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(54) **METHOD FOR PRODUCING METALLIC COMPONENTS, PARTICULARLY FOR TURBO MACHINES, HAVING SMALL EDGE RADII, AND COMPONENT PRODUCED THEREWITH**

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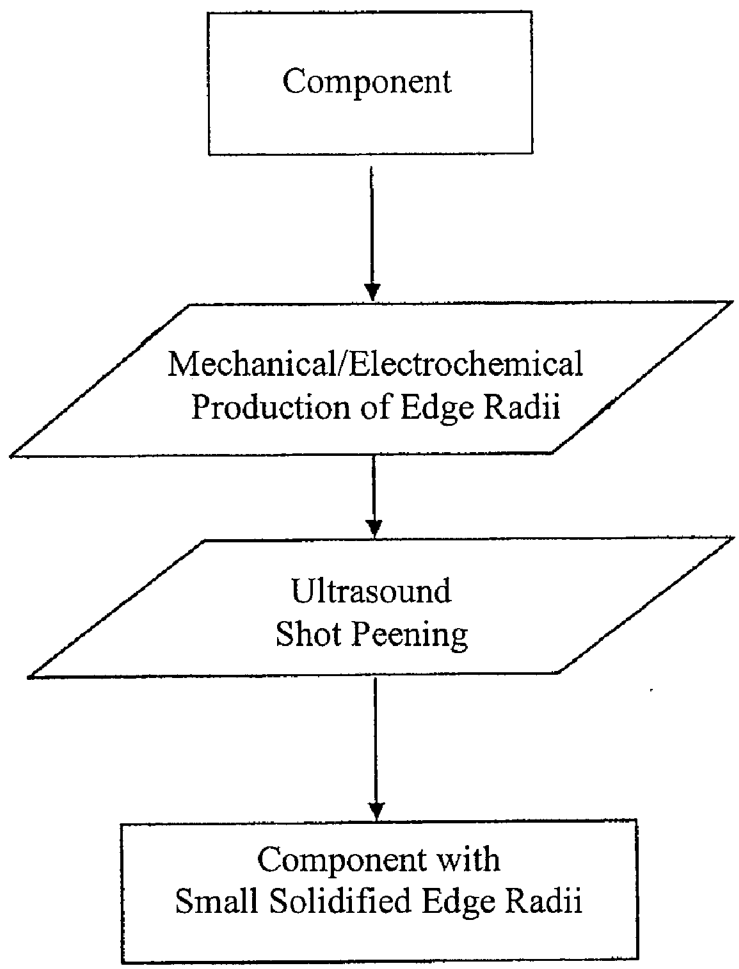
(57) **ABSTRACT**

A method for producing metallic components, and metallic components produced by the method, particularly for turbo machines, having small edge radii, is disclosed. The method includes mechanical and/or electrochemical machining of a component while producing a small edge radius and solidifying the small edge radius by ultrasonic shot peening. As a result of the method, the disadvantages of the prior art are avoided and a machine process that can be automated has been provided, the method permitting considerable savings of time and labor and leading to reproducible results.



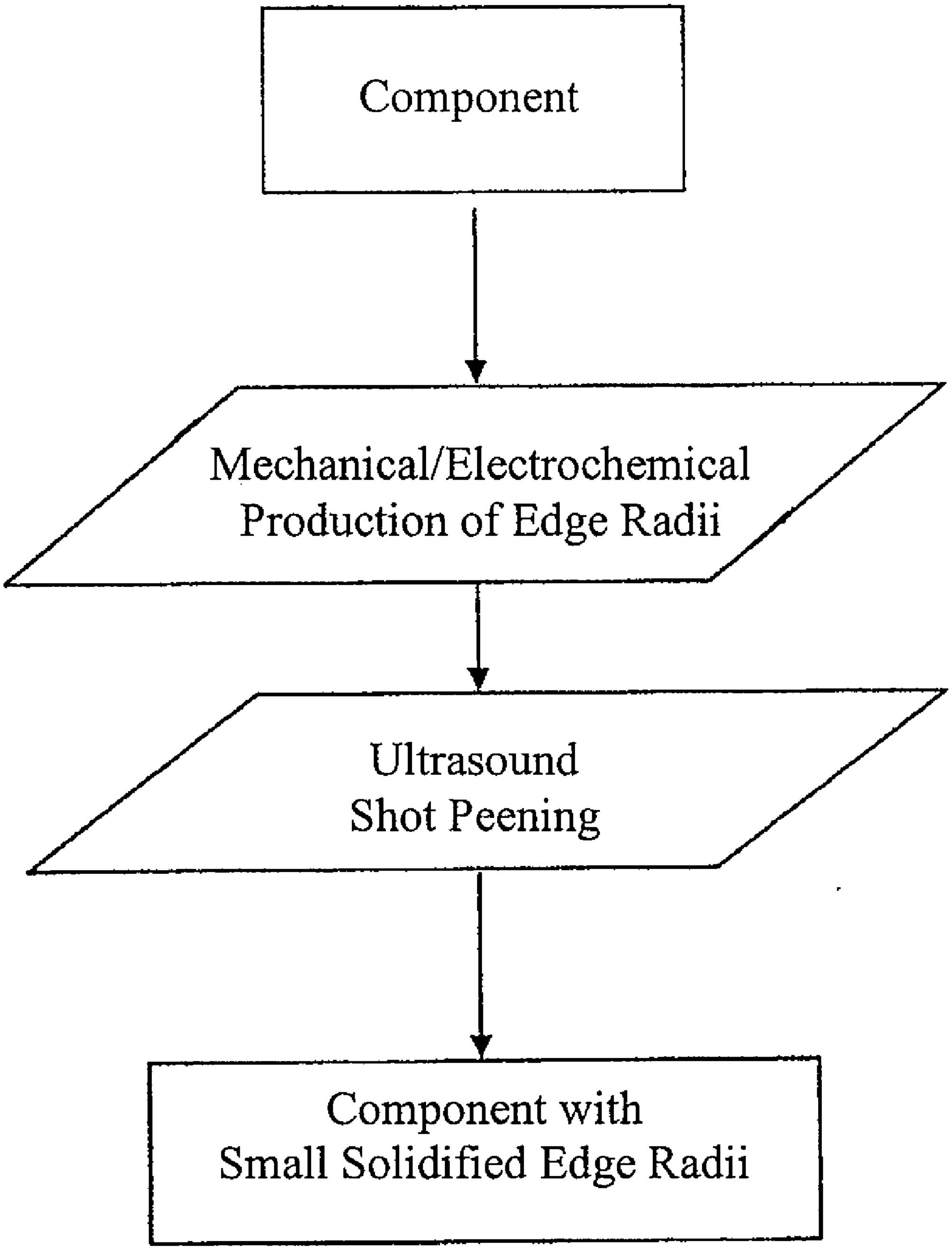

Component
Mechanical/Electrochemical
Production of Edge Radii
Ultrasound
Shot Peening
Component with
Small Solidified Edge Radii

Fig. 1

METHOD FOR PRODUCING METALLIC COMPONENTS, PARTICULARLY FOR TURBO MACHINES, HAVING SMALL EDGE RADII, AND COMPONENT PRODUCED THEREWITH

[0001] This application claims the priority of International Application No. PCT/DE2006/001972, filed Nov. 10, 2006, and German Patent Document No. 10 2005 054 866.0, filed Nov. 17, 2005, the disclosures of which are expressly incorporated by reference herein.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] The invention relates to a method for producing metallic components, particularly for turbo machines, having small edge radii.

[0003] The rounding of edges on components, particularly of turbo machines, may be necessary for the most varied reasons. These include the improvement of strength and/or aerodynamics, as well as avoiding the risk of injury. Depending on the component, these may be sharp edges on components that are attached to adjacent surfaces of the component. Alternatively, the edges may also form planar or three-dimensional surfaces which connect adjacent, generally considerably larger, surfaces of the component. The last-mentioned case usually applies to relatively roughly pre-manufactured edges on flow-mechanically effective blades of turbo machines, in particular on guide vanes and rotor blades of gas turbines, in which case the blade edges must be connected to the adjacent pressure side and/or suction side of the blade in consideration of aspects of strength and aerodynamics.

[0004] Until now, the rounding of blade edges which, due to manufacturing specifics, are generally only roughly pre-machined has been done largely by manual process, usually with hand-guided machines such as belt-sanders, etc. This involves high costs regarding time and labor, whereby even targeted control and testing ultimately do not ensure a reproducible, uniform machining result. It has been known to roughen blade surfaces prior to coating operations by abrasive blasting in order to clean the surface and improve the adhesion of the layer.

[0005] From German patent document DE 103 19 020, a method and a device for rounding edges on components, in particular of turbo machines, have been known, whereby one edge toward at least two adjacent surfaces of the component must be rounded. The center of a blast of largely abrasive particles is directed approximately tangentially to the bisector between two surfaces on the edge and moved—with defined advance—relative to the component along the edge in this way, so that a defined abrasion of the component material of the surfaces takes place during the rounding operation.

[0006] Until now, the components for turbo machines having small and minute edges or a specific geometry of the edges such as, for example, blade roots or blade profile parts, have been solidified by conventional steel shot peening. In so doing, the components must be rounded to at least an "ideal" radius of 0.3 mm. Edges of less than 45° must be rounded at the fringes toward the component surface. In so doing, areas that are peened for solidification must be defined to be at least 0.05 mm. Only this avoids material shifting.

[0007] In view of these known methods and their disadvantages or their technological limits in applications, it is the object of the invention to provide a method for producing metallic components, particularly for turbo machines, having small edge radii, the method permitting considerable savings of time and labor and leading to reproducible results by using a machine process that can optionally be automated. The results should be a quality that is as perfect as possible and the least possible rate of waste.

[0008] In so doing, the inventive method for producing metallic components, particularly for turbo machines, having small edge radii, comprises the following steps:

[0009] Mechanical and/or electrochemical machining of a component while producing a small edge radius; and

[0010] Solidifying the small edge radius by ultrasonic shot peening.

[0011] As a result of the invention, the disadvantages of the prior art are avoided and a machine process that can be automated is provided, the method permitting significant savings of time and labor and leading to reproducible results.

[0012] In particular, the method in accordance with the invention permits a stable process for the manufacture of small and minute radii and/or specific geometric configurations of the edges. In areas that must be peened for solidification, the edge radii must be defined to be at least 0.05 mm. As a result, there is, in fact, no material shifting. Referring to the suggested method, minimum data regarding the edges or geometry of the radii is sufficient. Due to the inventive combination of the production of small and minute geometric configurations of edge radii and the unselective ultrasonic shot peening with round spheres displaying the quality of ball-bearings, a reproducible and optimal manufacturing quality is achieved.

[0013] With the use of the inventive method, small and minute radii are solidified and a cost reduction of approximately 50% is achieved, because the otherwise common manufacturing costs for producing a radius of at least 0.3 mm do not occur. In addition, process stability is substantially increased and the occurrence of material shifting is effectively prevented. Finally, considering components such as, for example, blade roots of engines, the surface percentage of the bearing surface is increased.

[0014] An advantageous development of the inventive method provides that a frequency of 18 kHz to 20 kHz be used for ultrasonic shot peening. Tests have shown that frequencies below 20 kHz are advantageous.

[0015] Another advantageous development of the inventive method provides that a vibration amplitude of 40-80 μm be used with ultrasonic shot peening. Here, tests have shown that a vibration amplitude of 40 μm produces particularly good solidification results on the edge radii.

[0016] Another advantageous development of the inventive method provides that the duration of ultrasonic shot peening per peening area be 20 seconds to 30 minutes, preferably 5 minutes to 15 minutes. In so doing, the duration largely depends on the component material that is to be solidified.

[0017] Another advantageous development of the inventive method provides that a sphere size of 0.3 mm to 2 mm be used in ultrasonic shot peening. Also, in this case the selection of the sphere size is of importance with regard to the component material that is to be solidified and the size of the component.

[0018] Another advantageous development of the inventive method provides that a sphere hardness of up to 70 HRC be used in ultrasonic shot peening. This corresponds approximately to ball-bearing quality.

[0019] Another advantageous development of the inventive method provides that a ball mass of 1 g to 100 g per component be used in ultrasonic shot peening. However, the spheres in the housing of the ultrasonic shot peening device should not be packed too densely in order allow an appropriate vibration of the spheres.

[0020] Another advantageous development of the inventive method provides that one/more component(s) to be solidified be placed/mounted in a housing. Depending on the component, peening for the solidification of only individual sections or areas is possible.

[0021] Another advantageous development of the inventive method provides that the housing have a volume of 15 mm^3 to 8 m^3, preferably of 1 m^3 to 3 m^3. In so doing, the housing dimensions are a direct function of the sizes of the components.

[0022] Another advantageous development of the inventive method provides that spheres of steel, tungsten carbide, ceramic or glass be used for ultrasonic shot peening. In so doing, alloyed and unalloyed steels may be used. A ceramic material that may be used is, for example, zirconium oxide.

[0023] An inventive component for a turbo machine displays the features, namely, that the component is produced of metal and has edge radii <0.3 mm, preferably 0.05 mm, which have been peened for solidification.

[0024] In so doing, the component edges may have different angles, e.g., 45° or 90°. Such types of edges may be, for example, blade edges of compressor blades and/or turbine blades or also edges on blade roots. As a result of the process-stable production with the inventive method, material shifting of the solidified areas is virtually avoided. In this case, minimum data regarding the edges or the geometric configuration of the radii is sufficient.

BRIEF DESCRIPTION OF THE DRAWING

[0025] Additional measures that improve the invention are hereinafter explained in greater detail, together with the description of a preferred exemplary embodiment of the invention and with reference to the drawing.

[0026] FIG. **1** is a flowchart of a first embodiment of a method in accordance with the invention.

DETAILED DESCRIPTION OF THE DRAWING

[0027] FIG. **1** shows a flowchart of a first embodiment of an inventive method which uses a metallic component for machining. In particular considering blades of turbo machines, high-quality alloys, e.g., nickel-based alloys, are used. Further, these blade components frequently have so-called fur-tree blade roots with several edges. In accordance with the invention, the component is initially machined, for example, machined down, or ground or treated electrochemically, for example, by an erosion process. In so doing, corresponding edges are produced or reworked.

[0028] During the next method step, the component is transferred to an ultrasonic shot peening station. The component, depending on its size, is placed in a housing having a size of 15 mm^3 to 8 m^3. Then the minute radii of 0.05 mm are solidified by ultrasonic shot peening. The peening process lasts approximately 1 minute to 5 minutes. Referring to the described ultrasonic shot peening, a piezoelectric transducer emits ultrasonic waves with an adjustable frequency of 18 kHz to 20 kHz. The housing of the ultrasonic shoot peening devices contains, in addition to the component, ideal steel spheres, i.e., spheres displaying ball-bearing quality and a hardness of approximately 70 HRC, and a sphere size of 0.3 mm to 2 mm. The sound waves are amplified when they pass through an acoustic amplifier in a housing with the components to be processed and with the ball-bearing spheres. The spheres that are excited by the ultrasound waves with a vibration wave of 40 μm impinge on the vibrating walls and are reflected by the walls' surfaces. The spheres collide with each other and are scattered in an unordered manner like gas molecules in the housing. As a result of this, a reproducible homogeneous solidification of the edges and radii is achieved. In so doing, the components themselves do not come into contact with the housing walls.

[0029] Consequently, a component with minute solidified edge radii of 0.05 mm is produced. Considering the blade roots of engines, the percentage of the bearing surface is thus increased considerably.

[0030] In principle, the method in accordance with the invention can be used with all types of components and, in particular, with turbo machine blades, be it housings, disks, rings, compressors, pumps and turbines in axial, diagonal and radial construction.

1-11. (canceled)

12. A method for producing a metallic component, comprising the steps of:

mechanical and/or electrochemical machining of the component while producing a small edge radius; and

solidifying the small edge radius by ultrasonic shot peening.

13. The method according to claim **12**, wherein the metallic component is a component of a turbo machine.

14. The method according to claim **12**, wherein a frequency of 18 kHz to 20 kHz is used for the ultrasonic shot peening.

15. The method according to claim **12**, wherein a vibration amplitude of 40-80 μm is used for the ultrasonic shot peening.

16. The method according to claim **12**, wherein a duration of the ultrasonic shot peening per peening area is 20 seconds to 30 minutes.

17. The method according to claim **16**, wherein the duration is 5 minutes to 15 minutes.

18. The method according to claim **12**, wherein a sphere size from 0.3 mm to 2 mm is used for the ultrasonic shot peening.

19. The method according to claim **12**, wherein a sphere hardness of up to 70 HRC is used for the ultrasonic shot peening.

20. The method according to claim **12**, wherein a sphere mass of 1 g to 100 g per component is used in the ultrasonic shot peening.

21. The method according to claim **12**, wherein the metallic component is mounted in a housing.

22. The method according to claim **21**, wherein the housing has a volume of 15 mm^3 to 8 m^3.

23. The method according to claim **22**, wherein the housing has a volume of 1 m^3 to 3 m^3.

24. The method according to claim **12**, wherein spheres consisting of steel, tungsten carbide, ceramic or glass are used for the ultrasonic shot peening.

25. A component for a turbo machine, wherein the component is comprised of metal and has an edge radii <0.3 mm, and wherein the edge radii is solidified by peening.

26. The component according to claim **25**, wherein the edge radii is <0.05 mm.

27. A method for producing a metallic component, comprising the steps of:

producing a small edge radius by mechanical and/or electrochemical machining of the component; and

solidifying the small edge radius by ultrasonic shot peening.

28. The method according to claim **27**, wherein the ultrasonic shot peening step includes exciting spheres by ultrasonic waves such that the spheres impinge off of walls of a housing that houses the component and the small edge radius of the component.

29. The method according to claim **27**, wherein the ultrasonic shot peening step includes the step of amplifying sound waves by an acoustic amplifier in a housing that houses the component.

30. The method according to claim **27**, wherein the small edge radius is <0.05 mm.

31. The method according to claim **28**, wherein the spheres each have a size ranging between 0.3 mm to 2 mm.

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