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(54) BLADE OR VANE OF DIFFERING ROUGHNESS AND PRODUCTION PROCESS

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(57) ABSTRACT

A blade or vane of different roughness and a process for producing such a blade or vane are presented. The performance of the blade or vane of a compressor or of a turbine can be improved because of the different configuration of the roughness of the surfaces on the suction side and the pressure side of the blade or vane.

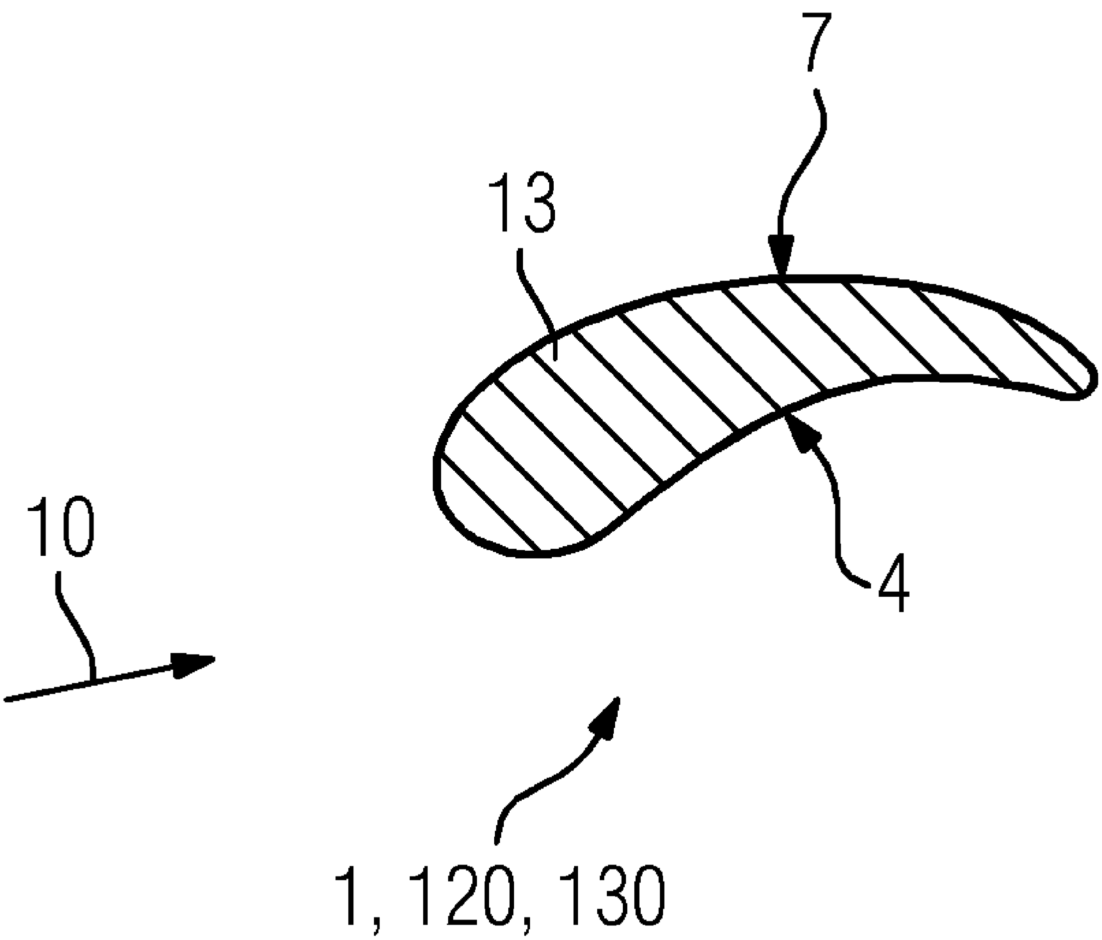


FIG 1

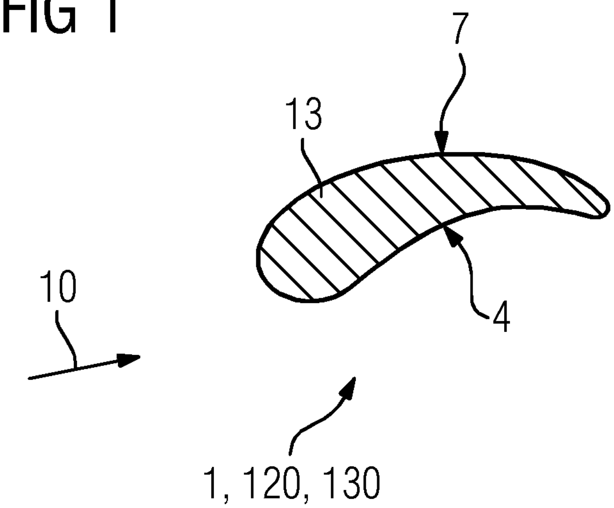


FIG 2

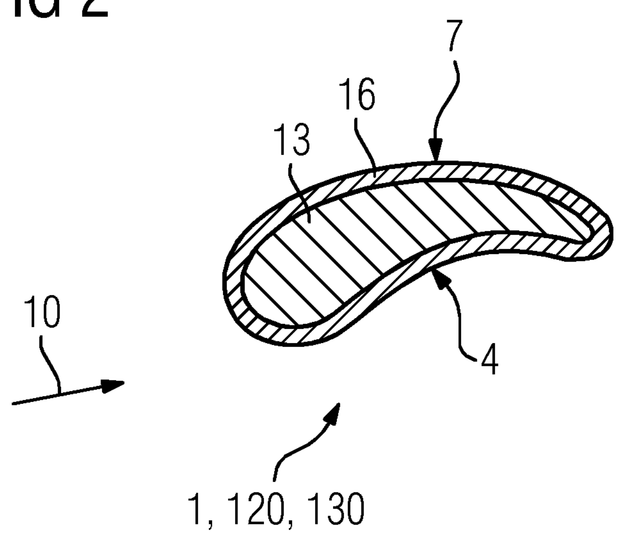
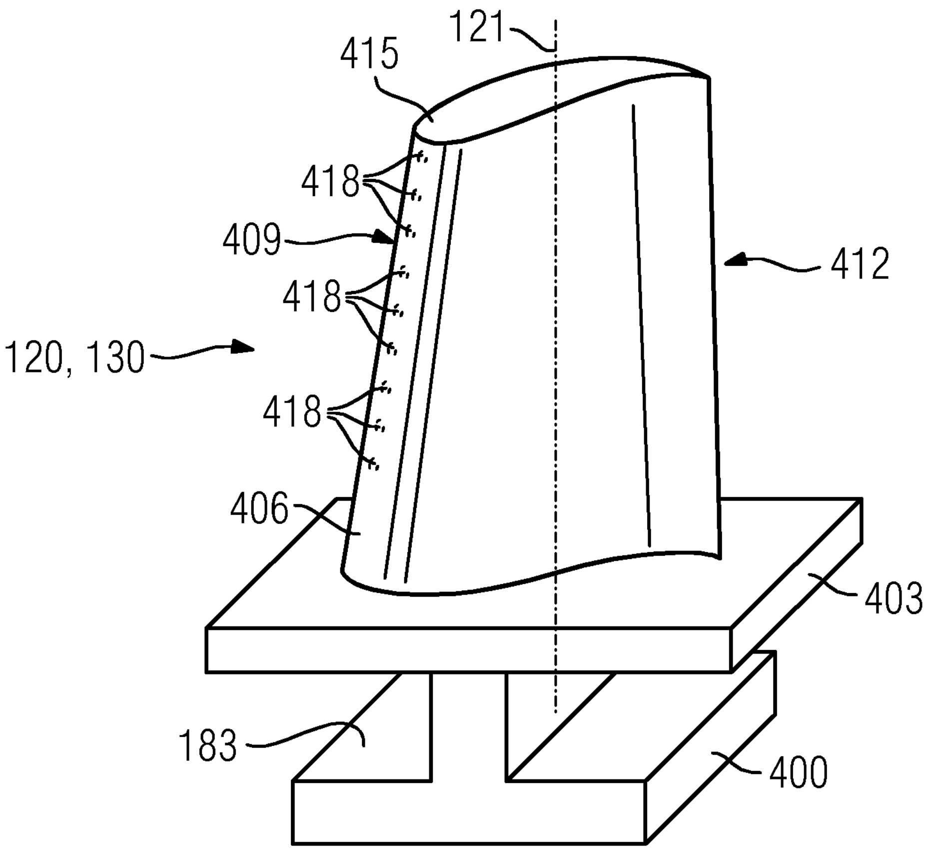


FIG 3



BLADE OR VANE OF DIFFERING ROUGHNESS AND PRODUCTION PROCESS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to European Patent Office application No. 12189743.3 EP filed Oct. 24, 2012, the entire content of which is hereby incorporated herein by reference.

FIELD OF INVENTION

[0002] The invention relates to a blade or vane which is formed with a differing roughness on its surfaces, and to production processes.

BACKGROUND OF INVENTION

[0003] Blades or vanes are used in compressors or in steam or gas turbines. Here, a medium such as air or hot gas flows past the turbine blade or vane, such that there is interaction between this medium and the surface of the blade or vane. This interaction is important for the operation of the blade or vane.

SUMMARY OF INVENTION

[0004] It is therefore an object of the invention to specify a blade or vane in particular for compressors or turbines, such as steam turbines or gas turbines, which has an improved performance.

[0005] The object is achieved by a blade or vane and by production processes as claimed in as claimed in the independent claims. The dependent claims list further advantageous measures which can be combined with one another, as desired, in order to achieve further advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIGS. **1**, **2** show cross sections through a blade or vane,

[0007] FIG. **3** shows a turbine blade or vane.

DETAILED DESCRIPTION OF INVENTION

[0008] The figures and the description represent merely an exemplary embodiment of the invention.

[0009] FIG. **1** shows a blade or vane **1**, **120**, **130**, in particular a turbine blade or vane, in cross section, with the suction side **7** and the pressure side **4**, a medium flowing around the blade or vane **1**, **120**, **130** in the direction of flow **10**.

[0010] According to the invention, the suction side **7** has a smoother or less rough form than the pressure side **4**.

[0011] In particular, the pressure side **4** is formed to be at least two times, preferably three times, rougher than the suction side **7**.

[0012] In this respect, it is immaterial whether the surface of the blade or vane **1** is not coated (FIG. **1**) or whether an outermost coating is a metallic and/or ceramic coating, if appropriate with metallic sublayers (FIG. **2**).

[0013] The roughnesses are then set or produced accordingly on the substrate surface or the metallic or ceramic surface.

[0014] In the case that the substrate **13** has no coating, this can be effected by subsequent machining, i.e. by roughening the pressure side **4** or smoothing the suction side **7**.

[0015] If the substrate is a cast part, the casting mold into which the metal is cast for producing the substrate **13** can also be accordingly configured with a differing roughness over its inner surface in order to produce the roughnesses.

[0016] Similarly, subsequent machining is possible, i.e. the substrate **13** is smoothed or roughened.

[0017] In the event that there are coatings on substrates **13**, it is likewise possible to set the degree of roughness so that the different roughness is already set by the coating. This is possible preferably as a result of differently sized powder grains which are used for the coating.

[0018] Similarly, subsequent machining is possible, i.e. the layer **16** is smoothed or roughened.

[0019] Various roughness definitions can be used for determining the roughness. A roughness of ≤6 μm for the suction side **7** and/or a roughness of at least 20 μm, in particular of 20 μm to 30 μm, for the pressure side **4** are advantageously obtained or set.

[0020] This configuration according to the invention of the blade or vane increases the pressure within a compressor or a turbine, which leads to an increase in performance.

[0021] FIG. **3** shows a perspective view of a rotor blade **120** or guide vane **130** of a turbomachine, which extends along a longitudinal axis **121**.

[0022] The turbomachine may be a gas turbine of an aircraft or of a power plant for generating electricity, a steam turbine or a compressor.

[0023] The blade or vane **120**, **130** has, in succession along the longitudinal axis **121**, a securing region **400**, an adjoining blade or vane platform **403** and a main blade or vane part **406** and a blade or vane tip **415**.

[0024] As a guide vane **130**, the vane **130** may have a further platform (not shown) at its vane tip **415**.

[0025] A blade or vane root **183**, which is used to secure the rotor blades **120**, **130** to a shaft or a disk (not shown), is formed in the securing region **400**.

[0026] The blade or vane root **183** is designed, for example, in hammerhead form. Other configurations, such as a fir-tree or dovetail root, are possible.

[0027] The blade or vane **120**, **130** has a leading edge **409** and a trailing edge **412** for a medium which flows past the main blade or vane part **406**.

[0028] In the case of conventional blades or vanes **120**, **130**, by way of example solid metallic materials, in particular superalloys, are used in all regions **400**, **403**, **406** of the blade or vane **120**, **130**. Superalloys of this type are known, for example, from EP 1 204 776 B1, EP 1 306 454, EP 1 319 729 A1, WO 99/67435 or WO 00/44949.

[0029] The blade or vane **120**, **130** may in this case be produced by a casting process, by means of directional solidification, by a forging process, by a milling process or combinations thereof.

[0030] Workpieces with a single-crystal structure or structures are used as components for machines which, in operation, are exposed to high mechanical, thermal and/or chemical stresses.

[0031] Single-crystal workpieces of this type are produced, for example, by directional solidification from the melt. This involves casting processes in which the liquid metallic alloy solidifies to form the single-crystal structure, i.e. the single-crystal workpiece, or solidifies directionally.

[0032] In this case, dendritic crystals are oriented along the direction of heat flow and form either a columnar crystalline grain structure (i.e. grains which run over the entire length of the workpiece and are referred to here, in accordance with the language customarily used, as directionally solidified) or a single-crystal structure, i.e. the entire workpiece consists of one single crystal. In these processes, the transition to globular (polycrystalline) solidification needs to be avoided, since non-directional growth inevitably forms transverse and longitudinal grain boundaries, which negate the favorable properties of the directionally solidified or single-crystal component.

[0033] Where the text refers in general terms to directionally solidified microstructures, this is to be understood as meaning both single crystals, which do not have any grain boundaries or at most have small-angle grain boundaries, and columnar crystal structures, which do have grain boundaries running in the longitudinal direction but do not have any transverse grain boundaries. This second form of crystalline structures is also described as directionally solidified microstructures (directionally solidified structures). Processes of this type are known from U.S. Pat. No. 6,024,792 and EP 0 892 090 A1.

[0034] The blades or vanes **120**, **130** may likewise have coatings protecting against corrosion or oxidation, e.g. (MCrAlX; M is at least one element selected from the group consisting of iron (Fe), cobalt (Co), nickel (Ni), X is an active element and stands for yttrium (Y) and/or silicon and/or at least one rare earth element, or hafnium (Hf)). Alloys of this type are known from EP 0 486 489 B1, EP 0 786 017 B1, EP 0 412 397 B1 or EP 1 306 454 A1.

[0035] The density is preferably 95% of the theoretical density.

[0036] A protective aluminum oxide layer (TGO=thermally grown oxide layer) is formed on the MCrAlX layer (as an intermediate layer or as the outermost layer).

[0037] The layer preferably has a composition Co-30Ni-28Cr-8Al-0.6Y-0.7Si or Co-28Ni-24Cr-10Al-0.6Y. In addition to these cobalt-based protective coatings, it is also preferable to use nickel-based protective layers, such as Ni-10Cr-12Al-0.6Y-3Re or Ni-12Co-21Cr-11Al-0.4Y-2Re or Ni-25Co-17Cr-10Al-0.4Y-1.5Re.

[0038] It is also possible for a thermal barrier coating, which is preferably the outermost layer and consists for example of ZrO_2, Y_2O_3—ZrO_2, i.e. unstabilized, partially stabilized or fully stabilized by yttrium oxide and/or calcium oxide and/or magnesium oxide, to be present on the MCrAlX. The thermal barrier coating covers the entire MCrAlX layer.

[0039] Columnar grains are produced in the thermal barrier coating by suitable coating processes, such as for example electron beam physical vapor deposition (EB-PVD).

[0040] Other coating processes are possible, for example atmospheric plasma spraying (APS), LPPS, VPS or CVD. The thermal barrier coating may include grains that are porous or have micro-cracks or macro-cracks, in order to improve the resistance to thermal shocks. The thermal barrier coating is therefore preferably more porous than the MCrAlX layer.

[0041] Refurbishment means that after they have been used, protective layers may have to be removed from components **120**, **130** (e.g. by sand-blasting). Then, the corrosion and/or oxidation layers and products are removed. If appropriate, cracks in the component **120**, **130** are also repaired. This is followed by recoating of the component **120**, **130**, after which the component **120**, **130** can be reused.

[0042] The blade or vane **120**, **130** may be hollow or solid in form. If the blade or vane **120**, **130** is to be cooled, it is hollow and may also have film-cooling holes **418** (indicated by dashed lines).

1. A curved blade or vane, comprising:
a suction side; and
a pressure side,
wherein the blade or vane comprises a different roughnesses between a surface of the suction side and a surface of the pressure side, and
wherein the surface of the suction side comprises a lesser roughness than the surface of the pressure side.

2. The blade or vane as claimed in claim **1**, wherein the blade or vane comprises an uncoated substrate surface, and wherein the different roughnesses are formed on the substrate surface.

3. The blade or vane as claimed in claim **1**, wherein a metallic coating is applied to the blade or vane as an outermost layer and comprises the different roughnesses.

4. The blade or vane as claimed in claim **1**, wherein a ceramic coating is applied to the blade or vane as an outermost layer and comprises the different roughnesses.

5. The blade or vane as claimed in claim **1**, wherein roughness of the surface of the pressure side is at least two times greater than roughness of the surface of the suction side.

6. The blade or vane as claimed in claim **1**, wherein roughness of the surface of the pressure side is at least three times greater than roughness of the surface of the suction side.

7. The blade or vane as claimed in claim **1**, wherein the surface of the suction side comprises a roughness of ≤6 μm.

8. The blade or vane as claimed in claim **1**, wherein the surface of the pressure side comprises a roughness of ≥20 μm.

9. The blade or vane as claimed in claim **1**, wherein the surface of the pressure side comprises a roughness of 20 μm to 30 μm.

10. The blade or vane as claimed in claim **1**, wherein roughness of the surface of the suction side is at least 20% less rough than the surface of the pressure side.

11. The blade or vane as claimed in claim **1**, wherein the blade or vane is for a compressor or a turbine.

12. A process for producing a blade or vane, comprising:
producing the blade or vane according to claim **1**,
wherein only the surface of the pressure side of the blade or vane is roughened.

13. A process for producing a blade or vane, comprising:
producing the blade or vane according to claim **1**,
wherein only the surface of the suction side of the blade or vane is smoothed.

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