Abstract: The object of the present invention is a laser cutting equipment, comprising a table (1) along which a band of sheet-metal (2) unwound from a coil moves continuously, a gate assembly (3) equipped with a laser head (4), and a control system (5), wherein the gate assembly (3) is slidable moved over the table (1) surface in two perpendicular table (1) plane axes, and the table (1) comprises a plurality of supporting rolls (6), deployed perpendicular to the sheet-metal (2) transport direction at preset distances, not larger than the diameter of a single support roll (6), wherein the supporting rolls (6) are bearing mounted in such a way that they can freely rotate around their own axes, and there is a follow-up table (7) equipped with a slot (8) to evacuate material subject to laser machining in the table (1) between the supporting rolls (6), while the movement of the follow-up table (7) along the axis of the sheet-metal (2) movement is coordinated with the gate assembly (3) movement, characterized in that the supporting rolls (6) are seated in the table guide (9) and are slidably moved in it along the axis of the sheet-metal (2) transport direction, wherein the supporting rolls (6) are connected with one another by means of flexible connectors (10). The object of the invention is also a method of laser cutting.

Title: LASER CUTTING EQUIPMENT AND LASER CUTTING METHOD
Laser cutting equipment and laser cutting method

The object of the invention is a laser equipment and a laser cutting method intended primarily for cutting sheet-metal continuously unwound from coils.

Laser cutting equipment is becoming more and more popular, also due to the continuous development of laser light sources that manifests itself mainly in the laser power increase, which allows for machining a broader spectrum of materials. Cutting with a laser beam has many advantages, the most significant ones being high accuracy (depending on the diameter of the laser beam spot, even single microns are possible), high-speed, possibility to cut out complex shapes, limited heat impact zone, or a small material loss. A particular application of laser cutting is laser cutting of sheet-metal which enables performance of precise flat metal elements, even from sheet-metal unwound continuously from a coil.

From international patent application No. WO2012034923, a method of laser cutting out of prescribed elements and an equipment carrying out the method is known, the equipment consists of a table and a gate with a laser head moving about it slidably. The design of the gate allows moving the laser head in two axes, and a big performance of laser cutting of any two dimensional shape limited by the gate movement range. The working element that is subject to cutting, for example a sheet of thin metal, is placed on the table on a transparent surface with protrusions extending from it so that the sheet-metal is supported only by a single point of each protrusion. Such table surface structure enables evacuation of material ejected on the opposite side of the laser beam impact in order
to protect the other side of the cut sheet-metal from damage. However, such structure does not allow for cutting sheet-metal delivered in a continuous way without stopping and the transparent surface becomes dirty by the ejected melted cut material, which requires performance of a complicated and time-consuming cleaning stage afterwards.

Document DE 102004034256, in turn, discloses a system for laser cutting of thin materials. The system comprises, in particular, to belt feeders situated in such a way that between the end of the first belt feeder and the end of the second belt feeder there is a gap allowing to evacuate the material released during laser cutting. The belt feeders are designed in such a way that the said gap can move along the direction of transport of the material band subject to machining and the movement is coordinated with the movement of the gate with a laser had mounted on it in such a way that the gap is always under the laser beam from the head. The gate with the laser head provides movement into perpendicular directions, enabling cutting any two-dimensional shapes from the metal sheet band transported along the table. Laser cutting is, in this arrangement, Limited to the size of the gate and the laser head unit, brass the construction of the belt conveyors imposes their length greater than the length of the gate and the laser head unit. Furthermore, controlling the movement of the gap between the conveyors is obstructed because it requires coupling a larger number of components and taking into account a larger number of factors. Moreover, belt conveyors as such are not suitable for some applications in sheet-metal unwound from coil, in particular in case of subjecting the sheet-metal to thermal treatment in previous stages, which is connected with the necessity to cool down the sheet-metal before placing it on such belt conveyor, extending the production process and inducing its negative economic effect.
International patent application No. WO2010085486 discloses a system for laser cutting intended for cutting from bands of thin sheet-metal. The system comprises two conveyor assemblies consisting of a number of the arranged conveyor belts, situated along the transfer direction of the material subject to laser cutting in such a way that between the first conveyor assembly and the second conveyor assembly there is a gap. The gap present between the conveyor assemblies is to provide free space for evacuating the material subject to laser cutting, e.g. melted metal. The laser cutting system comprises also a bridge crane system with a gate comprising a laser head which enables movement in two perpendicular axes, each conveyor assembly comprises a number of transporting bells, wherein each of them can independently change its shift along the sheet-metal transport direction and the movement, as well as the movement of bridge crane assembly, is controlled by means of an appropriate controller. This system, due to the application of independent conveyor belts, enables adjusting the shape of the gap between the conveyor assemblies to the requirements of cutting, i.e. it is possible to perform, among others, arced or oblique cuts in the sheet-metal. Like in the previous case, the conveyor assemblies must be much longer than that bridge crane assembly in order to cover the whole bridge crane area, and independent control of conveyor belts requires using of complex solutions, based on separate, often computer-based, control systems. Besides, conveyor belts can get damaged during transporting hot sheet-metal leaving from previous annealing stages.

The technical challenge faced by the present invention WO2010085486 presented such an equipment and a method of laser cutting, and allowing for cutting sheet-metal, in particular sheet-metal unwound from a coil, preferably hot sheet-metal unwound from a coil, coming from the previous thermal treatment process, wherein the equipment and the
corresponding method should provide proper evacuation of material during laser cutting without causing damage to the table, they should allow to perform laser cutting on the whole working area of the table, wherein the solution should be simple in implementation, free from complex control systems, and must not cause damage to the transported sheet-metal. Unexpectedly, the said technical problems have been solved by the present invention.

The first object of the present invention is a laser cutting equipment, comprising a table along which a band of sheet-metal unwound from a coil moves continuously, a gate assembly equipped with a laser head, and a control system, wherein the gate assembly is slidably moved over the table surface in two perpendicular table plane axes, wherein the table comprises a plurality of supporting rolls, deployed perpendicular to the sheet-metal transport direction at preset distances, not larger than the diameter of a single support roll, wherein the supporting rolls are bearing mounted in such a way that they can freely rotate around their own axes, and there is a follow-up table equipped with a slot to evacuate material subject to laser machining in the table between the supporting rolls, and the movement of the follow-up table along the axis of the sheet-metal movement is coordinated with the gate assembly movement, characterized in that the supporting rolls are seated in the table guide and are slidably moved along the axis of the sheet-metal transport direction, wherein the supporting rolls are connected with one another by means of flexible connectors. In a preferred embodiment of the present invention, the supporting rolls have a drive, preferably electric, controlled from the control system in order to give them rotational speed, corresponding to the linear speed of the sheet-metal band movement. In another preferred embodiment of the invention, the flexible connectors are selected from a group comprising: pull tabs, chains, ropes, threads. In
another preferred embodiment of the invention, the supporting rolls are made of material resistance to high temperatures, preferably of steel. In an even more preferable embodiment of the present invention, the slot in the follow-up table has a variable width.

The second object of the present invention is a method of laser cutting of sheet-metal unwound from a coil, comprising the following steps:

a) a band of sheet-metal is placed on the table,

b) the sheet-metal band is moved continuously on the surface of the table, being a plurality supporting rolls, situated perpendicular to the sheet-metal transport direction in preset distances not greater than the diameter of a single supporting roll,

c) a gate assembly equipped with a laser head is moved over the surface of the table,

d) the follow-up table, disposed between the rolls, equipped with a slot to evacuate material subject to laser treatment is moved,

de) the required pattern, preset by the control system, is cut with a laser beam emitted from the laser head,

wherein steps b), c), d), and e) are carried out at the same time, and the movement of the follow-up table along the axis of the sheet-metal movement direction is integrated with the movement of the gate assembly, characterized in that the supporting rolls are seated in the table guide (9) enabling slidable movement of the supporting rolls along the axis of sheet-metal transport direction and the supporting rolls are connected with one another by flexible connectors so that the gate assembly can move over the whole table surface, providing concurrent evacuation of material subjected to laser cutting.
through the slot in the follow-up table. In a preferred embodiment of the present invention, the supporting rolls have a drive, preferably electric, controlled from the control system in order to give them rotational speed, corresponding to the linear speed of the sheet-metal band movement. In another preferred embodiment of the invention, the flexible connectors are selected from a group comprising: pull tabs, chains, ropes, threads. In an even more preferable embodiment of the present invention, the slot in the following table has a variable width.

The application of follow up rolls with the movement integrated with the movement of the gate assembly with the laser head in the present invention allows to move into directions XI and X2, thus it is possible to cut material unwound from a coil without the necessity to change the unwinding speed or to stop the material for the time of cutting. Furthermore, due to mounting the supporting rolls in bearings, they can be freely rotated by that material being cut, thanks to which they do not damage the material surface.

Application of supporting rolls rotation drive, in turn, in order to give them rotation speed corresponding to the linear speed of sheet-metal movement significantly reduces friction and is required with materials with thin coating and prone to wear and abrasion. Combination of the follow-up table movement with the movement of the gate with the laser head provides fixed position of the cutting beam in the slot, between the table supporting rolls, thanks to which the table does not get damaged by the laser beam during cutting. This, in turn, excludes the need to replace the elements of the table supporting the material, in comparison with traditional tables used in laser cutting equipment. The design of the laser cutting equipment according to the present invention provides a single element table module, wherein the gate movement is provided over the whole table surface. This increases the
versatility of the equipment, in particular is a component of a line processing sheet-metal unwound from a coil.

Exemplary embodiments of the present invention have been presented in the drawing, where fig. 1 presents an isometric view of the laser cutting equipment, fig. 2 presents an isometric view of the laser cutting equipment of fig. 1 with a magnified view of the laser head assembly situated over the slot, fig. 3 illustrates the longitudinal cross-section of the equipment of fig. 2 in a lateral view, with a magnified view of the laser head assembly situated over the slot, fig. 4 represents the front view of the laser cutting device with the magnified view of the guide assembly, and fig. 5 presents a top the laser cutting equipment.

Example

The laser cutting equipment according to the present invention has been illustrated in the figures 1-5. In particular, the equipment consists of a table 1, a gate assembly 3, and a control system 5. The table 1 comprises a frame comprising guides 9 on external lateral surfaces of longitudinal structural elements. The said guides 9 are adopted to receive cylindrical supporting rolls 6 that make the working area of the table 1, on which sheet-metal band 2 unwound from a coil is continuously moved. A plurality of cylindrical supporting rolls 6 are arranged perpendicular to the sheet-metal transport direction 2, with the preset distance between the neighboring supporting rolls 6, being 1/4 the diameter the supporting roll 6. Each supporting troll 6 has a bearing which provides it with a free movement around its own axis, due to which the sheet-metal 2 moving in on the table 1 does not get damaged due to friction against the table 1 surface. Furthermore, the supporting rolls number six have an independent electric drive controlled by means of the control system 5, which enables putting them into rotational movement.
of a speed corresponding to the linear speed of the sheet-metal band 2 moving it on the table 1. Additionally, the supporting rolls 6 are made of material resistance to high-temperature, i.e. steel, thus the sheet-metal band 2, leaving the preceding thermal treatment step, does not need additional cooling steps or stopping in order to lower the temperature. A plurality of supporting rolls number six are connected with one another by means of the pull tab 10, thus they are movement is coordinated with retaining full flexibility. Flexible pull tabs 10 join to neighboring supporting rolls 6 in such a way that they keep constant relative position in the force the slidable movement of each next supporting role 6. Between the supporting rolls 6, substantially central supporting rolls 6 appearing in a series, a follow-up table 7 having a variable slot 8 is situated. The follow-up table 7 is connected with a series of supporting rolls 6 by means of flexible pull tabs 10 so that it moves together with the supporting rolls 6, keeping constant position between the supporting rolls 6.

Over the table 1 the gate assembly 3 is situated, equipped with a laser head 4, in such a way that it moves slidably along the whole length of the table 1. The laser head 4 is mounted on a carriage which provides independent movement of laser head 4 along the width of the table 1, perpendicular to the movement of the gate, cup therefore, the laser head 4 can move along to perpendicular axes or the whole surface of the table 1. The movement of the gate assembly 3 in the transport direction of sheet-metal 2 is coordinated with the movement of the follow-up table 7 in such a way that the slot 8 in the follow-up table 7 is always situated under the laser nozzle 11 of the laser head 4, thus enabling evacuation of the Material, i.e. melted metal, outside the table 1 surface area, providing keeping it clean and undamaged.
In the presented embodiment of the invention, the application of the follow-up table 7, with the movement integrated with the movement of the gate assembly 3 with the laser head 4 enabled movements in two directions, X1 and X2 (additionally to the perpendicular direction y), thanks to which it was possible to cut material 2 unwound from a coil without the necessity to change the unwinding speed or stopping the material 2 for the time of cutting. Furthermore, due to mounting the supporting rolls 6 in bearings, they could be freely rotated by the cut material 2, thanks to which they do not damage the material 2 surface. The application of supporting rolls 6 rotation drive, in turn, in order to give them rotation speed corresponding to the linear speed of sheet-metal 2 movement significantly reduced friction and was particularly favorable in case of materials with thin coating, prone to wear and abrasion. Combination of the follow-up table 7 movement with the movement of the gate assembly 3 with the laser head 4 provided fixed position of the cutting beam in the slot 8, between the supporting rolls 6 of the table 1, thanks to which the table 1 did not get damaged by the laser beam during cutting. That, in turn, excluded the need to replace the elements of the table 1 supporting the material 2, in comparison with traditional tables used in laser cutting equipment. The design of the laser cutting equipment according to the present invention allowed to provide a single element table 1 module, wherein the gate 3 movement is provided over the whole table 1 surface. This allowed to increase the versatility of the equipment, in particular as a component of a line processing sheet-metal unwound from a coil.
Claims

1. Laser cutting equipment, comprising a table (1) along which a band of sheet-metal (2) unwound from a coil moves continuously, a gate assembly (3) equipped with a laser head (4), and a control system (5), wherein the gate assembly (3) is slidably moved over the table (1) surface in two perpendicular table (1) plane axes, and the table (1) comprises a plurality of supporting rolls (6), deployed perpendicular to the sheet-metal (2) transport direction at preset distances, not larger than the diameter of a single support roll (6), wherein the supporting rolls (6) are bearing mounted in such a way that they can freely rotate around their own axes, and there is a follow-up table (7) equipped with a slot (8) to evacuate material subject to laser machining in the table (1) between the supporting rolls (6), while the movement of the follow-up table (7) along the axis of the sheet-metal (2) movement is coordinated with the gate assembly (3) movement, characterized in that the supporting rolls (6) are seated in the table guide (9) and are slidably moved in it along the axis of the sheet-metal (2) transport direction, wherein the supporting rolls (6) are connected with one another by means of flexible connectors (10).

2. The equipment according to claim 1, characterized in that the supporting rolls (6) have a drive, preferably electric, controlled from the control system (5) in order to give them rotational speed, corresponding to the linear speed of the sheet-metal band (2) movement.

3. The equipment according to claim 1 or 2, characterized in that the flexible connectors are selected from a group comprising: pull tabs, chains, ropes, threads.
4. The equipment according to any of claims 1 to 3, characterized in that the supporting rolls (6) are made of material resistant to high temperatures, preferably of steel.

5. The equipment according to any of claims from 1 to 4, characterized in that the slot (8) in the follow-up table (7) has a variable width.

6. A method of laser cutting of sheet-metal unwound from a coil, comprising the following steps:

   a) a band of sheet-metal (2) is placed on the table (1),

   b) the sheet-metal band (2) is moved continuously on the surface of the table (1), being a plurality supporting bearing-mounted rolls (6), situated perpendicular to the sheet-metal (2) transport direction in preset distances, not greater than the diameter of a single supporting roll (6),

   c) a gate assembly (3) equipped with a laser head is moved over the surface of the table (1),

   d) a follow-up table (7), disposed between the rolls (6), and equipped with a slot (8) to evacuate material subject to laser treatment is moved,

   e) the required pattern, preset by the control system (5), is cut with a laser beam emitted from the laser head (5), wherein steps b), c), d), and e) are carried out at the same time, and the movement of the follow-up table (7) along the axis of the sheet-metal (2) movement direction is integrated with the movement of the gate assembly (3), characterized in that the supporting rolls (6) are seated in the table guide (9) enabling slidable movement of the supporting rolls (6) along the axis of sheet-metal (2) transport direction and the supporting rolls (6) are connected with one another by flexible connectors (10) so that the gate assembly (3) can
move over the whole table (1) surface, providing concurrent evacuation of material subjected to laser cutting through the slot (8) in the follow-up table (7).

7. Method according to claim 6, characterized in that the supporting rolls (6) have a drive, preferably electric, controlled from the control system (5) in order to give them rotational speed, corresponding to the linear speed of the sheet-metal band (2) movement.

8. Method according to claim 6 or 7, characterized in that the flexible connectors are selected from a group comprising: pull tabs, chains, ropes, threads.

9. Method according to any of claims from 6 to 8, characterized in that the slot (8) in the follow-up table (7) has a variable width.
INTERNATIONAL SEARCH REPORT

PCT/IB2016/053053

A. CLASSIFICATION OF SUBJECT MATTER

INV. B23K26/08  B23K26/38  B23K37/02  B65G13/07  B23K26/16

ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B23K  B23K26/08  B23K26/38  B23K37/02  B65G13/07  B23K26/16

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

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE 10 2004 034256 AI (SCHULER AUTOMATION GMBH &amp; CO [DE]) 16 February 2006 (2006-02-16) paragraphs [0033], [0035] ; figure 5</td>
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Date of the actual completion of the international search Date of mailing of the international search report
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