Method for repairing a variable guide vane and an accordingly repaired guide vane

The invention relates to a method of repairing a variable guide vane for a gas turbine having the features of the preamble of claim 1. The invention further relates to an accordingly repaired guide vane having the features of the preamble of claim 12.

Variable guide vanes are a particular type of guide vane and are provided in the compressor of some gas turbines, more particularly in certain aircraft engines. They are installed so as to be rotatable about their central axes and can be rotated back and forth between various positions.

Variable guide vanes are advantageous in that, for example when a low quantity of external air is supplied for combustion, for example in the event of low flight velocity of a commercial aircraft, the variable guide vanes can be rotated to achieve an optimal air supply to the combustion chamber.

In order to connect the variable guide vanes to adjacent components, they comprise what are known as rotationally symmetrical connection regions. These rotationally symmetrical connection regions are subject to increased wear and have to be repaired relatively frequently.

For this purpose, it is known and conventional from prior use to reconstruct and repair the damaged component regions by means of high velocity oxy-fuel spraying (HVOF) or plasma spraying.

However, the variable guide vanes thus repaired have reduced wear resistance, so that in use they wear again all the more rapidly.

The problem addressed by the invention is that of providing a method of repairing a variable guide vane, whereby the guide vane can be repaired and provided with comparatively improved wear properties. The problem also includes providing an accordingly repaired guide vane.

The invention solves the problem using the features of the independent claims.

To solve the problem, a method of repairing a variable guide vane for a gas turbine is proposed according to the invention, wherein filler material is applied to the variable guide vane by material application as part of the method, wherein the material is applied by laser beam build-up welding.

As already stated at the outset, variable guide vanes are usually repaired by means of high velocity oxy-fuel spraying (HVOF) or plasma spraying. Contrary to the opinion hitherto held that laser beam build-up welding is in principle unsuitable for repair owing to the high heat input, it has been proven by intensive development that it is in fact possible to repair variable guide vanes using laser beam build-up welding. In this process, the laser beam build-up welding is preferably controlled such that the heat introduced into the variable guide vane is as low as possible. A preferred option for achieving this includes a repair that is adapted to the specific damage.

In the prior art, a plasma spray layer is usually always applied over the entire circumference (360°); thus, for example, the complete outer platform or the entire pin notch of the variable guide vane is reconstructed.

The coating can only produce low deposit thicknesses in this instance. The bond of the spray layer to the base material has a low bonding strength compared with the configuration according to the invention. In addition, the workpiece usually has to be prepared by material removal and then has to be roughened to ensure uniform bonding properties of the layer. In the method according to the invention, these drawbacks do not occur or are at least less pronounced.

In a preferred configuration of the method, only the region having sustained damage is reconstructed by the laser beam build-up welding. It is not necessary to prepare said workpiece by material removal or to roughen said workpiece. The method thus already differs from other coating methods which involve preparation. For example, only a partial region (for example the outer platform or the pin notch of the variable guide vane) of 120°, that is to say (only) the region affected by erosion, and not the full 360°, is refilled using the method. This aspect is further explained at a later point on the basis of the drawings.

Owing to the use according to the invention of laser beam build-up welding, filler materials, for example powder, wire and/or pastes, can be used when welding nickel to nickel, for example. If powders or particles are used, in contrast to flame spraying there is the feature that the particles, in the case of materials having one component, or the powders, in the case of powders having the same melting point (such as nickel – nickel compounds), are generally completely dissolved in a molten bath.

From this molten bath, the material generally solidifies by heat being conducted into the base material. In the metallographic transverse section, after welding the particle size of the starting particles can therefore no longer be detected. Furthermore, no interlocking (positive connection) occurs, as is the case for plasma spraying, but instead an integrally bonded connection is produced. This means that, on the atomic level, atomic bonds are produced between the weld metal and the metal main body. This is promoted by some of the base material also being fused.

The metal connection or integrally bonded connection produced by the laser beam build-up welding is generally considerably stronger than the spray coating, which is partly interlocked and partly by welding. In addition, plasma layers generally have more pores than a well-configured welding process. A well-configured welding process means a preferred process in which gas pockets leave the molten metal before it solidifies.

Preferably, the filler material is in the form of a powder, preferably having powder particle sizes in a range of from 40 to 150 µm, more preferably 50 to 75 µm. As known from experience, the best results can be achieved using these powder sizes. Powder particle sizes in a range of from 5 to 150 µm of the filler material may also be suitable.

During laser beam build-up welding, powder and/or wire is preferably used as a filler material. Owing to it being supplied in powder- and/or wire form, lower porosities and better bonding can be achieved than with high velocity oxy-fuel spraying.

Furthermore, the layer strength is increased owing to the lower quantity of pores and the solidification from a molten metal. By using wire as a filler material, the level of utilisation of the filler materials can reach almost 100 %; a level of utilisation of from

30 to 95 % is normal for powders. A high level of utilisation increases the cost-effectiveness of the repair method.

Preferably, the variable guide vane is processed in an inert gas atmosphere. This gas environment is preferably a non-reactive or oxidising gas. Argon and helium are preferably provided.

Preferably, at least two further variable guide vanes are kept available in the inert gas atmosphere for processing. In this way, a plurality of variable guide vanes can be processed in parallel. When for example one or two variable guide vane(s) are in the cooling phase, this time can be used to process a third variable guide vane.

To solve the problem, a variable guide vane for a gas turbine is also proposed, the variable guide vane being repaired according to the above-described method. It is advantageous to use such a guide vane according to the invention, since it has increased wear resistance and an increased service life compared with known repaired variable guide vanes. Such a variable guide vane is more cost-effective, since it is reinforced at specific points of wear, and thus needs to be repaired less frequently.

The invention is described in the following on the basis of preferred embodiments with reference to the accompanying drawings, in which:

Fig. 1 is a side view of a variable guide vane with damage;

Fig. 2 is a plan view of a variable guide vane with weld lines shown;

Fig. 3 shows a guide vane arrangement for parallel welding on a plurality of variable guide vanes;

Fig. 4 shows a preferred linear guide vane arrangement;

Fig. 5 shows a preferred arc-shaped guide vane arrangement.

particularly in the range of from 1.0 to 2.0 mm. In this respect, the local heat input is advantageous, since rotationally symmetrical components in particular are particularly susceptible to deformations which would occur in the case of relatively extensive heat input. In particular, owing to the method proposed according to the invention, no warping or distortion of the pin 6, which is circular in cross section, or of the bushing occurs, so that the re-worked components after the re-working remain centred with respect to each other, as required.

Owing to the method according to the invention, it is possible here to restrict the repair to merely the region of wear 9 which has actually sustained damage. The methods known from the prior art only provide for the relevant portion – that is to say the outer platform, for example – to be completely (360°) machined off and then rebuilt.

As shown in the example in Fig. 2, owing to the method according to the invention, solely a partial region of a portion, that is to say for example a third (120°) of the outer platform 5, can also be machined off and reconstructed.

The heat input introduced into the variable guide vane can thus be reduced. In addition, by using particular materials (described in detail above), the wear resistance of the repaired variable guide vanes can be increased.

By means of the parallel laser beam build-up welding (also already described above) of a plurality of variable guide vanes 1, the heat input into each guide vane can be further reduced.

The preferred arrangements of variable guide vanes 1 used therefor are shown in Fig. 3 to 5.

For example, as shown, six variable guide vanes 1 can be processed simultaneously, preferably, however, considerably more, for example up to 50 variable guide vanes 1, are processed simultaneously.

Preferably, at least so many variable guide vanes 1 are processed simultaneously that the laser can be continuously utilised for processing. This means that so many

Claims

1. Method of repairing a variable guide vane (1) for a gas turbine, wherein filler material is applied to the variable guide vane (1) by material application as part of the method, characterised in that the material is applied by laser beam build-up welding.

2. Method according to claim 1, characterised in that the material application includes applying a wear-resistant material.

3. Method according to any of the preceding claims, characterised in that the material is applied to the inner and/or outer platform (3, 5) of the variable guide vane (1).

4. Method according to any of the preceding claims, characterised in that the material is applied to the inner and/or outer pin (2, 6) of the variable guide vane (1).

5. Method according to any of the preceding claims, characterised in that the material application includes applying stellite or nitride, preferably titanium nitride, chromium nitride and/or boron nitride.

6. Method according to any of the preceding claims, characterised in that the material application includes applying hard-material composite layers comprising carbides, preferably tungsten carbide or titanium carbide.

7. Method according to any of the preceding claims, characterised in that a plurality of material layers is applied to the variable guide vane (1) in succession, and, between applying two material layers to the variable guide vane (1), at least one material layer being applied to at least one further, preferably to at least two further, variable guide vanes (1).

8. Method according to any of the preceding claims, characterised in that a metallurgical bond is produced as part of the method between the variable guide vane (1) and the filler material that is applied.

9. Method according to any of the preceding claims, characterised in that the filler material is in the form of a powder, preferably having powder particle sizes in a range of from 40 to 150 µm, more preferably 50 to 75 µm.

10. Method according to any of the preceding claims, characterised in that the variable guide vane (1) is processed in an inert gas atmosphere.

11. Method according to claim 10, characterised in that at least two further variable guide vanes (1) are kept available in the inert gas atmosphere for processing.

12. Variable guide vane (1) for a gas turbine, characterised in that the variable guide vane (1) is repaired using a method according to any of claims 1 to 11.

Method for repairing a variable guide vane and an accordingly repaired guide vane

The invention relates to a method of repairing a variable guide vane for a gas turbine having the features of the preamble of claim 1.

Variable guide vanes are a particular type of guide vane and are provided in the compressor of some gas turbines, more particularly in certain aircraft engines. They are installed so as to be rotatable about their central axes and can be rotated back and forth between various positions.

Variable guide vanes are advantageous in that, for example when a low quantity of external air is supplied for combustion, for example in the event of low flight velocity of a commercial aircraft, the variable guide vanes can be rotated to achieve an optimal air supply to the combustion chamber.

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However, the variable guide vanes thus repaired have reduced wear resistance, so that in use they wear again all the more rapidly.

The problem addressed by the invention is that of providing a method of repairing a variable guide vane, whereby the guide vane can be repaired and provided with comparatively improved wear properties.

The invention solves the problem using the features of the independent claims.

To solve the problem, a method of repairing a variable guide vane for a gas turbine is proposed, wherein filler material is applied to the variable guide vane by material application as part of the method, wherein the material is applied by laser beam build-up welding.

As already stated at the outset, variable guide vanes are usually repaired by means of high velocity oxy-fuel spraying (HVOF) or plasma spraying. Contrary to the opinion hitherto held that laser beam build-up welding is in principle unsuitable for repair owing to the high heat input, it has been proven by intensive development that it is in fact possible to repair variable guide vanes using laser beam build-up welding. In this process, the laser beam build-up welding is preferably controlled such that the heat introduced into the variable guide vane is as low as possible. A preferred option for achieving this includes a repair that is adapted to the specific damage.

In the prior art, a plasma spray layer is usually always applied over the entire circumference (360°); thus, for example, the complete outer platform or the entire pin notch of the variable guide vane is reconstructed.

The coating can only produce low deposit thicknesses in this instance. The bond of the spray layer to the base material has a low bonding strength compared with the configuration according to the invention. In addition, the workpiece usually has to be prepared by material removal and then has to be roughened to ensure uniform bonding properties of the layer. In the method according to the invention, these drawbacks do not occur or are at least less pronounced.

In a preferred configuration of the method, only the region having sustained damage is reconstructed by the laser beam build-up welding. It is not necessary to prepare said workpiece by material removal or to roughen said workpiece. The method thus already differs from other coating methods which involve preparation. For example, only a partial region (for example the outer platform or the pin notch of the variable guide vane) of 120°, that is to say (only) the region affected by erosion, and not the full 360°, is refilled using the method. This aspect is further explained at a later point on the basis of the drawings.

Owing to the use of laser beam build-up welding as disclosed herein, filler materials, for example powder, wire and/or pastes, can be used when welding nickel to nickel, for example. If powders or particles are used, in contrast to flame spraying there is the feature that the particles, in the case of materials having one component, or the powders, in the case of powders having the same melting point (such as nickel – nickel compounds), are generally completely dissolved in a molten bath.

From this molten bath, the material generally solidifies by heat being conducted into the base material. In the metallographic transverse section, after welding the particle size of the starting particles can therefore no longer be detected. Furthermore, no interlocking (positive connection) occurs, as is the case for plasma spraying, but instead an integrally bonded connection is produced. This means that, on the atomic level, atomic bonds are produced between the weld metal and the metal main body. This is promoted by some of the base material also being fused.

The metal connection or integrally bonded connection produced by the laser beam build-up welding is generally considerably stronger than the spray coating, which is partly interlocked and partly by welding. In addition, plasma layers generally have more pores than a well-configured welding process. A well-configured welding process means a preferred process in which gas pockets leave the molten metal before it solidifies.

Preferably, the filler material is in the form of a powder, preferably having powder particle sizes in a range of from 40 to 150 µm, more preferably 50 to 75 µm. As known from experience, the best results can be achieved using these powder sizes. Powder particle sizes in a range of from 5 to 150 µm of the filler material may also be suitable.

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30 to 95 % is normal for powders. A high level of utilisation increases the cost-effectiveness of the repair method.

Preferably, the variable guide vane is processed in an inert gas atmosphere. This gas environment is preferably a non-reactive or oxidising gas. Argon and helium are preferably provided.

Preferably, at least two further variable guide vanes are kept available in the inert gas atmosphere for processing. In this way, a plurality of variable guide vanes can be processed in parallel. When for example one or two variable guide vane(s) are in the cooling phase, this time can be used to process a third variable guide vane.

To solve the problem, a variable guide vane for a gas turbine is also proposed, the variable guide vane being repaired according to the above-described method. It is advantageous to use such a guide vane as disclosed herein, since it has increased wear resistance and an increased service life compared with known repaired variable guide vanes. Such a variable guide vane is more cost-effective, since it is reinforced at specific points of wear, and thus needs to be repaired less frequently.

The invention is described in the following on the basis of preferred embodiments with reference to the accompanying drawings, in which:

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Owing to the method as disclosed herein, it is possible here to restrict the repair to merely the region of wear 9 which has actually sustained damage. The methods known from the prior art only provide for the relevant portion – that is to say the outer platform, for example – to be completely (360°) machined off and then rebuilt.

As shown in the example in Fig. 2, owing to the method as disclosed herein, solely a partial region of a portion, that is to say for example a third (120°) of the outer platform 5, can also be machined off and reconstructed.

The heat input introduced into the variable guide vane can thus be reduced. In addition, by using particular materials (described in detail above), the wear resistance of the repaired variable guide vanes can be increased.

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Claims

1. Method of repairing a variable guide vane (1) for a gas turbine, wherein filler material is applied to the variable guide vane (1) by material application as part of the method, wherein the material is applied by laser beam build-up welding, and wherein the filler material is in the form of a powder, characterised in that the powder particle size of the filler material is in a range from 5 µm to 150µm.

2. Method according to claim 1, characterised in that the material application includes applying a wear-resistant material.

3. Method according to any of the preceding claims, characterised in that the material is applied to the inner and/or outer platform (3, 5) of the variable guide vane (1).

4. Method according to any of the preceding claims, characterised in that the material is applied to the inner and/or outer pin (2, 6) of the variable guide vane (1).

5. Method according to any of the preceding claims, characterised in that the material application includes applying stellite or nitride, preferably titanium nitride, chromium nitride and/or boron nitride.

6. Method according to any of the preceding claims, characterised in that the material application includes applying hard-material composite layers comprising carbides, preferably tungsten carbide or titanium carbide.

7. Method according to any of the preceding claims, characterised in that a plurality of material layers is applied to the variable guide vane (1) in succession, and, between applying two material layers to the variable guide vane (1), at least one material layer being applied to at least one further, preferably to at least two further, variable guide vanes (1).

8. Method according to any of the preceding claims, characterised in that a metallurgical bond is produced as part of the method between the variable guide vane (1) and the filler material that is applied.

9. Method according to any of the preceding claims, characterised in that the powder particle size of the filler material is in a range of from 40 to 150 µm, more preferably 50 to 75 µm.

10. Method according to any of the preceding claims, characterised in that the variable guide vane (1) is processed in an inert gas atmosphere.

11. Method according to claim 10, characterised in that at least two further variable guide vanes (1) are kept available in the inert gas atmosphere for processing.