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(54) Cold bending machine, operating by controlled drawing of elongated profiles

(57) Computer assisted machine for the cold bending operations, by controlled drawing on the three spatial dimensions, of metallic or composite profiles, in elongated forms, such as the profiles used in the automobile industry. The machine is characterised by the fact that all driving movements, necessary to bend the profile into the desired geometric configuration, are performed by the machine itself, while the tools are made up of only the parts that come in contact with the profile being shaped, during the bending operation. Additionally, the machine is capable of controlling the bending of the materials in a single production lot, or in different lots with varying mechanical characteristics, but otherwise subjected to acceptance specifications, in order to obtain, in all instances, components that respect specified tolerances.

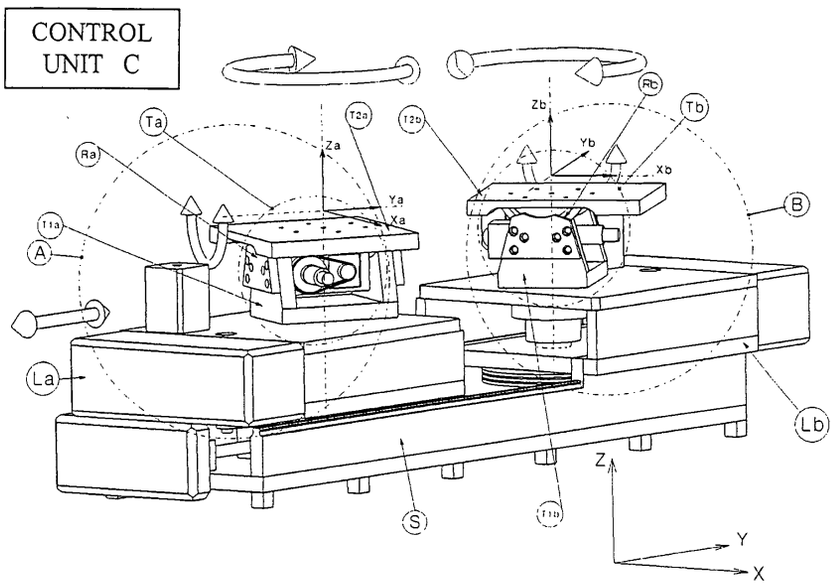

FIG. 1

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Description

Presentation:

[0001] this invention concerns a machine for the cold bending operation, employing controlled drawing on the three spatial dimensions, of elongated metallic or composite profiles, such as the profiles used in the automobile industry.

The prior art.

[0002] Machine tools for the movement of bending equipments for elongated profiles are well known, such as the one described in WO9319864. These machines operate exclusively on two dimensions and can therefore execute bending operations on one geometric plane only. For products having geometry outside the plane, it is necessary to mount specific fixtures on the machine, to enable the tools to make the necessary driving movements. Each of these products, therefore, requires the construction of special complex fixtures, each of them can be used for no more than one product. In these fixtures, individual movements are not made independently of each other, because the prior art does not provide for an independent or autonomous motor drive for each degree of freedom of the machine.

Objectives:

[0003] One objective of the present invention is obtaining a machine that performs cold bending operations through the controlled drawing of elongated profiles on three dimensions, wherein the tooling fixtures to be used for each product are reduced in complexity, by transferring the driving movements to the machine once and for all, so allowing said driving movements to be used for products with various configurations, leaving to the tooling fixtures the unique function of gripping and holding the product to be worked.

[0004] A second objective of the present invention is complete managing bending operations of materials in the same lot of production, or in different lots, having mechanical characteristics that respond to acceptance specifications, but which are otherwise different from each other, and therefore they are characterised by different springback values.

[0005] A third objective of the present invention is implementing a new equipment that acts mainly on numerical values of parameters defining driving movements, instead on the physical parts of the machine.

[0006] A final objective of the present invention is limiting the machine resetting and zero adjusting operations, prior to lot production, only to positioning of the gripping and holding fixtures on the machine.

Detailed description of the invention:

[0007] the afore mentioned objectives are reached by a machine for bending of metallic or metallo-plastic profiles, which operates on three dimensions, by using, in the preferred embodiment, five degrees of freedom, each of them is independent from the other four and it corresponds to only one of the five allowed driving movements. Each of these five movements has an independent, or autonomous, motor drive.

[0008] The machine is equipped with sensors that detect the forces in action and the relevant torques.

[0009] The working cycle of the machine is defined by five diagrams, each describing one of the five degrees of freedom versus the elapsed time. Each one of the five diagrams is determined by the geometry of the product that has to be obtained. The values of each of the five quantities are computer controlled by a specific software program.

[0010] This program is capable of adjusting the values of the five measured quantities to the different mechanical characteristics of the profiles. In fact, it frequently happens that, within a single production lot, there are profiles made up with different materials, but, otherwise, they respond to the acceptance specifications, and that, moreover, these profiles must be made to conform to the required tolerances of the finished product. In particular, it is important, in this type of production, to take into account the springback effect of the material. The above-mentioned computer program makes the machine instantly adjust to need, so that profiles having different mechanical characteristics are made in order to respect specified tolerances. The adjustment of the machine action is made by measurement of the torque and force values, carried out by the above-mentioned sensors.

Description of the figures.

[0011] Figure 1 is a view of the entire machine and control panel. The five arrows show the five degrees of freedom of the machine.

[0012] Figure 2 illustrates the machine in a different position, indicating the sensors detecting forces and torques, and a transmission drive.

[0013] As it can be seen in figures 1 and 2, the machine is made up of two mechanical units, A and B, mounted on a supporting bench S and of a control unit C. Units A and B perform driving movements effecting the three-dimensional bending, accordingly by operating on the variation of the five degrees of freedom.

[0014] With reference to fig. 1, XYZ is a reference system of fixed orthogonal cartesian coordinates, where Y is parallel to the horizontal longitudinal axis of the bench and Z is a vertical axis.

[0015] Each of the units A and B is made up of a box (L), which contains the transmission drives for rotation around the vertical axis. A small turret (T) is mounted

on this box. The turret is made up of two parts, T_1 and T_2, which are connected through a hinge movement R , resting on a cradle. This cradle is operated by a ball bearing screw that ,in turn, is driven by motorized belt.

[0016] Let us call $X_AY_AZ_A$ an orthogonal cartesian reference system, with Z_A being vertical, Y_A coinciding with the axis of rotation of the hinge R_A, originating at the intersection of the rotating axis of the hinge with the axis of vertical rotation. By the relevant definition $X_BY_BZ_B$ for unit B, the degrees of freedom are thus specified hereinafter. The following degrees of freedom are allowed to unit A:

- a translation along Y, defined by the parameter y_A;
- a rotation around Z_A, defined by the angle α_A;
- an oscillation around Y_A, defined by the angle β_A.
- The following movements are allowed to unit B:

- a rotation around Z_B, defined by the angle α_B;
- an oscillation around YB, defined by the angle β_B;

[0017] A characteristic feature of this invention is in that the values of the five parameters y_A, α_A, β_A, α_B, β_B, at the beginning of the working cycle, may be assigned arbitrarily, albeit they must be chosen inside the respective range of variation. At the beginning of the working cycle, this allows:

- the orientation of the axes of rotation of the hinges (through the rotation around the vertical axes Z_A and Z_B);
- the inclination of the tool holding tables (by rotation around the axes of hinges Y_A and Y_B);
- the setting of the distance between axes Z_A e Z_B;

according to the bending requirements of each specific profile .

[0018] The prior art provides the possibility of performing translation and rotation movements only on the horizontal plane. For products that present a development on the third dimension, the prior art requires specific equipments and driving movements specifically designed for each of such products. This special equipments cannot, therefore, be re-configured or reset for each of different products. With the present invention and due to introduction of the five independent degrees of freedom, products with different geometric configurations can be produced by the same machine, by mounting on the machine the relevant tooling equipments, that are made up of only the parts that have to come in direct contact with the profile to be bent(that is pliers, profile gripping and holding devices), while the bending movements are performed by the machine with an appropriate choice of the five bending parameters, or degrees of freedom, as described here above.

[0019] Once the initial configuration has been established, as described above, and the total time T has been set for the bending cycle, in correspondence to n values of the angle of rotation α_B around Z_B, each value is assumed by the platform B at the instant t; (i=1-n), the values of the other four variables are assigned (y_A, α_A, β_A, β_B) Thus, a univocal dependence on time of the five parameters that numerically describe the five degrees of freedom is established. In this way, a matrix of 5 x n numerical elements is built: this matrix is the basis for the electronic management of the machine.

[0020] The machine is equipped with force and torque sensors (nf1, nf2, ...nf5), which instantly communicate the values to the central unit.

[0021] The central unit completely manages the machine through a specific software program. Once the above data has been inserted for each value of the finite parameter t_i, as described, the control unit carries out the driving movements, corresponding to the 5 x n input values . The set of values is subject to modification according to the characteristics of the material being worked and to the data supplied by the sensors: thus, it is possible to compensate for different material springback, depending on the mechanical characteristics of the profile to be bent.

[0022] The movements are carried out as follows:

the translation along Y of the platform A is obtained by a ball bearing screw, driven by a motorized belt;
the rotation of A and B around the axes of rotation zA e zB is obtained by employing a toothed-belt drive, driven by an electric motor;
the oscillations of A and B around the axes of rotation yA e yB are obtained by employing a cradle to increase the lever arm of the force supplied by the ball bearing screw, driven by a toothed-belt and electric motor.

[0023] In the machine of the present invention the tooling stage deals with applying the tool fixtures on the tool tables only, while the resetting, or zero adjusting stage, is carried out solely by the machine by its processing software.

[0024] Additionally, the need for machine retooling is satisfied just only by varying the numerical values of the bending degrees of freedom, by the processing software, avoiding any direct mechanical intervention on the machine.

[0025] The objectives of the present invention may be reached by a choice of a different number of bending degrees of freedom, for the machine.

Claims

1. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, **characterised by** the fact that each of the driving movements necessary to obtain the profile in the desired geometric configuration is performed by the machine itself, while said tools are

made up solely of the parts that come into contact with the profile being processed, said tools are not given autonomous movement capability , said tools having the sole function of gripping and holding the profile during the processing cycle.

2. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the first claim, **characterised by** the fact that the driving movements necessary to obtain the profile are performed according to at least five degrees of freedom, each of which is independent from the remaining other degrees.

3. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions , according to the preceding claims, **characterized by** the fact that is possible to assign any initial configuration of at least five degrees of freedom, each within its own range of variation.

4. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterized by** the fact that, by the choice of the initial values of set of the degrees of freedom, it is possible to start the working cycle from any initial position.

5. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions , according to the preceding claims, **characterised by** the fact that the machine is computer managed on the basis of a set of values, for each individual degree of freedom, in *n* preset instants, pertaining to the time of the processing cycle.

6. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterised by** the fact that the machine is computer managed on the basis of a matrix of at least 5 x *n* numerical elements.

7. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterised by** the fact that the machine possesses sensors for the detecting forces and torques involved, in order to fit instantly the values of the degrees of freedom assumed during the processing time to the material of the specific working product, so as to compensate for the different values of the material springback.

8. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterised by** the fact that the machine is managed by a computerized system, whose software is based on a matrix of at least 5 x *n* numerical elements, whose values are instantly modified according to the values of forces and torques detected by the sensors during the processing cycle.

9. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to any one of the preceding claims, **characterised by** the fact that the longitudinal translation of the mobile platform is performed by a ball bearing screw, driven by a chain that, in turn, is powered by an electric motor; the rotations around the vertical axes of the turrets are performed by a toothed-belt and chain drive, powered by an electric motor; the oscillations of the tool-bearing tables around the oscillating axes are performed by using a circular sector cradle, in order to increase the force lever arm supplied by the ball bearing screw, driven by a toothed-belt powered by an electric motor.

10. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterised by** the fact that the tooling stage of the machine consists only of fixing the tools to the tooling tables, while the stage of resetting and zero adjusting is carried out exclusively by the machine, through its software program.

11. Machine for driving cold bending tools, by controlled drawing of elongated profiles in the three spatial dimensions, according to the preceding claims, **characterised by** the fact that during the stage of retooling for bending, it is possible to vary the numerical values of at least five degrees of freedom, by using the software program, without having to intervene on the physical organs of the machine.

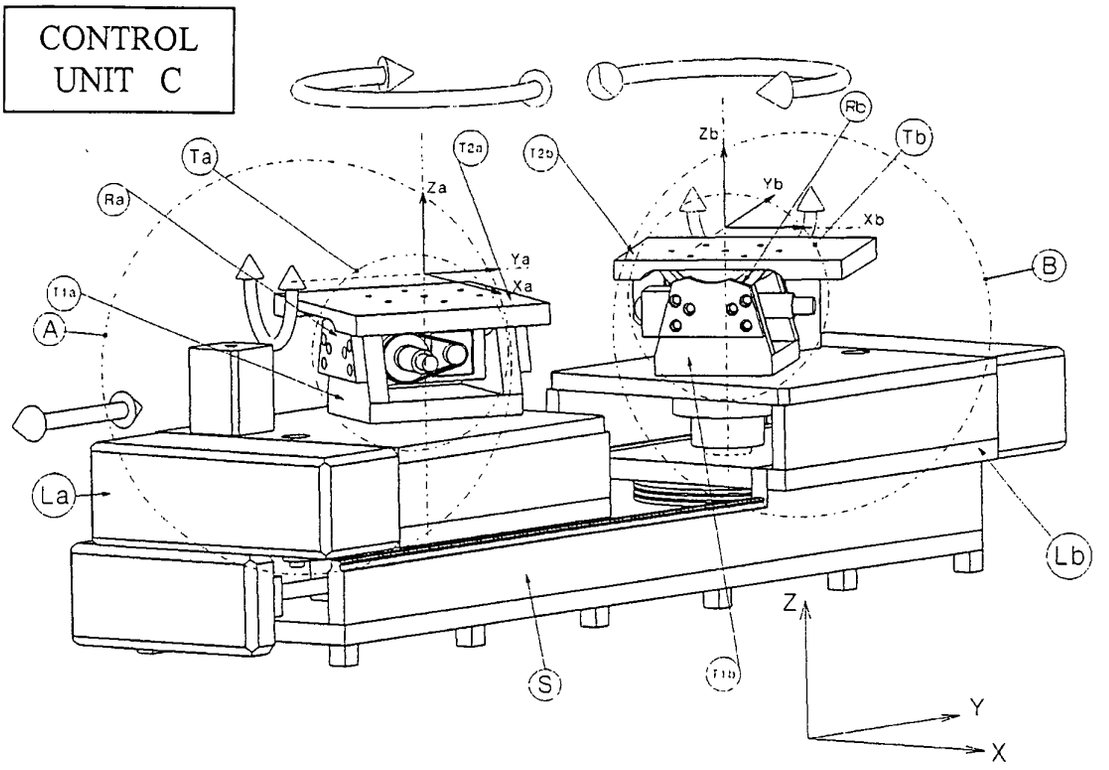
CONTROL UNIT C
Ta
T2a
T2b
Rb
Tb
Zb
Yb
Xb
Za
Ra
Ya
Xa
T1a
A
B
La
Lb
S
T1b
Z
Y
X

FIG. 1

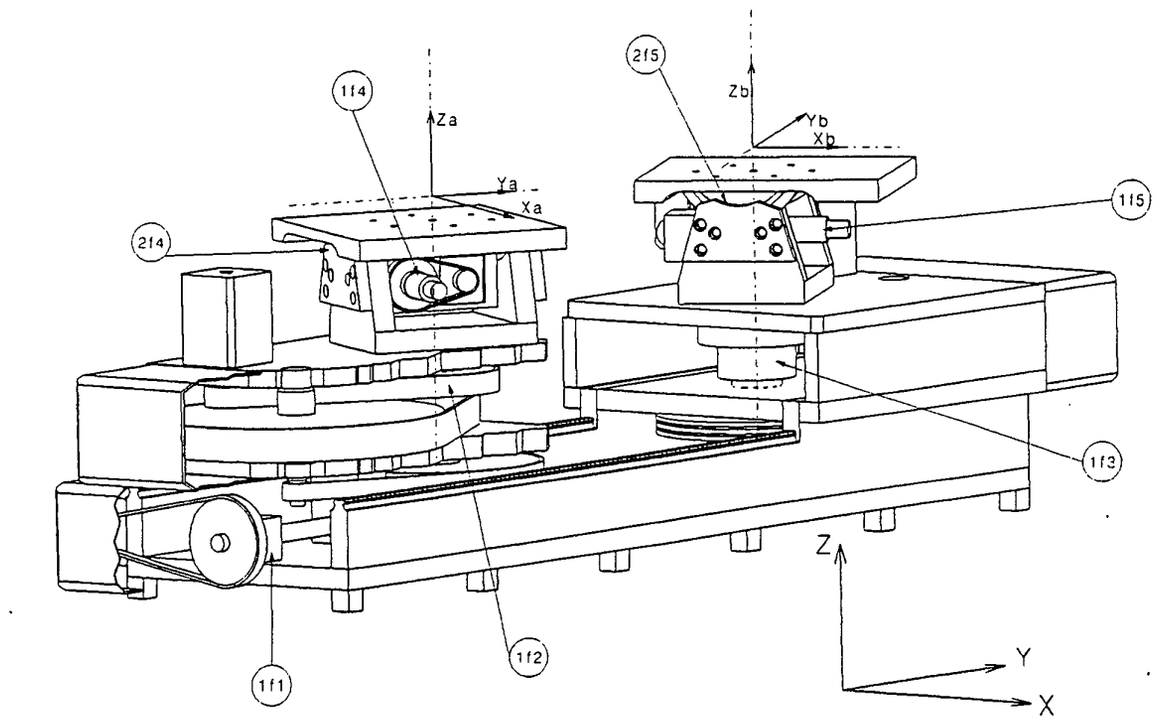
2f5
Zb
Yb
Xb
1f4
Za
Ya
Xa
1f5
2f4
1f3
1f2
1f1
Z
Y
X

FIG. 2