8, wherein said cavity has a passageway from an inlet to an outlet, and said additional opening is located downstream of said foreign material.

11. The method of claim 7, wherein said flushing step comprises high pressure cleaning.

12. The method of claim 7, further comprising the step of closing said additional opening.

13. The method of claim 7, wherein said part is a blade or vane.

14. A method of repairing a part, comprising the steps of:

providing a part with an internal cavity, at least one opening in communication with said cavity, and foreign material within said cavity;

creating an additional opening in said part; and

removing said foreign material;

wherein said removing step occurs through said additional opening.

15. The method of claim 14, wherein said removing step comprises flushing said cavity with a fluid.

16. The method of claim 15, wherein said flushing step comprises high pressure cleaning.

17. The method of claim 14, wherein said creating step positions said additional opening adjacent said foreign material.

18. The method of claim 17, wherein said creating step positions said additional opening downstream of said foreign material.

19. The method of claim 14, further comprising the step of locating said foreign material within said cavity, wherein said creating step is responsive to said locating step.

20. The method of claim 14, further comprising the step of closing said additional opening.

21. The method of claim 14, wherein said part is a blade or vane.

22. A part, comprising:

an exterior surface;

an internal cavity;

at least one opening through said surface and in communication with said cavity; and

a repaired section of said surface;

wherein said repaired section was an additional opening that provided a temporary exit or entrance to said cavity for removing foreign material from said cavity.

23. The part of claim 22, wherein said part is a gas turbine engine part.

24. The part of claim 22, wherein said part is a blade or vane.