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(54) LAMINATION CYLINDER

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(57) **ABSTRACT**

A lamination cylinder includes a surface structure, on which a plurality of craters is defined having a different geometry and a random distribution. Some of the craters are partially superimposed with respect to each other.

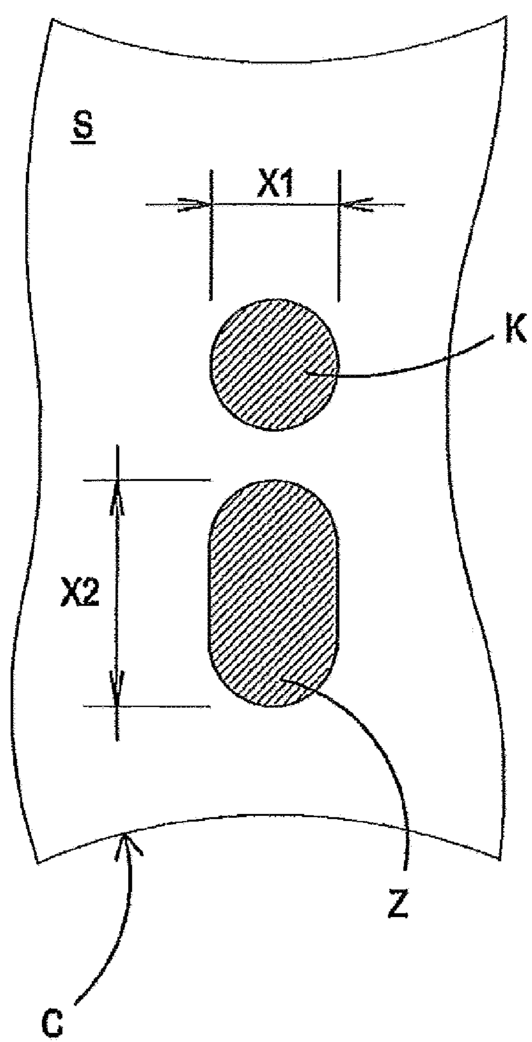


Fig. 1

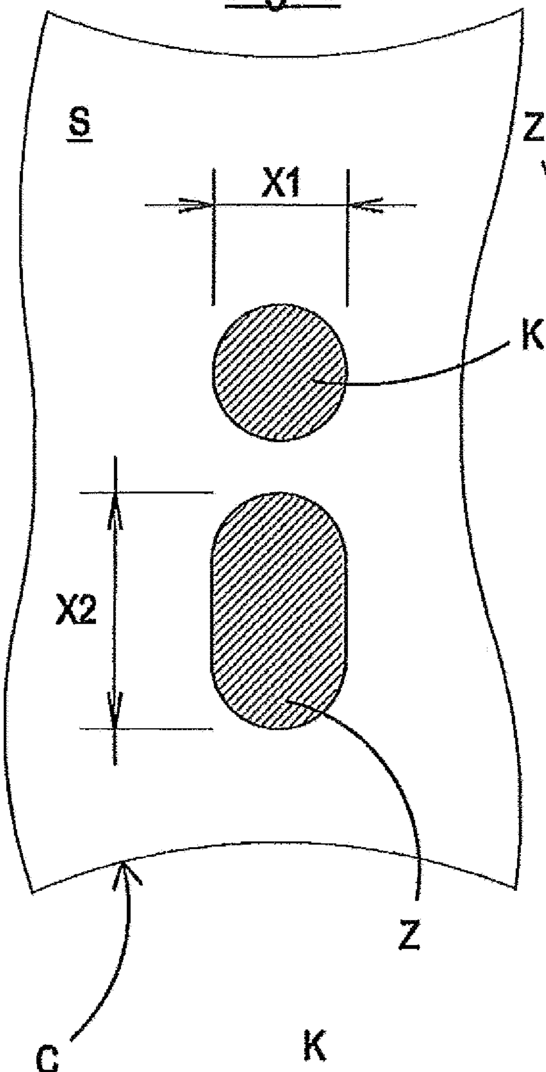
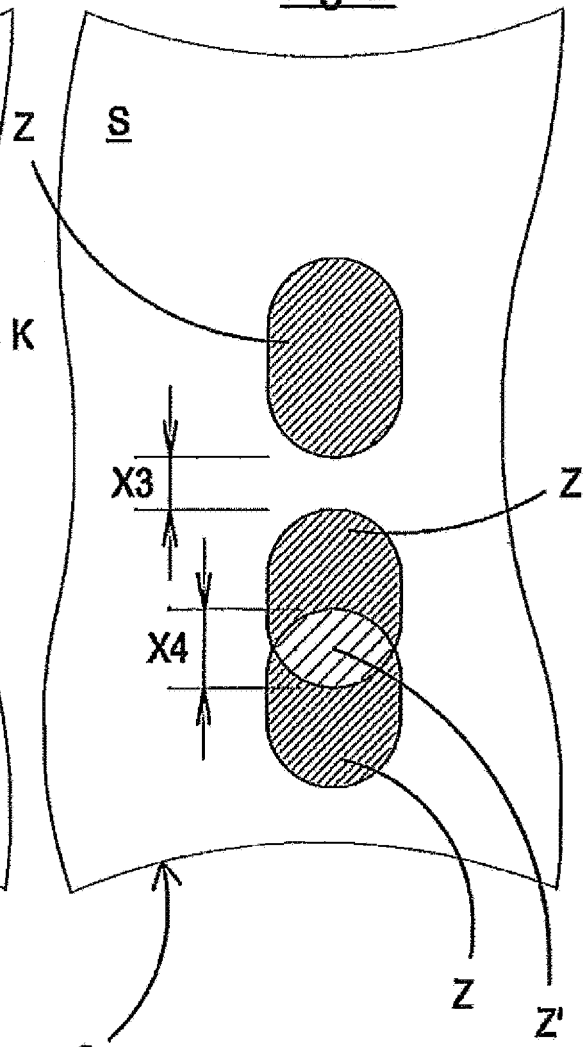


Fig. 2



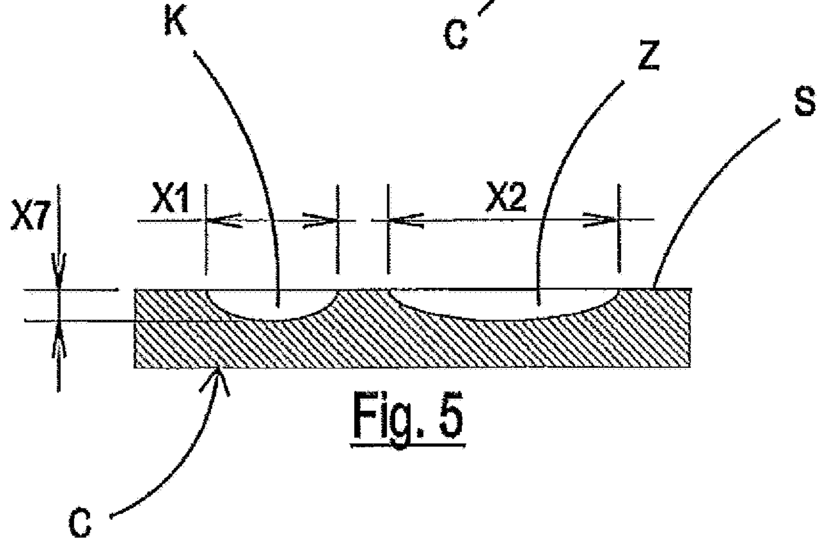


Fig. 5

Fig. 3

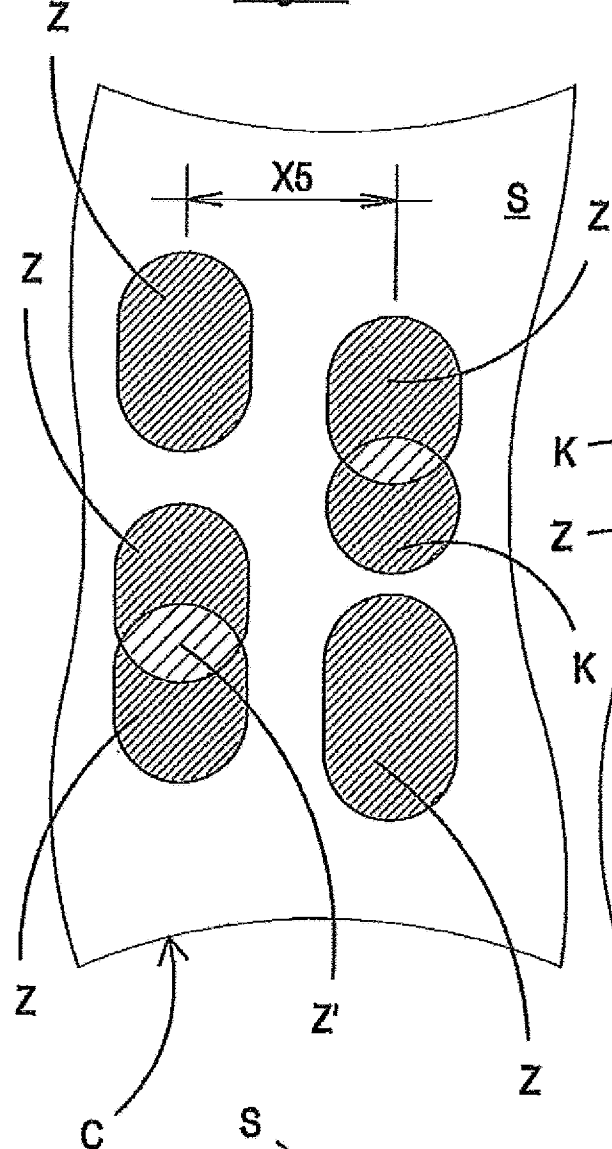
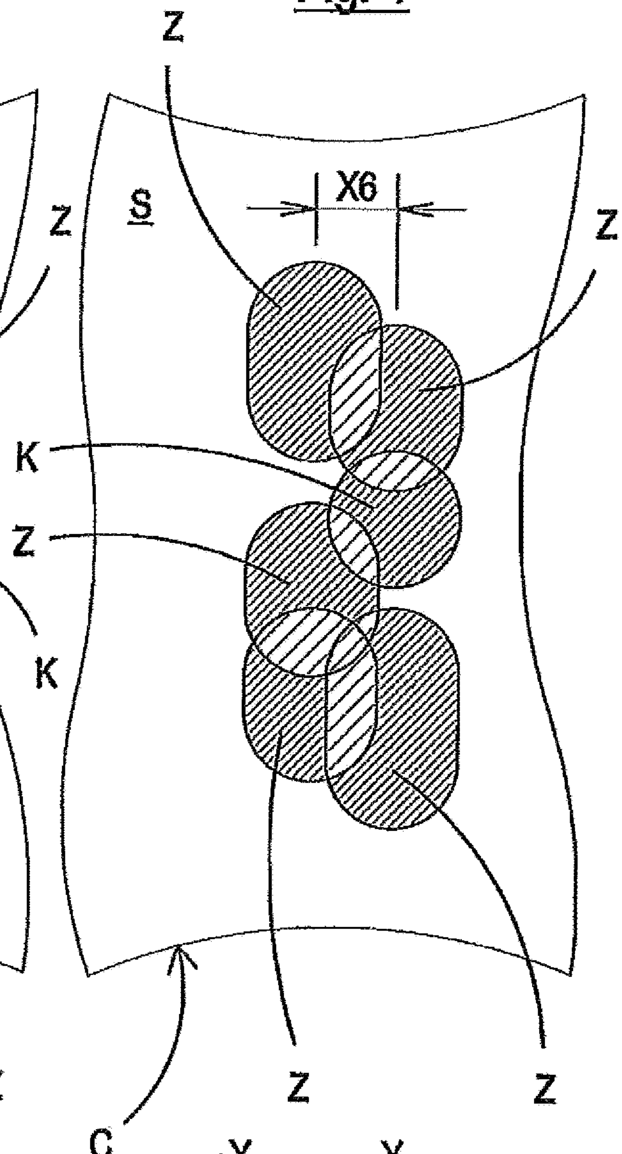


Fig. 4



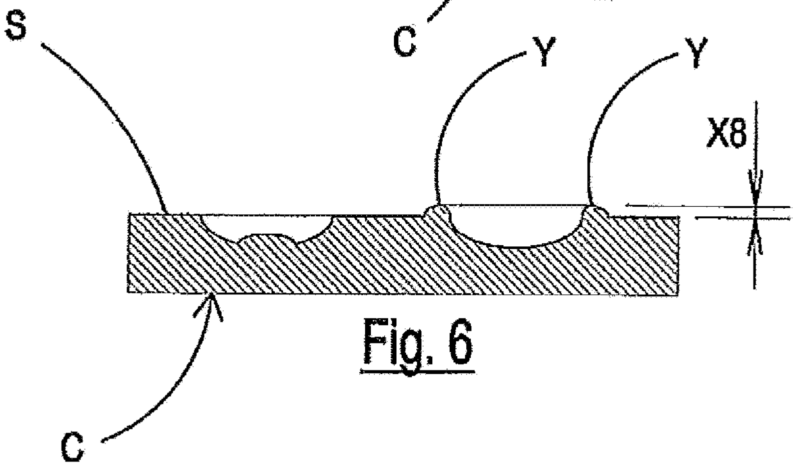
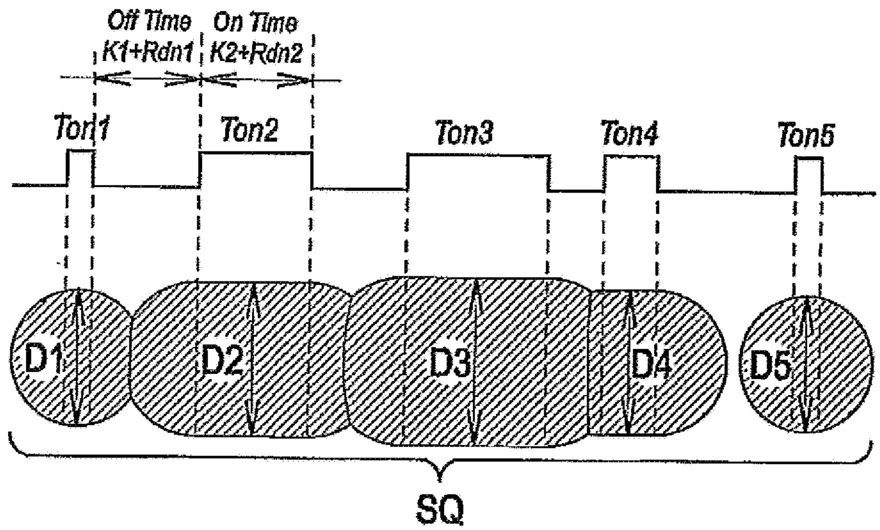


Fig. 6

Fig. 7



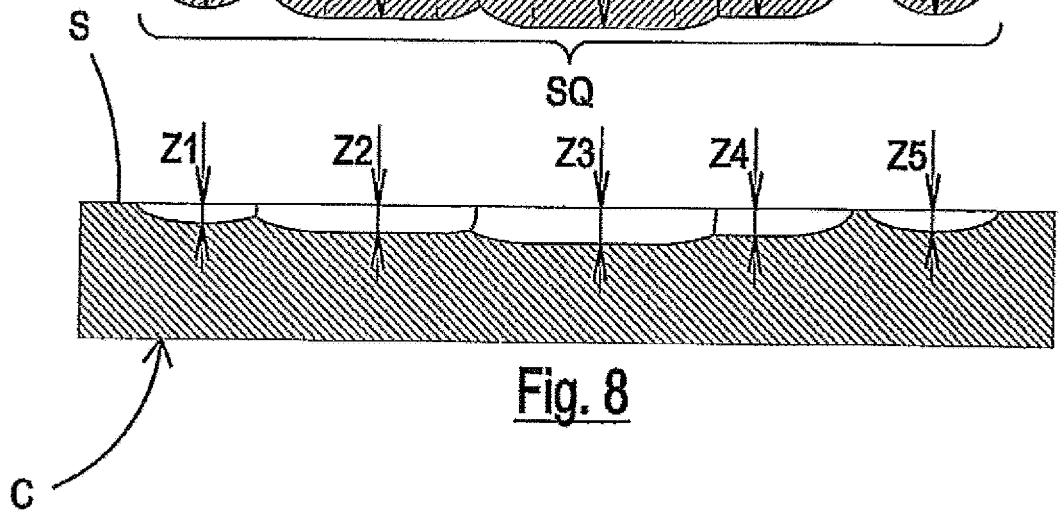


Fig. 8

K1 = constant part
Rnd1 = random part

K2 = constant part
Rnd2 = random part

Toff2 = K1 + Rnd1
Ton2 = K2 + Rnd2

D1 < D2
D2 < D3

D3 > D4
D4 > D5

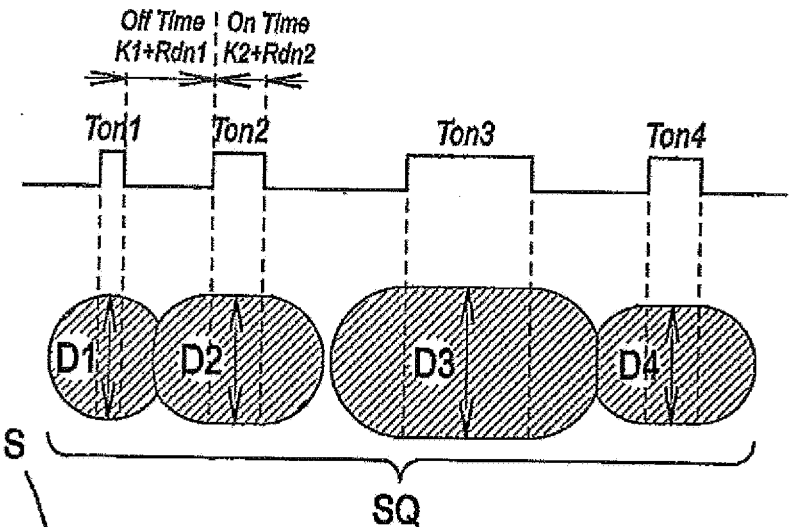
Z1 < Z2
Z5 < Z3

Ton1 < Ton2
Ton2 < Ton3

Ton3 > Ton4
Ton4 > Ton5

Fig. 9

Fig. 10



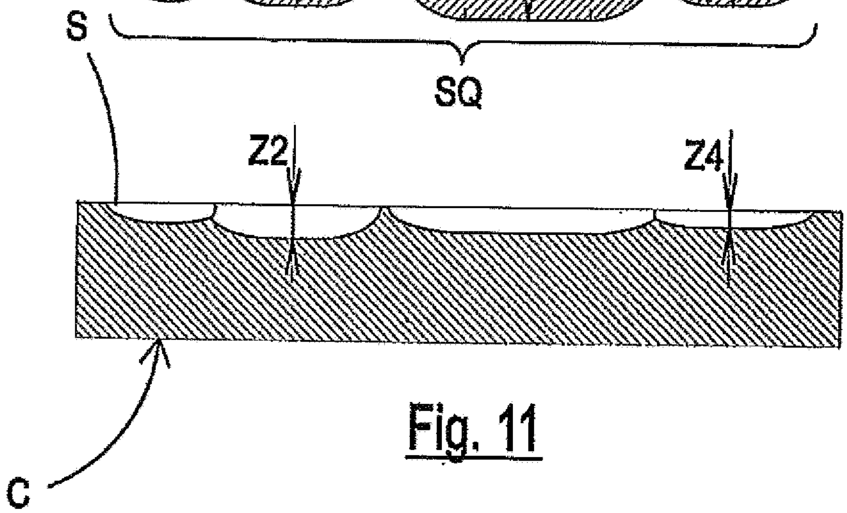


Fig. 11

PK1 = constant part
PRnd1 = random part

P1 = PK1+PRnd1

Z2 > Z4
D2 > D4

D1 < D2
D2 < D3
D3 > D4

P2 > P4
Ton2 = Ton4

Ton1 < Ton2
Ton2 < Ton3
Ton3 > Ton4

Fig. 12

LAMINATION CYLINDER

FIELD OF THE INVENTION

[0001] The present invention relates to a lamination cylinder.

[0002] In particular, the present invention relates to a lamination cylinder having certain surface characteristics suitable for allowing the same cylinder to be advantageously used in rolling mills, to which the following description refers specifically, at the same time maintaining its generic nature, for producing sheets, in particular metal sheets and similar products, with surface characteristics, including roughness, which are such as to make them suitable for use in applications such as molding, coating and varnishing.

BACKGROUND OF THE INVENTION

[0003] A process for the lamination of metals, generally includes passing a metallic sheet through a pair of rotating cylinders, the torque of which provides the sheet with a certain thickness and hardness and, in some cases, for example in the cold lamination of flat products for the construction of automobiles and household appliances, with a specific surface roughness, as the geometric surface characteristics are reproduced, in negative, on the treated sheet.

[0004] The above roughness parameter, and consequently the geometric surface characteristics of the lamination cylinders, is predetermined in relation to the final use of the sheet obtained by passage through the above-mentioned pair of cylinders, and is also defined as a random distribution of ridges and craters with internal dimensions within a certain range of values.

[0005] The above-mentioned cylinders used for lamination must generally be periodically rectified due to the deterioration to which they are subject during the production process and not always this rectification process is sufficient for providing the surface of the cylinder with all the necessary characteristics, at times requiring, for example in the above applications, an additional surface treatment which allows a certain roughness degree to be obtained and controlled.

[0006] The surface treatment of a lamination cylinder for obtaining the desired roughness is currently performed using various technologies, of which the most widely-used are blasting and electro-erosion, also known to experts in the field as EDT (Electro Discharge Texturing).

[0007] These treatment technologies provide for a good regulation of the average roughness, but are characterized by a dangerous process and a high environmental impact and consequently with considerable complexity in the management and disposal of the residues, in addition to the operating costs.

[0008] Blasting, for example, requires considerably sized plants which, for their functioning, use large turbines which are noisy and dangerous. This process, moreover, generates dust emitted from the abrasive sand of significant toxicity, which must be purified and filtered by a specific system. Finally, the nature of the blasting process requires considerable maintenance due to the abrasive that is used, which damages numerous components which cannot be adequately protected. In addition to the above, blasting does not provide for a good control of the roughness and consequently the cylinders treated with this process produce a laminated product which, with respect to roughness, has poor homogeneity.

[0009] The above-mentioned electro-erosion or EDT is a technology, which currently offers the best results from a qualitative point of view, due to the homogeneity of the roughness that is obtained and the total absence of traces from the processing.

[0010] This technology, however, is potentially dangerous due to the wide use of flammable products, such as a dielectric liquid, which requires the installation of a sophisticated irrigation system in order to reduce the consequence of fire. EDT also has an extremely significant environmental impact, as dielectric fluid is highly toxic and must be frequently disposed of using special procedures.

[0011] Another known technology, although rarely used, adopts a process called EBT (Electron Beam Texturing), in which the material is melted locally by a beam of electrons, forming a micro-crater and a ridge of molten material deposited on the walls of the crater.

[0012] A considerable drawback of this technology is the processing of the cylinder, which must be performed inside a vacuum chamber. This makes this technology extremely costly and not particularly suitable for metallic lamination processes.

[0013] There are analogous drawbacks with the ECD (Electrolytic Chrome Deposition) process, which uses a pulsed current for creating a rough surface, which, moreover, creates considerable problems from the standpoint of disposal.

[0014] Finally, another currently available method employs a laser beam suitable for defining a certain surface roughness of the lamination cylinder.

[0015] The use of a laser beam is overcomes the problems of the above described methods and has various advantages, in particular the optimum creation of craters on the surface of the lamination cylinder. Furthermore it has no drawbacks from the environmental standpoiny.

SUMMARY OF THE INVENTION

[0016] The object of the present invention is, therefore, to provide a lamination cylinder having a particular distribution of craters with a roughness defined and formed on the surface, preferably with the use of pulsed laser beams.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The structural and functional characteristics of the present invention and its advantages over the known art will appear even more evident from the following description, with reference to the enclosed drawings, which show schematizations of some preferred but non-limiting embodiments of the surface of a lamination cylinder, in which:

[0018] FIG. **1** illustrates the main single forms of reproducible craters on the surface of a lamination cylinder according to the invention;

[0019] FIG. **2** represents, in a plan view, a first preferred configuration of craters created on the surface of a lamination cylinder;

[0020] FIG. **3** represents, in a plan view, a second preferred configuration of craters created on the surface of a lamination cylinder according to the invention;

[0021] FIG. **4** represents, in a plan view, a third preferred configuration of craters created on the surface of a lamination cylinder according to the invention;

[0022] FIG. **5** illustrates, in a side sectional view, a portion of a lamination cylinder according to the invention, having the two forms of craters of FIG. **1**;

[0023] FIG. **6** illustrates, in a side sectional view, a further portion of a lamination cylinder according to the invention;

[0024] FIG. **7** represents, in a plan view, a fourth preferred configuration of craters created on the surface of a lamination cylinder according to the invention;

[0025] FIG. **8** illustrates, in a side sectional view, a portion of the surface of a lamination cylinder according to the invention, having the forms of craters of FIG. **7**;

[0026] FIG. **9** is a table of the values of some variables for obtaining the craters illustrated in FIGS. **7** and **8**;

[0027] FIG. **10** represents, in a plan view, a fifth preferred configuration of craters created on the surface of a lamination cylinder according to the invention;

[0028] FIG. **11** illustrates, in a side sectional view, a portion of the surface of a lamination cylinder according to the invention, having the forms of craters of FIG. **10**; and

[0029] FIG. **12** is a table of the values of some variables for obtaining the craters illustrated in FIGS. **10** and **11**.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0030] With reference to the enclosed figures, S indicates as a whole the peripheral surface of a lamination cylinder C on which circular craters K and oval craters Z are produced according to particular arrangements, also superimposed with respect to each other, as specified hereunder, thus reproducing a random distribution with no apparent patterns, but with a good consistency and with a wide range of roughness parameters.

[0031] Said craters K and Z are advantageously formed on the surface S preferably by means of pulsed laser-ray beams, varying the power and duration of the laser beam, in addition to the activation frequency.

[0032] The circular craters K have a diameter X**1**, whereas the oval craters Z have a diameter X**1** and a length X**2**.

[0033] According to the first preferred but non-limiting configuration illustrated in FIG. **2**, oval craters Z are created on the surface S of the cylinder in sequence according to a helical path. The arrangement is such that each oval crater Z is formed along the helix at a distance X**3** from an ovaloid and elongated crater Z' defined by the partial superimposition of two oval craters Z positioned at a distance X**4** from each other along the helix.

[0034] According to the second preferred but non-limiting configuration illustrated in FIG. **3**, a crater KZ defined by a circular crater K partially superimposed with respect to an oval crater Z and a further oval crater Z, are added to the arrangement of craters Z, Z' represented in FIG. **2**. The distance between the two arrangements is equal to a value X**5**, equal to the distance between two consecutive helixes.

[0035] According to the third preferred but non-limiting configuration illustrated in FIG. **4**, the circular craters K and oval craters Z are created on the surface S variably superimposed with respect to each other according to variable and random sequences, and with distances X**6** which are also variable and random determined by the distance of two consecutive helixes.

[0036] The depths X**7** of the craters and the thicknesses X**8** of the ridges Y thus formed (FIGS. **5** and **6**) can also be varied as desired, thus obtaining a desired roughness degree.

[0037] According to the fourth preferred but non-limiting configuration illustrated in FIGS. **7** and **8**, the circular craters K and the oval craters Z are substantially aligned along the helix, have transversal dimensions/diameters Di with a varied and random trend, for example increasing-decreasing-increasing as can be seen in FIG. **7**, and are created on the surface S variably superimposed with respect to each other according to a predefined sequence SQ, and with a depth having a varied and random trend, as can be seen in FIG. **8**.

[0038] In order to obtain the arrangement of craters of the fourth configuration of FIGS. **7** and **8**, the switching-on and switching-off time of the laser source is suitably modulated, generating a pulsed laser beam according to what is specifically indicated in the values of the table of FIG. **9**. This way, a first crater of the sequence SQ can and is obtained, for example, with a diameter D**1** obtained by a laser pulse having a shorter duration Ton**1** with respect to the laser pulse having the duration Ton**2**, which generates a second crater with a diameter D**2**, and this implies that the two subsequent craters have different depths Z**1**<Z**2** and different diameters D**1**<D**2**.

[0039] According to the fifth preferred but non-limiting configuration illustrated in FIGS. **10** and **11**, with the values of the table of FIG. **12**, the sequence SQ of craters is obtained by suitably modulating the emission power P of the pulsed laser according to a constant signal, to which a random signal is added. This provides for the formation of craters having different dimensions and depths.

[0040] In addition to what is described above, the present invention offers the advantage of managing the ratio between the surface, on which the craters described above are created, and the non-treated surface, as desired. This characteristic offers a further parameter available to the surface treatment process of the cylinder for improving the characteristics of the laminated product.

[0041] Finally, it should be pointed out that, as the sequence of craters on the surface of the cylinder is generated by means of a melting process in a controlled atmosphere, the hardness characteristics of the surface of the cylinder are generally improved with respect to the above described traditional processes, as the cooling of the material takes place in an atmosphere of a suitable gas at a controlled temperature. This enables the cylinder to tolerate longer lamination processes without consequences, without deteriorating the quality of the laminated product.

[0042] The protection scope of the invention is defined by the following claims.

The invention claimed is:

1. A lamination cylinder comprising:

a surface structure on which a plurality of craters is defined, said craters having different geometries and being distributed along a helical path,

wherein some of said plurality of craters are partially superimposed with respect to each other,

wherein some of said plurality of craters are at least partially surrounded by a ridge,

wherein said plurality of craters comprises circular craters and oval craters,

wherein said plurality of craters is obtained with a pulsed laser beam in constant power mode and by varying a duration of the pulsed laser beam within random time intervals, such to obtain said craters with different and random dimensions in terms of crater diameter, crater length along said helical path, crater depth, height of crater ridge, and distance between neighboring craters, and

wherein use of the laser causes an increased hardness of a surface of the lamination cylinder, thereby causing the lamination cylinder to tolerate longer lamination processes without loss of quality of a laminated product.

2. The lamination cylinder according to claim **1**, wherein said plurality of craters are rounded.

3. The lamination cylinder according to claim **1**, wherein said circular craters are partially superimposed over said oval craters.

4. The lamination cylinder according to claim **1**, wherein said oval craters are partially superimposed over each other.

5. The lamination cylinder according to claim **1**, wherein said circular craters are partially superimposed over said oval craters, and said oval craters are partially superimposed over each other, and wherein said circular craters and said oval craters are in turn partially superimposed in order to define a predetermined roughness.

6. The lamination cylinder according to claim **1**, further comprising smooth areas between at least some of said craters.

7. The lamination cylinder according to claim **1**, wherein said craters are distributed along a plurality of helical paths.

8. The lamination cylinder according to claim **7**, wherein said plurality of helical paths have varying distances therebetween.

9. A method of etching a lamination cylinder comprising:

providing the lamination cylinder; and

defining a plurality of craters on the lamination cylinder, the plurality of craters having different geometries and being distributed along one or more helical paths partially superimposed with respect to each other, some of the plurality of craters being at least partially surrounded by a ridge,

wherein the step of defining the plurality of craters comprises:

rotating the lamination cylinder around a longitudinal axis; and

etching the lamination cylinder with a laser beam along the one or more helical paths,

wherein the laser beam is pulsed in constant power mode at varying intervals of time and for varying durations within random time intervals, such to obtain said craters with different and random dimensions in terms of crater diameter, crater length along said one or more helical paths, crater depth, height of crater ridge, and distance between neighboring craters, thereby causing some of plurality of the craters to be partially superimposed with respect to each other, and

wherein use of the laser beam causes an increased hardness of a surface of the lamination cylinder, thereby causing the lamination cylinder to tolerate longer lamination processes without loss of quality of a laminated product.

10. The method according to claim **8**, wherein the laser beam is pulsed to cause some of the plurality of craters to have a circular perimeter and some of the plurality of craters to have an elongated perimeter.

11. The method according to claim **9**, wherein there is a single helical path.

12. The method according to claim **9**, wherein there is a plurality of helical paths.

13. A method of etching a lamination cylinder comprising:

providing the lamination cylinder; and

defining a plurality of craters on the lamination cylinder, the plurality of craters having different geometries being partially superimposed with respect to each other along a helical path, some of said plurality of craters being at least partially surrounded by a ridge,

wherein the step of defining the plurality of craters comprises:

rotating the lamination cylinder around a longitudinal axis; and

etching the lamination cylinder with a laser beam along one or more helical patterns,

wherein the laser beam is pulsed at varying intervals of time in constant power mode and for varying durations within random time intervals, thereby causing the craters to achieve random dimensions in terms of crater diameter, crater length along said one or more helical patterns, crater depth, height of crater ridge, and distance between neighboring craters and further causing some of the plurality of craters to be partially superimposed with respect to each other, and

wherein emission power of the laser beam is modulated according to a constant signal, to which a random signal is added, thus allowing dimensions and depths of the craters to be varied.

* * * * *