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(54) **COMPONENT WITH A METALLURGICALLY BONDED COATING**

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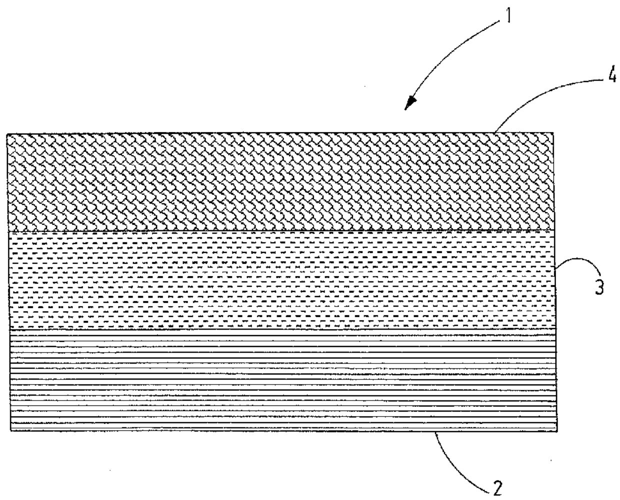
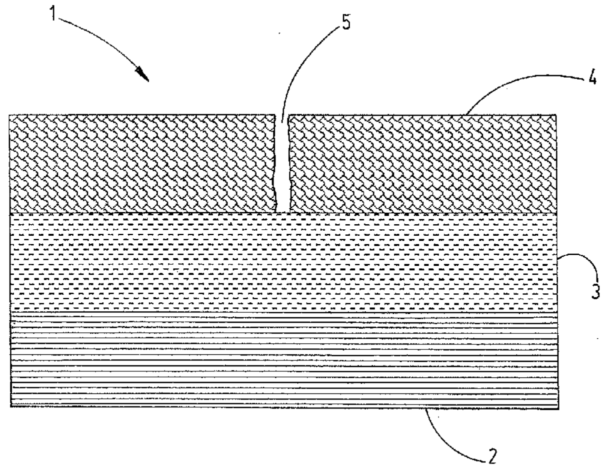
(57) **ABSTRACT**

The invention relates to a component (**1**) having a coating (**3**) that is metallurgically bonded on as well as thermally sprayed on and re-melted. In order to prevent wear phenomena from continuing to occur when force impacts occur in the component (**1**) and further surface stress occurs, the invention provides that the coating (**3**) is provided with a thermal spray layer (**4**).





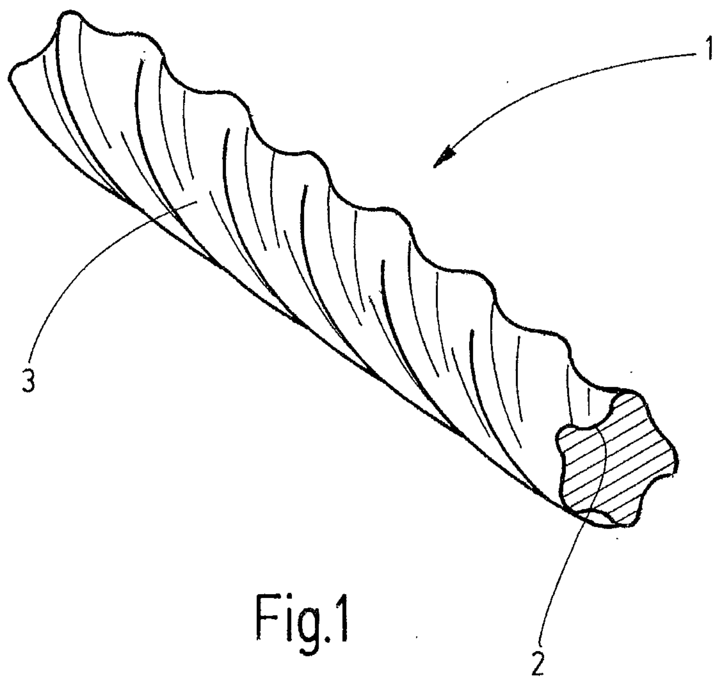


Fig.1

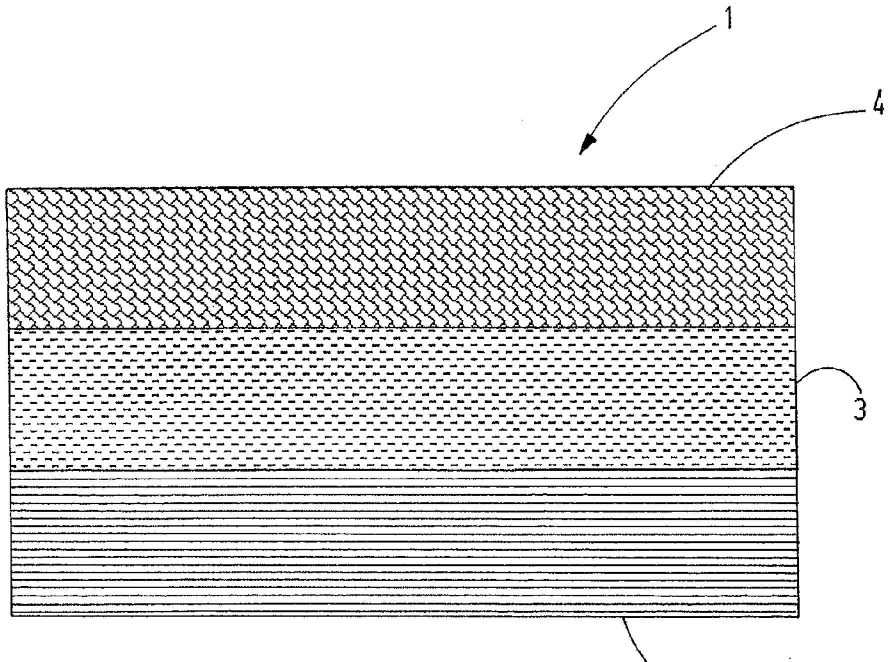


Fig.2a

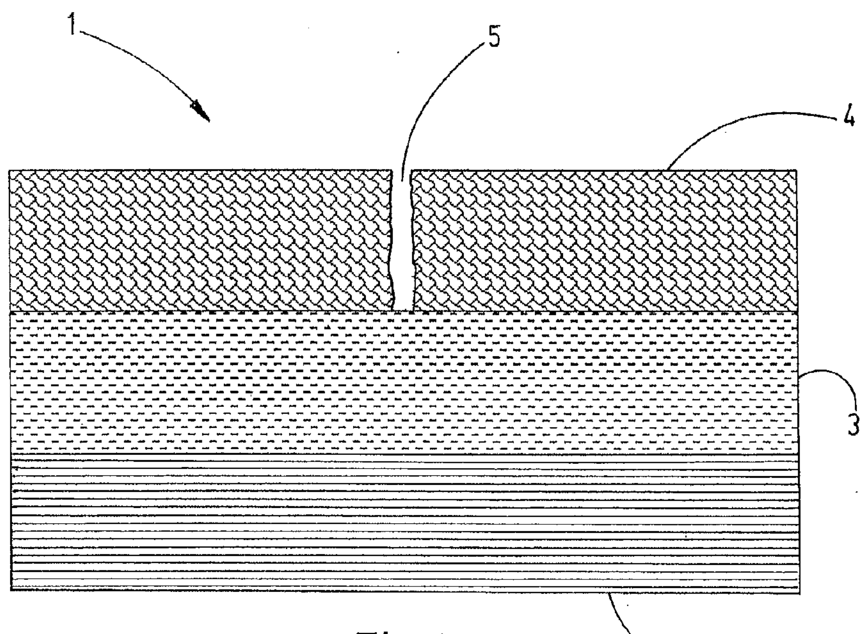


Fig.2b

COMPONENT WITH A METALLURGICALLY BONDED COATING

[0001] The invention relates to a component having a coating that is metallurgically bonded as well as thermally sprayed on and re-melted.

[0002] Furthermore, the invention relates to a method for the production of a metallurgically bonded coating, which is thermally sprayed onto a surface of a component and re-melted.

[0003] Components of the type stated initially are known and familiar to a person skilled in the art, whereby re-melting of thermally sprayed layers by means of laser technology has increasingly been the topic of scientific studies in the very recent past.

[0004] Metallurgically bonded coatings, in the production of which the advantages of thermal spraying are combined with those of laser re-melting, demonstrate high-quality wear-protection and corrosion-protection properties.

[0005] Industrial implementation takes place in such a manner that after the coating, which is present in the form of an IN 625 HVOF layer, for example, is applied to a surface of a component, such as a turbine blade, individual melting lines are produced by means of the movement of a concentrated circle and an approximately circular, rectangular or ellipsoid point of light. In this connection, the movement devices of the bean guides required for this purpose require great precision, which is dependent on the geometry of the melting point, the requirements of the overlap of the melting lines, and on the required reproducibility of the production of the melting line.

[0006] A metallurgically bonded layer of the type mentioned initially is disclosed, for example, by GB 10 39 633, whereby re-melting of a thermally sprayed-on layer takes place by means of a laser apparatus that guides a point-shaped point of light over the sprayed-on layer and melts the latter. In this connection, both the spray ply, in each instance, and the entire layer are re-melted by means of the laser. Improved mechanical properties of the coating result from this; in particular, the mechanical adhesion of the thermal spray layer is improved by means of the re-melting.

[0007] Metallurgically bonded coatings of the type mentioned initially are also the topic of a recently published work that discusses inherent stresses of IN 625 HVOF layers applied to steel and TI6AI4V, which layers have been re-melted by means of lasers. In this connection, inherent tensile stresses were found in the re-melted IN 625 layer. The publication shows the difficulties in achieving non-critical stress states, i.e. neutral stress and pressure clamping, by means of laser re-melting. A CO_2 laser with a round laser spot was used, which was guided over the component surface at a frequency of 200 Hz, over a length of 126 mm (Arif, A. F. M., Yilbas, B. S., Surface Engineering, Volume 25, No. 3, April 2009, pp. 249-256).

[0008] In another work that also appeared recently, HVOF WC—CrC—Ni layers having a thickness of 280 μm were heat-treated and compacted by means of a laser. In this connection, the properties of porosity, hardness, and wear-resistance were improved. The laser spot selected was an oval geometry 5 mm×4 mm with an overlap of 30% at a displacement speed of 400 mm/min, at 400 Watts laser power (Journal of the Korean Physical Society, Volume 54, No. 3; March 2009).

[0009] These metallurgically bonded coatings known from the state of the art, which are thermally sprayed onto the surface of a component and re-melted by means of laser technology, have the disadvantage that when force impacts occur in the component and further surface stress occurs, wear phenomena continue to occur.

[0010] It is therefore the task of the invention to avoid these disadvantages.

[0011] This task is accomplished with the characteristics of claim **1**. Advantageous embodiments of the invention are evident from the dependent claims.

[0012] The invention provides that the metallurgically bonded coating is provided with at least one thermal spray layer.

[0013] The core idea of the invention is to provide the metallurgically bonded coating with a cover ply that is thermally sprayed on. Surprisingly, it was shown that during expansion of a component to which a metallurgical coating is bonded, beyond the value permissible for the cover ply, tearing of the cover ply alone occurs. In the coating according to the invention, therefore no continuation of the crack into the re-melted coating takes place. As a result, a tight corrosion-protection layer continues to exist, which protects the base material, i.e. the material of the component, from corrosion attack.

[0014] Concrete components according to one of claims **1** to **10** are double cylinders and screws that are used in plastics-processing extrusion machines. In the double cylinder, two screws convey and compact thermoplastic plastic material such as PVC, among others, for example, under high pressure and temperature. The plastic materials have abrasive additives such as glass fibers, wood flour, and pigments mixed into them. The proportion of abrasively acting additives can amount to more than 50 vol.-%. The double cylinders and screws are subject to great wear; furthermore, the screws support themselves on the interior cylinder surface, which leads to great surface pressure and milling stress of the surfaces. During the processing of PVC, the decomposition of PVC can occur and hydrochloric acid can be formed, which causes corrosion on cylinder and screw.

[0015] A hard-metallic layer on the basis of metal-bonded tungsten carbide such as WC—CoCr or WC—CrC—Ni, applied by means of the HVOF method, is suitable as a coating for withstanding abrasive wear.

[0016] HVOF layers on the basis of WC have no metallurgical bond, but rather adhere on the basis of a mechanical adhesion mechanism. The mechanical adhesion is predominantly influenced by the kinetic energy of the particles and the hardness of the base material. When applied to medium-hard base materials with 40-45 HRC, the HVOF layers achieve a shear strength of 250-350 MPa, and in the case of hard base materials with 55-57 HRC, a lower shear strength of 50-150 MPa.

[0017] It has been shown that for double extrusion cylinders, the coating must be applied to the base material with great adhesion and a shear strength of 250 MPa, so that the coating is able to withstand the mechanical stress. Furthermore, a supporting zone with a depth of at least 0.5 mm and a hardness of 55 HRC must be present underneath the coating, so that the metal-bonded WC layer is not pressed into the base material by means of the high surface pressure and rolling action.

[0018] The proposed coating system allows a shear strength of >250 MPa of the hard-metallic coating on a supporting layer in the base material having a hardness of 55 HRC. In this connection, a first, thin, medium-hard layer is applied to a Ni base alloy and re-melted by means of a laser, and subsequently, a WC-HVOF coating is applied. The metallurgically bonded layer is, according to the invention, a medium-hard coating having a hardness of 40-45 HRC, composed of a Ni base alloy, for example of the NiCrMo type, with components of boron, silicon, and carbon.

[0019] In the case of harder cylinder materials such as, for example, 42CrMo4 or X40Cr17Mo, laser re-melting of the first thermally applied Ni base layer leads to a metallurgically bonded NiCrMo—BSiC coating that is tight and protects against corrosion. Hardening of the base material underneath the first layer composed of the NiCrMo—BSiC alloy takes place as the result of the laser re-melting. In the cylinder and screw materials mentioned, a hardness zone having a hardness of 55-57 HRC is produced at a depth of approx. 0.5-2 mm. The first re-melted layer is thin, 5-30 μm, and has an average hardness of 40-45 HRC. It has been shown that the high shear forces and surface pressures are passed into the hardened zone of the base material by way of the thin, medium-hard, metallurgically bonded Ni base layer, without any critical plastic deformation and pressing-in of the hard WC coating taking place.

[0020] The coating according to the invention allows a hard-metallic HVOF coating having a shear strength of 250 MPa, applied to the inner surface of the double cylinder and the cylinder surface of the screw, which brings about hardening of the base material by means of the laser re-melting of the first thermally applied coating, and allows a sufficient supporting effect of the coating. The coating allows protection from hydrochloric acid sub-surface corrosion by means of the laser re-melted NiCrMo—BSiC alloy, if cracks in the HVOF WC coating occur as the result of the great mechanical stress.

[0021] Furthermore, it has been shown that the coating according to the invention is not only corrosion-resistant, impact-resistant, and crack-resistant, but also has great tolerance to expansion.

[0022] Applications can be components having a complex geometry, such as, for example, turbine blades, ball valves, screw rotors or the inner surfaces of pipes, such as cylinders.

[0023] Production of the coating according to the invention is characterized by three steps:

[0024] 1. Production of a thin coating by means of thermal spraying, i.e. a coating having a thickness of preferably between 5 and 300 μm, on the surface of a component. In particular, an oxidation-resistant and/or corrosion-resistant material serves as the material of the surface.

[0025] 2. Re-melting of the thermally applied coating. In this connection, re-melting preferably takes place by means of laser technology.

[0026] 3. Spraying at least one further layer onto the re-melted coating. In this connection, the layer is preferably a plasma layer composed of oxide ceramic material or an HVOF layer composed of metal-bonded carbides.

[0027] Plasma spraying and high-velocity flame spraying are variants of thermal spraying that can particularly be used.

[0028] Preferably, the thermal spray layer is re-melted. Here, too, laser technology is a proven tool for re-melting. The advantage of the re-melted layer is the formation of an alloy in the metallurgically bonded, thermally sprayed-on and re-melted coating that lies underneath.

[0029] A further advantageous embodiment of the invention provides that the layer is a plasma layer composed of oxide ceramic material. This layer is advantageously characterized in that it has great hardness and low heat conductivity, so that this layer is particularly suitable for heat-insulating components.

[0030] A practicable variant of the invention provides that the layer composed of metal-bonded carbides is, in particular, an HVOF layer composed of WC—CrC—Ni. In this way, a layer is produced that has great hardness and impact resistance. In addition, it is electrically conductive and demonstrates great heat conductivity.

[0031] Furthermore, the use of the layer sequence according to one of claims **1** to **10** in an extrusion double cylinder is provided for.

[0032] In the following, the invention will be explained in greater detail using the drawings. These show, in a schematic representation:

[0033] FIG. **1** a conventional component that is provided with a metallurgically bonded as well as thermally sprayed on and re-melted coating, and

[0034] FIGS. **2***a* to **2***b* a component according to the invention with and without crack formation.

[0035] FIG. **1** shows a conventional component that is provided with a coating **3**.

[0036] The coating **3** is metallurgically bonded to the surface **2** of the component **1** and re-melted. Previously, the coating **3** was thermally sprayed onto the surface **2** of the component **1**. The component shown in FIG. **1** is a screw rotor. The thickness of the coating **2** amounts to 5 μm to 300 μm.

[0037] In a manner essential to the invention, the metallurgically bonded coating **3** is provided with a thermal spray layer **4**, as is furthermore evident from FIG. **2***a*. In FIG. **2***a*, **2***b*, the complete component **1** shown in FIG. **1** is not shown for reasons of the illustration. The layer **4**, the thickness of which amounts to approx. 30 μm, is a layer that has been thermally sprayed onto the metallurgically bonded coating **3**. The layer **4** is a plasma layer composed of an oxide ceramic material. Alternatively, the layer can also be an HVOF layer composed of WC—CrC—Ni.

[0038] The advantage of the layer structure from FIG. **2***a* is illustrated by FIG. **2***b*. If crack formation occurs due to increased stress on the component, the crack formation occurs only in the layer **4**. As is evident from FIG. **1***b*, the crack **5** extends only in the layer **4**, without having any continuation in the metallurgically bonded coating **3**.

[0039] The present invention is not restricted, in terms of its embodiment, to the exemplary embodiment indicated above. Instead, a number of variants is possible, which make use of the solution shown also in embodiments of a different type.

[0040] For example, the layer **4** can also have a thickness between 5 μm and 300 μm, preferably 5 μm and 150 μm, for reasons of cost reduction particularly preferably 5 μm to 30 μm.

[0041] Furthermore, the coating **3** can be composed of a hot-gas-oxidation-resistant material such as MGAlY, or of a corrosion-resistant material such as NiGMo.

[0042] Furthermore, the following can be provided within the scope of the invention:

[0043] a layer **4** on a hardened surface, restricted to the inner coating of the component **1**, restricted to the geometry of a double cylinder, restricted to injection with a rotating burner,

[0044] a layer sequence according to claim **1** with a <5 μm re-melted layer **4** on a hardened surface,

[0045] a rotating inner coating burner with RMTU,

[0046] an HVOF inner coating burner for small inside diameters and powder for it, a double burner chamber, a hydrogen atomizer, kerosene, Lambda<1, short spraying distance, protective effect by means of active gas, powder plasma-spheroidized, <15 μm, preferably 0.5-6 μm, 2-9 μm,

[0047] an inner coating of the component **1** composed of metal-bonded tungsten carbide and molybdenum,

[0048] a power conveyor for fine particles, vibrations, balls, a bed of balls, vibration direction, a conveying channel, groove, funnel or cylinder, a conveying disk,

[0049] a pipe with an inner and an outer coating, combination of laser-HVOF and HVOF, and laser-HVOF soft and laser-HVOF hard, a corrosion-resistant hard-metallic HVOF layer, for example composed of powder WC CrC Ni with a low metallic binder proportion in the layer.

[0050] Also provided is a tungsten carbide powder for the production of layers and bodies, spherical, plasma-spheroidized, composed of tungsten, chromium, carbon, and a binder metal such as Fe, Co, Ni, WC with chromium, for example WC CrC Ni with a low metallic binder proportion, fine WC and fine CrC, structure WC, W2C, (WCr)2C, Cr3C2, Cr7C3, Cr23C6 with W proportions (CrW)23C6, (WCr)3NiC, (WCr)4Ni2C, (WC)6Ni6C, chromium carbide is the carbon supplier. In this connection, the carbon is present in excess and is released as graphite. This promotes the suppression of n-carbides that cause brittleness.

REFERENCE SYMBOL LIST

[0051] **1** component

[0052] **2** surface

[0053] **3** coating

[0054] **4** spray layer

[0055] **5** crack

1. Component (**1**) having a coating (**3**) that is metallurgically bonded as well as thermally sprayed on and re-melted, wherein the coating (**3**) is provided with at least one thermal spray layer (**4**).

2. Component according to claim **1**, wherein the layer (**4**) is re-melted.

3. Component according to claim **2**, wherein the thickness of the layer (**4**) amounts to between 5 and 500 μm.

4. Component according to claim **2**, wherein the thickness of the layer (**4**) amounts to between 5 and 150 μm.

5. Component according to claim **3**, wherein the thickness of the layer (**4**) amounts to between 5 and 30 μm.

6. Component according to claim **1**, wherein the layer (**4**) is a plasma layer composed of oxide ceramic material.

7. Component according to claim **1**, wherein the layer (**4**) is composed of metal-bonded carbides, particularly an HVOF layer composed of WC—CrC—Ni.

8. Component according to claim **1**, wherein the coating (**3**) is composed of a hot-gas-oxidation-resistant material.

9. Component according to claim **1**, wherein the coating (**3**) is corrosion-resistant.

10. Component according to claim **1**, wherein the coating (**3**) is situated on the surface (**2**) and/or the inner surface of the component (**1**).

11. Method for the production of a metallurgically bonded coating (**3**), which is thermally sprayed onto a surface (**2**) of a component (**1**) and re-melted by means of a laser, wherein at least one further layer (**4**) is thermally sprayed onto the coating (**3**).

12. Method according to claim **11**, wherein the layer (**4**) is re-melted.

13. Method according to claim **12**, wherein the layer (**4**) is re-melted by means of a laser.

14. Method according to claim **11**, wherein the layer (**4**) is applied by means of plasma spraying.

15. Method according to claim **11**, wherein the layer (**4**) is applied by means of high-velocity flame spraying.

* * * * *