The present invention concerns a twist drill comprising a shank and a cutting portion which is defined by the axial length of the chip flutes and which is at least partially coated. To provide a twist drill having the aforementioned features and a process for the production thereof, which on the one hand have very good properties in terms of service life and chip formation or chip transport, but which on the other hand are also highly suited for reconditioning including coating, in accordance with the invention it is proposed that the cutting portion has substantially over its usable length a first coating, wherein there is provided a second coating which is different from the first coating only in the region of the tip of the drill and which extends over an axial length which corresponds at a maximum to twice the nominal diameter of the drill.
COATED TWIST DRILL

[0001] The present invention concerns a twist drill having a shank and a cutting portion which is defined by the axial extent of flutes and which is at least partially coated.

[0002] The invention also concerns a process for the production of a corresponding twist drill.

[0003] Coated twist drills have long been known. In that respect the coating can serve very different purposes. In general the attempt is made to increase the resistance to wear of the drill, in particular in the region of the drill tip, by a corresponding coating. If moreover the drill geometry or the specific uses mean that the round lands or guide lands or the peripheral surfaces of the drill are also stressed they can also be protected from premature wear by a complete coating on the cutting portion. Other coatings which are generally restricted to the region of the tip of a drill, beside increasing the resistance to wear, are also intended in particular to influence the chip shape and to produce a chip which either breaks quickly or which rolls up very tightly and which can be transported by the chip flutes extending in a spiral configuration, more easily than long, less heavily curved chips. Chip transport is important in particular in relation to drills whose cutting portions are relatively great in comparison with the diameter (nominal diameter of the cutting portion), being for example more than six times the nominal diameter.

[0004] Frequently however it can happen that chip transport is even worsened in relation to an uncoated drill, by virtue of the coating on the chip flutes, which it will be appreciated is at least partially dependent on whether the layer does or does not involve a surface treatment, for example by grinding, polishing or smoothing. Depending on the respective machining condition or machinability and wear characteristics of the flute surface however a coating on the flutes can additionally improve chip transport. It will be appreciated that the drills involved here are metal drills, that is to say drills which are provided for working on metallic workpieces, in which respect however different metallic materials may also exhibit very different chip cutting characteristics.

[0005] In that respect the main focus of the coatings was in the past clearly on improving the wear characteristics and the production of chips which are easy to transport. Both essentially relate to the region of the tip of the drill, in particular the region of the main cutting edges and the chip flute portions directly adjoining same, that is to say the rake surface. Nonetheless drills in accordance with the state of the art were hitherto coated predominantly along the entire cutting portion because limiting a coating to the tip region is more complicated and expensive in conventional coating installations, than a complete coating.

[0006] In the meantime, numerous different coatings have been developed to optimize the wear and chip formation characteristics, the best-known and most wide-spread coating being titanium nitride (TiN). Numerous further layers have been developed on the basis of that layer, the further layers additionally containing for example carbon or aluminum such as for example (AlTiN), (TiAlN) or Ti(CN). In part titanium has also been replaced by chromium (as for example in the case of (CrAlN)), and coatings based on tungsten carbide (WC/C) have also been developed.

[0007] Some of those coatings are only possible with a high level of complication and expenditure and while observing complex process parameters. Because of the complexity of highly developed coating processes and because of the special composition of high-efficiency coatings, a coating of that kind is only possible at all in very few specialized areas of operation. On the other hand however there is a need for corresponding drills which are worn in the region of their main cutting edges to be re-ground, in which case the coating in the region of the drill tip also has to be renewed again. Renewing a corresponding high-efficiency coating is however uneconomical for individual drills or for relatively small numbers of items, as typically occur for re-grinding in an industrial operation using corresponding drills. In contrast, simple coatings as have already been known for a prolonged period of time are relatively easily available without involving major effort.

[0008] Irrespective of the aforementioned problems, there is a further problem which specifically concerns such drills which are coated at their periphery, that is to say in particular along the round lands or guide lands and the outside surfaces of the drill flute lands. That problem is described by the technical term “pitting” or “pitting formation” and involves the wear-resistant layer chipping off the guide lands, more specifically typically in a region which is spaced from the drill tip or from the cutting corner defined by the transition from the main cutting edge to the secondary cutting edge. In the case of pitting formation, often it is not only the applied layer but also a part of the subjacent base material of the guide land or round land of the drill, that is fixedly connected to the applied layer, that chips off. Upon a first use of the drill that does not yet have a detrimental effect because the main cutting edge and the chip rake surface are not affected by the pitting since, as already mentioned, that chipping off of the layer at the guide lands occurs only at a certain distance from the cutting corner or from the main cutting edge. It will be noted however that those chipped-off regions become a problem when re-grinding the drill, more specifically when the worn tip of the drill is removed to such a degree that the main cutting edge is displaced further back in the direction of the shank and then the freshly produced cutting corner (at the transition from the main cutting edge to the secondary cutting edge) can very readily come into the region affected by the pitting. That means that the cutting corner is undefined and the drill can only be limitedly used, it wears more rapidly and must be shortened until by chance a position which is not affected by the pitting is reached at both sides on the oppositely disposed round lands. It will be appreciated that this also reduces the useful working life of the drill.

[0009] It has been found that of all things more recent types of very hard and brittle layers which are particularly suitable in particular for affording wear protection at the main cutting edges and the chip rake surfaces have a very severe tendency to such pitting formation.

[0010] In comparison with that state of the art the object of the present invention is to provide a twist drill having the features set forth in the opening part of this specification and a process for the production thereof, which on the one hand ensure very good properties in regard to service life and chip formation and chip transport, but which on the other hand are also highly suited for re-working, including subsequent coating on the other hand.

[0011] In regard to the twist drill itself that object is attained in that the cutting portion has a first coating substantially over the entire useable length of the cutting portion, wherein there is provided a second coating that is different from the first
coating only at the tip of the drill and there includes a region which measured from the drill tip corresponds at a maximum to twice the nominal diameter of the drill.

[0012] That makes it possible to satisfy the in part mutually contradictory requirements on the one hand for a very durable layer which however does not adversely affect chip transport and on the other hand for particular resistance to wear but also re-workability of the drill tip. By way of example in first manufacture of the drill the cutting portion can be provided substantially over its entire length with a high-performance layer which is possibly not yet optimum in terms of resistance to wear but in return is also not exposed to the danger of pitting or spalling of the layers. Preferably such a high-performance layer should afford a lower level of friction in relation to the chips. An additional, particularly hard and wear-resistant layer can then possibly be applied to that layer, wherein the additional layer is however restricted to the tip of the drill and for that reason alone is not or is only immaterially affected by pitting and also does not adversely influence chip transport, by virtue of its short length. Pitting is avoided not only by virtue of the fact that the second layer extends only over a relatively short distance beyond the cutting edge, but also by virtue of the fact that in the proximity of the cutting edges the second layer is applied to the first layer and not directly to the base material of the drill, wherein, even if the second layer chips off the first layer in that region, at any event the first layer itself is not affected by that chipping.

[0013] When working and re-grinding worn drills the drill tip is effectively shortened by a certain amount and removed to such a degree that all severely worn regions which are concentrated in particular around the main cutting edges disappear. The second layer is typically of its greatest thickness at the end of the drill and/or around the main cutting edges and then becomes progressively thinner towards the shank end until it is reduced to zero at the latest approximately at twice the diameter, measured from the drill tip. Accordingly, the thicker regions of the second layer are simultaneously removed with the removal of the drill tip so that the subsequent re-coating of the new tip with the second layer is effected on residues which are possibly still present of the second layer and the adjoining regions which are possibly not yet affected by the original second layer so that the result is a coated drill tip which is completely identical to the original drill tip.

[0014] In that respect it is desirable if the second layer is so selected that it can be restored without involving major complication and effort and without a complex process control.

[0015] In the drill reconditioning operation the first layer which extends from the tip to the shank end of the cutting portion remains substantially preserved as the drill is shortened or removed essentially only at the particularly severely wearing tip with the main cutting edges so that the positive properties of the first layer in respect of chip transport, the avoidance of surface pickup phenomena and protection for the guide lands is also retained.

[0016] Preferably the present invention is applied to twist drills whose cutting portion is of an axial length of at least four times the diameter. In the case of shorter drills chip formation and chip transport play a lesser part so that it is possible substantially to concentrate on protection from wear, for which purpose it is generally possible to manage with a single layer although for particular situations of use the double layer according to the invention may nonetheless be appropriate in relation to short drills.

[0017] A particularly preferred twist drill according to the invention is one in which the cutting portion is at least six times its diameter. In that case the cutting portion is defined by the axial length of the chip flutes or that useable part which can be moved downwardly into a drilled hole without blocking chip discharge.

[0018] In the preferred embodiment the second layer is limited in respect of its axial extent to between 0.3 and 1.5 times, in particular to between 0.3 and 1.2 times, the nominal diameter, measured in each case from the tip of the drill. It is possible to completely dispense with the first coating on the free clearance surfaces of the main cutting edges at the end of the drill, especially as when re-conditioning a worn drill that tip region is in any case completely ground away so that in the re-grinding operation and subsequent re-coating procedure with the second layer it is in any case only the second layer that is applied to the clearance surfaces at the end.

[0019] A particularly preferred twist drill according to the invention is one in which at least the cutting portion but preferably the entire drill including the shank is produced from solid hard metal. Although solid hard metal drills which typically comprise a tungsten carbide-cobalt compound are in themselves already relatively wear-resistant, it is however nonetheless also possible by coatings in relation to solid hard metal drills, to still considerably improve the properties both in regard to resistance to wear and also in regard to chip formation and chip transport.

[0020] The first layer can have an advantageous effect in particular but not only in relation to solid hard metal drills, in regard to a whole series of properties. On the one hand many of the metallic elements which constitute the materials to be machined can diffuse into the WC-Co compound, which is also substantially metallic, of a solid hard metal drill. Conversely elements can also diffuse out of the solid hard metal, and that respectively manifests itself in corresponding detrimental ageing effects. In addition particularly in the proximity of the cutting edges, when machining many metallic materials, there is a severe tendency for the chips to build up by a welding effect.

[0021] Many modern coatings in contrast involve a more or less ceramic character, that is to say they are not metallic, they act as a diffusion barrier layer for metals and they are also not subject to the risk of welding build-up of the chips. In addition ceramic layers of that kind have thermally insulating properties and finally they also contribute to a further wear resistance as they are generally even harder than the base material of the drill, even if the drill in turn comprises solid hard metal.

[0022] Many of those properties such as for example thermal insulation and resistance to chip welding build-up are particularly important in the proximity of the cutting edge, but other properties are also significant for chip transport and load-bearing capability and breaking strength of the drill and are therefore important for the entire cutting part of the drill. With the two coatings according to the invention, it is possible to optimally fulfill and combine the different demands on the coatings in the proximity of the cutting edge and in regions which are further back.

[0023] In addition however it is not out of the question for the first and second coatings to comprise an identical material, in which respect however it will be noted that they may certainly still differ in respect of layer thickness, variation in the layer thickness in dependence on the axial position and the surface nature, that is to say smooth or not smooth. In that respect consideration is to be given in particular to the fact
that, in a grinding or smoothing operation, in principle the cutting edges are also detrimentally affected so that it may be appropriate for the second layer in the proximity of the main cutting edges to be applied only after smoothing or grinding of the first layer and after grinding of the drill tip.

[0024] A particularly preferred configuration of the present invention is one in which the applied first and second layers are of different colors. In that way it is possible to clearly see how far the second layer extends over the tip of the drill, how far by which layer is worn, and what type of drill is confronting the person handling it, as drills with different coatings can certainly be adapted to special, different machining operations or materials.

[0025] In addition it is desirable if the color of the first complete layer also differs from the color of the base material. That also makes it easier to recognize any flaws or any wear phenomena on the first layer.

[0026] A particularly preferred embodiment of the invention is one in which the first layer is smoothed at least in the region of the chip flutes and in those chip flutes at least outside the region of the tip, which is covered by the second layer. The coating applied to the round lands and the adjoining, relieved peripheral surfaces of the drill flute lands can also be selectively smoothed. In that respect in particular the drill tip can be left untouched in order not to cause wear of the main cutting edges from the outset due to the smoothing operation. Alternatively however the tip grind and the coating operation with the second layer can be effected only after the step of smoothing the cutting part provided with the first layer and in particular the chip flutes.

[0027] A process according to the invention for the production of corresponding twist drills has the features:

[0028] a) providing a generally cylindrical drill blank comprising a shank and a cutting portion having possibly pre-shaped chip flutes as well as a drill tip to be provided with main cutting edges,

[0029] b) producing the chip flutes, the round lands and the relieving the adjoining the round lands, at the final dimension, apart from coatings which are still to be applied,

[0030] c) completely coating at least the chip flutes of the round lands and the peripheral surfaces forming the periphery of the drill lands with a first layer,

[0031] d) grinding the drill tip including removing any first layer also applied to the end clearance surfaces, and

[0032] e) coating the drill tip with a second layer, wherein the second layer, measured from the tip of the drill, extends axially over a region which at a maximum corresponds to twice the nominal diameter of the drill.

[0033] In that respect the sequence of the steps (c) and (d) could also be reversed although the above-specified sequence is preferred.

[0034] In regard to that sequence of the process steps, a procedure as is also implemented when reconditioning the drill tip is effectively already used upon fresh production of the drill. Accordingly a reconditioned drill practically completely corresponds in all its properties to a new drill, apart from the fact that it has become slightly shorter due to the re-grinding operation.

[0035] Furthermore a preferred process is one in which the first layer is smoothed at least in the chip flutes and in that respect at least outside the region affected by the second layer. In addition it may be advantageous if the guide lands and peripheral surfaces of the drill lands are also smoothed after application of the first layer. That smoothing operation is intended to reduce friction with the drilled hole walls and/or chips produced by the drill tip and in particular to promote chip transport. As already mentioned it will be noted however that smoothing can be limited to a region at spacing from the main cutting edges, or the smoothing operation can be effected between foregoing steps (c) and (d).

[0036] Further advantages, features and possible uses of the present invention will be clearly apparent from the description hereinafter of a preferred embodiment and the accompanying drawings.

[0037] FIG. 1 shows a side view of a twist drill according to the invention,

[0038] FIG. 2 shows a section through the drill of FIG. 1 along line II-II in FIG. 1.

[0039] FIG. 3 shows a view along the axis 12 onto the end or tip 3 of the drill, and

[0040] FIG. 4 shows an enlarged axis view of the tip and the adjoining region of the drill.

[0041] FIG. 1 shows a drill which is generally identified by reference 100 and which has a shank 10 and a cutting portion 1. The cutting portion 1 is characterized by chip flutes 2 extending from the drill tip 3 to close to the shank 10. The chip flutes extend in a spiral at a certain helical angle or twist angle around the axis 12 of the drill, wherein the twist angle of the chip flutes 2, or more precisely the twist angle of the secondary cutting edges which are formed at the transition of the chip flutes 2 to the guide lands 6, must be selected to be sufficiently large relative to the axis 12 in order to provide for effective chip transport from the tip 3 of the drill to the shank and out of the chip flutes. Typically that so-called “twist angle” is in the range of between 20° and 40° relative to the axis 12.

[0042] As can be seen in detail by reference to FIGS. 1 through 4 the drill in accordance with the embodiment illustrated here has at its tip two slightly convexly curved cutting edges 5 and the transverse cutting edge bridging over the two main cutting edges 5 is substantially reduced in terms of a cutting edge. The main cutting edges 5 are adjacent at the end of the drill by a clearance surface comprising a first bevel-like portion 4a and a portion 4b which is angled in relation thereto and at a larger fall angle. Coolant bores 11 can be seen at the end as shown in FIG. 3 of the drill (and also in FIGS. 2 and 4). The diameter of the drill is defined by two oppositely disposed cutting corners 13 formed by the transition between the main cutting edges 5 and the secondary cutting edges 8 which extend along the periphery of the cutting portion in a helical configuration around the drill. Adjoining the secondary cutting edges 8 are so-called “guide lands” or also “round lands” which are effectively clearance surfaces lying on a cylindrical surface, of the secondary cutting edges 8, and which contribute to stabilizing and guiding the drill in a bore hole. The peripheral surfaces 9 of the drill, adjoining the guide lands 6 (see FIGS. 2 through 4) are undercut in relation to the round lands 6 or reduced to a smaller diameter to reduce the friction of the drill in the bore hole.

[0043] FIG. 2 shows the drill in section along line II-II in FIG. 1, and it is also possible to see here the coolant bores 11 as well as the flutes 2 and the bottom 2a of the flutes 2, the bottom being provided with the first layer.

[0044] The entire cutting portion 1, that is to say the portion from the drill tip 3 to the end of the flutes 2, is coated with a first layer comprising a wear-resistant material which promotes chip transport. Only a front end portion 7 at the tip 3 of the drill, in addition to the first coating, has a second layer
which is applied to the first layer and which comprises a particularly wear-resistant material. In that respect the end clearance surfaces 4a, b can be left untouched by the first layer so that they are only coated with the second layer. The axial length of the portion 7 is preferably in the range of between 0.3 and 1.2 times the diameter and in the illustrated embodiment approximately corresponds to the diameter. [0045] The first coating is smoothed above the region 7 of the second coating at least within the chip flutes. That can be effected for example by wet or dry blasting, by brushing or by magnet-abrasive removal. [0046] When regrinding a corresponding drill tip essentially the material on the rake surfaces 4a, b is removed, in which case possibly also the cutting tip at the center of the drill or the transition thereof to the chip flutes has to be regrind. That means that a considerable part of the region 7 provided with the second layer is also reduced. After the main cutting edge including the cutting corners, that is to say the transitions to the secondary cutting edges formed at the round lands 6, are in the finished ground condition, coating is again effected over a corresponding fresh region 7, exclusively with the material of the second layer, in which case the first layer in any case is retained. In that way re-coating has to be effected only with the material of the second layer. Any residue of the second layer which has still remained of the previous region 7 at the tip of the drill does not have a troublesome effect in that respect, especially as the thickness of the second layer preferably continuously decreases from the drill tip in the direction of the shank. [0047] Preferably the first and second layers comprise a different material so that the demands on their properties, which in principle are somewhat different, can also be suitably optimized. In addition however aspects regarding the capability of producing the coatings also play a part. If desired the two coatings can also comprise the same material. [0048] The following coatings have proven to be particularly desirable, in which respect the left-hand half of the Table specifies preferred first layers and the right-hand half specifies the preferred second layers, which in principle can be combined together as desired:

<table>
<thead>
<tr>
<th>1st layer:</th>
<th>2nd layer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition*</td>
<td>Color</td>
</tr>
<tr>
<td>TiN</td>
<td>gold</td>
</tr>
<tr>
<td>TiN</td>
<td>gold</td>
</tr>
<tr>
<td>Ti(CN)</td>
<td>gray-blue</td>
</tr>
<tr>
<td>Ti(CN)</td>
<td>reddish</td>
</tr>
<tr>
<td>Ti(CN) + TiN</td>
<td>gold</td>
</tr>
<tr>
<td>Ti(CN) + TiN</td>
<td>gold</td>
</tr>
<tr>
<td>(TiAl)N</td>
<td>gray-blue</td>
</tr>
<tr>
<td>(AlTi)N</td>
<td>gray-blue</td>
</tr>
<tr>
<td>(TiAl)N</td>
<td>gray-blue</td>
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<tr>
<td>(AlTi)N</td>
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<tr>
<td>(TiAl)N</td>
<td>gray-blue</td>
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<tr>
<td>(AlTi)N</td>
<td>gray-blue</td>
</tr>
<tr>
<td>(AlTi)N</td>
<td>cover layer</td>
</tr>
<tr>
<td>(AlTi)N</td>
<td>cover layer</td>
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<td>cover layer</td>
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<tr>
<td>(AlTi)N</td>
<td>cover layer</td>
</tr>
</tbody>
</table>

*essential component; also multi-layers with intermediate layers of a different composition or different structure
1. A twist drill comprising a shank and a cutting portion which is defined by the axial length of the chip flutes and which is at least partially coated, wherein the cutting portion has substantially over its useable length a first coating, wherein in addition a second is applied only in a region at the tip of the drill, which extends over an axial length which corresponds at a maximum to twice the nominal diameter of the drill.

2. A twist drill as set forth in claim 1 wherein the cutting portion is of an axial length which is at least four times the nominal diameter.

3. A twist drill as set forth in claim 2 wherein the axial length of the cutting portion is at least six times the nominal diameter.

4. A twist drill as set forth in claim 1 wherein the second coating is restricted to a region of the tip of the drill, which is between 0.3 times and 1.5 times, preferably between 0.3 times and 1.2 times, the nominal diameter.

5. A twist drill as set forth in claim 1 wherein the first layer is applied over the entire useable length of the cutting portion with the exception of the end clearance surfaces, wherein the end clearance surfaces are provided only with the second coating.

6. A twist drill as set forth in claim 1 wherein at least the cutting part of the drill and preferably the entire drill comprise solid hard metal.

7. A twist drill as set forth in claim 1 wherein the two layers differ at least by their color.

8. A twist drill as set forth in claim 1 wherein at least the color of the first layer differs from the base color of the drill.

9. A twist drill as set forth in claim 1 wherein the first layer is smoothed in the chip flutes at least outside the region of the second layer.

10. A twist drill as set forth in claim 9 wherein in addition the peripheral surfaces of the drill lands and/or the round lands of the cutting part are also smoothed.

11. A process for the production of a twist drill comprising the following steps:
   a) providing a drill blank comprising a shank and a cutting portion having possibly pre-shaped chip flutes as well as a drill tip to be provided with main cutting edges,
   b) grinding the chip flutes, the round lands and the peripheral surfaces adjoining the round lands,
   c) completely coating at least the chip flutes of the round lands and the peripheral surfaces forming the periphery of the drill lands with a first layer,
   d) grinding the drill tip including removing any first layer also applied to the end clearance surfaces, and
   e) coating the drill tip with a second layer different from the first layer, wherein the second layer, measured from the tip of the drill, extends axially over a region which at a maximum corresponds to twice the nominal diameter of the drill, wherein the sequence of steps c) and d) is reversible.

12. A process as set forth in claim 11 wherein the end clearance surfaces of the drill prior to step are not coated with the first layer and then only with the second layer.

13. A process as set forth in claim 11 wherein the first layer is smoothed at least in the region of the chip flutes outside the tip portion provided with the second layer.

14. A process as set forth in claim 13 wherein the first layer is additionally smoothed in the region of the round lands and the relieved peripheral surfaces.

15. A process as set forth in claim 11 wherein the first and second layers comprise the same material.

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