

Method for Repairing Rotor Blades

Specification

This invention relates to a method for repairing rotor blades of a gas turbine, in particular of an aircraft engine, where the damaged portion of the blade tip is removed and then reconstructed by laser cladding and finally finish-machined.

In laser cladding, material is deposited by melting the surface of the workpiece and simultaneously applying a filler material provided in powder form or as a welding wire. The highly stressed and expensive blades of an engine, both blades integrally connected to the rotor disk and separate blades attached conventionally to the rotor disk, can be repaired inexpensively by laser cladding when the blade tips are worn or damaged. First, the damaged or worn part is mechanically removed from the blade tip. Then the blade tip is locally melted along the edge or approximately in the direction of the rotational axis of the rotor disk using a CO₂ or Nd:YAG laser, and the melted area is supplied with a metal powder mixed with an inert gas and which fuses with the melted basic material. In this way, one material layer after the other is applied along the tip of the respective rotor blade until the original blade dimension is attained. This method is disadvantageous in that a large amount of thermal energy is imparted into the component due to the separate coating of every single blade, and a correspondingly high thermal distortion of the blade occurs. The high application rates necessary to perform the method also entail high expenditure for mechanical reworking, while the stress resistance and hardness of the applied coating are reduced with a higher coating thickness of the filler material applied by laser cladding.

The object underlying the present invention is to indicate a method for repairing rotor blades worn or damaged at their tips by laser cladding, requiring a reduced work expenditure and providing repaired blades of high quality.

It is a particular object of the present invention to provide solution to the above problematics by a method in accordance with the features of patent Claim 1.

Useful embodiments of the present invention become apparent from the sub-claims.

The basic idea of the invention is that laser cladding for reconstructing the blade tips does not take place in a continuous welding process along the blade edge, but during a cycle-by-cycle rotation of the rotor blades attached to a rotor disk at only one limited section of the respective blade edge for each cycle. This means that by the method in accordance with the invention, the rotor with the rotor blades fastened thereto detachably or in one piece is rotated step by step, and while the rotor is stationary the respective rotor blade currently underneath a stationary laser-cladding unit is heated and melted at its tip in a limited area using a laser beam generated in a certain time interval, and coated point by point with a metal powder flow supplied in a certain time interval. This process is repeated after every rotation of the rotor disk and every horizontal adjustment of the laser-cladding unit until the blade tips of all rotor blades have been coated, point by point and coating by coating in a plurality of individual welding steps, over the entire length of the blade edges and finally up to the necessary blade height, and after the laser-cladding unit has in the meantime been adjusted vertically upwards for application of a further material coating. The advantages of the method are reduced time expenditure for the repair of rotor blades and improved tribological properties of the blade material in the area of the repaired and highly stressed blade tips.

In an embodiment of the invention, inert gas is supplied continuously or discontinuously during discontinuous and point-by-point laser cladding.

An exemplary embodiment of the present invention is described in greater detail in light of the drawing, whose only one figure represents an arrangement for repairing the tips of rotor blades of a gas-turbine engine.

A rotor 1 with rotor blades 2 attached to its circumference is connected to a drive unit 3 that causes the rotor 1 to perform a step-by-step rotary movement with the aid of a control unit 4 connected to the drive unit 3. The damaged or worn portion of the blade tips was previously removed in a machining process. The coating of the blades 2 thus prepared on the blade tips 16 is achieved by laser cladding using a horizontally and vertically adjustably arranged laser-cladding unit 5 including laser optics 6, a coating head 7 and an inert gas head 8. The laser optics 6 are connected via glass fiber plugs 9 and a glass fiber 10 to a laser unit 13 connected to a laser cooler 11 and a laser control 12. A laser beam 14 is aimed by the laser optics 6 at a point of the blade tip 16 extending approximately in the direction of the rotational axis 15 of the rotor 1 and currently located underneath the laser optics 6.

A powder nozzle 23 fastened to the coating head 7 is connected via a powder gas hose 17 to a powder conveyor 18 which is connected via a conveying gas hose 19 to a gas source (not shown). The metal powder conveyed by the gas is supplied via the powder nozzle 23 to the molten bath generated by the laser beam 14 at the blade tip 16 in order to achieve in this way an approximately point-by-point material deposition at the blade tip. A inert gas nozzle 20 attached to the inert gas head 8, aimed at the molten bath at the blade tip and connected via an inert gas line 21, having an inert gas volume flow measuring device 22 incorporated therein, to an inert gas source (not shown) ensures material deposition in an inert gas atmosphere.

During coating of the blade tips 16, the rotor 1 with the blades 2 attached to its circumference is rotated step by step. When a blade tip is underneath the laser optics 6 in an idle state, a laser beam 14 is generated at a certain time interval, said laser beam effecting selective melting in a limited area of the appropriate blade tip. The molten bath is supplied with a limited amount of powder – while inert gas is supplied at the same time – via the powder nozzle 23. By a cycle-by-cycle rotation of the rotor, the other blade tips too are coated in the manner

described above in a limited area of the respective blade tip. Then the laser-cladding unit 5 is moved horizontally, and that area of the blade tip adjacent to the previously coated area is coated point by point using laser cladding in each case. This process is repeated until a continuous first material coating has been applied over the entire length of all blade tips. Then the laser-cladding unit 5 is moved vertically upwards and – as previously described – further coatings are applied until the original blade height has been reached with an allowance for subsequent machining.

Due to the discontinuous and point-by-point coating conducted in a step-by-step rotary movement, in each case only small heat effect zones are generated in the blade material. The low amount of heat imparted to the blade minimizes distortion of the workpiece. The small heat effect zones furthermore result in steep temperature gradients and accordingly high cooling rates, leading to greater hardness of the applied material coating and hence an improved friction and wear behaviour of the blades. In addition, the time spent for laser cladding and for reworking of the coated blades is reduced.

List of reference numerals

1	Rotor, rotor disk
2	Rotor blades
3	Drive unit
4	Control unit of 3
5	Laser-cladding unit
6	Laser optics
7	Coating head
8	Inert gas head
9	Glass fiber plug
10	Glass fiber
11	Laser cooler
12	Laser control
13	Laser unit
14	Laser beam
15	Rotational axis of 1
16	Blade tip
17	Powder gas hose
18	Powder conveyer
19	Conveying gas hose
20	Inert gas nozzle
21	Inert gas line
22	Inert gas volume flow measuring device
23	Powder nozzle

What is claimed is:

1. Method for repairing rotor blades of a gas turbine, in particular of an aircraft engine, where the damaged portion of the blade tip is removed and then reconstructed by laser cladding and finally finish-machined, characterized in that the rotor (1) with the rotor blades (2) fastened thereto detachably or in one piece is rotated step by step, and while the rotor (1) is stationary the respective rotor blade (2) currently underneath a stationary laser-cladding unit (5) is heated and melted at its tip (16) in a limited area using a laser beam (14) generated in a certain time interval, and coated point by point with a metal powder flow supplied in a certain time interval, and, by doing so, the blade tips (16) are coated, point by point in the circumferential direction and step by step, over the entire length and finally up to the necessary blade height.
2. Method in accordance with Claim 1, characterized in that, during discontinuous and point-by-point laser cladding, inert gas is supplied continuously or discontinuously.