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PEENING THE TOPS OF COOLED BLADES

- The invention relates to a method for the surface treatment and compressive prestressing by peening of the tops and aerodynamic surfaces of cooled blade tips comprising a cavity in their tops, said blades being
- 5 hollow and having an internal cooling circuit communicating with the outside via cooling air passage orifices formed in particular in said tops and said aerodynamic surfaces. —
- 10 A cooled blade, for example a jet engine turbine blade, is hollow and under the root has a sizeable opening through which a flow of cooling air tapped from a compressor stage is injected. The blade aerofoil comprises, on the leading edge, on the trailing edge,
- 15 on the flanks and on the top, small holes which allow the heated-up cooling air which flows inside the blade to be removed so as to be replaced with fresh cooling air and which allow the conveying of this heated-up cooling air onto the exterior surface of the blade to
- 20 isolate it from the combustion gases of the jet engine. These holes, which may be cylindrical or may be in the form of slots, have relatively small transverse dimensions, at most equal to 1 mm. Furthermore, the aerodynamic surfaces are generally extended at the top
- 25 of the blade by an exterior wall forming, at the top of the blade, a cavity which is open toward the top.

Turbine blades in operation are subjected to considerable centrifugal forces and to high thermal

30 stresses. Hence, it is necessary to compressively prestress the external surfaces of the aerofoils so as to delay the onset of cracks detrimental to the integrity and life of these blades, and particularly the end surfaces of the blades which are subjected to

35 the greatest centrifugal forces.

This compression is also needed in the case of blades whose tops have been repaired. Repairing the top of a blade consists in building up the uneven regions using

weld metal, in practice by TIG electric arc welding. This build-up is followed:

- by machining to reconstruct the shape of the blade, and

- 3 - by peening by blasting beads or shot so as to compress the surface of the built-up regions and prevent the appearance of cracks at the welds during the subsequent heat treatments and when the blade is in use.

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When the top of the blade has a cavity open toward the top, the inside of the wall delimiting this cavity has also to be peened.

- 15 At the present time, the surfaces of the blade tips are compressively prestressed by peening using beads ejected by air jet peening nozzles. These nozzles are able to project only beads the diameter of which is smaller than 1 mm, and typically between 0.1 and
- 20 0.5 mm. It is therefore necessary to plug the blade cooling holes, prior to peening, to prevent the beads from entering them. The top of the blade is then offered up to one or more air jet peening nozzles and the nozzles are moved in order to make the peening
- 25 uniform. After the peening operation, the cooling holes have to be unplugged.

It is also possible not to plug the holes during peening. In such a case, it is then necessary, for

- 30 example by dissolving them in acid, to remove any beads which may remain in the cooling holes or may have entered the interior cavity of the blade.

Peening with nozzles takes a great deal of time because

- 35 since the beads are of small diameter they have low kinetic energy. Furthermore, the small diameter of the beads leads to damage to the surface finish of the blade.

During peening, the nozzle has to be moved in various orientations, so as to reach the entire peripheral wall of the end of the blade and also the interior wall of the upwardly open cavity when there is one. When
5 peening is performed by hand, it is, by nature, not very repeatable. When peening is automated, it entails control over numerous parameters, and is therefore difficult to control and to repeat. —

10 It is also known practice for peening to be carried out using flappers equipped with beads. This method, known as "flapper peening", consists in using a small spindle comprising, at its end, strips of plastic, to the end
15 of which beads are bonded. Peening is performed by rotating the spindle. As the beads are held on the strips, they do not enter the cooling holes. The disadvantage with this method is that the tool soon degrades as beads are torn off and the strips become frayed, and that, above all, it is not possible
20 effectively topeen the interior of the open cavity at the top of the blade.

It is an object of the invention to propose a method for peening blade tips which makes it possible to
25 create prestresses which are repeatable identically on all the blades, and in a shorter peening time.

It is another object of the invention to propose a method for peening blade tips which eliminates the
30 operations of plugging and unplugging the cooling air passage orifices before and after the peening operation respectively.

The invention achieves its objective in that peening is
35 performed by means of a mist of beads created in a sealed chamber containing at least one blade tip, said mist being created by the active surface of a sonotrode excited by means of producing ultrasonic oscillations and delimiting part of said chamber, and in that use is

made of beads which have a diameter greater than that of the cooling air passage orifices.

Advantageously, the beads have a diameter of between
5 0.8 and 5 mm.

Because the beads have a diameter greater than that of the cooling air passage orifices, there is no longer any need to carry out the operations of plugging and
10 unplugging these orifices, and the kinetic energy of the beads allows the peening time to be reduced.

Furthermore, the beads of the mist of beads moving in random directions strike the surfaces of the blade tip
15 at varying angles, and this improves the surface finish by comparison with beads projected by a nozzle in a predominant direction, this being especially the case since the beads used in the method according to the invention have a diameter greater than the diameter of
20 the beads that can be projected by a nozzle.

Finally, all the external surfaces of the blade tip exposed in the chamber are subjected at the same time to the impacts of the beads, and this considerably
25 reduces the risk of blade tip deformation.

The invention also relates to tooling for implementing the method according to the invention.

30 This tooling comprises a blade support plate having at least one through-orifice, the cross section of which is tailored to the cross section of the end of a blade aerofoil, a frame, on one face of which the support plate can be fixed, and a sonotrode, the vibrating
35 plate of which is capped by said frame and arranged facing the support plate.

The invention also relates to a method for repairing blades.

According to this method, the uneven regions of the blade are built up with weld metal, are machined to reconstitute the shape of the blade, and are peened according to the method of the invention described
5 hereinabove so as to prevent the appearance of cracks at the welds during subsequent heat treatments and when the blade is in use.

Other features and advantages of the invention will
10 become apparent from reading the following description which is given by way of example and with reference to the appended drawings, in which:

- Figure 1 is perspective view of a cooled jet engine
15 turbine blade;

- Figure 2 is a view from above of blade supporting tooling for implementing the method according to the invention;

- Figure 3 is a view in section on III-III of figure 2
20 of the blade supporting tooling capping the active surface of a sonotrode; and

- Figure 4 is a perspective view of a support plate on which two blades are mounted.

25 Figure 1 shows a cooled jet engine turbine blade 1, for example, which has a root 2 intended for fixing said blade 1 into a groove formed in the peripheral wall of a turbine wheel, a platform 3 surmounting the blade root 2 and internally delimiting the stream for
30 combustion gases which flows from the combustion chamber and an aerofoil 4 of aerodynamic shape which extends from the platform and which, at the upstream end in the direction of the flow of the combustion gases, has a leading edge 5 and at the downstream end
35 has a trailing edge, this leading edge 5 and this trailing edge 6 being connected in a known way by a pressure face 7 and a reduced-pressure face 8. The aerofoil 4 is closed off at its outer end or top by a wall 9 arranged below the outer ends 7a, 8a of the

pressure face 7 and of the reduced-pressure face 8. These outer ends delimit, with the wall 9, a cavity 10 and, with the stator casing, seal the outer stream of combustion gases.

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The blade 1 is hollow and has an internal cooling air circuit supplied by large-sized orifices 11 formed in the blade root 2. Cooling air passage orifices 12 are formed in the leading edge 5, the trailing edge 6, the pressure face 7, the reduced-pressure face 8 and the top wall 9. These orifices 12 may be circular or may be in the form of slots. In the case of circular orifices 9, their diameter is at most equal to 1 mm and, in the case of slots, their transverse dimension is at most equal to 1 mm.

The object of the invention is to provide a method for compressively prestressing the outer end region 13 of the aerofoil 4 which extends, for example, over a height H of 10 mm, and which comprises the wall 9 delimiting the cavity 10 and the outer portions of the leading edge 5, of the trailing edge 6, of the pressure face 7 and of the reduced-pressure face 8.

25 Figures 2 and 3 show an example of tooling 20 used to implement the method.

The tooling 20 essentially comprises a support plate 21 for supporting several blades 1. This plate 21 has through-orifices 22, the cross section of which is roughly the same as the cross section of the end of an aerofoil 4, and, on one of its faces, rests 23 for the platforms 3, designed so that when an end of an aerofoil is introduced into an orifice 22, and the platform 3 of the corresponding blade 1 rests on a rest 23, the outer end region 13 of said blade 1 emerges from the face 24 of the support plate 21 which is the opposite face to the rests 23.

The support plate 21, which has a rectangular overall shape, is intended to be fixed in a rebate 25 formed on one face of a frame 26, the thickness of which exceeds the height H of the outer end region 13 of the blades 1
5 carried by the support plate 21.

The frame 26, equipped with the support plate 21, caps the vibrating surface 27 of a sonotrode 28 excited by means of producing ultrasonic oscillations, which means
10 are not depicted in the drawings. The vibrating plate 27 is arranged facing the support plate 21 and at a small distance from the outer ends of the blade aerofoils 4. The vibrating plate 27 constitutes the active wall of a chamber 29 delimited by the interior
15 wall 30 of the frame 26 and by the face 24 of the support plate 21.

Beads 31 with a diameter greater than the diameter of the cooling air passage orifices 12 in the blades 1,
20 and typically of between 0.8 and 5 mm, are introduced into the chamber 29. The clearance there is between the interior wall 30 of the frame 26 and the periphery of the vibrating surface 27 is smaller than the diameter of a bead. The beads 31 cannot thus escape from the
25 chamber 29.

When the vibrating plate is subjected to ultrasonic oscillations, a mist of beads is created in the chamber 29. The beads 31 bounce off the interior wall 30 of the
30 frame 26 and the face 24 of the support plate 21. The walls of the outer end regions 13 of the blades 1 are thus struck by a number of beads.

The frequency of the ultrasonic waves, the dimensions
35 of the vibrating surface 27 of the sonotrode 28 and of the frame 26, and the acoustic energy are calculated to be such that the end regions 13 of the blades are peened uniformly and in a very short peening time.

CLAIMS

1. A method for the surface treatment and compressive prestressing by peening of the tops (9) and aerodynamic surfaces (7, 8) of cooled blade tips (1) comprising a cavity (10) in their tops, said blades (1) being hollow and having an internal cooling circuit communicating with the outside via cooling air passage orifices (12) formed in particular in said tops (9) and said aerodynamic surfaces (7, 8),
wherein peening is performed by means of a mist of beads (31) created in a sealed chamber (29) containing at least one blade tip (1), said mist being created by the active surface (27) of a sonotrode (28) excited by means of producing ultrasonic oscillations and delimiting part of said chamber (29), and wherein use is made of beads (31) which have a diameter greater than that of the cooling air passage orifices.
2. The method as claimed in claim 1, wherein the beads (31) have a diameter of between 0.8 and 5 mm.
3. The method as claimed in claim 2, wherein the chamber (29) contains several blade tips (1).
4. Tooling for implementing the method as claimed in any one of claims 1 to 3, and which comprises a blade support plate (21) having at least one through-orifice (22), the cross section of which is tailored to the cross section of the end (13) of a blade aerofoil (4), a frame (26), on one face of which the support plate (21) can be fixed, and a sonotrode surface (28), the vibrating plate (27) of which is capped by said frame and arranged facing said support plate (21).



5. A method for repairing a blade in which the uneven regions of the blade are built up with weld metal and machined to reconstitute the shape of the blade, wherein, after machining, the surface treatment method as claimed in any one of claims 1 to 3 is applied so as to prevent the appearance of cracks at the welds during subsequent heat treatments and when said blade is in use.

