Title: METHOD AND APPARATUS FOR DETERMINING THE THICKNESS OR THE SPRINGBACK OF A WORK-PIECE BENT BY A PRESS BRAKE

Abstract: The invention relates to a method and apparatus for determining the thickness of a workpiece or its springback in a press brake. The method includes the steps of detecting the deformation or strain in the punch (1) and/or the die (4) during bending, and translating it into an electric signal, by means of suitable devices located directly on the working parts; possibly amplifying the electric signal by means of an amplifier (5) and transmitting said signal to a press brake controller (6), which processes the collected data and corrects the angle of the workpiece being bent. The process allows to determine the springback of the bent sheet, thereby increasing processing accuracy.
Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
TITLE: METHOD AND APPARATUS FOR DETERMINING THE THICKNESS OR THE SPRINGBACK OF A WORKPIECE BENT BY A PRESS BRAKE

DESCRIPTION

This invention relates to a method and an apparatus for determining the thickness of a workpiece or the springback of a workpiece bent by a press brake.

Press brakes are generally used to bend a metal plate or sheet at predetermined bend angles.

More simply, they are comprised of a punch, which can be moved toward a corresponding die, the latter having the shape to be imparted to the sheet to be bent.

A first problem arises when the sheet has an uneven thickness, whereby a bend angle differing from the expected angle is formed and obtained.

In view of obviating this first drawback, the art described in patent US 6,581,427 discloses a method which determines the actual thickness of the sheet between the punch and the die, by measuring the pressure of the brake's punch-driving hydraulic cylinders, and adapts the system to the new correct value, thereby allowing it to operate with new displacement values.

The above patent also discloses the possibility of performing such control functions using devices for detecting the mechanical stress exerted by the cylinders on the punch (more precisely on the punch-supporting beam), or using devices for detecting the strain between the parts of the frame of the press brake.

In other words, the system disclosed in the above patent acquires physical parameter measurements very
far from the actual working location, i.e. the sheet between the punch and the die, because the punch-driving cylinders are located away from such location and often hold a beam which in turn supports the punch.

Obviously, if the strain detection devices are located in the proximity of the cylinders or on the frame of the press brake, then the detected signal is not exactly the same as the one generated by the interaction between the sheet, the die and the punch, and contains various errors arising from outside the press brake, such as vibrations generated by other mechanical parts.

An additional drawback is that such interaction might be acquired with values being attenuated by propagation through the parts of the press brake.

Also, the detector devices placed on the structural part of the press brake provide a highly attenuated signal, thence having considerable errors, when the sheet workpieces to be bent have small sizes and/or thicknesses, relative to the maximum bending force that might be exerted by the press brake.

Therefore, the object of this invention is to detect the deformations and/or strains generated directly on the punch and/or the die upon bending, to uniquely and precisely determine the correct sheet bending angle, by exact recognition of the start and/or the end of the bending operation.

The recognition of the bending start time allows to directly determine the sheet thickness, while accounting for the instant position of the punch by means of the press brake control system.

This allows to correct the bending system parameters, by compensating for any errors deriving
from sheet thickness variations.

Another general problem of press brakes is that, upon bending, the sheet has a springback, which deviates the bend angle from the desired one.

By measuring the stress-strain curve, which progressively decreases at the end of springback after bending, the actual springback of the bent sheet may be determined, even prior to its being completely released from the press brake, by acquiring an intermediate measurement, in partial springback conditions, relating it to the corresponding position of the punch as detected by the controller of the press brake, and extrapolating the position of the punch in full springback conditions.

Therefore, in a subsequent bending step, the detected angle error may be corrected, and a correctly bent workpiece may be obtained.

Thanks to this arrangement, as defined in the annexed claims, the springback problem is obviated, because the instruments which identify the deformations and/or strains of the punch and/or the die are also springback meters when considering the difference between the maximum penetration of the punch into the die at the end of a bending operation, and that obtained by direct measurement or extrapolation, at the end of springback, as the strain is wholly released and the die or the punch are consequently deformed.

If the device is combined with an external bend measuring device, not described in detail because it can be produced with various methods and in a well-known manner, a full measuring system is obtained, which can make bends at desired angles with a higher accuracy, even without prior knowledge of the thickness
and size of the workpiece and the mechanical properties of its material.

The advantages achieved thanks to this invention may be summarized as a more accurate measurement of the sheet strain, as the available signal is independent of the workpiece size and, as a result, of the machine load.

The available signal is unaffected by the workpiece length, because even a small sheet piece is sufficient to produce an adequate strain in the portion of the relevant tool on which the deformation sensor is located.

Furthermore, even thin sheets may provide important deformation signals, because the tools for this kind of sheets are generally sized in view of the expected bending stresses thereon, and are subjected to the same deformations as the tools that are designed to bend thicker sheets.

The high signal quality provided by this invention allows to use extrapolation methods, which allow the sheet not to be necessarily fully released, which would prevent the formation of a second bend, to correct the former.

These objects and advantages are achieved by a method for determining the thickness of a workpiece or its springback for a press brake according to this invention, which is characterized by the annexed claims.

These and other features will be more apparent from the following description of a few embodiments, which are shown by way of example and without limitation in the accompanying drawings, in which:

- Figure 1 shows a punch of a press brake with an
associated deformation or strain measuring device;

- Figure 2 shows a die of a press brake with an associated deformation or strain measuring device;

- Figure 3 shows a diagram of the method for obtaining automatic correction of the bend angle once the punch and/or die deformation information has been acquired;

- Figure 4 shows a variant of the diagram of Figure 3.

Referring to Figure 1 and 2, a punch 1 and a die 4 are shown, which are used in a press brake to bend a metal sheet therebetween at predetermined bend angles.

A device 2 is located on the punch 1 to detect the deformation and/or strain generated thereon during bending, and translate it into an electric signal.

Likewise, a similar device 3 is located on the die 4, for detecting the deformations and/or strains generated on the die 4 during bending.

Figures 3 and 4 diagrammatically show the steps, i.e. the method, used for causing the press brake to adjust its process parameters and produce a sheet bent at the desired angle.

More specifically, this method includes the steps of detecting the deformation or the strain of the punch 1 and/or the die 4 during bending and translating it into an electric signal; then, the electric signal may be adequately amplified by means of an amplifier 5 to be further transmitted to a controller 6.

Based on the data collected at the start of the bending operation, the controller 6 corrects the thickness in the calculation of the penetration required to obtain the desired bend in the workpiece.

Based on the data collected in the releasing step,
the controller 6 extrapolates and calculates the error in full springback conditions, without the workpiece being actually released, and corrects the bend on the same workpiece, thereby avoiding any error due to correcting the bend on a released workpiece.

In a variant embodiment, not shown, an additional device is combined with the press brake as described above, for detecting the bend angle so that the method becomes useful both for determining the angle obtained during bending and the sheet springback, and further improving the processing accuracy.
CLAIMS

1. A method for determining the thickness or the springback of a workpiece bent by a press brake, said workpiece being placed between the die (4) and the punch (1) of the press brake, characterized in that it comprises the steps of:
   - detecting the deformation or strain in the punch (1) and/or the die (4) and translating it into an electric signal; said detection occurring at the start of the process, during bending and release of the punch (4);
   - amplifying the electric signal by means of an amplifier (5);
   - transmitting the electric signal to a controller (6) of the press brake, which processes the collected data and corrects the angle of the workpiece being bent.

2. A method as claimed in claim 1, characterized in that, based on the data collected at the start of the bending operation, the controller (6) corrects the thickness in the calculation of the penetration required to obtain the desired bend in the workpiece.

3. A method as claimed in claim 1, characterized in that, based on the data collected in the releasing step, the controller (6) extrapolates and calculates the error in full springback conditions, without the workpiece being actually released, and corrects the bend on the same workpiece, thereby avoiding any error due to correcting the bend on a released workpiece.

4. A method as claimed in claim 1, characterized in that the deformation or strain in the punch (1) and/or the die (4) is detected by means of at least one
strain gage located on said punch (1) and/or die (4).

5. An apparatus for determining the thickness or the springback of a workpiece bent by a press brake, characterized in that it comprises:

- at least one device (2, 3) for measuring the deformation and/or strain in the punch (1) and/or die (4), said device being mounted to the punch (1) and/or to the die (4) of the press brake;

- a signal amplifier (5), which amplifies the signal received by the deformation and/or strain measuring devices (2, 3);

- a controller (6) for receiving the amplified signal.

6. A device as claimed in claim 5, characterized in that the controller (6) processes the data collected at the start of the bending operation and thereby appropriately corrects the thickness in the calculation of the penetration required to obtain the desired bend in the workpiece.

7. A device as claimed in claim 5, characterized in that the controller (6) processes the data collected in the releasing step after the first bend and thereby appropriately corrects the bend angle in the subsequent bend.

8. A device as claimed in claim 3, characterized in that the device (2, 3) for measuring the deformation and/or strain in the punch (1) and/or die (4) is a strain gage.
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

**B21D**

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)

**B21D**

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, PAJ**

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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**X** Further documents are listed in the continuation of Box C.  
**X** See patent family annex.

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**"X"** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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