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Method for extending the life of the attachments that
attach blades to a rotor

Description

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Technical field of the invention

The invention relates to the attachments that attach
blades to a rotor and more specifically to a method for
10 extending their life, this method employing a
particular embodiment of the "ultrasonic" peening
technique.

State of the art and problem posed

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In an aerojet engine, the bladed rotors traditionally
consist of a rim, at the periphery of which a number of
removable blades are mounted. The mounting device is
known in this patent application as a "blade
20 attachment". This device comprises a dovetail groove
machined in the rim and a root also in the shape of a
dovetail machined at the base of the blade, assembly
being by fitting the root into the groove. In a more
elaborate embodiment known as the "Christmas tree root"
25 embodiment, the dovetail has several "bulbs" of
decreasing size, typically three bulbs, each bulb
separately performing the function of the dovetail. In
what follows, these two forms of attachment will be
termed indifferently "dovetail attachments". The blade
30 roots are fitted into the grooves by sliding with
limited clearance, the roots then being immobilized
without clearance by various locking means. It will be
understood that the grooves and the blade roots are the
site of high stress concentrations and that they
35 therefore have to be produced with particular care.
Turbojet rotors are conventionally made of steel,
titanium alloy or a nickel or chromium-based
superalloy.

Conventionally, rotors undergo peening by projecting small beads made of a hard material using one or more compressed-air nozzles. This peening has the effect of creating compressive prestress at the surface of the rotor over a depth of a few tenths of a millimeter, this prestress delaying the onset of cracks resulting from the high stresses and thus extending the life of the rotor. If need be, peening is preceded by a heat treatment of the part to be treated in order to relieve the residual stresses that remain in this part. When certain portions of the part do not need to be peened, they are customarily protected by coating them with a material, such as an elastomer, that has sufficient hardness to resist the impact of the beads.

Intensive peening with an Almen intensity of the order of F15A to F17A and making it possible to create a compressive prestress of the order of 900 to 1100 MPa (mega pascals) at the surface of the rotor is desirable, these rotors customarily being made of steel, of titanium alloy or of chromium-based or nickel-based superalloy. Unfortunately, such peening greatly increases the roughness of the treated surfaces and thus reduces the resistance to wear by vibrational friction of the surfaces of the grooves and of the blade roots which are in mutual contact.

This increase in the roughness of a surface undergoing intensive peening by blasting small beads is backed by various documents:

- Patent EP 0 922 532 paragraph [0005] column 1, lines 33 to 38. One of the recommended solutions is to reduce the intensity and coverage of the peening, paragraph [0006], lines 39-40. This same patent indicates at line 41 that this may result in a reduction in the life of the part.
- In the magazine "Souder [Welding]" No. 5 of September 1998, the study "Le principe du choc laser et ses applications au traitement des matériaux [The

principle of laser shock and its applications to materials treatment]" makes a comparison between "laser shock" peening and conventional peening and indicates in the penultimate paragraph of page 13
5 that conventional peening creates microcraters resulting from the impacts of the beads and increasing roughness. According to the examples given in the first table on page 14, the roughness (Ra) of a machined surface can increase from 2.3 μm to 5.5 μm
10 after intensive peening.

The article "Le grenailage de précontrainte [Prestressing peening]", published in 1992 by CETIM page 105-123 reports a national conference held on 25
15 and 26 September 1991 at Senlis in France. In the penultimate paragraph of page 108, it indicates that the peening of a machined surface leads to an increase in the roughness value. This same article specifies, in the last paragraph of this same page, that the
20 roughness can be reduced by performing the peening in several passes of decreasing intensity. It should be understood that intensive peening to start with increases the roughness and that the increasingly lighter peening operations which follow reduce the
25 roughness by evening out the peened surface. This solution does, however, have the disadvantage of being lengthy because several peening operations are needed; the first prestressing the peened surface and the next peening operations gradually reducing the roughness
30 which appeared during the first peening operation.

The problem to be solved is that of simultaneously increasing the fatigue strength and the resistance to vibrational friction of the rotors at the blade
35 attachments, it being necessary for this increase not to lead to an appreciable increase in the time and cost involved in manufacturing the rotors.

Peening by blasting beads is currently experiencing a new embodiment known as "ultrasonic peening" where the beads are no longer blasted out of a nozzle by a jet of compressed air but by the percussion against these beads of the surface of a sonotrode vibrating at frequencies of the order of 20 to 60 kHz, the beads being kept inside a chamber, the part to be peened being, depending on its dimensions, immersed inside the chamber or offered up to an opening of this chamber.

Patent FR 2 743 742 discloses an application of ultrasonic peening to cookware allowing the microcavities created beforehand on the surface of the utensil to be reduced to encourage the adhesion of a coating to part of the utensil. This patent indicates, on page 5 line 32, that the cookware is made of aluminum. It is known that that material is soft, and its prestressing does not exceed 150 to 200 MPa. It is very much below the desired prestressing of 900 to 1100 MPa. That patent also indicates on page 1, line 31 that the surface obtained is smooth, but specifies on page 5, line 14 that the peening (which it refers to as "billage") lasts from 0.5 to 5 seconds. Even for a soft material, this then is only a very light surfacing peening that is in no way comparable with the intensive compressive prestressing peening operations carried out on aeronautical parts, the surfaces of these parts having to be exposed to the peening for a duration of 4 to 10 minutes at least. That patent therefore provides no solution to the problem that is to be solved.

Summary of the invention

The invention proposes a method for extending the life of attachments that attach blades to a rotor, the rotor comprising a rim to the periphery of which are attached a number of removable blades, the blade attachments comprising two components, one of the components being a dovetail groove arranged at the periphery on the rim,

the other component being a root arranged on the blade, the root being of a shape that complements the groove, the root being able to be fitted into the groove so as to attach the blade to the rotor, at least one
5 component being peened by the projecting of beads so as to create compressive prestress at its surface.

Such a method is noteworthy in that peening is performed using the "ultrasonic" method, the beads being projected by the percussion of a sonotrode set in
10 vibration, the beads being contained in a chamber and forming a mist inside the chamber, the constituent to be peened being brought into contact with the mist of beads,

and in that peening is performed with an Almen
15 intensity at least equal to F8A.

The inventors have found that intensive ultrasonic peening only slightly increases the roughness of the treated part, unlike conventional peening employing a
20 nozzle with a jet of compressed air. The invention thus puts this unexpected property to use to increase the fatigue strength of the blade attachments while at the same time maintaining good resistance to wear by vibrational friction.

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One advantage of the invention is that it also increases the resistance to wear by vibrational friction of the blade attachments, because the high compressive prestressing of the surfaces of the
30 components of the blade attachments causes them to harden by work hardening.

Advantageously, use will be made of beads with a diameter at least equal to 0.8 mm so as to improve the
35 effectiveness of the peening and to stabilize or even reduce the roughness of the treated parts.

Advantageously, the compressive prestress will be at least equal to 500 MPa.

In one particular embodiment of the method, the invention proposes its application to "axial" grooves on the rims of bladed rotors.

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In another particular embodiment of the method, the invention proposes its application to the "annular" grooves on the rims of bladed rotors.

10 In another particular embodiment of the method, the invention proposes its application to the roots of the blades.

Description of the figures

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The invention will be better understood and the advantages it affords will become more clearly apparent in the light of a detailed description of the properties of ultrasonic peening, of three examples of
20 application to blade attachments and of the appended figures.

Figure 1 illustrates the deformation of the material under the effect of the impacts of the moving beads.

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Figure 2 illustrates the rim of a rotor and shows the "axial" grooves at its periphery.

Figure 3 illustrates the mounting of a blade on a rim
30 with axial grooves.

Figures 4 and 5 illustrate, in a front view and in a profile view, the method of the ultrasonic peening of the axial grooves, figure 4 being a view in section on
35 B of figure 5, this figure 5 itself being a view in section on A of figure 4.

Figure 6 illustrates the rim of a rotor with "annular" grooves.

Figure 7 illustrates the mounting of a blade on a rim with annular grooves.

Figures 8 and 9 illustrate in a front view and a profile view, the method for the ultrasonic peening of the annular grooves. Following the model of the previous example, figure 8 is a section on D of figure 9, this figure 9 itself being a section on C of figure 8.

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Figures 10 and 11 illustrate, in a front view and a view from above, the method for the ultrasonic peening of the blade roots, figure 10 being a view in section on E of figure 11.

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Detailed description

Tests have shown that intense "ultrasonic" peening does not appreciably increase the roughness of the treated surfaces, unlike conventional peening involving blasting the beads using a nozzle with a jet of compressed air. The table below shows some comparative results obtained on a part made of nickel-chrome-based refractory superalloy:

- 25 - the first row shows the roughnesses (Ra) measured before peening,
- the second row shows the roughnesses (Ra) measured on the same surfaces after conventional peening with a high Almen intensity of F17A and prestressing of as much as 1000 MPa under the peened surface,
30 - the third row shows the roughnesses (RA) measured on these same surfaces after ultrasonic peening equivalent to the previous peening operation with an Almen intensity of F17A with prestressing of as much
35 as 1000 MPa under the surfaces.

	Surface 1 (milled)	Surface 2 (turned)
Roughness (Ra) before peening	0.27 μm	0.90 μm
Roughness (Ra) after conventional peening, Almen intensity = F17A, bead $\varnothing$ = 0.315 mm	1.53 μm	1.94 μm
Roughness after US peening, Almen intensity = F17A, bead $\varnothing$ = 1.5 mm	0.47 μm	0.93 μm

In a first example illustrated in column 1, surface 1, machined by milling with a roughness $R_a = 0.27 \mu\text{m}$ has its roughness increased by $1.67 \mu\text{m}$ [sic] after conventional peening, whereas its roughness increases only by $0.2 \mu\text{m}$ with ultrasonic peening, this surface 1 being arranged parallel to the sonotrode.

10 In a second example illustrated in column 2, surface 2 machined by turning with an $R_a = 0.90 \mu\text{m}$ has its roughness increased by $0.63 \mu\text{m}$ [sic] after conventional peening, whereas this roughness remains practically unchanged after ultrasonic peening, this surface 2 this time being arranged at right angles to the sonotrode.

This remarkable property of ultrasonic peening, which is of allowing intensive peening without appreciably increasing the roughness of the treated surface, could be explained thus in the light of figure 1: the beads 1 supplied with kinetic energy by the percussions of the vibrating sonotrode bounce off the sonotrode itself onto the walls of the chamber and onto the surface 3 of the part 2 being peened, these beads 1 then bouncing off this surface at an angle α , β of incidence which is random with a roughly uniform distribution between 0 and 90° and in any direction. This being the case:

- The beads 1a impacting the surface to be peened at an angle α close to the normal to this surface will be effective in creating significant compressive prestress at the points of impact, these beads however leaving, on the impacted surface 3, craters 4 which are surrounded by bulges 5 that form rough patches.
- Conversely, the beads 1b impacting the surface 3 at a small angle β , that is to say rather skimming the surface 3, will tend to even out the bulges 5 and to at least partially refill the craters 4, these beads 1b obviously not being very effective or not being effective at all at creating sufficient compression prestress. The role of the skimming beads is confirmed by the previous table. In effect, surface 2 receives rather more skimming beads because it is ultrasonically peened in a position perpendicular to the sonotrode, which explains why the roughness increases practically not at all.

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It can therefore be said that intensive peening that does not appreciably increase the roughness of the peened surface 3 needs to be able to combine, on the treated surface, impacts of beads 1a at angles of incidence α close to the normal to this surface 3 and impacts of beads 1b skimming this surface. An angle of incidence α close to the normal to the surface is to be understood as meaning an angle α at least equal to 45° , the effectiveness of the impact being better the closer this angle α is to 90° . A skimming angle of incidence β is to be understood as being an angle β less than 45° and preferably of between 15° and 30° .

It will be noted that intensive peening according to the invention also entails a "coverage" ranging from 120% to 300%, that is to say that peening is performed for a duration T equal to 120% to 300% of the duration T₁ needed to obtain a normal coverage of 98%, the

normal coverage being the ratio between the impacted area and the total area exposed to peening.

However, in the case of conventional peening, the beads
5 strike the peened surface with an angle of incidence
and a preferred direction, this angle of incidence
having to be high enough to prestress the peened
surface. As a result, the bulges that form around the
10 craters are not evened and, on the contrary, tend to
collect in ripples which are clearly visible under a
microscope with a magnification of x50 to x100, the
craters tending themselves to collect in furrows more
or less perpendicular to the ripples.

15 A not insignificant advantage of ultrasonic peening is
that it requires only a small quantity of beads to
implement it. It is therefore possible, in this
instance, to use high-quality beads comparable with
steel or ceramic ballbearings. Unlike conventional
20 peening:

- these beads are perfectly spherical and therefore
give a better surface finish,
- these beads which are very hard do not break and
therefore do not produce sharp edges likely to damage
25 the surface finish of the peened part.

Reference will now be made to figure 2. The bladed
rotor comprises a rim 10 having an overall shape of
revolution about a geometric axis 11, this rim 10 being
30 radially bounded toward the outside by a peripheral
surface 12 and laterally by two flanks 13. The rim 10
at its periphery 12 has a number of approximately
straight "axial" grooves 14 each having a mouth 15
extended laterally by the two lateral openings 16, the
35 mouth 15 opening onto the periphery 12, and the lateral
openings 16 opening onto the flanks 13. The grooves 14
have an approximately trapezoidal "dovetail" profile
with a narrower mouth 15. These grooves 14 may be

parallel to the geometric axis 11 or may be oblique. They may be straight or in the shape of a circular arc.

Reference will now be made to figure 3. A blade 20
5 comprises, in succession from top to bottom in this figure, thin aerofoil 21, a platform 22 extending laterally on each side of the blade 20, and a root 23 of approximately trapezoidal shape that complements the — shape of the groove 14. The blade 20 is fitted via its
10 root 23 into the groove 14 with limited clearance, the root 23 then being immobilized in the groove 14 by various locking means not depicted. The root 23 comes into contact with the groove 14 along two lines of contact 24 situated to the rear of the mouth 15 and set
15 back from this mouth 15. The attachment 26 for attaching the blade 20 comprises the groove 14 and the root 23.

Reference will now be made simultaneously to figures 4
20 and 5. The sonotrode 30 comprises a vibrating surface 31 capable of being introduced into the mouth 15 of the groove 14. The sonotrode 30 slides in a sleeve 32 with a clearance E smaller than the diameter of the beads 1. The sealing of the sonotrode 30 against the beads with
25 respect to the mouth 15 may be provided by the sleeve 32. In a preferred embodiment, however, this sealing is provided more simply by giving the sonotrode 30 a shape that complements that of the mouth 15, for example a rectangular shape in the case of straight grooves, with
30 a clearance E smaller than the diameter of the beads 1. The sleeve 32 supports two stoppers or wings 33 one on each side of the sonotrode 30, these wings being capable of covering the openings 16 of the groove 14 with a clearance E smaller than the diameter of the
35 beads 1. It will be understood that the sonotrode 30 and the wings 33 collaborate to close the groove 14 and contain the beads in this groove 14 during peening.

With such a device, the method for the ultrasonic peening of the axial grooves 14 comprises the following operations:

- 5 - arranging the rim 10 above the sonotrode 30 in an appropriate position for bringing each axial groove 14 over the sonotrode 30 by rotating the rim 10 about its geometric axis 11,
- 10 - arranging a dose of beads 1 on the sonotrode 30, the sonotrode preferably being retracted into the sleeve 32 so as to constitute, above its vibrating surface 31, a receptacle capable of containing the beads 1,
- turning the rim 10 to bring each axial groove 14 in turn over the sonotrode 30, each axial groove 14 then being subjected to the following operations:
 - 15 - covering the lateral openings 16 with the wings 33 and bringing the sonotrode 30 into the mouth 15 of the axial groove 14, this operation being performed preferably by simultaneously raising the sonotrode 30 and the sleeve 32 until the wings 33 cover the
 - 20 openings 16, the sonotrode 30 then being raised alone into the mouth 15, which has the effect simultaneously of bringing the beads 1 into the groove 14 and of placing the sonotrode 30 in the working position,
 - 25 - peening the axial groove 14 by setting the sonotrode 30 in vibration,
 - withdrawing the sonotrode 30.

30 It is advantageous for the vibrating surface 31 of the sonotrode 30 to be brought into the mouth 15 itself, the vibrating surface 31 being more or less level with the narrowest section of this mouth. This has the effect of:

- 35 - improving the homogeneity and isotropy of the mist of beads 1 produced inside the groove 14, so as to better combine intensive prestressing and low roughness particularly on the lines of contact 24 at the rear and set back from the mouth 15,

- protecting the mouth 15 itself from peening, this mouth 15 forming roughnesses and therefore likely to be crushed by the impacts of the beads 1.

5 Reference will now be made to figure 6. The bladed rotor in this second example comprises a rim 10 having an overall shape of revolution about a geometric axis 11, this rim 10 being bounded radially toward the outside by an annular peripheral surface 12. In this
10 example, the rim 10 comprises, at the periphery 12, three annular grooves 14, the descriptions of which are identical: each annular groove 14 comprises a mouth 15 which is also annular and opens onto the periphery 12. Each groove also comprises a local opening 18 also
15 opening onto the periphery 12, this opening being known as the "local opening" 18. Each annular groove 14 has a more or less trapezoidal "dovetail" profile with a narrower mouth 15.

20 Reference will now be made to figure 7. A blade 20 comprises, in succession from top to bottom in this figure, a thin aerofoil 21, a platform 22 extending laterally on each side of the blade 20 and a root 23 of a more or less trapezoidal shape that complements the
25 shape of the groove 14, the root 23 in this example being arranged transversely to the aerofoil 21. This figure also shows, for information, the section 21a of the aerofoil 21. The blade 20 is fitted via its root 23 into the annular groove 14 with a limited clearance and
30 is immobilized by locking means not depicted. Each annular groove 14 thus accommodates a number of blades 20, the root 23 of which is introduced through the local opening, referenced 18 in figure 6, and brought into position by sliding along the annular groove 14.
35 The root 23 comes into contact with the annular groove 14 along two lines of contact 24 which are also annular and situated to the rear of the mouth 15. The term "attachments 26 for attaching the blades 20" is to be

understood also as meaning the annular groove 14 and the roots 23.

Reference will now be made simultaneously to figures 8 and 9. The sonotrode 30 comprises a vibrating surface 31 capable of being introduced into the mouth 15 of the groove 14. The sonotrode 30 slides in a sleeve 32 with a clearance E smaller than the diameter of the beads 1. The sonotrode 30 can be sealed to the mouth 30 with respect to the beads by the sleeve or by any other means. In a preferred embodiment, however, this feeling is most simply achieved by giving the sonotrode 30 a rectangular cross section with a width equal to that of the mouth 15 less a clearance E smaller than the diameter of the beads 1. The sleeve 32 supports two wings 33 one on each side of the sonotrode 30, these wings being capable of sliding in the annular groove 14 with a clearance E smaller than the diameter of the beads 1. It will be understood that the sonotrode 30 and the wings 33 collaborate to contain the beads 1 inside a portion of the annular groove 14 and against the walls of this groove 14.

With such a device, the method for the ultrasonic peening of an annular groove 14 comprises the following operations:

- arranging the rim 10 over the sonotrode 30 in an appropriate position for causing the annular groove 14 to travel over the sonotrode 30 by rotating the rim 10 about its geometric axis 11,
- arranging a dose of beads 1 on the sonotrode 30, the sonotrode preferably being retracted into the sleeve 32 so as to constitute, above its vibrating surface 31, a receptacle capable of containing the beads 1,
- presenting the local opening 18 over the sonotrode 30,
- bringing the sonotrode 30 and the two wings 33 into the local opening 18, the sonotrode 30 being even with the mouth 15 and aligned with this mouth 15, the

- two wings 33 lying one on each side of the sonotrode (30) and aligned with the axial groove (14),
- turning the rim 10 and setting the sonotrode 30 in vibration when the two wings 33 and the sonotrode 30 are in the annular groove 14,
 - stopping the sonotrode 30 as soon as a wing 33 comes out in the local opening 18,
 - stopping rotation of the rim 30 when both wings 33 and the sonotrode 30 are in the local opening 18.

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Reference will now be made simultaneously to figures 10 and 11. Topeen the roots 23 of the blades 20, use is made of a chamber 40, the bottom 41 of which has an opening 42 through which a sonotrode 30 passes with a clearance E smaller than the diameter of the beads 1, the chamber 40 being covered by a, preferably thin, lid 45, the lid 45 having a number of openings 46 of a shape that complements the roots 23 to be treated, the distance between the lid 45 and the sonotrode 30 being at least equal to the height of the roots 23 so that the bases 23a of the roots 23 do not touch the sonotrode 30.

With such a device, the method for the ultrasonic peening of the roots 23 of the blades 20 comprises the following operations:

- introducing a dose of beads 1 into the chamber 40,
- introducing the roots 23 into the openings 46 of the lid 45 and immobilizing the blades 20 on the lid 45,
- setting the sonotrode 30 in vibration to carry out the peening.

One advantage of the method is that it avoids coating with a protective coating those parts of the blade which do not need to be peened, namely the platform 22 and the aerofoil 21, this protection being afforded by the lid, the platform 22 and the aerofoil 21 remaining behind the lid 45 outside the chamber 40.

Advantageously, the roots 23 are provisioned above the vibrating surface 31 of the sonotrode 30 so as to ensure homogeneous peening of all the roots 23.

- 5 Advantageously also, the blades 20 having a cooling cavity opening at the base 23a of the root 23, this base 23a is positioned at a distance from the sonotrode 30 which is smaller than the diameter of the beads 1 so as to prevent the beads 1 from entering the cooling
10 cavity.



Claims

1. A method for extending the life of attachments
that attach blades to a rotor, the rotor
5 comprising a rim (10) to the periphery (12) of
which are attached a number of removable blades
(20), the blade attachments being referenced (26)
and comprising two components (14, 23), one of the
components (14) being a dovetail groove arranged
10 at the periphery (12) on the rim (10), the other
component (23) being a root arranged on the blade
(20), the root (23) being of a shape that
complements the groove (14), the root (23) being
able to be fitted into the groove (14) so as to
15 attach the blade (26) to the rim (10), at least
one component (14, 23) being peened by the
projecting of beads (1) so as to create
compressive prestress at its surface,
wherein:
 - 20 a) peening is performed using the "ultrasonic"
method, the beads (1) being projected by the
percussion of a sonotrode (30) set in
vibration, the beads (1) being contained in a
chamber (40) and forming a mist inside the
25 chamber (40), the constituent (14, 23) to be
peened being brought into contact with the mist
of beads (1),
b) peening is performed with an Almen intensity at
least equal to F8A.
- 30 2. The method as claimed in claim 1, wherein the
beads (1) have a diameter at least equal to
0.8 mm.
- 35 3. The method as claimed in claim 1 or 2, the part
being made of a material from the group of steel,
titanium alloy, chrome-based superalloy, nickel-
based superalloy, wherein the prestressing is at
least 500 MPa.



4. The method as claimed in any of claims 1 to 3 applied to the peening of the axial grooves (14), these axial grooves (14) being approximately straight and open at each end, the lateral openings thus formed being referenced (16), wherein use is made of a sonotrode capable of being introduced into the mouth (15) of the grooves (14) with means for sealing the sonotrode (30) in the mouth (15), and two wings (33) capable of covering the lateral openings (16) and of closing them off with a clearance E smaller than the diameter of the beads (1), and which comprises the following operations:
- 15 - arranging the rim (10) above the sonotrode (30) in an appropriate position for bringing each axial groove (14) over the sonotrode (30) by rotating the rim (10) about its geometric axis (11),
 - 20 - arranging a dose of beads (1) on the sonotrode (30),
 - turning the rim (10) to bring each axial groove (14) in turn over the sonotrode (30), each axial groove (14) then being subjected to the following operations:
 - 25 - covering the lateral openings (16) with the wings (33) and bringing the sonotrode (30) into the mouth (15) of the axial groove (14),
 - peening the axial groove (14) by setting the sonotrode (30) in vibration,
 - 30 - withdrawing the sonotrode (30).
5. The method as claimed in any of claims 1 to 3 applied to the peening of an annular groove (14), this annular groove (14) comprising a local opening (18) for passing the roots (23) of the blades (20), wherein use is made of a sonotrode (30) that can be introduced into the mouth (15) of the annular
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grooves (14) with means for sealing the sonotrode (30) to the mouth (15), and two wings (33) capable of passing into the annular groove (14) with a clearance E smaller than the diameter of the beads (1),

and which comprises the following operations:

- arranging the rim (10) over the sonotrode (30) in an appropriate position for causing the annular groove (14) to travel over the sonotrode (30) by rotating the rim (10) about its geometric axis (11),
- arranging a dose of beads (1) on the sonotrode (30),
- presenting the local opening (18) over the sonotrode (30),
- bringing the sonotrode (30) and the two wings (33) into the local opening (18), the sonotrode (30) being even with the mouth (15) and aligned with this mouth (15), the two wings (33) lying one on each side of the sonotrode (30) and aligned with the axial groove (14),
- turning the rim (10) and setting the sonotrode (30) in vibration when the two wings (33) and the sonotrode (30) are in the annular groove (14),
- stopping the sonotrode (30) as soon as a wing (33) comes out in the local opening (18),
- stopping rotation when both wings (33) and the sonotrode (30) are in the local opening (18).

6. The method as claimed in any of claims 1 to 3 applied to the peening of blade roots, wherein use is made of a chamber (40), the bottom (41) of which has an opening (42) through which a sonotrode (30) passes with a clearance E smaller than the diameter of the beads (1), the chamber (40) being covered by a thin lid (45), the lid (45) having a number of openings (46) of a shape that complements the roots (23), the distance

between the lid (45) and the sonotrode (30) being at least equal to the height of the roots (23), and which method comprises the following operations:

- 5 - introducing a dose of beads (1) into the chamber (40),
 - introducing the roots (23) into the openings (46) of the lid (45) and immobilizing the blades (1),
 - 10 - setting the sonotrode (30) in vibration to carry out the peening.
7. The method as claimed in claim 7, wherein all the blades (20) are positioned above the vibrating
- 15 surface (31) of the sonotrode (30).
8. The method as claimed in claim 7, the blades (20) having a cooling cavity opening at the base (23a) of the root (23), wherein the base (23a) is
- 20 positioned at a distance from the sonotrode (30) which is smaller than the diameter of the beads (1).

