METHOD FOR SURFACE STRENGTHENING AND SMOOTHENING OF METALLIC COMPONENTS

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With a method for surface strengthening and smoothening of metallic components, in particular of rotors or rotor drums, the components are loaded into a vessel and subjected to a tumbler movement. The metallic components are strengthened and smoothened by a relative movement between the workpiece surface and the drum surface in one process step. The strengthening elements have a circumferential, rounded edge area, or compressive strengthening area for strengthening the surface, and extending from both sides, a flatly curved smoothening area for smoothening the surface roughened by strengthening. With low time and apparatus investment, workpieces can be provided that feature high fatigue strength and advantageous aerodynamic properties.

Abstract

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With a method for surface strengthening and smoothening of metallic components, in particular of rotors or rotor drums, the components are loaded into a vessel and subjected to a tumbler movement. The metallic components are strengthened and smoothened by a relative movement between the workpiece surface and the drum surface in one process step. The strengthening elements have a circumferential, rounded edge area, or compressive strengthening area for strengthening the surface, and extending from both sides, a flatly curved smoothening area for smoothening the surface roughened by strengthening. With low time and apparatus investment, workpieces can be provided that feature high fatigue strength and advantageous aerodynamic properties.
METHOD FOR SURFACE STRENGTHENING AND SMOOTHENING OF METALLIC COMPONENTS

[0001] This application claims priority to German Patent Application DE102009021582.4 filed May 15, 2009, the entirety of which is incorporated by reference herein.

[0002] This invention relates to a method for surface strengthening and smoothening of metallic components, in particular of rotors or rotor drums with integral blading for aircraft engines, and to a strengthening element conceived for the performance of the method.

[0004] The rotors of gas turbines, in particular aircraft engines, are subject to high operational stress especially in the bladed area. In order to reduce the wear resulting therefrom and increase fatigue strength, it is known to strengthen the surface of the rotors in the bladed area by shot peening. In this process, steel or ceramic peening shot accelerated by compressed air is propelled with high speed via nozzles onto the surface sections to be strengthened which, in particular in the bladed area, are subject to high wear. Other known methods for surface strengthening are ultrasonic peening, laser-shock peening or roller burnishing.

[0005] In order to reduce the high apparatus and time investment incurred with sectional surface strengthening by shot peening, it is proposed in Specification EP 1731262 A1 to load the component to be surface-strengthened into a vessel which is filled with spherical shot and performs a tumbling movement. The tumbling movement produces a relative movement between the workpiece moving together with the vessel and the spherical shot, as a result of which the shot impacts the workpiece surface thereby effecting strengthening of the latter.

[0006] Besides surface strength, minimum roughness of the surface of the rotors of aircraft engines is a further important requirement for good aerodynamic properties and maximum efficiency of the engine. However, shot peening involves a significantly increased surface roughness which fails to satisfy the requirements on the efficiency of the engine and demands a subsequent surface-smoothening grinding and polishing treatment incurring considerable work and equipment investment.

[0007] In a broad aspect, the present invention provides a method for surface strengthening and smoothening of metallic components, in particular of rotors with integral blading for aircraft engines, which keeps apparatus and time investment low and effects both strengthening and smoothening of the workpiece surface, which otherwise, while being strengthened, would also be roughened by the impacting shot.

[0008] In the process of surface strengthening and smoothening of metallic components, in particular of rotors or rotor drums with integral blading for aircraft engines, the components are loaded into a vessel filled with strengthening elements and performed a tumbling movement, are strengthened by vertically and horizontally circulating as well as vibrating movements of the strengthening elements and, in the same operation, the strengthened surface is also smoothened.

[0009] Simultaneous strengthening and smoothening of the workpiece surface is obtained by a specific shape of the strengthening elements moved relative to the workpiece surface, these having a circularly or elliptically circumferential, rounded edge area, or compressive strengthening area for strengthening the surface, and, extending therefrom on both sides, a flatly curved area for smoothening the surface. The workpieces, for example, an aircraft-engine rotor drum including several rotors with integral blading, can thereby be strengthened and immediately smoothened in one operation in one and the same apparatus with low time and apparatus investment and will have high fatigue strength and advantageous aerodynamic properties.

[0010] For producing the kinetic energy required for strengthening and smoothening, the strengthening and smoothening elements have a mass adjusted to the movement imparted onto them. Owing to their flattened shape, the strengthening and smoothening elements, despite the relatively large volume, will also access confined workpiece areas. Surface areas of the workpiece which are not to be strengthened are masked during the treatment.

[0011] The strengthening and smoothening elements provided for the performance of the method have a circularly or elliptically circumferential, rounded edge area or compressive strengthening area, respectively, and, extending therefrom on both sides, a flatly curved smoothening area.

[0012] The circumferential compressive strengthening area cross-sectionally forms a circle segment with small radius, while the smoothening area forms a spherical segment with many times larger radius.

[0013] In an advantageous development of the present invention, the strengthening and smoothening elements are provided as spheres with formed-on, circumferential ring, with a rounded free edge of the ring forming the compressive strengthening area and the two free spherical surfaces the smoothening area.

[0014] In a further development of the present invention, the strengthening and smoothening elements are provided as flattened spheres whose circumferential small-radius edge area forms the compressive strengthening area and the opposite large-radius areas extending on both sides from the edges form the smoothening areas.

[0015] In a further development of the present invention, the strengthening elements are lenticular.

[0016] In a further development of the present invention, the strengthening elements are disk-shaped.

[0017] In a further development of the present invention, the strengthening elements are made of stainless steel.

[0018] The present invention is more fully described in light of the accompanying drawing.

[0019] FIG. 1 shows an embodiment of an apparatus for compressive strengthening and simultaneous smoothening of the surface roughened by the peening pressure.

[0020] FIG. 2 shows an embodiment of a strengthening and smoothening element for use in the present method, having an oval cross-section all around.

[0021] FIG. 3 shows an alternative embodiment of the strengthening and smoothening element, having a lenticular shape;
[0022] FIG. 4 shows an alternative embodiment of the strengthening and smoothing element, having a raised circumferential ring;

[0023] FIG. 5 shows a further alternative embodiment of the strengthening and smoothing element, having a raised circumferential ring; and

[0024] FIG. 6 shows a further alternative embodiment of the strengthening and smoothing element, having a raised circumferential ring.

[0025] FIG. 1 shows, connected to an unbalanced motor drive 1, a vessel 2 with a centrally arranged base 3 and, arranged thereon, a mounting plate 4 for retaining the workpiece 5 to be processed. The workpiece 5 is a rotor drum 7 including several rotors 6 welded to joined to each other and integrally bladed (blisks) of which the surfaces exposed to operation to an air or hot-gas flow, in particular the blade surfaces and the surfaces remaining between the blades 8, are both to be strengthened by application of peening pressure to obtain high fatigue strength and be provided with the low surface roughness necessary to enhance the aerodynamic properties and the efficiency of the turbomachine. The vessel 2, which is provided with a protective lining 9, is filled with a processing medium 11 made up of a multitude of strengthening and smoothing elements 10 to a level beyond the rotor drum 7. For clarity, the strengthening and smoothing elements 10 are shown enlarged in the drawing. As shown in the drawing, those portions of the workpiece 5, here the rotor drum 7, whose surface is to be excluded from processing, or which are to be prevented from being accessed by the strengthening and smoothing elements 10, can be masked with masking elements 12.

[0026] An essential characteristic of the strengthening and smoothing elements 10 in the vessel 2 is that they have considerably larger mass than the spherical shot used in shot peening and accelerated by compressed air. This large mass is required for the production of the kinetic energy necessary for peening pressure strengthening of the workpiece surface since only the tumbling movement of the vessel 2 and the workpiece 5 is available for effecting vibration and circular movement and, compared to shot peening, low acceleration of the strengthening and smoothing elements 10. This large mass is essentially achieved in that the strengthening and smoothing elements 10 have an essentially oval cross-sectional shape (see FIG. 2) or a lenticular shape (see FIG. 3). Compressive strengthening is effected by impingement of the edge areas, or the compressive strengthening area 13 with correspondingly small radius (corresponding to a sphere diameter of 0.8 mm, for example) of the strengthening and smoothing elements 10, while the large-radius areas, or smoothing areas 14, impinging on the thus strengthened, but roughened surface of the workpiece 5 provide, in one and the same process, for a surface smoothing of the surface roughened by compressive shot strengthening. Upon strengthening and smoothing, roughness values of less than 0.25 μm [Ra] are, for example, achievable which are favorable for aerodynamics and thus the efficiency of the engine.

[0027] Accordingly, besides the relatively high mass, an important characteristic of the strengthening and smoothing elements 10, which simultaneously act as smoothing elements, is the provision of approximately semicircular compressive strengthening areas 13 and, opposite these, nearly flat smoothing areas 14 with always considerably larger radius. The strengthening and smoothing elements 10 can, for example, be lenticular or disk-shaped (see FIG. 3), or be satellite-like elements (see alternative embodiments shown in FIGS. 4, 5 and 6) cross-sectionally re-created to the shape of the planet Saturn. The flatly conceived cross-sectional shape of the strengthening and smoothing elements 10, although significantly larger in comparison with conventional peening shot, enables them, despite their larger volume, to access even confined spaces and therein effect compressive strengthening in conjunction with smoothing of the workpiece surface. Variations on the shown shapes also fall within the scope of the invention.

LIST OF REFERENCE NUMERALS

[0028] 1 Unbalance motor drive
[0029] 2 Vessel
[0030] 3 Base
[0031] 4 Mounting plate
[0032] 5 Workpiece
[0033] 6 Rotor with integral blading
[0034] 7 Rotor drum
[0035] 8 Blades
[0036] 9 Protective lining
[0037] 10 Strengthening and smoothing elements
[0038] 11 Processing medium
[0039] 12 Masking element
[0040] 13 Compressive strengthening area, edge area
[0041] 14 Smoothing area

What is claimed is:

1. A method for surface strengthening and smoothing a metallic component, comprising:
   providing strengthening elements having circumferentially rounded compressive strengthening areas for strengthening a surface of the metallic component, and, extending therefrom on both sides, flatly curved smoothing areas for smoothing the surface roughened by strengthening; and
   placing the metallic component and a plurality of the strengthening elements in a vessel, and creating a relative movement between the surface of the metallic component and the strengthening elements to simultaneously strengthen and smooth the surface of the metallic component.

2. The method of claim 1, and further comprising:
   causing the strengthening elements to circulate horizontally and vertically within the vessel, as well as to have vibratory movement;
   adjusting a mass of each strengthening element to these movements; and
   causing the strengthening elements to access confined areas of the metallic component via a flattened shape of the strengthening elements.

3. The method of claim 2, and further comprising masking surface areas of the metallic component which are not to be strengthened.

4. The method of claim 3, and further comprising providing the compressive strengthening areas in at least one of a circular and an elliptical form.

5. The method of claim 4, and further comprising providing the compressive strengthening area of each strengthening element with cross-sectionally circle segment form having a small radius, and providing the smoothing areas in spherical segment form having a several times larger radius then the compressive strengthening area.
6. The method of claim 1, and further comprising providing the strengthening elements as spheres, each with a formed-on, circumferential ring, with a rounded free edge of the ring forming the compressive strengthening area and the two free spherical surfaces forming the smoothening area.

7. The method of claim 1, and further comprising providing the strengthening elements as flattened spheres whose circumferential small-radius edge area forms the compressive strengthening area and whose opposite large-radius areas form the smoothening areas.

8. The method of claim 7, and further comprising providing the strengthening elements in lenticular form.

9. The method of claim 7, and further comprising providing the strengthening elements in disk-shaped form.

10. The method of claim 4, and further comprising providing the strengthening elements in stainless steel.

11. The method of claim 1, wherein the metallic component is at least one of an aircraft engine rotor and an aircraft engine rotor drum.

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