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(57) **Abrégé/Abstract:**

The invention relates to a focusing nozzle for abrasive water jet cutting consisting of a nozzle body of carbide metal comprising a bore, in which at least the bore wall has a single- or a multi-layer coating of hard material.
According to the invention, the hard material coating has a coat with titanium nitride content at least at the free surface.



Abstract

The invention relates to a focusing nozzle for abrasive water jet cutting consisting of a nozzle body of
5 carbide metal comprising a bore, in which at least the bore wall has a single- or a multi-layer coating of hard material.

According to the invention, the hard material coating has a coat with titanium nitride content at least at
10 the free surface.

FOCUSING NOZZLE

The invention relates to a focusing nozzle for abrasive water jet cutting consisting of a nozzle body of
5 carbide metal comprising a bore for focusing the cutting jet, in which at least the bore wall has a single- or a multi-layer coating of hard material.

Such focusing nozzles form part of cutting heads for
10 abrasive water jet cutting in which the cutting water jet and the abrasive medium used for cutting, such as corundum or sand, are mixed in a mixing chamber in order to increase the cutting effect of the cutting water jet. The focusing nozzles serve to accelerate and
15 center the water jet and the simultaneously admitted abrasive medium. In order to improve mixing of the abrasive medium into the water jet, the focusing nozzles generally have a funnel-like widening on the inlet side. The bore connected thereto and passing
20 through the focusing nozzle has a diameter in the range of roughly 0.2 – 1.5 mm. Despite the enclosure of the abrasive medium in the water jet, the focusing nozzles are subjected to very severe wear. If the wear on the bore wall is too severe, the centering effect is no
25 longer sufficient and the nozzle has to be replaced. As each nozzle change involves a prolonged and therefore costly interruption in the work process, considerable efforts have been made in the past to increase the service life of such focusing nozzles as far as
30 possible. For example, highly wear-resistant tungsten carbide-based, hard metal alloys with very low metallic binder contents or even ceramic materials were frequently used for such focusing nozzles. But even using these high-grade materials, the achievable service
35 lives were still not sufficiently satisfactory.

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In order to further increase the service life, efforts were therefore made to protect the inner wall of the through-bored centering nozzle against excessive wear by using coatings of hard material. The problem here is that it is difficult to
5 uniformly apply a protective coating of hard material to the inner walls of these relatively long bores of small diameter.

WO 98/15386, for example, describes a focusing nozzle whose inner wall has a wear-resistant, diamond-like coating of amorphous carbon (DLC). The coating is applied by means of a
10 laser arc coating method, whereby a highly activated plasma has to be generated in the vacuum by means of a pulsed arc discharge between a source of the coating material and the nozzle to be coated. For this, the surface to be coated must be freely accessible so that the focusing nozzle can be split into
15 several segments for coating of the bore wall. After coating, these segments have to be tightly assembled again, a process involving a considerable amount of work.

Some embodiments of the present invention may therefore apply a coating to the inner wall of a hard metal focusing nozzle that
20 is sufficiently resistant to wear, and at the same time is easy to apply without time-consuming segmenting of the nozzle.

Some embodiments of the invention relate to a focusing nozzle for abrasive water jet cutting consisting of a nozzle body of hard metal comprising a bore for focusing the cutting jet, in
25 which at least the bore wall has a single- or a multi-layer coating of hard material, wherein the hard material coating has a layer with titanium nitride content at least at the free surface.

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According to some embodiments of the invention, the hard material coating has a layer with titanium nitride content at least on the free surface. It was not to be expected that the use of such a coating as a hard material coating would allow a
5 significant improvement in the wear resistance of focusing nozzles to be achieved, since the hardnesses of the layer with titanium nitride content at the surface are hardly higher than the hardness of the hard

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metal base material employed, and far lower than the hardness of a diamond-like coating (DLC) already used to coat such focusing nozzles according to the prior art described at the beginning. The coating according to the invention can be applied in one or more layers, also by applying other hard material layers. All that is important is that the layer at the surface has a titanium nitride content. Apart from pure titanium nitride, titanium carbonitride or titanium oxycarbonitride, for example, are also conceivable for this surface layer. Although the hardness of known DLC layers is not quite achieved with the coating according to the invention, but in favor of the application of the coating according to the invention is possible without problems using CVD methods.

With this coating method, the reaction gases can be selectively directed through the bore of the focusing nozzle, so that the time-consuming multiple segmenting of the nozzle body according to the prior art can be avoided. The increase in the service life of focusing nozzles with the coating according to the invention by comparison with focusing nozzles of uncoated hard metal is outstanding and extends up to a doubling of the service life.

The service-life-prolonging effect, surprising in view of the minor differences in hardness between base material and coating, is probably attributable to the fact that with focusing nozzles of uncoated hard metal, the wet operating conditions, exacerbated by in some cases low pH values, result in surface corrosion that causes a dissolving-out of the metallic binder from the hard metal alloy. The remaining superficial hard material skeleton has a considerably lower resistance to abrasion compared with a hard metal alloy bonded completely with metallic binder. The coating according to the invention substantially prevents surface corrosion and hence a dissolving-out of binding medium.

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Even when working with jets in which no significant dissolving-out of metallic binder occurs due to a high pH value, a considerable improvement in the service life can be ascertained as a result of the coating according to the invention attributable to the additional smoothing effect of the coating, particularly in the area immediately behind the entry cone of the focusing nozzle. The smoother surface in this area calms the incoherent jet zone far more quickly, leading to a great reduction in wear.

It has proved to be particularly favorable for the hard material coating to be applied as a single titanium nitride or titanium carbonitride layer.

The most expedient layer thicknesses for the hard material coating lie in the range from 1-15 μm .

Layers with titanium nitride content can be particularly well applied using CVD (chemical vapor deposition) methods. These methods offer the great advantage that the reaction gases can be easily directed, so that the hard material coatings produced thereby can be deposited even at points with difficult access, so that the inside walls of the narrow bores in the focusing nozzles can also be coated without problems.

A hard metal with up to 1.5% w/w cobalt as metallic binder, up to 3% w/w mixed carbides, and tungsten carbide with a grain size of less than 0.4 μm as rest has proved to be effective as base material for the focusing nozzle.

The invention is described in greater detail below by reference to examples.

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Example 1

Focusing nozzles with 76 mm length, 9 mm outside diameter and 0.7 mm bore diameter were produced by extrusion and sintering from a hard metal alloy with 1% w/w cobalt as metallic binder and tungsten carbide with 0.2 μm mean grain size as rest. The focusing nozzles had a hardness of 2550 HV₁₀. Some of the focusing nozzles were subsequently coated at the surface, including the bore wall, with a 6.5 μm thick TiN layer in a medium-temperature CVD process. The layer hardness was roughly 2450 HV_{0.1}. The focusing nozzles had a golden yellow coloration. In a comparison test with uncoated reference nozzles, some of the focusing nozzles coated according to the invention were used under practical conditions for water jet cutting. The water pressure was 2250 bar, with a pH value of the water of 6.1. Sand with a mean grain size of 260 μm and a feed rate of 9 g/s was used as abrasive medium. As a result, prolongations of the service life of the coated focusing nozzles compared with the uncoated focusing nozzles in the order of a factor of 1.8 to 2.1 were observed.

Example 2

Focusing nozzles were produced as described under example 1. Some of these focusing nozzles were coated at the surface, including the bore wall, with a two-layer hard material coating consisting of an 8 μm thick TiCN layer and a 4 μm thick TiN layer in a medium-temperature CVD process. The uppermost layer of the coating was the TiN layer. The hardness of the coating was approx. 2450 HV_{0.1}.

In the comparison test between the focusing nozzles coated according to the invention and the uncoated reference nozzles during water jet cutting, the water pressure was 2250 bar, the pH value of the water 7.3. Sand with a grain size of 260 μm and a feed rate of

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9 g/s was again used as abrasive medium. As a result, prolongations of the service life of the coated focusing nozzles according to the invention compared with the uncoated focusing nozzles in the order of a factor of 1.3 to 1.6 were observed.

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CLAIMS:

1. A focusing nozzle for abrasive water jet cutting consisting of a nozzle body of hard metal comprising a bore for focusing the cutting jet, in which at least the bore wall has a
5 single- or a multi-layer coating of hard material, wherein the hard material coating has a layer with titanium nitride content at least at the free surface.
2. The focusing nozzle for abrasive water jet cutting as claimed in claim 1, wherein the hard material coating is
10 applied as a single titanium nitride or titanium carbonitride layer.
3. The focusing nozzle for abrasive water jet cutting as claimed in claim 1 or 2, wherein the layer thickness of the hard material coating lies in the range from 1 to 15 μm .
- 15 4. The focusing nozzle for abrasive water jet cutting as claimed in one of claims 1 to 3, wherein the coating is applied by means of CVD processes.
5. The focusing nozzle for abrasive water jet cutting as claimed in one of claims 1 to 4, wherein the hard metal for the
20 main body consists of up to 1.5% w/w cobalt as metallic binder, up to 3% w/w mixed carbides, and tungsten carbide with a grain size of less than 0.4 μm .