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METHOD AND DEVICE FOR THE ULTRASONIC PEENING OF THE
"AXIAL" RECESSES THAT ATTACH BLADES TO A ROTOR

The invention relates to a method of surface treating
and compressively prestressing by peening the wall of
at least one oblong cavity formed in a part, said
cavity opening to the outside via a lateral mouth and
5 having two ends capable of having frontal openings.

In particular, it is necessary to compressively
prestress the wall of an axial recess of a turbomachine
rotor capable of containing a blade root, the lines of
10 contact between the axial recess and the blade root of
which are highly stressed. What happens in operation is
that the turbine or fan blades immobilized in the axial
recesses by various means, are subjected to
considerable centrifugal forces leading to significant
15 frictional wear at these lines of contact. This
frictional wear reduces the life of the parts in
operation and leads to them having to be changed
regularly.

20 In order to improve the fatigue strength of the turbine
rotor and to harden the surface of the axial recesses
in the region of the lines of contact, it is known
practice for the axial recesses to be peened using
beads ejected from a compressed air nozzle introduced
25 into each recess. The beads cause permanent compression
of the treated surface over a shallow thickness,
opposing the onset and propagation of cracks at the
surface of the part.

30 These nozzles are able to project only microbeads of a
diameter smaller than 1 mm, and typically of between
0.3 mm and 0.5 mm.

This method is necessarily lengthy because the entire
35 surface area of the cavity is treated only by a
succession of local treatments which may, furthermore,
introduce unwanted local deformation and cause the
incrustation of bead residue. Furthermore, in this
method, the distribution of the beads, both in terms of

position and in terms of speed, is according to a Gaussian law.

5 In addition, the peening performed is light in order not to generate excessive roughness in the region of the treated zone, and this leads to a limited hardening of the surface. The problem is that since the diameter of the projected beads is small, the more intense the peening, the greater the damage caused to the surface
10 finish.

Finally, the method which involves numerous parameters is difficult to control and difficult to reproduce.

15 The object of the invention is to propose a method for peening oblong cavities, particularly axial recesses of turbine rotors which makes it possible to recreate reproducible prestresses in all the cavities, in a shorter period of time, while at the same time allowing
20 more intense peening, that is to say a greater depth of compression at the surface without, however, introducing injury and while at the same time limiting the damage caused to, or incrustation of, the treated surface.

25 The invention achieves its objective by the fact that the peening method is the ultrasonic method and comprises the following steps:

- 30 a) a dose of beads of a determined diameter is placed on a vibrating surface of a sonotrode already arranged in an intermediate position in a sleeve surrounding said vibrating surface, said sleeve having opposed closing-off means capable of closing off the frontal openings,
- 35 b) the lateral mouth of the cavity is placed facing said sonotrode,
- c) said sonotrode supporting the dose of beads and said sleeve are moved together and approximately vertically toward a raised peening position in which

the closing-off means close off the frontal openings of the cavity and in which the sonotrode, arranged facing the lateral mouth, delimits, with the sleeve, the closing-off means and the cavity, a chamber sealed to the beads, and

d) the wall of the cavity is ultrasonically peened by generating a mist of beads in said chamber by means of the sonotrode excited by means of producing ultrasonic oscillations.

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The method makes it possible to obtain a uniform distribution of the provision of the beads constituting a mist of beads. As the beads of the mist of beads travel in random directions, they strike the walls of the cavities at varying angles, and this improves the surface finish by comparison with beads projected by a nozzle in one predominant direction.

Furthermore, the entirety of the surface is subjected at the same time to the impacts of beads, and this considerably diminishes the risk of deformation of the cavity, particularly of the recess containing the blade root.

To generate the mist of beads, all that is required is for at least one bead to come into contact with the vibrating surface when the sonotrode is excited. Hence the sonotrode may be arranged obliquely with respect to the vertical.

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Advantageously, having moved the sonotrode and the sleeve at the same time, the sonotrode is moved approximately vertically with respect to the sleeve, so that the vibrating surface closes off the mouth.

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As the volume in which the mist of beads is distributed is smaller than the volume obtained when the vibrating surface remains outside the mouth, the method requires a shorter peening treatment time.

In this case, having peened the wall of a cavity, the sonotrode is moved toward its intermediate position in the sleeve, the treated cavity is replaced with another cavity to be treated, the sonotrode is moved toward its peening position and the wall of the other cavity to be treated is ultrasonically peened.

If the vibrating surface is not introduced into the mouth, having peened the wall of a cavity, the treated cavity is replaced with another cavity to be treated, and the wall of the other cavity to be treated is ultrasonically peened.

When the part comprising at least one cavity to be treated is not circular, or alternatively when the issue is one of continuously treating a succession of parts which have just one cavity, the geometry of the part is not always suited to the device and it is necessary to move both the vibrating surface and the closing-off means in order to clear the space available between the steps of respectively bringing in each piece and/or cavity.

When the sleeve has to move back in order to change from one cavity to another because of the geometry of the part, having peened the wall of a cavity, the sonotrode and the sleeve are moved together toward a lowered position, the treated cavity is replaced with another cavity to be treated, the sonotrode and the sleeve are moved together toward the raised peening position, and the wall of the other cavity to be treated is ultrasonically peened.

According to an alternative form of embodiment, having peened the wall of a cavity, the sonotrode is moved toward its intermediate position in the sleeve, the sonotrode and the sleeve are moved together toward a lowered position, the treated cavity is replaced with another cavity to be treated, the sonotrode and the

sleeve are moved together toward the raised peening position, the sonotrode is moved approximately vertically with respect to the sleeve so that the vibrating surface closes off the mouth and the wall of
5 the other cavity to be treated is ultrasonically peened.

When the method is used to treat a circular part, a rotor rim for example, comprising a number of axial
10 cavities formed at the periphery of said rotor rim and having wall portions which diverge from each mouth, the rotor rim is turned stepwise about its axis of rotation arranged horizontally so as bring each axial cavity in turn to face the sonotrode after a cavity has been
15 treated.

As a preference, a deflector is placed in the cavity so as to encourage the peening of the internal flanks of the lateral mouth.

20 The deflector may be of approximately triangular geometry with sides parallel to the divergent wall portions so as to reduce the effect of the peening of the zone situated between said deflector and the bottom
25 of the cavity.

At the end of the treatment, the sonotrode is advantageously moved approximately vertically toward a lowered position in the sleeve, in which position the
30 dose of beads can be driven from the vibrating surface toward a reservoir through slots formed in the sleeve after the cavities in the part have been peened.

Thus, the dose of beads can easily be recovered so that
35 it can either be reused in a subsequent treatment or be replaced.

Advantageously, use is made of a dose of beads the diameter of which exceeds 0.8 mm.

The beads used in the method according to the invention have a larger diameter than the diameter of the beads that can be projected by a nozzle, which means that the peening can be more intense while at the same time
5 causing less substantial damage to the surface.

The invention also relates to an installation for implementing the method.

10 According to the invention, this installation comprises:

a sonotrode arranged in a sleeve equipped with closing-off means capable of closing off the frontal openings of a cavity, said sonotrode being capable of projecting
15 beads of a determined diameter into a chamber delimited by the wall of the cavity, the vibrating surface of said sonotrode, the sleeve and the closing-off means (14),

means of producing ultrasonic oscillations capable of
20 exciting said sonotrode,

first means for moving said sonotrode approximately vertically, and second means for moving said sleeve approximately vertically,

a first clearance smaller than the diameter of the
25 beads being formed between said sonotrode and said sleeve.

Preferably, a second clearance smaller than the diameter of the beads is formed between said vibrating
30 surface arranged in the mouth of the cavity and said mouth.

The installation advantageously comprises a third clearance smaller than the diameter of the beads formed
35 between one end of the sleeve and the mouth which when the vibrating surface is not closing off the mouth, ensures the chamber is sealed correctly.

The installation may comprise a number of acoustic assemblies each comprising a sonotrode and a sleeve, arranged around the rotor rim, said acoustic assemblies being capable of moving in an axial direction of the rotor rim.

The various elements of the installation are arranged in such a way that no bead can jam said elements capable of moving. Furthermore, the sonotrode and the sleeve comprising the closing-off means have a geometry tailored to the shape of the cavity to be treated. In particular, the vibrating surface is of a shape that complements the space left by mouth and the closing-off means are formed in such a way as to close off the openings of said cavity correctly.

Advantageously, the second movement means are capable of moving the closing-off means and the sonotrode at the same time.

The first movement means and the second movement means can advantageously be operated simultaneously.

At the beginning of the treatment, the sleeve and the sonotrode are placed in an intermediate position in which the space generated by the closing-off means of said sleeve and the vibrating surface of said sonotrode constitutes a reservoir for the dose of beads. Next, said sleeve and said sonotrode supporting the dose of beads are moved jointly with the same movement. Finally, the sonotrode and/or the closing-off means can be moved individually, depending on the geometry of the cavity to be treated, until, respectively, the vibrating surface closes off the mouth of the cavity and the closing-off means close off the openings of the cavity.

Advantageously, the installation comprises support means for supporting at least one part that is to be

treated and means of driving said support means to bring a cavity step by step over the sonotrode.

5 The installation advantageously comprises means for driving the dose of beads from the vibrating surface toward a reservoir.

10 These simple means make it possible to drive the dose of beads during a treatment if necessary, or at the end thereof, either to refresh the beads or to replace them.

15 Further features and advantages of the invention will become apparent from reading the following description given by way of non-limiting example and made with reference to the appended drawings in which:

- figure 1 is a front view of a rotor rim,
- figure 2 is a front view of a fan blade arranged in
20 an axial cavity formed at the periphery of the rotor rim,
- figure 3 is an axial section of the installation, the sleeve and the sonotrode being placed in the raised peening position,
- 25 - figure 4 is a perspective view of the sleeve containing the sonotrode placed in the raised peening position, inside said sleeve,
- figure 5 is a section of figure 3 on V-V,
- figure 6 is a section through the sleeve containing
30 the sonotrode, in its intermediate position, and
- figure 7 is a section through the sleeve containing the sonotrode in its lowered position.

35 Figure 1 shows a rotor rim 1 which comprises a number of approximately axial recesses 2 formed at the periphery of the rotor rim 1 and uniformly spaced about the axis of rotation 1A of the rotor rim. These recesses 2 have a frontal opening 3 at each end. These recesses 2 are in the shape of dovetails and have a

mouth 2A open radially toward the outside and of approximately straight shape so as allow the fitting of the approximately dovetail-shaped blade roots 4 of the fan blades 6. The recesses 2 may be straight or curved.

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Each blade root 4 is mounted axially by sliding in a recess 2. A wedge (not depicted) which holds the blade root 4 against the walls of the corresponding recess 2 may be engaged between the blade root 4 and the bottom
10 of the recess 2.

Figure 2 shows that the walls of the recess 2 and the blade root 4 rest on one another along two lines of contact 2B.

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The object of the invention is to propose a method and an installation for compressively prestressing the wall 2C of each recess 2 and, in particular, the regions of the two lines of contact 2B, so as to increase the
20 resistance to wear of these lines of contact 2B, the wear being brought about by friction between the blade root 4 and the wall of the recess 2, and thus improve the fatigue strength of the rotor rim 1.

25 Figures 3 and 5 show an example of an installation used for implementing the method and in which just one acoustic assembly is used, said acoustic assembly being capable of moving vertically. The acoustic assembly essentially comprises a sonotrode 8 arranged
30 in a sleeve 16 equipped with closing-off cheeks 14. The installation is positioned under the rotor rim 1. The sonotrode 8, and the sleeve 16, are placed in a raised peening position as depicted in figure 3. In this raised peening position, the sonotrode 8 preferably
35 closes off the mouth 2A and the closing-off cheeks 14 formed on the sleeve 16 close off the two openings 3.

Beads 10 of a diameter of between 0.8 mm and 5 mm, preferably equal to 1 mm, are projected by the

vibrating surface 8A, oriented upward, of the sonotrode 8, into the chamber 12 delimited by the wall 2C, the vibrating surface 8A and the closing-off cheeks 14. The vibrating surface 8A is excited by a vibration generator 18, for example a quartz generator, so as to create a mist of beads 10 in the chamber 12.

The clearance e1 formed between the sonotrode 8 and the sleeve 16 is smaller than the diameter of the beads 10, which means that no bead 10 can slip between the vibrating surface 8A and the sleeve 16.

With reference to figures 3 to 5, the vibrating surface 8A is approximately rectangular and has a length L1 approximately equal to the length L2 of the recess 2 measured axially. The sonotrode 8 is in the raised peening position in the sleeve 16 which borders the vibrating surface 8A. The closing-off cheeks 14 are of simple shape, for example rectangular, so as to completely cover up the openings 3. The width of the vibrating surface 8A is approximately equal to the width of the mouth 2A.

Figure 5 shows that the recess 2 is of concave shape with walled portions 2'C which diverge from the mouth 2A. A deflector 15 borne by the closing-off cheeks 14 has been introduced into the recess 2. Said deflector 15 is triangular with sides approximately parallel to the wall portions 2'C and to the bottom of the recess. In particular, it makes it possible to lessen the effect of the peening of the bottom of the recess and to increase the peening of the walls 2'C.

The clearance e2 formed between the vibrating surface 8A of the sonotrode 8 and the mouth 2A is smaller than the diameter of the beads 10 so that no bead 10 can escape from the chamber 12.

If the vibrating surface 8A does not close off the mouth during peening, a third clearance e3 lying between one end 16A of the sleeve 16 and the mouth 2A ensures that the chamber 12 is sealed.

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A first slide 20 allows the sonotrode 8 to be moved vertically by causing said sonotrode 8 to slide in the sleeve 16. A second slide 22, borne by a support structure 24, itself allows the sonotrode 8 and the sleeve 16 both to move approximately vertically. Operating means (not depicted) allow said first slide 20 and said second slide 22 to be operated.

The first slide 20 may be borne either by the second slide 22, as shown in figure 5, or by the support structure 24, in which case the two slides 20 and 22 need to be operated synchronously in order to raise the sonotrode 8 and the sleeve 16 together toward the raised peening position.

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Before beginning the operation of treating an axial recess 2, the sonotrode 8 is placed in an intermediate position in the sleeve 16, in which position the space delimited by the sleeve 16 and the vibrating surface 8A constitutes a receptacle 26 able to contain the dose of beads 10 deposited on the vibrating surface 8A, as depicted in figure 6.

Having fixed the rotor rim 1 by holding means (not depicted), a first cell 2 is brought to face the sonotrode 8 by rotating the rotor rim 1 about its axis of rotation 1A using drive means (not depicted). The drive means for example comprise a stepping motor.

The sonotrode 8 and the sleeve 16 are moved to their raised peening position then the first recess 2 is peened by actuating the vibration generator 18. As soon as the peening of the first recess 2 is over, the sonotrode 8 is extricated from the mouth 2A toward its

intermediate position, then a second recess 2 is brought up to face the sonotrode 8 by rotating the rotor rim 1 through an angle equal to the angle separating two consecutive axial recesses 2 about its axis of rotation 1A, and so on and so forth until all of the axial recesses 2 formed on the rotor rim 1 have been treated.

At the end of the treatment, or on demand, the sonotrode 8 is withdrawn to its lower position depicted in figure 7, in which the dose of beads 10 is extricated. The beads 10 are, for example, blown from the surface 8A using a fan 28 through slots 30 formed in the sleeve 16 and recovered in a reservoir 32. Said beads 10 can then be refreshed or alternatively replaced with a view to a later treatment.

It is to be noted that the sonotrode 8 can be moved in an oblique direction without departing from the scope of the invention. What is important is that there should be at least one bead 10 in the receptacle 26 in contact with the surface 8A when the sonotrode 8 is started up, so as initiate the formation of the mist of beads.



CLAIMS

1. A method of surface treating and compressively prestressing by peening the wall (2C) of at least one oblong cavity (2) formed in a part (1), said cavity (2) opening to the outside via a lateral mouth (2A) and having two ends capable having frontal openings (3),
which method comprises the following steps:
 - a) a dose of beads (10) of a determined diameter is placed on a vibrating surface (8A) of a sonotrode (8) already arranged in an intermediate position in a sleeve (16) surrounding said vibrating surface (8A), said sleeve having opposed closing-off means (14) capable of closing off the frontal openings (3) of said cavity (2),
 - b) the lateral mouth (2A) of the cavity (2) is placed facing said sonotrode (8),
 - c) said sonotrode (8) supporting the dose of beads (10) and said sleeve are moved together and approximately vertically toward a raised peening position in which the closing-off means (14) close off the frontal openings (3) of the cavity (2) and in which the sonotrode, arranged facing the lateral mouth (2A), delimits, with the sleeve (16), the closing-off means (14) and the cavity, a chamber (12) sealed to the beads (10), and
 - d) the wall (2C) of the cavity (2) is ultrasonically peened by generating a mist of beads (10) in said chamber (12) by means of the sonotrode (8) excited by means of producing ultrasonic oscillations (18).
2. The method as claimed in claim 1, wherein, having moved the sonotrode (8) and the sleeve (16) together, the sonotrode (8) is moved approximately vertically with respect to the sleeve (16) so that



the vibrating surface (8A) closes off the mouth (2A) .

3. The method as claimed in claim 2, wherein, having
5 peened the wall (2C) of a cavity (2), the
 sonotrode (8) is moved toward its intermediate
 position in the sleeve (16), the treated cavity is
 replaced with another cavity (2) to be treated,
 the sonotrode (8) is moved toward its peening
10 position and the wall (2C) of the other cavity to
 be treated is ultrasonically peened.
4. The method as claimed in claim 1, wherein, having
 peened the wall (2C) of a cavity (2), the treated
15 cavity (2) is replaced with another cavity (2) to
 be treated, and the wall (2C) of the other cavity
 (2) to be treated is ultrasonically peened.
5. The method as claimed in claim 1, wherein, having
20 peened the wall (2C) of a cavity (2), the
 sonotrode (8) and the sleeve (16) are moved
 together toward a lowered position, the treated
 cavity is replaced with another cavity to be
 treated, the sonotrode (8) and the sleeve (16) are
25 moved together toward the raised peening position,
 and the wall (2C) of the other cavity to be
 treated is ultrasonically peened.
6. The method as claimed in claim 2, wherein, having
30 peened the wall (2C) of a cavity (2), the
 sonotrode (8) is moved toward its intermediate
 position in the sleeve (16), the sonotrode (8) and
 the sleeve (16) are moved together toward a
 lowered position, the treated cavity is replaced
35 with another cavity to be treated, the sonotrode
 (8) and the sleeve (16) are moved together toward
 the raised peening position, the sonotrode is
 moved approximately vertically with respect to the
 sleeve (16) so that the vibrating surface (8A)



closes off the mouth (21) and the wall (2C) of the other cavity to be treated is ultrasonically peened.

- 5 7. The method as claimed any of claims 3 to 6,
intended to treat a circular part, a rotor rim (1)
for example, comprising a number of axial cavities
(2) formed at the periphery of said rotor rim (1)
and having wall portions (2'C) which diverge from
10 each mouth, wherein the rotor rim (1) is turned
stepwise about its axis of rotation (1A) arranged
horizontally so as bring each axial cavity (2) in
turn to face the sonotrode (8) after a cavity has
been treated.
- 15 8. The method as claimed in claim 7, wherein a
deflector (15) is placed in the cavity so as to
encourage the peening of the internal flanks of
the lateral mouth (2A).
- 20 9. The method as claimed in one of claims 1 to 8,
wherein use is made of a dose of beads (10) the
diameter of which exceeds 0.8 mm.
- 25 10. An installation for implementing the method as
claimed in any of claims 1 to 9, and which
comprises:
a sonotrode (8) arranged in a sleeve (16) equipped
with closing-off means (14) capable of closing off
30 the frontal openings (3) of a cavity (2), said
sonotrode (8) being capable of projecting beads
(10) of a determined diameter into a chamber (12)
delimited by the wall (2C) of the cavity (2), the
vibrating surface (8A) of said sonotrode (8), the
35 sleeve (16) and the closing-off means (14),
means (18) of producing ultrasonic oscillations
capable of exciting said sonotrode (8),
first means (20) for moving said sonotrode (8)
approximately vertically, and second means (22)



for moving said sleeve (16) approximately vertically,

a first clearance (e1) smaller than the diameter of the beads (10) being formed between said sonotrode (8) and said sleeve (16).

11. The installation as claimed in claim 10, wherein a second clearance (e2) smaller than the diameter of the beads (10) is formed between the vibrating surface (8A) arranged in the mouth of the cavity (2) and said mouth (2A).
12. The installation as claimed in either of claims 10 and 11, wherein, a third clearance (e3) smaller than the diameter of the beads (10) is formed between one end (16A) of the sleeve (16) and the part.
13. The installation as claimed in any of claims 10 to 12, wherein the second movement means (22) are capable of moving the closing-off means (14) and the sonotrode (8) at the same time.
14. The installation as claimed in any of claims 10 to 13, wherein the first movement means (20) and the second movement means (22) can be operated simultaneously.
15. The installation as claimed in any of claims 10 to 14, and which comprises support means for supporting at least one part (1) that is to be treated and means of driving said support means, to bring one cavity (2) step by step over the sonotrode (8).
16. The installation as claimed in any of claims 10 to 15, and which comprises means (28) for driving the dose of beads (10) from the vibrating surface (8A) toward a reservoir (32).