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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Method for the production of mechanical parts provided with a wear- and/or corrosion-resistant coating.**

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Description

The present invention relates to a method for the production of components having a wear- and/or corrosion-resistant coating.

In particular, the present invention relates to a method for the coating of products required to withstand high hammering, rolling and frictional stresses with or without corrosion due to external agents, both cold and hot, with materials which have high wear resistance. According to known technology, such products (for example, tappets, cams, eccentrics, dies, etc.) are normally constituted by a metal body which is not particularly resistant to wear and/or corrosion, in which the most stressed portion is covered with a coating of more expensive material selected in dependence on the type of stress and/or corrosive environment to which the product in question will be subject.

The coating of the metal substrates with friction- and/or corrosion-resistant materials is carried out hot, for example, by the techniques of deferred-arc plasma, laser-beam melting bond, spray coating by means of plasma, etc.

After this hot coating, the material of the coating is stressed by considerable residual internal tensile forces as it cools and these persist in the finished product. These forces arise since the substrate, through the forces due to the adhesion between the substrate and the coating material, prevents the latter from shrinking freely from the temperature used for the coating to the ambient temperature.

These residual stresses, added to the effects of the stresses suffered in use of the product and/or added to the corrosive act ion of external agents (stress corrosion), greatly limit the useful "life" of the product. In fact, cracks may be generated in the coating which, by losing its continuity, also loses its ability to resist wear and/or corrosion. Moreover, the cracks generated in the coating may be propagated in the base material of the product and may cause fractures which compromise the required functionality or may be highly dangerous.

JP-A-159566 describes a method for the production having a wear-and/or corrosion resistant coating on a portion thereof comprising the steps of forming the element, applying the coating to said portion of the element and subjecting the element with the coating to hot isostatic pressing. The element may be a sintered compact; by the hot isostatic pressing a coating is obtained having good exfoliation resistance with reduced porosity and increased density.

The object of the invention is to provide a method which allows to control the internal stress of the coating.

Such object is achieved by means of a method wherein the wear-and/or corrosion resistant coating is applied to a sintered element and then subjected to a hot thermal treatment characterised by the steps of

- forming the element by the cold compression of powders,
- pre-sintering the thus formed cold compressed element just to the extent of the element being susceptible of further dimensional shrinkage as the result of a further sintering step to obtain a prefixed residual stress,
- applying said coating to the element, said coating having a melting point higher than the sintering temperature of the element and having a wear- and/or corrosion resistance higher than that of the element, and
- subjecting the element with the coating to pressureless sintering, to cause a dimensional shrinkage of said element and coating, whereby the residual tensile internal stresses of the coating layer are nullified or converted in compression.

In this way, by making use of the known phenomenon of contraction of parts during sintering, it is possible to eliminate completely or to bring to a predetermined value the residual internal stresses of the coating layer.

According to another characteristic, the component is subjected to a pre-sintering treatment before the application of the coating.

In this way, it is possible to coat components which already have a certain mechanical strength. Furthermore, with the pre-sintering, it is possible to define, and hence more precisely to control, the dimensional variations of the sintered and coated parts and therefore the residual stress in the coating layer.

Further advantages and characteristics of the method according to the invention will become clear from the detailed description which follows, provided purely by way of non-limiting example, with reference to the appended drawings, in which:

Figure 1 is a cross-section of a so-called green formed from powders,

Figure 2 is a section of the pre-sintered part obtained from the green of Figure 1,

Figure 3 is a view similar to Figure 2 and shows the pre-sintered part of Figure 2 provided with a wear-resistant coating, and

Figure 4 is a section which shows the sintered part obtained from the pre-sintered part of Figure 3.

With reference to the drawings, a green is indicated 10 and, after the sintering process, is intended to constitute a tappet element of an internal combustion engine, comprising a shaft 11 and

a flat 13 provided with a working surface 12. The green 10 may, for example, be made of sintered low-alloy steel corresponding, for example, to a conventional C10. After formation of the green 10, achieved by cold compression in a die, it is introduced into a pre-sintering furnace (not illustrated), both in order to obtain a more easily handled product and in order to be able to control the dimensional shrinkage, shown in the drawings by broken lines R. A pre-sintered part 14 is thus obtained which has characteristics of strength such as to enable it to proceed without problems to the subsequent stage of coating of the working surface 12 with a layer 16 of coating material having a melting point higher than the sintering temperature of the green and having high wear- and/or corrosion-resistance. The layer 16 is constituted by powders deposited at high temperature by various techniques (deferred-arc plasma, laser meeting bond, plasma spray etc.). The hot application of the coating 16 means that, as it bonds to the pre-sintered part 14 which is at a lower temperature, the coating is subjected during cooling to internal tensile stresses which persist after cooling.

The next stage involves the passage of the pre-sintered part 14, with the layer of coating 16, into a sintering furnace in which the pre-sintered part 14 is transformed, at a high temperature, and for a time from 1 to 3 hours into a sintered part 18 with a further change in dimensions. This change means that the layer of coating 16 of the pre-sintered part 14 is transformed into a layer 16' in which the tensile stress condition is cancelled out or transformed into a compressive stress condition which, in the specific case of a tappet with a flat, is particularly suitable for the type of stress to which the product will be subjected in use (impact, rolling and sliding stress from the cam acting on the tappet). In other cases, it may be convenient to eliminate any stress condition between the coating 16' and the sintered part 18, or it may be opportune to maintain a condition of slight tensile stress so that any problems of thermal stress can be resolved without disadvantages to the part. This "piloting" of the stress condition of the coating layer 16' may be obtained by a suitable selection of the particle size and elements of the powders used to produce the green 10, defined in dependence on the reduction in volume which is to be obtained as a result of the self-densification undergone by the product in the sintering process. Another variable on which it is possible to act to produce the desired stress condition in the coating 16' is the duration of the initial pre-sintering stage.

The method according to the invention has advantages for the sintering of ceramic powders or metal-ceramic powder mixtures too.

Claims

1. A method for the production of elements, particularly mechanical elements, having a wear- and/or corrosion-resistant coating, wherein said coating is applied to a sintered element and then subjected to a hot thermal treatment, characterised by the steps of:
   - forming the element by the cold compression of powders,
   - pre-sintering the thus formed cold compressed element just to the extent of the element being susceptible of further dimensional shrinkage as the result of a further sintering step to obtain a prefixed residual stress,
   - applying said coating to the element, said coating having a melting point higher than the sintering temperature of the element and having a wear- and/or corrosion-resistance higher than that of the element, and
   - subjecting the element with the coating to pressureless sintering, to cause a dimensional shrinkage of said element and coating, whereby the residual tensile internal stresses of the coating layer are nullified or converted in compression.

2. A method according to Claim 1, characterised in that the coating is applied by means of deferred-arc plasma.

3. A method according to Claim 1, characterised in that the coating is applied by means of laser melting bond.

4. A method according to Claim 1, characterised in that the coating is applied by means of plasma spray coating.

5. A method according to any one of the preceding claims, characterised in that the element is obtained from metal powders.

Patentansprüche

1. Verfahren zur Herstellung von Teilen, insbesondere mechanischen Teilen, mit einer verschleiß- und/oder korrosionsfesten Beschichtung, wobei die Beschichtung auf ein gesintertes Teil aufgebracht und dann einer Hitzebehandlung unterworfen wird, gekennzeichnet durch die Schritte:
   - Formen des Teils durch Kaltverdichtung von Pulvern,
   - Vorsintern des so geformten, kaltverdichteten Teils gerade in dem Ausmaß, daß

das Teil einer weiteren dimensionalen Schrumpfung als Ergebnis eines weiteren Sinterungsschrittes unterworfen werden kann, um eine vorgegebene Restspannung zu erhalten,

- Aufbringen der Beschichtung auf das Teil, wobei die Beschichtung einen Schmelzpunkt hat, der höher als die Sintertemperatur des Teils ist, und eine Verschleiß- und/oder Korrosionsfestigkeit aufweist, die höher als diejenige des Teils ist, und
- Aussetzen des Teils mit der Beschichtung einem drucklosen Sintervorgang, um eine dimensionale Schrumpfung des Teils und der Beschichtung zu bewirken, wodurch die inneren Rest-Zugspannungen der Beschichtungslage auf Null gebracht oder in Druck umgewandelt werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Beschichtung mittels aussetzendem Lichtbogenplasma aufgebracht wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Beschichtung durch Laserschmelzverbinden aufgebracht wird.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Beschichtung durch Plasmaspritzbeschichten aufgebracht wird.

5. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das Element aus Metallpulvern hergestellt ist.

Revendications

1. Procédé pour la production d'éléments en particulier d'éléments mécaniques ayant un revêtement résistant à l'abrasion et/ou à l'érosion, dans lequel ledit revêtement est appliqué à un élément fritté puis soumis à un traitement thermique à chaud, caractérisé par les étapes qui consistent :

- à former l'élément par compression à froid de poudres ;
- à pré-fritter l'élément comprimé à froid ainsi formé jusqu'au point d'obtenir l'élément susceptible d'un rétrécissement dimensionnel ultérieur résultant d' une étape de frittage supplémentaire afin d'obtenir une contrainte résiduelle prédéterminée ;
- à appliquer ledit revêtement à l'élément, ledit, revêtement ayant une température de fusion supérieure à la température de frittage de l'élément, et ayant une résistance à l'abrasion et/ou à la corrosion supérieure à celle de l'élément ; et
- à soumettre l'élément et le revêtement à un frittage sans compression, afin de provoquer un rétrécissement dimensionnel dudit revêtement et de l'élément, grâce à quoi les tensions internes résiduelles de traction de la couche de revêtement sont annulées ou converties en des contraintes de compression.

2. Procédé selon la revendication 1, caractérisé en ce que le revêtement est appliqué au moyen d'un plasma à arc dévié.

3. Procédé selon la revendication 1, caractérisé en ce que le revêtement est appliqué au moyen d'une liaison par fusion laser.

4. Procédé selon la revendication 1, caractérisé en ce que le revêtement est appliqué par pulvérisation par plasma.

5. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'élément est obtenu à partir de poudres métalliques.

FIG. 1

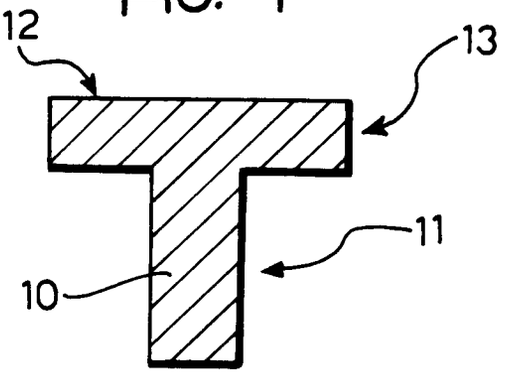

FIG. 2

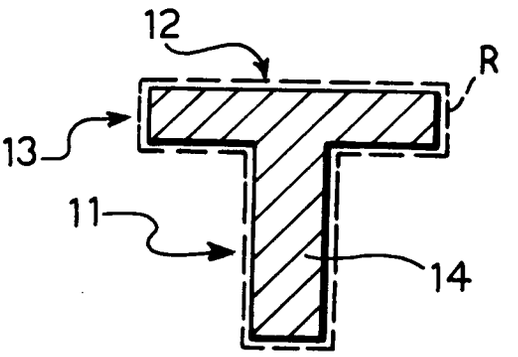

FIG. 3

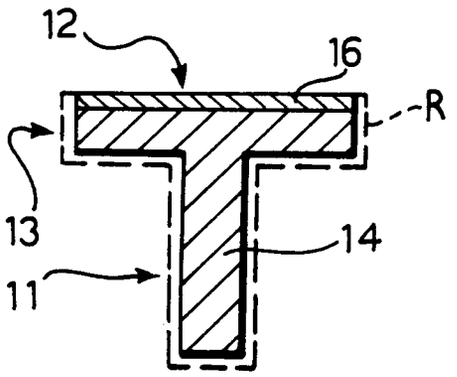

FIG. 4