A surface having specially formed recesses and component is provided. The component has a layer with a surface, having elongate recesses, which have a longitudinal direction, wherein the recesses are arranged at an angle which differs considerably from 0°, in particular 90°±20°, with respect to a direction of overflow over the surface, and are at least partially widened transversely to the longitudinal direction thereof in the region of the surface with respect to the base of the recess, in which the recess is widened proceeding from the base only above a certain height within the recess, and in particular the recess has a constant width before it, in which the recess does not extend through the entire thickness of the layer.
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SURFACE HAVING SPECIALLY FORMED RECESSES AND COMPONENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National Stage of International Application No. PCT/EP2012/066062 filed Aug. 17, 2012, and claims the benefit thereof. The International Application claims the benefit of European Application No. EP11186464 filed Oct. 25, 2011. All of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The invention relates to the special configuration of elongate recesses within a surface and to a component.

BACKGROUND OF INVENTION

[0003] Compared to metals, ceramic materials have a relatively low ductility, and cracks can arise as a result of stresses. Particularly in the case of components coated with ceramic, such as gas turbine components, instances of spalling can occur in the ceramic layer. This takes place primarily in regions of cooling air bore outlets in the form of what are known as shaped holes at the surface of the ceramic layer. High thermal stresses, which lead to the premature onset of cracking in the ceramic layer and then to spalling, arise here during the operation of a hollow cast and cooled turbine blade or vane. Therefore, recesses are often introduced, as in WO 2009/126194 A1.

SUMMARY OF INVENTION

[0004] It is therefore an object of the invention to solve this problem. The object is achieved by a surface and by a component as claimed.

[0005] 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] FIG. 1 shows a component having a recess,

[0007] FIGS. 2, 3 show a special form of the recess,

[0008] FIG. 4 shows a turbine blade or vane,

[0009] FIG. 5 shows a combustion chamber,

[0010] FIG. 6 shows a gas turbine, and

[0011] FIG. 7 shows a list of superalloys.

DETAILED DESCRIPTION OF INVENTION

[0012] The description and the figures represent merely exemplary embodiments of the invention.

[0013] In general terms, the invention relates to surfaces of solid components, layers, in particular ceramic surfaces, but also metals, which can have a certain brittleness, such as NiCoCrAlY alloys in a certain temperature range.

[0014] FIG. 1 shows a merely exemplary high-temperature component 120, 130, 155 (FIGS. 4, 5) having a surface 19 around which medium flows in a direction of overflow 10.

[0015] Elongate recesses 4 are not arranged parallel with respect to a direction of overflow 10 over the surface 19, but rather at an angle which differs considerably from 0°, preferably at an angle of 90°+/-20°, with respect to the direction of overflow 10.

[0016] The recesses 4 have a longitudinal direction 11.
The blade or vane 120, 130 may in this case be produced by a casting process, also by means of directional solidification, by a forging process, by a milling process or combinations thereof.

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.

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 solidsifies to form the single-crystal structure, i.e. the single-crystal workpiece, or solidifies directionally.

In this case, dendritic crystals are aligned 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, a 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.

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.

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.

The density is preferably 95% of the theoretical density.

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).

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.

It is also possible for a thermal barrier coating, which is preferably the outermost layer and consists for example of ZrO2, Y2O3—ZrO2, 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.

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

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.

Refrubishment 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.

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).

FIG. 5 shows a combustion chamber 110 of a gas turbine.

The combustion chamber 110 is configured, for example, as what is known as an annular combustion chamber, in which a multiplicity of burners 107, which generate flames 156 and are arranged circumferentially around an axis of rotation 102, open into a common combustion chamber space 154. For this purpose, the combustion chamber 110 overall is of annular configuration positioned around the axis of rotation 102.

To achieve a relatively high efficiency, the combustion chamber 110 is designed for a relatively high temperature of the working medium M of approximately 1000°C to 1600°C. To allow a relatively long service life even with these operating parameters, which are unfavorable for the materials, the combustion chamber wall 153 is provided, on its side which faces the working medium M, with an inner lining formed from heat shield elements 155.

On the working medium side, each heat shield element 155 made from an alloy is equipped with a particularly heat-resistant protective layer (MCrAlX layer and/or ceramic coating) or is made from material that is able to withstand high temperatures (solid ceramic bricks).

These protective layers may be similar to the turbine blades or vanes, i.e. for example 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.

For example ceramic thermal barrier coating, consisting for example of ZrO2, Y2O3—ZrO2, i.e. unstabilized, partially stabilized or fully stabilized by yttrium oxide and/or calcium oxide and/or magnesium oxide, may also be present on the MCrAlX.

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

Other coating processes are conceivable, for example atmospheric plasma spraying (APS), LPPS, VPS or CVD. The thermal barrier coating may have grains that are
porous and/or include micro-cracks or macro-cracks in order to improve the resistance to thermal shocks.

[0059] Refurbishment means that after they have been used, protective layers may have to be removed from heat shield elements 155 (e.g. by sand-blasting). Then, the corrosion and/or oxidation layers and products are removed. If appropriate, cracks in the heat shield elements 155 are also repaired. This is followed by recasting of the heat shield elements 155, after which the heat shield elements 155 can be reused.

[0060] A cooling system may also be provided for the heat shield elements 155 and/or their holding elements, on account of the high temperatures in the interior of the combustion chamber 110. The heat shield elements 155 are then for example hollow and may also have cooling holes (not shown) which open out into the combustion chamber space 154.

[0061] FIG. 6 shows, by way of example, a partial longitudinal section through a gas turbine 100.

[0062] In the interior, the gas turbine 100 has a rotor 103 with a shaft 101 which is mounted such that it can rotate about an axis of rotation 102 and is also referred to as the turbine rotor.

[0063] An intake housing 104, a compressor 105, a, for example, toroidal combustion chamber 110, in particular an annular combustion chamber, with a plurality of coaxially arranged burners 107, a turbine 108 and the exhaust-gas housing 109 follow one another along the rotor 103.

[0064] The annular combustion chamber 110 is in communication with a, for example, annular hot-gas passage 111, where, by way of example, four successive turbine stages 112 form the turbine 108.

[0065] Each turbine stage 112 is formed, for example, from two blade or vane rings. As seen in the direction of flow of a working medium 113, in the hot-gas passage 111 a row of guide vanes 115 is followed by a row 125 formed from rotor blades 120.

[0066] The guide vanes 130 are secured to an inner housing 138 of a stator 143, whereas the rotor blades 120 of a row 125 are fitted to the rotor 103 for example by means of a turbine disk 133.

[0067] A generator (not shown) is coupled to the rotor 103.

[0068] While the gas turbine 100 is operating, the compressor 105 sucks in air 135 through the intake housing 104 and compresses it. The compressed air provided at the turbine-side end of the compressor 105 is passed to the burners 107, where it is mixed with a fuel. The mix is then burnt in the combustion chamber 110, forming the working medium 113.

[0069] From there, the working medium 113 flows along the hot-gas passage 111 past the guide vanes 130 and the rotor blades 120. The working medium 113 is expanded at the rotor blades 120, transferring its momentum, so that the rotor blades 120 drive the rotor 103 and the latter in turn drives the generator coupled to it.

[0070] To be able to withstand the temperatures which prevail there, they may be cooled by means of a coolant.

[0071] Substrates of the components may likewise have a directional structure, i.e. they are in single-crystal form (SX structure) or have only longitudinally oriented grains (DS structure).

[0072] By way of example, iron-based, nickel-based or cobalt-based superalloys are used as material for the components, in particular for the turbine blade or vane 120, 130 and components of the combustion chamber 110.

[0073] 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.

[0074] The blades or vanes 120, 130 may likewise have coatings protecting against corrosion (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, scandium (Sc) and/or at least one rare earth element, or hafnium). 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.

[0075] A thermal barrier coating, consisting for example of ZrO₂-Y₂O₃-ZrO₂, i.e. unstabilized, partially stabilized or fully stabilized by yttrium oxide and/or calcium oxide and/or magnesia oxide, may also be present on the MCrAlX.

[0076] Columnar grains are produced in the thermal barrier coating by suitable coating processes, such as for example electron beam physical vapor deposition (EB-PVD).

[0077] The guide vane 130 has a guide vane root (not shown here), which faces the inner housing 138 of the turbine 108, and a guide vane head which is at the opposite end from the guide vane root. The guide vane head faces the rotor 103 and is fixed to a securing ring 140 of the stator 143.

1.-11. (canceled)

12. A component having a layer with a surface, comprising elongate recesses, which have a longitudinal direction, wherein the recesses are arranged at an angle which differs considerably from 0°, with respect to a direction of overflow over the surface, and are at least partially widened transversely to the longitudinal direction thereof in the region of the surface with respect to the base of the recess, wherein the recess are widened proceeding from the base only above a certain height within the recess, and wherein the recess does not extend through the entire thickness of the layer.

13. The component as claimed in claim 12, wherein the recess has a front edge and a rear edge, and wherein the widened portion is formed at the rear edge.

14. The component as claimed in claim 12, wherein the recess has a rectangular cross section at least in certain points transversely to the longitudinal direction as far as the widened portion.

15. The component as claimed in claim 12, wherein the recesses are arranged at an angle of 90°±/−20° with respect to a direction of overflow over the surface.

16. The component as claimed in claim 12, wherein the recess has a corrugated form along the longitudinal direction.

17. The component as claimed in claim 12, wherein the widened portion has a cross section which is at least 10% larger than that of the base.

18. The component as claimed in claim 12, wherein the component is in the form of a surface of a solid component.

19. The component as claimed in claim 12, wherein the component is in the form of a ceramic layer.
20. The component as claimed in claim 12, wherein the front edge extends virtually perpendicular to the surface.

21. The component as claimed in claim 12, wherein the surface comprises a ceramic surface.

22. The component as claimed in claim 12, wherein the angle is $90^\circ \pm 20^\circ$.

23. The component as claimed in claim 12, wherein the recess has a constant width before the certain height.

24. The component as claimed in claim 13, wherein the widened portion is formed at the outflow-side end.

25. The component as claimed in claim 14, wherein the recess has a completely rectangular cross section transverse to the longitudinal direction as far as the widened portion.

26. The component as claimed in claim 16, wherein the recess has an S shape along the longitudinal direction.

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