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(54) Title: COATING FOR LOWERING FRICTION EFFECT AND IMPROVING WEAR RESISTANCE OF A COMPONENT IN A FIBRE WEB MACHINE AND PROCESS OF PRODUCING THE SAME

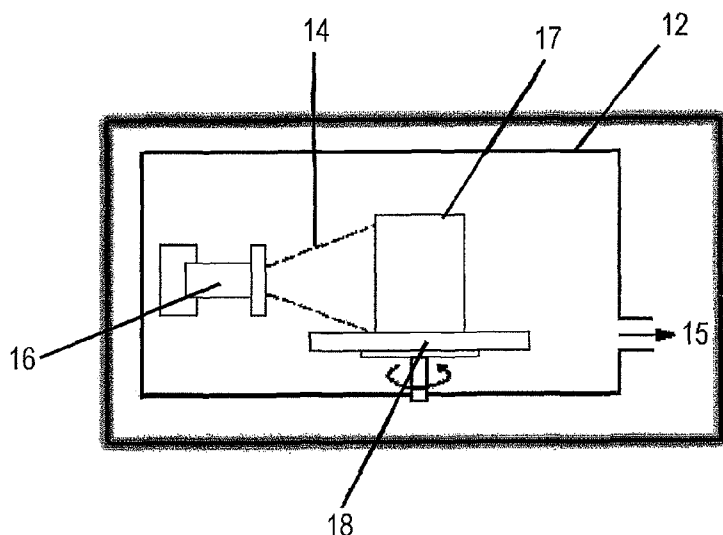


FIG. 2

(57) Abstract: The present invention relates to a coating of low friction and improved wear resistance and the method of producing the same. A base material is provided with a titanium layer and a pure carbon (ta-C) layer is coated on top of it. Said coating also exhibits high hardness and bending stress resistance. Preferably, said coating is applied to components of paper making machines and show superior performance in cooperation with fibre web.

**Coating for lowering friction effect and improving wear
resistance of a component in a fibre web machine and
process of producing the same**

5 Technical field

The present invention relates to a coating having, a method for producing the same and components provided with said coating.

10 Background art

Today and in the future, too, paper, board and tissue machines have and will have components (like suction box decks in wire section, felt suction box in decks in press section, extended nip shoes of belt rolls, rolls, cylinders, doctor blades, metal belts etc.) in high friction contact against a counter surface (like wire, felt, belt, roll, cylinder, blade, etc.). The friction effect of these components remarkably increase power consumption of the machine drives, in other words electric energy demand of the machine line and, in addition thereto, subject the counter surface to wear, which leads to production losses due to production break for worn component changes. Consequently, there is a consistent need for surfaces of lower friction and higher wear resistance.

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The prior art comprises ceramic decks in wire and press sections, covered rolls and cylinders, different materials for doctor blades as well as fabrics on paper machines.

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However, the surfaces disclosed in the prior art have relatively high friction against counter surfaces, which causes considerable power demand, fabric wear and production loss for the mill.

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Further, there is known a plasma deposition process as illustrated by Fig. 1. According to this process, gas 1 is introduced into the vacuum chamber 2, which is ionized by an electrode 3 into plasma 4. The outlet 5 of said chamber is connected to a not shown vacuum pump. The plasma contains energetic ions which, supported by electron beams, have enough energy to vaporize a substrate provided on an evaporating dish 6 and this vapor is accelerated towards a component 7. Typically, a temperature of 270 to 400°C is applied.

It is known from the prior art, for instance WO 99/54520, to apply coating materials such as DLC (diamond-like carbon) by PVD processes. The coatings described in WO 99/54520 have a low friction and a hardness level of 6,000 to 10,000 HV. The thickness of the coating is uniform all over and is typically 10 to 100 µm.

SUMMARY OF THE INVENTION

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However these prior art DLC coatings are made using a hydrocarbon gas in a PVD process, whereby a hydrogenated amorphous carbon (a-C:H) structure is formed. Therein, hydrogen weakens the hardness and wear resistance.

25

It is the object of the present invention to provide a surface coating on components with enhanced characteristics regarding wear resistance, low friction, and bending stress resistance and the process for producing the same. Preferably, said coating is used for components that belong to paper making machines and are exposed to strong contact interaction and specifically show superior performance in cooperation with fibre web.

30

A first aspect of the invention concerns a method of producing a coating having low friction and improved wear resistance, characterised by the steps of forming on a base material a titanium layer for improving adhesion,

5 evaporating a graphite material to obtain a carbon plasma, and accelerating said carbon plasma to a high speed before it hits the surface, thereby forming a pure carbon layer (ta-C) on top of said titanium layer.

Preferably on top of said pure carbon layer (ta-C), a
10 fluorinated diamond-like carbon (ta-C:F) is formed.

A second aspect of the invention is related to a coating having low friction and improved wear resistance, comprising a titanium layer on a base material, and a pure
15 carbon layer (ta-C) formed on top of said titanium layer, wherein a hydrogen free amorphous carbon surface has 60 to 70 % of diamond bonds (sp^3) and 30 to 40 % of graphite bonds (sp^2), and a thickness of the coating is 0.1 to
- 10 μm .

20 Preferably, this coating has a coefficient of friction in dry contact of ta-C against metal or itself of 0.1, and a coefficient of friction in lubricated contact of ta-C against metal or itself of 0.01 to 0.05.

Further, the coating preferably has a hardness of
25 4,000 to 10,000 HV. Moreover, an elastic modulus of the coating is preferably 500 to 800 GPa. In addition, the coating is preferred to have an abrasion resistance 10 times better compared to PVD DLC C-H or WC/C coating.

30 A third aspect of the invention pertains to a component to be used in fibre web machines in a sliding contact against a counter surface of the fibre web machine, having a coating according to the second aspect of the invention. Preferably, the component having said coating is
35 a metal belt.

The surface of a substrate is cleaned with ultra sound, solvent and/or ion spray cleaning. In case of steel, oxide removal is performed. The substrate should have a surface roughness of smaller than 0.5 μm .

Plasma sources are used in which ionised plasma is shot with high kinetic energy in a vacuum chamber to the surface to be coated. Different acceleration units are necessary to achieve a high plasma flow of 10,000 km/sec. Further, different materials can be used with different plasma sources. The coating process according to the present invention allows the coating to be performed in a temperature range below 100 °C, preferably in a temperature range between 50 and 60 °C.

The carbon atoms are bonded together to form a diamond-like hydrogen free coating. This coating exhibits extreme low friction due to the absence of hydrogen. The coating according to the present invention has an abrasion resistance which is ten times better compared to a PVD DLC C-H or WC/C coating. The coefficient of friction in a metal/metal+oil system is 0.12 to 0.001. Said substrate can be coated in a thickness of smaller than 10 μm . The coating according to the present invention has a Vicker's hardness of from 5000 to 10000 H, a modulus of elasticity of from 500 to 800 GPa and a heat transfer capacity as copper. Additionally, the coating exhibits acid resistance.

Further, it has been found out that the surface roughness of the coating is the same as the surface roughness of the substrate. Accordingly, the surface roughness of the substrate is copied to the surface of the coating. This makes it possible to form impels or pockets

on the substrate prior to the coating process which are maintained in the surface even after the coating process.

That is, a hydrogen-free amorphous carbon surface with small scale topography and low friction can be formed. Said surface may also comprise lubricating pockets which further decrease the friction between the coated surface and its counter surface. Further, due to the absence of hydrogen, the coating also has a superior corrosion resistance.

The coating can be produced economically over a large surface with high raw material utilising efficiency. The coating can be overlapped, thus allowing coverage of a large surface by coating smaller areas at a time. The thickness of the coating can be adjusted and, when needed, the coating can be adjusted to a small area. The coating process of the present invention has the advantage that it allows coating of a surface in situ. This enables new coatings as well as repairs to be made on-site or in-machine (particularly for rolls, cylinders and belts). The coating devices are of moderate prices.

Moreover, the coating shows a superior performance in cooperation with a fibre web. Further, the present inventors have found out that the bending stress resistance of a metal belt coated with the coating of the present invention exhibits fatigue values which are 15 to 35 % higher.

The coatings according to the present invention have been tested and the coatings exhibit a very high resistance to wear and bending, and also have a very low friction. In fact, the coating can be made more resistant, with a lower friction than DLC (Diamond-Like-Coatings) made by PVD or PACVD methods. Further, the coatings of the present

invention can be applied more easily on large surfaces. It has a big market potential since the coated surface brings an added value to a variety of products.

5 New products could be developed by utilising the coating of the invention, for example a low friction convergent gap for dewatering in wire section. With current surfaces such a product is not economically reasonable because of its high power effect and surface wear.

10

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 schematically shows a plasma deposition
15 process of the common prior art

Figure 2 schematically shows the method of producing a coating according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the invention are specifically described below.

25 Figure 2 illustrates a reaction chamber 12 equipped with a gas-outlet 15 which is connected to a not shown vacuum pump to ensure for low pressure conditions. The plasma accelerator 16 electromagnetically accelerates the plasma 14 to a speed of 10000km/s towards the component 17
30 provided on a rotatable or moving apparatus 18. Thereby, said component 17 is coated at a temperature under 100°C and preferably of only 50-60°C. The plasma source used is not especially limited and preferably comprises laser beam or vacuum arc techniques known in the art.

35

The ta-C coatings according to the present invention are typically made in the following way.

First, a base material is coated with a titanium layer
5 to improve adhesion of the ta-C coating. Subsequently, a pure carbon layer (ta-C) is coated thereon.

The ta-C coatings of the present invention are made by evaporating graphite and accelerating the carbon plasma to a high speed before it hits the surface (cf. Fig. 2). By
10 this particular feature, a hydrogen free amorphous surface with 60 to 70 % of diamond bonds (sp^3) and 30 to 40 % of graphite bonds (sp^2) is formed. Compared to the prior art cited above, the thickness of the ta-C coatings of the present invention is typically less than 10 μm .

15

Optionally, a mixed carbon (ta-C) and fluorine layer may be coated on top of the carbon layer. This optional layer can be used to improve, for example, cleanability
- properties of the surface in paper or board machine applications. This is important especially when the surface is heated and in contact with the web. Further, by using optional layers, for example hydrophilic / hydrophobic properties of the surface can be adjusted.

25

The coating according to the invention is applied for a component or components of web making machines, in particular for components being in sliding contact with fibres to be processed. The coating can be preferably utilised for a roll, a metal belt, a doctor blade, or other
30 sliding elements in a wire and press section (for instance high vacuum box, uhle box, shoe of an extended nip press, and so on) of paper making machines.

Claims

1. Method of producing a coating having low friction and improved wear resistance, characterised by the steps of forming on a base material a titanium layer for improving adhesion,

evaporating a graphite material to obtain a carbon plasma, and

accelerating said carbon plasma to a high speed before it hits the surface,

thereby forming on top of said titanium layer a pure carbon layer (ta-C).

2. Method according to claim 1, wherein on top of said pure carbon layer (ta-C) a mixed carbon (ta-C) and fluorine layer is formed.

3. Coating having low friction and improved wear resistance, comprising

a titanium layer on a base material, and

a pure carbon layer (ta-C) formed on top of said titanium layer, wherein

a hydrogen free amorphous surface has 60 to 70 % of diamond bonds (sp^3) and 30 to 40 % of graphite bonds (sp^2), and a thickness of the coating is 0.1 to 10 μm .

4. Coating according to claim 3, wherein a coefficient of friction in dry contact of ta-C against metal or itself is 0.1, and a coefficient of friction in lubricated contact of ta-C against metal or itself is 0.01 to 0.05.

5. Coating according to claim 3 having a hardness of 4,000 to 10,000 HV.

6. Coating according to claim 3 having an elastic modulus of 500 to 800 GPa.

7. Coating according to claim 3 having an abrasion resistance 10 times better compared to PVD DLC C-H or WC/C coating.

8. Component to be used in fibre web machines in a sliding contact against a counter surface of the fibre web machine, having a coating according to any of claims 3 to 7.

9. Component according to claim 8, wherein said component is a metal belt.

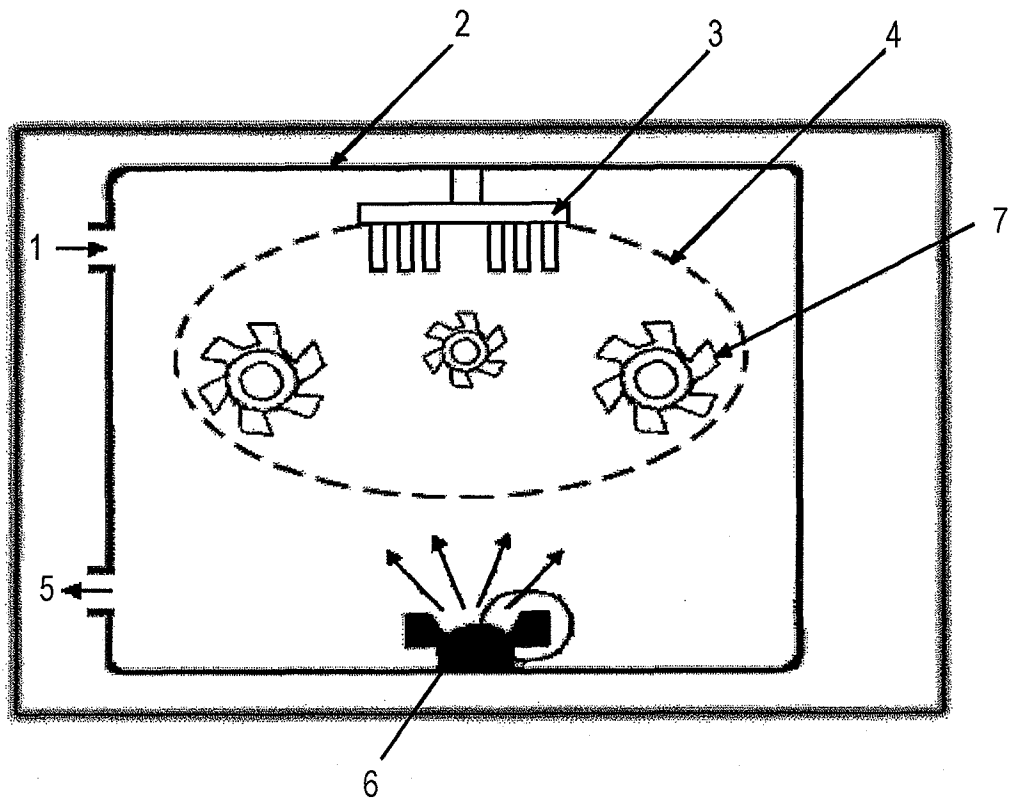


FIG. 1

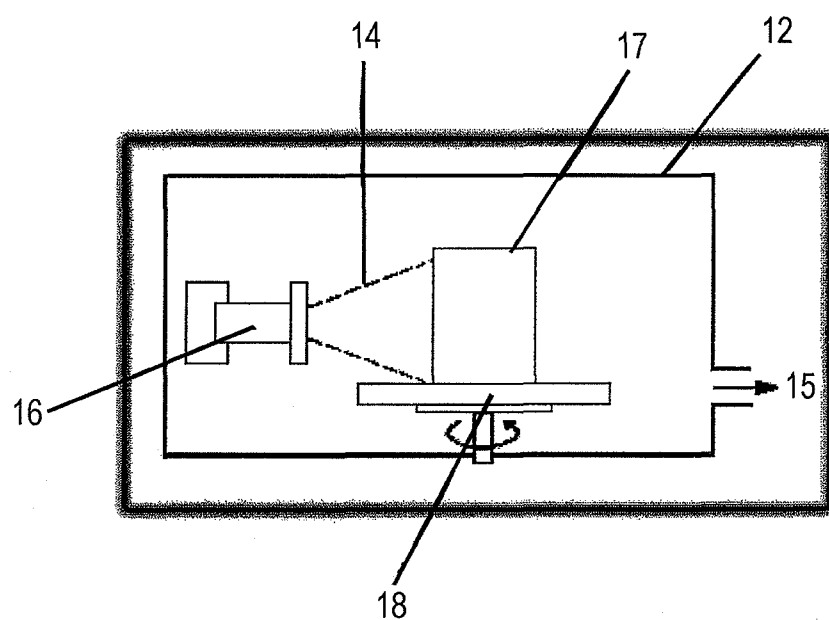


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2008/060800

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C14/06

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, IBM-TDB, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/104263 A (ALJBATECH LTD [RU]; KOLPAKOV ALEXANDR YAKOVLEVICH [RU]; INKIN VITALY N) 2 December 2004 (2004-12-02)	1,3-9
Y	column 3, lines 5-16; example 2	2
Y	US 2005/175839 A1 (HYODO HIROYUKI [JP]) 11 August 2005 (2005-08-11) paragraphs [0033], [0039], [0040]	2
X	WO 98/54376 A (PATINOR AS [NO]; GONCHARENKO VALERY PAVLOVICH [RU]; KOLPAKOV ALEXANDER) 3 December 1998 (1998-12-03) page 3, line 19 - page 4, line 8 page 8, lines 30-32	1,3-7
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2008/060800

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/224349 A1 (HOSENFELDT TIM M [DE] ET AL) 27 September 2007 (2007-09-27) paragraphs [0021], [0023], [0040], [0042], [0046], [0048], [0050] -----	1
X	WO 2007/020139 A (BEKAERT SA NV [BE]; DEKEMPENEER ERIK [BE]) 22 February 2007 (2007-02-22)	3,5-7
Y	column 2, line 27 - column 4, line 2	1
Y	column 5, lines 24-34	4
	column 9, line 29 - column 10, line 16 -----	
A	JP 2002 285328 A (FUJI ELECTRIC CO LTD) 3 October 2002 (2002-10-03)	3-6
Y	example 3; table 2 -----	4
A	JP 03 080191 A (NANBA YOSHIKATSU) 4 April 1991 (1991-04-04) the whole document -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2008/060800

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2004104263	A	02-12-2004	CN 1795285 A EP 1639149 A1 JP 2007501331 T RU 2240376 C1 US 2007134436 A1	28-06-2006 29-03-2006 25-01-2007 20-11-2004 14-06-2007
US 2005175839	A1	11-08-2005	NONE	
WO 9854376	A	03-12-1998	AU 7678598 A CN 1258322 A EP 0985057 A1 JP 2002501575 T RU 2114210 C1 US 6261424 B1	30-12-1998 28-06-2000 15-03-2000 15-01-2002 27-06-1998 17-07-2001
US 2007224349	A1	27-09-2007	CN 101010442 A DE 102004041235 A1 EP 1781835 A1 WO 2006021275 A1 JP 2008510863 T KR 20070045347 A	01-08-2007 02-03-2006 09-05-2007 02-03-2006 10-04-2008 02-05-2007
WO 2007020139	A	22-02-2007	CN 101432462 A JP 2009504448 T US 2008220257 A1	13-05-2009 05-02-2009 11-09-2008
JP 2002285328	A	03-10-2002	NONE	
JP 3080191	A	04-04-1991	NONE	