

(19)



(11)

**EP 1 990 445 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:

**12.11.2008 Bulletin 2008/46**

(51) Int Cl.:

**C23G 5/00** (2006.01)  
**F01D 25/00** (2006.01)

**F01D 5/00** (2006.01)

(21) Application number: **08251543.8**

(22) Date of filing: **28.04.2008**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT  
RO SE SI SK TR**

Designated Extension States:

**AL BA MK RS**

(30) Priority: **30.04.2007 US 796989**

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(54) **Method for removing carbide-based protective coatings**

(57) The present invention is a method for processing a metal component comprising exposing a carbide-based coating to fluoride ions, thereby extracting a carbide material from the carbide-based coating to provide

a residual coating on the metal component, and removing the residual coating from the metal component.

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## Description

### BACKGROUND

**[0001]** The present invention relates the repair of metal components, such as gas turbine engine components. In particular, the present invention relates to the removal of protective coatings during the repair of metal components.

**[0002]** Turbine engine components are exposed to extreme temperatures and pressures during the course of operation. As such, these engine components typically employ high-strength alloys (e.g., superalloys) to preserve the integrity of the components. However, over time, exposed portions of the components are subject to wear, cracking, and other degradations, which can lead to decreases in operational efficiencies and damage to the components.

**[0003]** Due to economic factors, it is common practice in the aerospace industry to restore turbine engine components rather than replace them. However, many of the engine components include protective coatings that need to be removed before the restoration can begin. For example, carbide-based coatings, such as chromium carbide-based coatings, are typically coated onto engine components to increase wear resistance and sliding mechanics between moving parts.

**[0004]** Current techniques for removing carbide-based coatings typically involve machining, grinding, or grit blasting the coatings. However, these techniques may remove portions of the underlying metal components along with the coatings. Thus, if the coating removal processes are not sufficiently monitored, they may reduce the wall thicknesses of the metal components to levels that are too thin for repair. In these situations, the metal component is no longer repairable, and is discarded or recycled. Accordingly, there is a need for a process for removing carbide-based coatings from metal components that also substantially preserves the underlying metal components.

### SUMMARY

**[0005]** The present invention relates to a method for processing a metal component having a carbide-based coating. The method includes exposing the carbide-based coating to fluoride ions, thereby extracting a carbide material from the carbide-based coating. This provides a residual coating on the metal component, which is then removed from the metal component.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### **[0006]**

FIG. 1 is a sectional view of a metal component containing a carbide-based coating.

FIG. 2 is a sectional view of the metal component

containing a residual coating after the carbide-based coating is exposed to fluoride ions.

FIG. 3 is a sectional view of the metal component after the residual coating is removed.

### DETAILED DESCRIPTION

**[0007]** FIG. 1 is a sectional view of metal component 10, which includes substrate 12 and coating 14. Metal component 10 may be any type of component capable of containing coating 14, such as turbine engine components. Substrate 12 is a metal substrate (e.g., nickel-based alloys and superalloys, cobalt-based alloys and superalloys, and combinations thereof) of metal component 10, and includes surface 16. Coating 14 is a carbide-based coating formed on surface 16 of substrate 12 (e.g., via plasma spray deposition) to provide wear resistance and sliding properties during use. As used herein, the term "carbide-based coating" refers to a coating that includes at least one carbide material. Examples of suitable carbide materials for use in the carbide-based coating include chromium carbide materials (e.g.,  $\text{Cr}_3\text{C}_2$ ,  $\text{Cr}_7\text{C}_3$ , and  $\text{Cr}_{23}\text{C}_6$ ), tungsten carbide materials (e.g., WC), and combinations thereof. Coating 14 may also include other materials, such as nickel chromium (NiCr) alloys, cobalt (Co) alloys, and combinations thereof. An example of a suitable chromium carbide-based coating for coating 14 includes about 75% by weight of a chromium carbide material and about 25% by weight of a nickel chromium alloy. Suitable coating thicknesses for coating 14 range from about 25 micrometers (about 1 mil) to about 500 micrometers (about 20 mils).

**[0008]** Pursuant to the present invention, coating 14 may be removed by initially exposing metal component 10 to fluoride ions, which react with coating 14 to extract at least a portion of the carbide material (e.g., the chromium-carbide material) from coating 14. Metal component 10 may be exposed to fluoride ions by placing metal component 10 in a chamber containing hydrogen fluoride (HF) gas. The chamber may also include additional gases (e.g.,  $\text{H}_2$ ) to accommodate desired pressures and reaction rates. While within the chamber, the hydrogen fluoride gas and metal component 10 are then heated to a temperature sufficient to generate the fluoride ions from the hydrogen fluoride gas. Examples of suitable temperatures for generating the fluoride ions include temperatures of at least about 820°C (about 1500°F), with particularly suitable temperatures ranging from about 870°C (about 1600°F) to about 1100°C (about 2000°F). This causes the fluoride ions of the hydrogen fluoride gas to react with coating 14, thereby extracting at least a portion of the carbide material from coating 14.

**[0009]** The amount of carbide material removed from coating 14 is generally dependent on the concentration of the fluoride ions, the temperature used, the surface area of coating 14, and the duration of the extraction. In one embodiment, the extraction is continued until at least about 50% by weight of the carbide material is removed

from coating 14. In a more preferred embodiment, the extraction is continued until at least about 75% by weight of the carbide material is removed from coating 14. In an even more preferred embodiment, the extraction is continued until at least about 90% by weight of the carbide material is removed from coating 14. The weight percents of the removed carbide material are based on the pre-extraction weight of coating 14. Examples of suitable durations for the extraction process range from about 10 minutes to about 3 hours, with particularly suitable durations ranging from about 30 minutes to about 1 hour. When the extraction process is complete, metal component 10 may be removed from the chamber and cooled.

**[0010]** FIG. 2 is a sectional view of metal component 10 after the extraction process, which includes residual coating 18 disposed on surface 16 of substrate 12. Residual coating 18 is the remaining coating of coating 14 (shown in FIG. 1) after the extraction process. Because of the carbide material removal, residual coating 18 primarily includes the non-carbide portion of coating 14 (e.g., the nickel chromium alloy) and any residual amount of the carbide material that was not extracted. However, because a substantial portion of the carbide material was removed, residual coating 18 is structurally weaker than coating 14. Thus, residual coating 18 can be removed from surface 16 of substrate 12 without requiring the high-intensity machining, grinding, or grit blasting that are typically used to remove carbide-based coatings.

**[0011]** Residual coating 18 may be removed from surface 16 with low-pressure abrasive techniques (e.g., low-pressure grit blasting). The duration of the removal process may vary depending on the pressure used. However, the pressure required to remove residual coating 18 is substantially less than what is otherwise required to remove a carbide-based coating not subjected to the fluoride-ion extraction process (i.e., coating 14). Suitable pressures for removing residual coating 18 from surface 16 include removal pressures that are less than 25% of removal pressures required to remove coating 14 from surface 16 in the same duration, with particularly suitable removal pressures including less than 10% of the removal pressures required to remove coating 14 from surface 16 in the same duration, and with even more particularly suitable removal pressures including less than 5% of the removal pressures required to remove coating 14 from surface 16 in the same duration. As used herein, the term "removal pressure" refer to a pressure that is actually applied to the coating (e.g., coating 14 or residual coating 18). For removal techniques that are distance dependant (e.g., grit blasting), the discharge pressure is typically greater than the pressure actually applied to the coating.

**[0012]** FIG. 3 is a sectional view of metal component 10 after the residual coating 18 is removed. After residual coating 18 is removed, the resulting metal component 10 may undergo the necessary repair processes to restore metal component 10 to operable condition. Because residual coating 18 (shown in FIG. 2) can be removed with a low-pressure technique, the risk of damaging surface

16 during the removal process is reduced. Accordingly, pursuant to the present invention, coating 14 (shown in FIG. 1) may be removed from substrate 12 while substantially preserving the dimensions of surface 16.

**[0013]** Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention.

## Claims

1. A method for processing a metal component (10) having a carbide-based coating (14), the method comprising:

exposing the carbide-based coating (14) to fluoride ions, thereby extracting a carbide material from the carbide-based coating (14) to provide a residual coating (18) on the metal component (10); and  
removing the residual coating (18) from the metal component (10).

2. The method of claim 1, further comprising heating the metal component (10) to a temperature of at least about 820°C.

3. The method of claim 2, wherein the metal component (10) comprises a material selected from the group consisting of a nickel-based alloy, a nickel-based superalloy, a cobalt-based alloy, a cobalt-based superalloy, and combinations thereof.

4. The method of any preceding claim, wherein at least about 50% by weight of the carbide material is extracted from the chromium carbide-based coating (14), based on a pre-extraction weight of the carbide-based coating.

5. The method of claim 4, wherein at least about 75% by weight of the carbide material is extracted from the carbide-based coating (14).

6. The method of claim 5, wherein at least about 90% by weight of the carbide material is extracted from the carbide-based coating (14).

7. The method of any preceding claim, wherein the residual coating (18) is removed from the metal component (10) with a first removal pressure that is less than 25% of a second removal pressure required to remove the carbide-based coating (14) from the metal component in a same duration.

8. The method of claim 7, wherein the first removal pressure is less than 10% of the second removal

pressure.

9. The method of claim 8, wherein the first removal pressure is less than 5% of the second removal pressure. 5
10. The method of any preceding claim, wherein the carbide material is selected from the group consisting of chromium carbide materials, tungsten carbide materials, and combinations thereof. 10
11. The method of any preceding claim, wherein the carbide-based coating is exposed to hydrogen fluoride.
12. The method of claim 11, further comprising: 15  
heating the metal component (10) to react the hydrogen fluoride with the carbide-based coating (14), thereby providing the residual coating (18) on the metal component. 20
13. The method of claim 12, wherein the metal component (10) and hydrogen fluoride and heated to a temperature of at least about 820°C. 25
14. The method of claim 12 or 13, wherein the hydrogen fluoride reacts with the carbide-based coating (14) until at least about 50% by weight of a carbide material is extracted from the carbide-based coating (14), based on a pre-extraction weight of the carbide-based coating. 30

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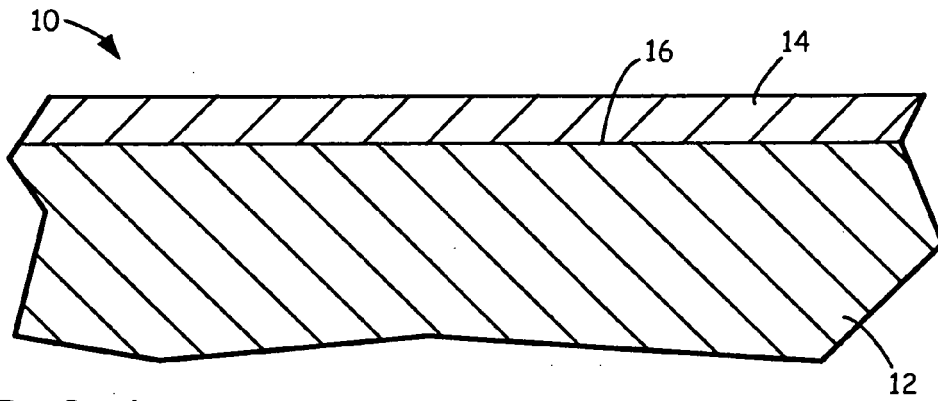


FIG. 1

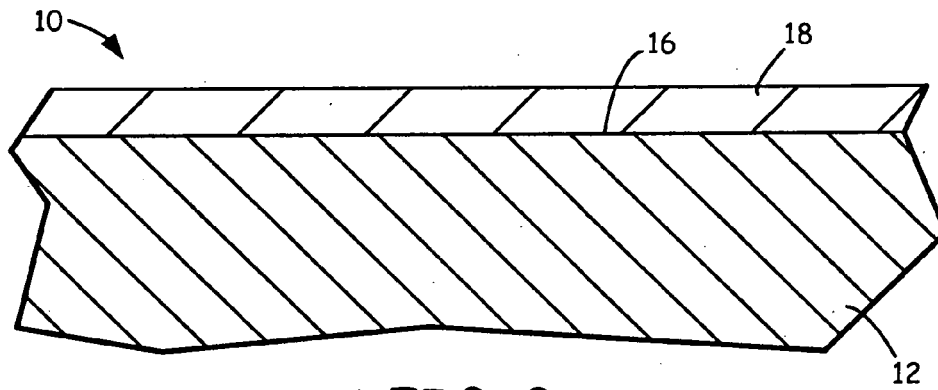


FIG. 2

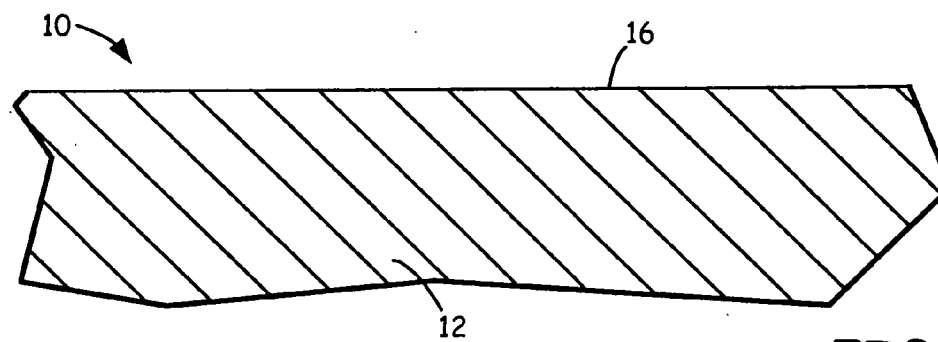


FIG. 3



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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 August 2008	Examiner Handrea-Haller, M
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EPO FORM 1503 03.82 (P04C01)



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