US008943659B2

(12) United States Patent
Bayer et al.

(10) **Patent No.: US 8,943,659 B2**
(45) **Date of Patent: Feb. 3, 2015**

(54) **METHOD AND DEVICE FOR THE SURFACE PEENING OF A PARTIAL ELEMENT OF A COMPONENT OF A GAS TURBINE**

(75) Inventors: **Erwin Bayer**, Dachau (DE); **Max Niegl**, Munich (DE); **Holger Polanetzki**, Dachau (DE); **Thomas Peschke**, Groebenzell (DE); **Thomas Dautl**, Weichs (DE); **Philipp Thuemmler**, Munich (DE)

(73) Assignee: **MTU Aero Engines GmbH**, Munich (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1421 days.

(21) Appl. No.: **12/519,127**

(22) PCT Filed: **Dec. 5, 2007**

(86) PCT No.: **PCT/DE2007/002196**

§ 371 (c)(1), (2), (4) Date: **Jan. 25, 2010**

(87) PCT Pub. No.: **WO2008/071162**

PCT Pub. Date: **Jun. 19, 2008**

(65) **Prior Publication Data**

US 2010/0125990 A1 May 27, 2010

(30) **Foreign Application Priority Data**

Dec. 13, 2006 (DE) 10 2006 058 678

(51) **Int. Cl.**

B21C 37/30 (2006.01)
B24C 1/10 (2006.01)
B24C 5/00 (2006.01)
F01D 5/28 (2006.01)

(52) **U.S. Cl.**

CPC . ***B24C 1/10*** (2013.01); ***B24C 5/005*** (2013.01); ***F01D 5/286*** (2013.01); *F05D 2230/41* (2013.01)

USPC **29/90.7**; 29/889.2; 29/889.23

(58) **Field of Classification Search**

CPC B24C 1/10; B23P 15/006; F01D 25/285; B23C 3/18

USPC 29/90.7, 889.2, 889.23

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,028,378 B2 *	4/2006	Cheppe et al.	....	29/90.7
2006/0174483 A1 *	8/2006	Bayer et al.	....	29/889.2

FOREIGN PATENT DOCUMENTS

EP	1 101 568 B1	5/2001
EP	1 623 794 A1	2/2006
FR	2 689 431	10/1993
WO	WO 02/24411 A1	3/2002

* cited by examiner

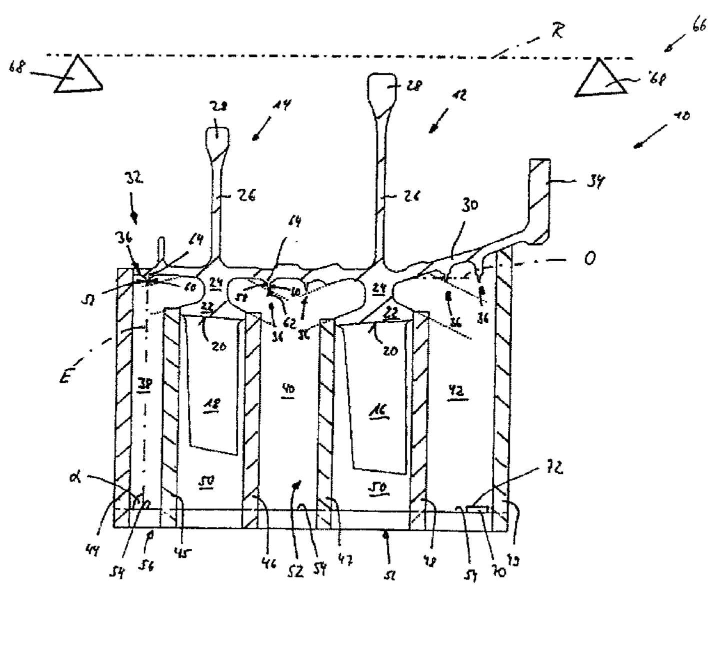
Primary Examiner — Ryan J Walters

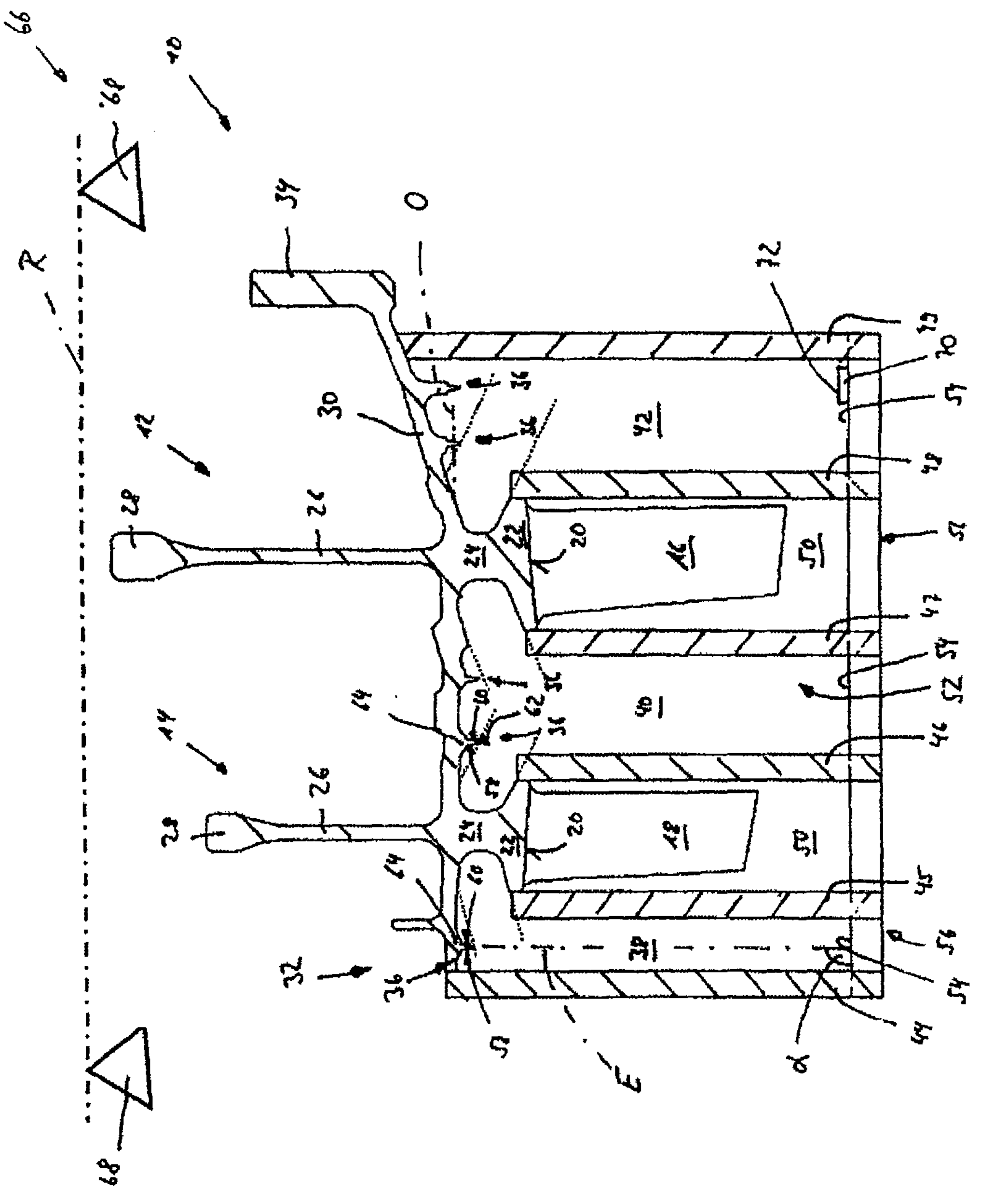
(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(57) **ABSTRACT**

A method and device for the surface peening, especially ultrasonic shot-peening, of at least one partial element of a component of a gas turbine, is disclosed. The partial element, e.g., a sealing fin, and at least one surface of a vibration device impinging the blasting material are positioned relative to each other at an angle between 70° and 90° based on the direction of extension of the sealing fin.

11 Claims, 1 Drawing Sheet





METHOD AND DEVICE FOR THE SURFACE PEENING OF A PARTIAL ELEMENT OF A COMPONENT OF A GAS TURBINE

This application claims the priority of International Application No. PCT/DE2007/002196, filed Dec. 5, 2007, and German Patent Document No. 10 2006 058 678.6, filed Dec. 13, 2006, the disclosures of which are expressly incorporated by reference herein.

The invention relates to a method and a device for the surface peening, in particular ultrasonic shot-peening, of at least one partial element of a component, in particular a blisk of a gas turbine.

This type of method and such a device are already known for example from European Patent Document No. EP 1 101 568 B1, wherein the rotor blades of a rotor embodied as a blisk are shot-peened to improve their fatigue strength. To do this, the rotor is positioned in a holding device such that it is held so that it can be rotated around its axis of rotation. By rotating the rotor, its rotor blades are guided through a peening chamber, which has a vibration device arranged on its underside in the form of an ultrasonic sonotrode having one vibrating surface running at least approximately horizontally. The peening chamber in this case is bordered both axially, i.e., in the area of the broadside of the rotor, and radially, i.e., in the area of the rotor blades, of the blisk by corresponding chamber walls.

One problem with these types of known methods for surface peening rotors is that, particularly in the case of thin-walled partial elements, there is a danger of deformation or warping from the surface peening. For this reason, today it is common to protect these types of partial elements particularly by means of a covering. Since these kinds of thin-walled partial elements of a blisk are frequently for example located in a joint area with an adjacent blisk, this covering can lead to insufficient strengthening of the joint area. In addition, a further problem is that the partial element itself sometimes cannot be strengthened.

As a result, the objective of the present invention is creating a method and a device of the type cited at the outset, which can be used to process partial elements of the component of the gas turbine that could not be processed until now, without the danger of deformations or warping from surface peening.

The inventive method provides that the surface of the at least one vibration device and a thin-walled sealing fin be positioned relative to each another at an angle between 70° and 90° based on the direction of extension of the sealing fin. In other words, the invention provides for the thin-walled sealing fin that previously could not be processed during surface peening of a rotor, in particular of a blisk, without deformations or warping, to be processed in such a way that the surface of at least one vibration device is arranged in the indicated angle range with respect to the sealing fin. This corresponding arrangement of the surface of the vibration device relative to the sealing fin makes it possible for its broadsides to be processed synchronously with blasting material during the peening process. Because both sides of the sealing fin are thereby acted upon uniformly by the blasting material, deformation or even bending away of the partial elements, which are normally a few millimeters thick and high, from the effect of the hail of shots is avoided. On the contrary, the front side and tip of the respective sealing fin, which comes into contact with the intake or rub coating when the engine is in operation, is strengthened in an optimum way. As a result, the abrasion hardness and service life of the front side or tip of the sealing fin increases considerably.

Another advantage is that the joining zones of the rotor or blisk that are frequently arranged in the region of the thin-walled sealing fins can be effectively strengthened so that the tensile internal stress in the heat impact zone of the joint can be converted to compressive stress close to the surface. In the case of a somewhat diagonal arrangement of the surface of the at least one vibration device based on the direction of extension of the sealing fin, it is possible to strengthen its web neck, i.e., the transition area between the sealing fin and an external circumferential wall of the rotor bearing the sealing fin.

In an especially advantageous embodiment, the surface of the at least one vibration device and the sealing fin are positioned relative to each other at an angle between 85° and 90°, and in particular at least approximately perpendicular, based on the direction of extension of the sealing fin. In other words, the surface of the at least one vibration device is preferably positioned at least approximately perpendicular relative to the sealing fin being processed so that an especially uniform and synchronous peening of the two broadsides of the sealing fin is produced and a deformation or bending away of the sealing fin is made impossible.

An especially uniform and reproducible strengthening of the respective sealing fin can be achieved if the sealing fin is processed in a peening chamber comprising the assigned vibration device. Because of the peening chamber, a constant quantity of blasting material and therefore consistent and uniform peening results can be achieved in this process in a simple way.

An especially synchronous and uniform peening of the two broadsides can be advantageously realized if the boundary walls of the peening chamber are arranged essentially parallel to the direction of extension of the sealing fin.

In another embodiment of the invention, a plurality of sealing fins is processed in a common peening chamber. This results in a process that is optimized in terms of processing time.

The advantages described in relation to the inventive method are also applicable in an identical way for the device according to the invention.

In this case, it has been shown to be particularly advantageous in terms of the device if a peening chamber is equipped with boundary walls, which as dividing walls divide two adjacent peening chambers from one another. As a result, the dividing walls can fulfill a dual function as the respective boundary wall, wherein the two adjacent peening chambers can be arranged at a close distance to one another.

It has also been shown to be advantageous if the peening chamber is provided with chamber walls that are embodied flexibly at least in sections. This makes it possible for the inventive device to be used even in the case of various components having differing geometry.

Finally, it has been shown to be advantageous if a distributing device is provided preferably within the peening chamber, with which the blasting material can be distributed over the surface of the at least one vibration device. The distributing device is preferably arranged correspondingly at the lowest point of the surfaces of the vibration devices so that blasting material gathering there is uniformly distributed, or also positioned in upper regions of the surfaces. As a whole, this results in a consistent quantity of blasting material being available over the entire surfaces so that an extremely uniform strengthening of the sealing fin can be realized.

Additional advantages, features, and details of the invention are disclosed in the following specification of a preferred exemplary embodiment as well as on the basis of the drawing.

BRIEF DESCRIPTION OF THE DRAWING

The drawing shows in a schematic sectional view a rotor of a gas turbine in the form of a blisk where respectively assigned peening chambers with respectively associated vibration devices are provided.

DETAILED DESCRIPTION OF THE DRAWING

The drawing shows in a schematic sectional view a rotor of a gas turbine in the form of a blisk, which in this case comprises two stages and, in the region of a circumferential wall, a plurality of thin-walled sealing fins surrounding the outer circumferential side, where respectively assigned peening chambers with respectively associated vibration devices are provided, whose respective surfaces are arranged at an angle of essentially 90° relative to the assigned sealing fin based on its direction of extension.

In the schematic and axial sectional view at hand depicting a rotatable rotor of a gas turbine in the form of a blisk **10**, it is possible to see two stages, which are respectively assigned a first and a second disk **12**, **14** as well as a ring from the first and second rotor blades **16**, **18**. What can be seen of each of the disks **12**, **14** is essentially a platform **20** depicted linearly on the outer circumferential side, which is connected radially inwardly to a lower platform region **22**. Each of the two lower platform regions **22** merges radially in the inward direction into a respective disk neck **24**, which connects the associated lower platform region **22** with a disk body **26**. The radial inner end of the respective disk body **26** is formed by an associated hub **28**, which represents a counterweight to the respective rotor blades **16**, **18**. The two disks **12**, **14** are connected via a circumferential wall **30**, which is embodied rotationally symmetrically around an axis of rotation R of the blisk **10** and extends on one side towards a wing **32** and on the other side towards a flange **34**.

On the outer circumferential side of the circumferential wall **30**, the blisk **10** at hand comprises five thin-walled sealing fins **36** embodied as partial elements, which project radially circumferentially outwardly from the circumferential wall **30** approximately perpendicular with respect to the axis of rotation R of the blisk **10**. These thin-walled sealing fins **36** are also generally called "fin sealing lips" or "sealing web" and feature a radial height of 3 mm and a thickness of 2 mm for example. The sealing fins **36** are used to cooperate with an intake or rub coating (not shown), which on the inner circumferential side is surrounded annularly by guide vanes (also not shown) attached to the turbine around the respective associated sealing fin **36**.

In order to strengthen the sealing fins **36** through surface peening by means of a blasting material in particular in the form of shots, a total of three peening chambers **38**, **40**, **42** are provided here, which are bordered by or divided from one another by respective boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49**. Along with the three peening chambers **38**, **40**, **42** assigned to the respective sealing fins **36**, two additional peening chambers **50** are provided, within which the rotor blades **16**, **18** can be strengthened by means of surface peening. Along with the boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49**, front walls **52** are also assigned to the peening chambers **38**, **40**, **42**, and these front walls may feature corresponding recesses as the case may be in the region of the sealing fins **36**.

The FIGURE shows that the four center boundary or dividing walls **45**, **46**, **47**, **48** are each sealed against the assigned platform **20** of the rotor blades **16**, **18**. This can prevent a loss or transfer of blasting material from the one into the other peening chamber **38**, **40**, **42**, or **50**. Corresponding sealing means can be arranged in this case between the respective boundary or dividing wall **45**, **46**, **47**, **48** and the assigned platform **20**. Alternatively or additionally, the gap or the distance between the respective boundary or dividing wall **45**, **46**, **47**, **48** and the assigned platform **20** is selected in such a way that the blasting material cannot get through in-between. The outer boundary or dividing walls **44** or **49** are arranged in a sealed manner in an appropriate way with respect to the circumferential wall **30**. In addition, the boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49** may also be embodied flexibly in order to make it possible to adapt to components or rotors with different geometry.

On the side of the assigned peening chamber **38**, **40**, **42** opposite from the sealing fins **36**, a respective surface **54** of an assigned vibration device **56** is provided, which is embodied here as an ultrasonic sonotrode (not shown) and is assigned to the respective peening chamber **38**, **40**, **42** as a front-side boundary wall. The respective ultrasonic sonotrode is used to set the respective surface **54** of the vibration device **56** into vibration, whereby the blasting material, which is embodied here as shot, is accelerated for shot-peening. In the present exemplary embodiment, one and same vibration device **56** is used for all the peening chambers **38**, **40**, **42**, i.e., also for the peening chambers **50** of the rotor blades **16**, **18**, wherein the vibrating surfaces or the surfaces **54** impinging the blasting material assigned to the respective peening chamber **38**, **40**, **42**, or **50** are correspondingly divided by the boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49**. However, each of the peening chambers **38**, **40**, **42** may also feature a separate vibration device **56**, which is also covered by the scope of the invention.

Each of the sealing fins **36** includes two broadsides (**58**, **60**) (annular in a top view) as well as a rounded narrow front side **62**. In addition, it is also evident that each sealing fin **36** includes a web neck **64**, through which the circumferential wall **30** merges into the sealing fin **36**. As the case may be, the sealing fin **36** can taper towards the outer circumferential side, as can be seen in particular in the FIGURE, wherein the respective individual partial surfaces of each of the two broadsides **58**, **60** essentially extend plane-parallel to each other. In this case, the dashed and dotted line E (peening chamber **38**) depicts a radial direction of extension on one of the sealing fins **36**. This direction of extension E is essentially identical in the case of all sealing fins **36** at hand.

So that the sealing fins **36** are not deformed or bent or otherwise warped during shot-peening, the surfaces **54** of the vibration device **56** assigned to the respective sealing fin **36** are positioned relative to each other at an angle α between 70° and 90° based on the radial direction of extension E of the corresponding sealing fin **36**. In the present exemplary embodiment this angle α is at least approximately 90°, because this allows an especially uniform peening of both broadsides **58**, **60** of the respective sealing fin **36** to be realized. This especially advantageous strengthening of the two broadsides **58**, **60** that can be achieved by this also materializes if the angle α is between 85° and 90°. Hence in the present exemplary embodiment, each of the surfaces **54** of the assigned vibration device **56** and a respective surface normal O (peening chamber **42**) of the respective corresponding broadside **58**, **60** of the corresponding sealing fin **36** essentially run at least parallel relative to one another. As a result, the two opposing broadsides **58**, **60** of the sealing fin **36** are synchronously surface peened by means of the surface **54** of the vibration device **56**. The boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49** of the peening chambers **38**, **40**, **42** in the case at hand run essentially parallel to the direction of extension E of the respective sealing web **36** or parallel to its respective broadsides **58**, **60**. If, as described above, the surface **54** is not arranged at least approximately perpendicular to the radial direction of extension of the sealing fin **36**, but the angle α is between 70° and 90°, then each of the boundary or dividing walls **44**, **45**, **46**, **47**, **48**, **49** runs relative to the respective surface normals O naturally also in a correlating angle.

The relative arrangement of the sealing fins **36** with respect to the corresponding surfaces **54** of the assigned vibration device **56** can be accomplished either by the respective peening chamber **38**, **40**, **42** being correspondingly positioned with respect to the blisk **10**, or vice versa by the blisk **10** being correspondingly arranged with respect to the respective peening chamber **38**, **40**, **42**. In the latter case, as shown here, a holding device **66** can be provided, which is used to arrange the blisk **10** with respect to the peening chamber **38**, **40**, **42**. In doing so, the holding device **66** comprises for example bearing blocks **68**, which are only indicated schematically in the FIGURE, through which the blisk **10** is mounted so that it can rotate around its axis of rotation R. As a result, each of the sealing fins **36** can be circumferentially strengthened or peened in one procedural step. However, the relative positioning of the sealing fins **36** and the surfaces **54** can also be accomplished by the chamber walls **44**, **45**, **46**, **47**, **48**, **49** of the respective peening chamber **38**, **40**, **42** being used as limit stops with respect to the circumferential wall **30** of the blisk **10**.

So that the blasting material does not gather excessively at one deepest point of the assigned peening chamber **38**, **40**, **42**, but is in fact distributed uniformly over the respective surfaces **54**, a distributing device **70** is provided, e.g., in the lower region of the peening chamber **42**, and the distributing device also comprises a vibrating surface **72**. The distributing device **70** in this case can also be embodied as an ultrasonic sonotrode. Other designs would also be likewise conceivable in this case such as a compressed air device, which is able to realize a homogeneous distribution of the blasting material over the respective surfaces **54**.

The fact that the device described here and/or the assigned method can be used not just in the case of a blisk **10**, but naturally also in the case of other components of gas turbines must be considered included in the scope of the invention.

The invention claimed is:

1. A method for surface peening of a partial element of a component of a gas turbine, comprising positioning the partial element relative to a surface of a vibration device, wherein the vibration device impinges blasting material, wherein the surface of the vibration device and the partial element are positioned relative to each other at an angle between 70° and 90° based on a direction of extension of the partial element, and wherein the partial element is a sealing fin;

wherein the sealing fin is surface peened in a first peening chamber that includes the vibration device, wherein boundary walls of the first peening chamber are arranged substantially parallel to the direction of extension of the sealing fin; and

wherein a rotor blade of the component is arranged in a second peening chamber that is adjacent to the first peening chamber, wherein one of the boundary walls of the first peening chamber is a side boundary wall of the second peening chamber.

2. The method according to claim **1**, wherein the surface of the vibration device and the sealing fin are positioned relative to each other at an angle between 85° and 90°.

3. The method according to claim **1**, wherein the surface of the vibration device and the sealing fin are positioned approximately perpendicular to each other.

4. The method according to claim **1**, wherein two opposing broadsides of the sealing fin are synchronously surface peened by the blasting material.

5. The method according to claim **1**, wherein a plurality of sealing fins are surface peened in the first peening chamber.

6. The method according to claim **1**, wherein during a surface peening of the sealing fin, the component is rotated around an axis of rotation of the component.

7. The method according to claim **1**, wherein the component is arranged relative to the surface of the vibration device by a holding device.

8. The method according to claim **1**, wherein the surface of the vibration device is a front boundary wall of the first peening chamber and wherein the boundary walls are opposing non-vibrating walls of the first peening chamber.

9. The method according to claim **8**, wherein two opposing broadsides of the sealing fin are synchronously surface peened by the blasting material.

10. A method for surface peening of a sealing fin of a rotor of a gas turbine, comprising:

positioning the sealing fin in a first peening chamber, wherein a surface of a vibration device is a front boundary wall of the first peening chamber, wherein opposing non-vibrating walls are side boundary walls of the first peening chamber, and wherein the surface of the vibration device and the sealing fin are positioned relative to each other at an angle between 70° and 90° based on a direction of extension of the sealing fin;

wherein the opposing non-vibrating side boundary walls of the first peening chamber are arranged substantially parallel to the direction of extension of the sealing fin;

surface peening the sealing fin by a blasting material vibrated by the vibration device;

positioning a rotor blade in a second peening chamber that is adjacent to the first peening chamber, wherein one of the opposing non-vibrating walls of the first peening chamber is a side boundary wall of the second peening chamber; and

surface peening the rotor blade by a blasting material.

11. The method according to claim **10**, wherein two opposing broadsides of the sealing fin are synchronously surface peened.

* * * * *