

Method for electrochemically stripping of gas turbine components

The invention relates to a method for electrochemically stripping of gas turbine components with the features of the preamble of claim 1.

Components in gas turbines, in particular in aircraft engines, are subject to different requirements. In the front section of the gas turbine and in the area of the compressor, the occurring temperatures are relatively low in comparison to the rest of the engine and therefore for components used in this area the temperature strength is less prioritised, the focus is rather on the resistance of the used parts, particularly the vanes and the blades, against oxidation, corrosion and erosion. This wear is, among other things, caused by solid particles, for example sand and dust, which are sucked in by the gas turbine and moved through the engine with the gas flow. The components can be damaged through the erosive effect of the particles, which leads to performance loss of the engine and requires a periodic change of the expensive components. To extend the life time of the vanes and blades used in the compressor, they are coated with wear-resistant coatings. But with time even this wear-resistant coatings are worn out. Before the wear-resistant coating can be reapplied during a routine overhaul of the gas turbine, the remains of the old coating need to be removed from the blades. Such a removal of the wear-resistant coating can often not be done without a damage of the base material of the blades. In particular physical methods, for example sandblasting, are always connected with a

removal of base material. The already relatively thin wall thickness of the blades is further reduced, and to make matter worse such a removal of the wear-resistant coating also changes the thickness ratios of the blades and therefore also the gas flow ratios. As an alternative to physical methods, like sandblasting for example, chemical and electrochemical methods have been established. These methods are usually specifically developed for each combination of base material and coating material, because depending on the type of material different parameters, for example compositions of the liquid medium, temperatures, voltages, currents, pH values or additives have to be chosen. Some coatings can only be removed from the base material with very specific cathode geometries, pulsed voltage or other aids in a satisfactory manner.

For example in the printed document DE 10 2004 009 757 A1 such a cathode is described, which is adapted to the component geometry, and which is supposed to increase the quality of the blade decoating. In addition to the cathode adapted to the blade, a pulsed voltage is also used.

For the removal of a different coating, the US patent 6 454 870 B1 describes an electrochemical decoating method called "stripping" which is particularly preserving to the components and removes the wear-resistant coating, in this case a chromium oxide coating, with the help of a medium based on hydrochloric acid.

New and complex wear-resistant coatings make it possible to realise a continuously higher erosion protection for engine components. One example for such an innovative variant of a wear-resistant coating is a so called multilayer system, whereas the multilayer system comprises one or several layer

systems arranged on top of each other, whereas a singular layer system always comprises a metal and a ceramic that is related to the element of said metal (for example Cr and CrN). Such multilayer systems are preferably applied via Electron Beam Physical Vapour Deposition (EB-PVD) on gas turbine components.

The described structure of the described innovative multilayer system shall be shortly explained with the usage of Figures 2 and 3: In the figure 2 a multi layer system 13 is shown, which is formed by four singular layer systems 11 arranged on top of each other, which have been applied on a substrate 10 for example by EB-PVD. A layer system 11 always comprises a metal 14 and a ceramic 15 that is related to the element of said metal 14. Related to said element of the metal 14 means that the metallic bonding partner of the ceramic 15 (in case of chromium nitride this would be chromium) comprises the same element as the metal 14. Therefore the ceramic 15 is composed from a non metallic bonding partner and a metallic bonding partner, whereas the metallic bonding partner comprises - at least predominantly - the same metallic element as the metal 14. The same metal is therefore present as the metal 14 in elementary form and additionally it forms the ceramic 15 with at least one non metallic element. In case of a layer system 11 from chromium and chromium nitride chromium is on the one hand present as the metal 14 and additionally in a bound form together with nitride as the ceramic 15 (chromium nitride). The ceramic 15 is in this case related to the element of the metal 14. Next to Cr and CrN, Cr and CrAlN, Ti and TiN as well as Ti and TiAlN are further examples of such a metal 14 and a ceramic 15 related in element.

The layer system 11 can also comprise additional layers; this state is illustrated in the figure 3. For example between the layer of metal 14 and the layer of ceramic 15 an intermediate layer from a metal alloy material 17 and an intermediate layer from graded metal ceramic material 16 can be provided.

By means of EB-PVD applied layers show a significantly higher adhesion to the base material and a lower porosity than in other methods, like plasma spraying methods for example. However the result is also that the layers are more difficult to remove than those applied with plasma spraying methods.

Usually ceramic layers can be removed much more poorly from components by electrochemical methods than the metallic layers (due to the usually lower electrical conductivity of ceramics), whereas the stripping is particularly problematic when several different types of layers are to be stripped at the same time. Furthermore not all electrochemical methods are preserving to the components, so the partly very aggressive solutions can also attack the base material of the component. The electrochemical stripping methods known from the prior art can lead to a uniform surface attack on the base material of the gas turbine components with such a multi layer system, but also to an intergranular desintegration of the microstructure. The electrolyte solutions used there, the so called galvanic baths, for example base on molten salt (Molten Salt Method) or on hydrochloric acid and can damage materials like titanium alloys or nickel-based alloys. Besides the direct uniform surface attack of the base material such electrolyte solutions can also cause intergranular corrosion in the base material. On such an attack the grain boundaries of the microstructure are dissolved faster than the grains themselves, which leads to full grains being extracted from the microstructure and a

gradual dissolving of the base material. Even if such a damage effect is not visible so much as the erosion from sandblasting, the microstructure of the base material is significantly weakened by the stripping method and the structural integrity is reduced. This effect occurs on each stripping process again, so the damage effect of the intergranular attack accumulates over the total life time of the blade. The base material microstructure is more and more worn out by each necessary stripping of the old wear-resistant layer performed during the routine reapplication of the wear-resistant layer, which stands in contradiction to the actual goal of the maintenance, the prevention of the engine components' erosion. Because no preserving stripping method is yet known for the described new multilayer system, it is usually removed by abrasive blasting processes, which, as described before, brings with it a removal of base material and therefore a damage of the component. An example for abrasive blasting methods is the blasting with aluminum oxide (corundum), which can cause a high material erosion itself and furthermore usually follows after the Molten Salt Method.

In line with these facts, it is the objective of the invention to provide a preserving method for the electrochemical stripping of gas turbine components and a corresponding apparatus for carrying out the method.

The invention solves this objective through a method with the features of claim 1 and an apparatus with the features of claim 10. Other preferred embodiments of the invention can be found in the dependent claims and the corresponding description and drawings.

According to the invention a method for solving the objective is provided, in which the gas turbine component made of from a Titanium alloy or stainless steel, which comprises a multi-layer system on the surface, is polarized as an anode in an electrolyte solution, and the electrolyte solution comprises sodium carbonate and a tartrate source. The method here described offers important advantages in comparison to the already established methods which are used for the stripping of gas turbine components. As has been found out in experiments, the base material of the gas turbine component is not attacked by the method according to the invention, wherein in particular material removal or the detrimental change of the micro-structure occurring in other chemical and physical methods does not occur. The reason for this is that through the combination of sodium carbonate and tartrate a solution is obtained by which the electrochemically detached metal ions (for example chromium ions) of the multilayer can be very efficiently complexed and thereby kept in the galvanic bath and the base material is passivated during the stripping und thereby further counteracts against a damage of the base material. The ceramic components of the multilayer system can accumulate as sludge during the stripping method.

Preferably the electrolyte solution has a pH value of 10 to 12, because it has been found out in experiments that in the pH value range of 10-12 the best results can be obtained.

Preferably sodium potassium tartrate and/or sodium tartrate and/or tartaric acid (which is present as tartrate in the pH value range of 10-12) is used as the tartrate source. These chemicals are easily available in large quantities and take environmental aspects of the galvanic process into account. For example sodium tartrate has only a very little to no rele-

vance to the environment and is an approved food additive with the number E 335. Also, sodium potassium tartrate is approved as a food additive with the number E 337, as is tartaric acid with the number E 334. While an approval as a food additive
5 does not mean that the substances are entirely harmless, but compared to many other galvanic baths that are industrially used for stripping, the food additive approval of the inventive electrolyte solution constituents is a clear indicator for its environmental compatibility.

10 Ideally the temperature of the electrolyte solution is in the range of 50-80°C, preferably 60-70°C. It is known that the temperature has a significant impact on the rate of chemical reactions. In the area of 40-80°C, preferably 60-70°C, the
15 best results can be obtained, the galvanic process runs in a controlled manner and very short process times (up to 2 hours) can be achieved. In addition to the bath temperature the foreign metal concentration in the solution is monitored and when it exceeds a defined limit value, the solution is disposed of
20 in accordance with the usual standards.

Preferably the voltage applied to the gas turbine component is in the range of 3-8 V, preferably 4-6 V. The voltage to be applied depends on the component to be stripped, wherein the
25 specified range is ideal for the plurality of gas turbine components made of titanium alloy or stainless steel. Too high voltages can cause unwanted base material removal, therefore the applied voltage is to be kept constant by a power supply. To ensure a gentle stripping, the voltage is preferably slowly
30 regulated up to the desired level.

Preferably steel is used as the cathode material. Since the cathode material can have a significant influence on the qual-

ity of the stripping process, a cathode material has to be chosen that has the best possible impact on the quality of the stripping process. Steel as cathode material leads to the best results for the method according to the invention.

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The described method is well suited for stripping multilayer systems that comprise the ceramic components CrN, CrAlN, TiN, or TiAlN.

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In the following the invention shall be illustrated on the basis of a preferred embodiment with reference to the accompanying drawings. In the figures can be seen in detail:

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Fig. 1: A schematic view of an apparatus for the electrochemical stripping of a gas turbine component

Fig. 2: Representation of a multilayer system

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Fig. 3: Representation of a singular layer system

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In the figure 1 a container 4 can be seen which contains an electrolyte solution 2. Furthermore a lowering apparatus 6 is provided, by which a gas turbine component 1 is lowered into the electrolyte solution 2. The gas turbine component 1 was previously cleaned from oil, grease, dirt or other contaminants. Such contaminants can negatively affect the stripping method and should therefore be thoroughly removed with known means.

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The gas turbine component 1 in this embodiment is made from a titanium alloy or stainless steel and comprises a multilayer system 13 on the surface. The lowering apparatus 6 also forms the anode and is connected to a power supply 5, which is fur-

ther connected to a cathode 8. The lowering apparatus 6 is preferably designed in such a way that it can mount and lower a plurality of gas turbine components 1 at the same time. Advantageously individual voltages can be set for different gas turbine components 1, in case this is favourable or necessary because of size and/or geometry differences. The power supply 5 is generally used to apply a positive charge on the gas turbine components 1, to switch them as anode, and to apply a negative charge on the cathode 8. The cathode 8 can be designed as a separate component being lowered into the electrolyte solution 2 or firmly installed in the electrolyte solution 2 or, as in this embodiment, be realised through the container 4 itself and thus surrounding the electrolyte solution 2 within a large area. The cathode 8 and/or the container 4 respectively is preferably made from steel and insulated to the outside, for example by a plastic coating. Here emerges one of the big advantages of the method according to the invention, because the cathode geometry can be relatively simple. A special geometry exactly adapted to the geometry of the gas turbine component 1 is not necessary. The method can therefore be performed with much less processing effort than many comparable methods known in the prior art. Another advantage of the method according to the invention without a geometrically adapted cathode is that by simple means a high quantity can be stripped at the same time. To further minimize the processing effort, the cathode 8 can also be preferably designed to be easily exchangeable. In case the cathode 8 wears down in some form, it can be easily replaced by this exchange option and the process does not have to be interrupted for a long time.

The composition of the electrolyte solution 2 is based on the base material and comprises sodium carbonate and a tartrate source for gas turbine components 1 that are made from a tita-

5 nium alloy or from stainless steel. In this embodiment, the electrolyte solution comprises sodium carbonate (150-250 g/l), and either sodium tartrate (60-90 g/l), sodium-potassium tartrate (60-90 g/l) or tartaric acid (25-40 g/l) in a composition having a pH value in the range of 10 to 12. The chemical components used in the method described here offer important advantages in comparison to the established procedures. The used base materials are not attacked, the material removal or the change of the microstructure observed in other chemical and physical processes do not occur. The temperature of the electrolyte solution 2 is set by a temperature control 3 at 60-70°C. The voltage applied to the gas turbine component 1 via the power supply 5 is slowly raised from 0 V to 4-6 V and held for so long until the multilayer system is stripped from the gas turbine component 1. Depending on the age of the electrolyte solution 2, the ideal holding time is different. Based on experience and optical inspection the exact time is determined at which the multilayer system 13 is fully stripped from the gas turbine component 1 and the gas turbine component 1 should be lifted out of the electrolyte solution 2 by the lowering apparatus 6. Residues of the multilayer system 13 can be removed with a soft brush if necessary. Through a bath monitoring means 7 the composition of the electrolyte solution 2 can be periodically controlled. Thereby the concentration of metal impurities in the electrolyte solution 2 can be monitored. If necessary a preparation of a fresh electrolyte solution 2 is prompted. The used up electrolyte solution 2 must then be disposed of according to current regulations. Since the composition of the electrolyte solution 2 is relatively environmentally friendly compared to other galvanic baths, the disposal is not only correspondingly simple and therefore cheap, but also advantageously from an environmental point of view and therefore completes the gentle inventive method for

electrochemically stripping of multi layer systems 13 from gas turbine components 1.

In the figure 2 an exemplary multilayer system 13 is shown, which can be gently stripped from a substrate 10 by the stripping method according to the invention. Thus, the substrate 10 is a gas turbine component 1 for instance. The multilayer system 13 was preferably applied by means of a PVD (Physical Vapor Deposition) method on the substrate 10 and/or the gas turbine component 1 respectively. In this example, the multilayer system 13 comprises four layer systems 11. The inventive method is preferably used for the stripping of multilayer systems 13 that comprise three to six layer systems 11, further preferred for multi layer systems 13 that comprise four or five layer systems 11.

The single layer systems 11 comprise a layer of metal 14 and a layer of ceramic 15 related to the element of said metal 14. A preferred layer system 11 is composed of a layer of metal 14 made of chromium and a layer of ceramic 15 made of chromium nitride or chromium aluminum nitride. Another preferred layer system 11 comprises titanium and titanium nitride or titanium aluminum nitride.

In addition to metal 14 and ceramic 15, the layer system 11 can comprise further layers. This is shown in the figure 3. The layer system 11 comprises two further layers. Preferably the layer system 11 comprises a layer of a metal alloy material 17 and a layer of graded metal ceramic material 16.

These intermediate layers can further increase the strength and adhesion of the multilayer system 13. Preferably the intermediate layers are also made from materials related in ele-

ment and homogenize the transition from metal 14 to ceramic 15.

Also for these more complex multilayer systems 13, in which
5 the layer system 11 comprises more than the two layers of
metal 14 and ceramic 15, the stripping method according to the
invention is well suited.

Reference list:

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|----|----|------------------------|
| 5 | 1 | gas turbine component |
| | 2 | electrolyte solution |
| | 3 | temperature control |
| | 4 | container |
| | 5 | power supply |
| 10 | 6 | lowering apparatus |
| | 7 | bath monitoring means |
| | 8 | cathode |
| | 10 | substrate |
| | 11 | layer system |
| 15 | 13 | multilayer system |
| | 14 | metal |
| | 15 | ceramic |
| | 16 | metal ceramic material |
| | 17 | metal alloy material |

Claims:

1. Method for the electrochemically stripping of gas turbine components (1) made of Titanium alloys or stainless steels in an electrolyte solution (2), wherein the gas turbine component (1) comprises a multilayer system (13) on the surface and is polarized as anode, characterized in that the electrolyte solution (2) comprises sodium carbonate and a tartrate source, and the multilayer system (13) comprises at least one layer system (11) of Cr and CrN and/or at least one layer system (11) of Ti and TiN and/or at least one layer system (11) of Cr and CrAlN and/or at least one layer system (11) of Ti and TiAlN.
2. The Method of claim 1, characterized in that the electrolyte solution (2) has a pH of 10 to 12.
3. The Method of claim 1 or 2, characterized in that sodium potassium tartrate and/or sodium tartrate and/or tartaric acid is used as tartrate source.
4. The Method as claimed in any of the preceding claims, characterized in that the temperature of the electrolyte solution (2) is in the range of 40-80°C, preferably 60-70°C.
5. The Method as claimed in any of the preceding claims, characterized in that the voltage applied to the gas turbine component is in the range of 3-8 V, preferably 4-6 V.
6. Apparatus for carrying out a method as claimed in any of the preceding claims comprising a container (4) which contains the electrolyte solution (2), a cathode (8) which is assigned to the electrolyte solution (2), and the gas tur-

bine component (1) made of Titanium alloys or stainless steels, wherein the gas turbine component (1) comprises a multilayer system (13) on the surface and is polarized as anode, characterized in that the electrolyte solution (2) comprises sodium carbonate and a tartrate source, and the multilayer system (13) comprises at least one layer system (11) of Cr and CrN and/or at least one layer system (11) of Ti and TiN and/or at least one layer system (11) of Cr and CrAlN and/or at least one layer system (11) of Ti and TiAlN.

7. The Apparatus as claimed in claim 6, characterized in that the cathode (8) is exchangeable.
8. The Apparatus as claimed in claim 6 or 7, characterized in that the cathode (8) is made of steel.
9. The Apparatus as claimed in any of the claims 6 to 8, characterized in that a plurality of gas turbine components (1) are simultaneously mountable.
10. The Apparatus as claimed in claim 9, characterized in that a different voltage can be set for each gas turbine component (1).

Abstract:

Method for the electrochemically stripping of gas turbine components (1) made of Titanium alloys or stainless steels in an electrolyte solution (2), wherein the gas turbine component
5 (1) comprises a multilayer system (13) on the surface and is polarized as anode, and wherein the electrolyte solution (2) comprises sodium carbonate and a tartrate source.

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(Fig. 1)