(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 977 842 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
08.10.2008 Bulletin 2008/41

(21) Application number: **07704735.5**

(22) Date of filing: **19.01.2007**

(51) Int Cl.:
B21D 22/00 *(2006.01)* ***B21D 22/24*** *(2006.01)*

(86) International application number:
PCT/ES2007/000021

(87) International publication number:
WO 2007/082972 (26.07.2007 Gazette 2007/30)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **23.01.2006 ES 200600138**

(71) Applicant: **FUNDACION FATRONIK**
20009 San Sebastian (ES)

(72) Inventors:
- **RODRIGUEZ GUTIERREZ, Pedro, Pablo**
  E-20009 San Sebastian (ES)
- **RIVERO RASTRERO, Maria, Asuncion**
  E-20009 San Sebastian (ES)
- **MAIDAGAN ONANDIA, Elixabete**
  E-20009 San Sebastian (ES)

(74) Representative: **Carpintero Lopez, Francisco et al**
Herrero & Asociados, S.L.
Alcalá 35
28014 Madrid (ES)

(54) MACHINE FOR SHAPING SHEET METAL AND SHAPING METHOD

(57) The machine comprises a means of fastening (2) that grips a sheet (1), substantially around its perimeter, a first tool (3) situated on one side of the sheet (1), with at least three degrees of freedom, corresponding to movements according to axes X, Y and Z, and a second tool (3') situated on a side opposite to the first side of the sheet, with at least two degrees of freedom, corresponding to movements according to axes X and Y. There is a relative movement, according to axis Z, between the second tool (3') and the means of fastening (2).

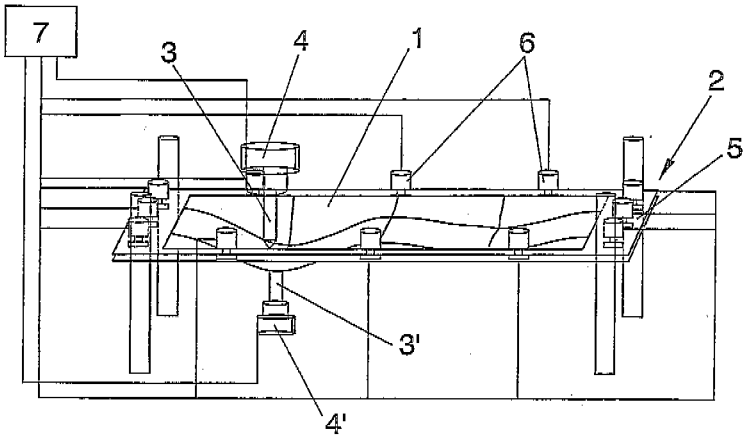

FIG. 1

EP 1 977 842 A1

Description

OBJECT OF THE INVENTION

[0001] The present invention is applicable to the manufacturing of pieces according to an incremental process for the treatment of metal sheets or plates.

[0002] The object of the invention is a sheet-forming machine and method, which does not use dies and which uses two mobile tools, which act in combination on both sides of the sheet for its localised and progressive deformation to create the final shape of the piece.

BACKGROUND OF THE INVENTION

[0003] Pieces produced by deforming metal sheets that are used in industrial sectors such as the automotive and aeronautical sectors, among others, are generally produced by stamping processes. The stamping operation requires the use of a press and two dies, an upper and lower die, which reproduce the shape into which the sheet is to be formed. These dies are particularly expensive and they only pay for themselves when they are used for the mass production of a large volume of pieces.

[0004] There are also certain industrial sectors wherein it is necessary to manufacture very short series of pieces, e.g. prototypes, products with a high degree of customisation or specific components, which do not justify investing in the type of dies used in a conventional stamping process.

[0005] Within this context, an incremental sheet-forming technology is known, which is based on the localised plastic deformation of a metal sheet by the action of a mobile tool that forms the sheet against a set of supports or dies that have a simpler geometry than that required by stamping dies, which normally have the exact geometry of the piece to be formed.

[0006] The incremental forming process is much slower than conventional stamping, but it requires a much smaller investment in dies, which means that it is profitable for the production of short series.

[0007] This process is also characterised by its great flexibility, as the fact that it does not require dies with the exact geometry of the piece makes it possible to use the same die to form pieces with different geometries and it is also simpler to change the design of the piece once the dies have been manufactured.

[0008] According to this method the sheet is secured by a peripheral frame and the tool can move across the entire surface of the sheet.

[0009] This technology is applicable to any sector and the only requirement for its use is that the material must be ductile. Pieces of stainless steel, low-carbon steels and various types of aluminium have been manufactured using this technology.

[0010] By using this method it is possible to reduce the costs in relation to conventional stamping processes, as one of the dies is eliminated. However, the cost associated with the use of a fixed lower die continues to be high, particularly when a piece with a complex geometry is to be produced.

[0011] Patent of invention EP 0970764, for example, discloses a sheet-forming apparatus that comprises an upper punch with movements in directions X, Y, Z and a lower die that can be moved in the direction of axis Z to form the piece. This same solution is reflected in patent of invention JP 2002102944.

[0012] Patent of invention JP 2003053436 contemplates the lower die being able to move in a vertical direction by the action of a cylinder.

[0013] Patent of invention JP 7132329 is essentially similar to EP 0970764, except that the lower die consists of a punch. The vertical movement of the mechanism that supports the plate, in combination with the movement of the upper punch against the plate that is in contact with the fixed lower punch, determines how the piece is formed. This same system is used in patent of invention 2003080320.

[0014] Patent of invention JP 2000153313 discloses a device equipped with an incremental tool with a rotating movement that is applied under pressure to the outline of the piece to be produced, the underside of which rests on a fixed tool situated opposite to the incremental tool.

[0015] Patent of invention JP 9085355 also discloses an apparatus with an upper punch that moves in a vertical direction and a lower punch with a movement in the direction of axes X, Y and Z.

[0016] In patent of invention WO 92/07672 the sheet to be formed has a relative movement, according to X and Y, in relation to an upper tool and a lower die. The upper tool and the lower die have a vertical movement according to axis Z.

DESCRIPTION OF THE INVENTION

[0017] The invention disclosed herein is applicable to the formation of metal sheets or plates by means of the progressive or incremental action produced by two tools situated on either side of the sheet, which form the material as they move in coordination over the sheet, following specific paths to produce the final geometry of the piece, causing deformations in the sheet, punching or grooves and even cutting the outer edges of the sheet.

[0018] The machine of the invention comprises:

- a means of fastening that grips a sheet, substantially around its perimeter,
- a first tool situated on a first side of the sheet,
- a second tool situated on the opposite side to the first side of the sheet.

[0019] According to the object of the invention, the first tool has at least three degrees of freedom, corresponding to movements according to axes X, Y and Z, and the second tool has at least two degrees of freedom, corresponding to movements according to axes X and Y, there

being a relative movement according to axis Z between the second tool and the means of fastening.

[0020] It is preferably contemplated that the second tool also has a movement according to axis Z. In this case, the means of fastening that acts on the sheet remains fixed.

[0021] Thus, the first tool and the second tool define a combined path on both sides and in contact with the sheet, bringing about the localised deformation of the sheet in each sector according to the design that is to form the final piece.

[0022] The first and/or second tool can comprise any of the following elements: a punch, a bit, a cutter, a welding head or a laser head, for performing all kinds of operations on the sheet, such as deformations, grooves, holes, cuts, final cutting of the outer edge of the piece and heating or welding of the sheet, until the desired final shape of the piece is achieved.

[0023] When punches are used, their size varies according to their application and they should preferably have a spherical point.

[0024] It is also possible for the first and/or second tool to rotate on its own axis and for the speed of rotation of the first and second tool to be the same or different.

[0025] Depending on the particular geometry of each piece, it is possible to form the sheet in a single step, or several steps may be necessary. The use of several steps results from the need to increase the plastic forming limit to achieve angles and geometries that cannot be achieved in one step.

[0026] The machine can include a lubrication device that applies lubricant to the sheet, either directly or via the first or second tool, e.g. by means of an internal tube leading to a sphere whose rotating movement distributes the lubricant on the sheet.

[0027] According to the invention, the machine comprises a means of fastening that grips the perimeter of the sheet, forming a frame with a wide opening that defines the working area wherein the tools move as the piece is being formed. The machine can comprise piezoelectric actuators that grip the sheet at various points and sensors that detect the stresses on the sheet and transmit the information to a controller that acts on the piezoelectric actuators to alter the grip on the sheet, allowing more or less material to flow towards the area that is being formed.

[0028] The controller will be able to run a program deriving from a 3D CAD/CAM program containing the information about the positions and speeds of the different axes of each of the tools and will therefore act by controlling the path and speed of the first and second tool. The controller can also control the force that must be exerted by the piezoelectric actuators that grip the sheet.

[0029] The forming process according to the present invention can therefore consist of the following steps:

- securing the sheet, around its perimeter, by the means of fastening, leaving the working area of the sheet free,
- positioning a first tool within the working area of a first side of the sheet,
- positioning a second tool within the working area of the side opposite the first side of the sheet,
- defining the path of the first and second tool using a CAD/CAM program,
- moving the first tool, according to axes X, Y and Z, on one side of the sheet and the second tool, according to axes X and Y, on the other side of the sheet, according to the paths defined by the CAD/CAM program, with a relative movement between the second tool and the means of fastening, according to axis Z, to bring about a localised and incremental deformation of the sheet.

[0030] The forming method preferably comprises the movement of the second tool, according to axis Z, whilst the means of fastening remains fixed.

[0031] The forming method additionally comprises the continuous detection of the stresses on the sheet and actuation of the means of fastening to alter the gripping force thereof, according to the stresses detected. Thus, the sheet can flow to a greater or lesser extent according to the stresses detected in the deforming areas.

DESCRIPTION OF THE DRAWINGS

[0032] To complement this description and in order to aid a better understanding of the invention's characteristics, according to a preferred practical embodiment thereof, there is a set of illustrative and non-limiting drawings integral to said description, which are as follows:

Figure 1. Shows a perspective view of the basic elements of a sheet-forming machine wherein the tools consist of respective punches mounted on heads that are situated on either side of the sheet.

Figure 2. Shows a schematic view wherein the movements of the tools shown in the previous figure can be observed.

PREFERRED EMBODIMENT OF THE INVENTION

[0033] With reference to the figures, a preferred embodiment of the sheet-forming machine that constitutes the object of this invention is described below.

[0034] The figures show the basic elements involved in the operation of forming a piece from a sheet (1) according to the invention. Figure 1 shows a schematic drawing of the machine of the invention, which comprises:

- a means of fastening (2) that grips the sheet around its perimeter, forming a peripheral frame (5) that determines a large central space corresponding to the working area of the sheet (1),

- a first tool (3), situated on one side of the sheet (1),
- a second tool (3'), situated on the opposite side to the first side of the sheet (1).

[0035] The first tool (3) has at least three degrees of freedom, according to axes X, Y and Z, and the second tool (3') has at least two degrees of freedom, corresponding to movements according to axes X and Y, there being a relative movement according to axis Z between the second tool (3') and the means of fastening (2).

[0036] In a preferred embodiment the second tool moves according to axis Z, whilst the means of fastening (2) remains fixed, as shown in figure 2.

[0037] The means of fastening (2) of the sheet (1) may comprise piezoelectric actuators (6) that establish how the sheet (1) is secured to the peripheral frame (5) with a variable gripping force, so that depending on the stress generated on the sheet by the deformation that is occurring, the grip on the sheet can be released, allowing it to flow towards the deformation area.

[0038] The sheet-forming machine includes a controller (7), which is shown in figure 1, that controls the path and speed of the first tool (3) and the second tool (3') and the force exerted on the sheet (1) by the piezoelectric actuators (6) to regulate the flow of material in the area of the sheet (1) that is being deformed.

[0039] The first tool (3) and/or the second tool (3') may comprise punches (3, 3'), which can optionally rotate, mounted on corresponding heads (4, 4') that come into contact with either side of the sheet (1), bringing about localised deformations followed by incremental movements to form the whole piece.

[0040] Optionally, the first tool (3) and/or the second tool (3') additionally has rotating movements θ, Φ around axis X and/or axis Y, respectively.

[0041] It is also anticipated that the first tool (3) and/or the second tool (3') may comprise a bit, a cutter, a laser head or a welding head.

Claims

1. Sheet-forming machine that comprises:

- a means of fastening (2) that grips a sheet (1), substantially around its perimeter,
- a first tool (3) situated on a first side of the sheet (1),
- a second tool (3') situated on the opposite side to the first side of the sheet,

characterised in that the first tool (3) has at least three degrees of freedom, corresponding to movements according to axes X, Y and Z, and the second tool (3') has at least two degrees of freedom, corresponding to movements according to axes X and Y, there being a relative movement according to axis Z between the second tool (3') and the means of fastening (2).

2. Sheet-forming machine according to claim 1, **characterised in that** the second tool (3') moves according to axis Z, whilst the means of fastening (2) remains fixed.

3. Sheet-forming machine according to claims 1 and 2, **characterised in that** at least one of the tools (3, 3') can rotate.

4. Sheet-forming machine according to any of the previous claims, **characterised in that** at least one of the tools (3, 3') additionally has a rotating movement θ around axis X.

5. Sheet-forming machine according to any of the previous claims, **characterised in that** at least one of the tools (3, 3') additionally has a rotating movement Φ around axis Y.

6. Sheet-forming machine according to any of the previous claims, **characterised in that** it includes a controller (7) that controls the path, speed and movement of the first tool (3) and the second tool (3'), as well as the force with which the means of fastening (2) grips the sheet (1).

7. Sheet-forming machine according to claims 1-6, **characterised in that** at least one of the tools (3, 3') comprises a punch.

8. Sheet-forming machine according to claims 1-6, **characterised in that** at least one of the tools (3, 3') comprises a bit.

9. Sheet-forming machine according to claims 1-6, **characterised in that** at least one of the tools (3, 3') comprises a cutter.

10. Sheet-forming machine according to claims 1-6, **characterised in that** at least one of the tools (3, 3') comprises a welding head.

11. Sheet-forming machine according to claims 1-6, **characterised in that** at least one of the tools (3, 3') comprises a laser head.

12. Sheet-forming method that comprises the steps of:

- securing the sheet (1), around its perimeter, by the means of fastening (2), leaving the working area of the sheet (1) free,
- positioning a first tool (3) on a first side of the sheet (1), within said working area of the sheet (1),
- positioning a second tool (3) on a side opposite to the first side of the sheet (1), within said work-

ing area of the sheet (1),
- defining the path of the first and second tool (3, 3') using a CAD/CAM program,
- moving the first tool (3), according to axes X, Y and Z, on one side of the sheet (1) and the second tool (3'), according to axes X and Y, on the other side of the sheet (1), according to the paths defined by the CAD/CAM program, with a relative movement between the second tool (3') and the means of fastening (2), according to axis Z, to bring about a localised and incremental deformation of the sheet (1).

13. Sheet-forming method according to claim 12, **characterised in that** it comprises the movement of the second tool (3'), according to axis Z, whilst the means of fastening (2) remains fixed.

14. Sheet-forming method according to claim 12, **characterised in that** it comprises the continuous detection of the stresses on the sheet (1) due to the movement of the first and second tools (3, 3') and the actuation on the means of fastening (2) to alter the gripping force thereof, according to the stresses detected.

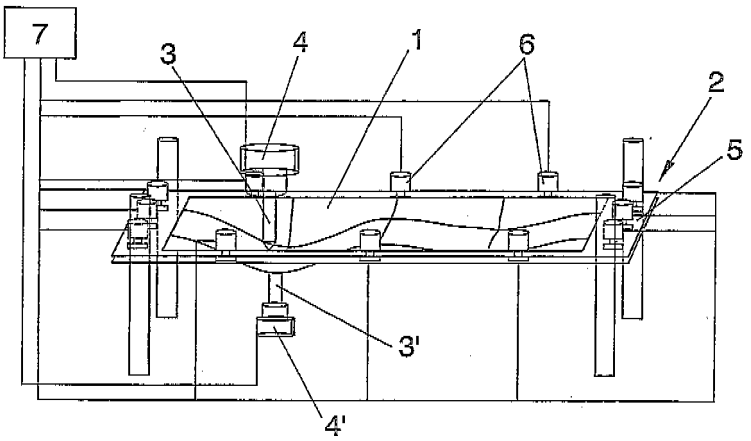

FIG. 1

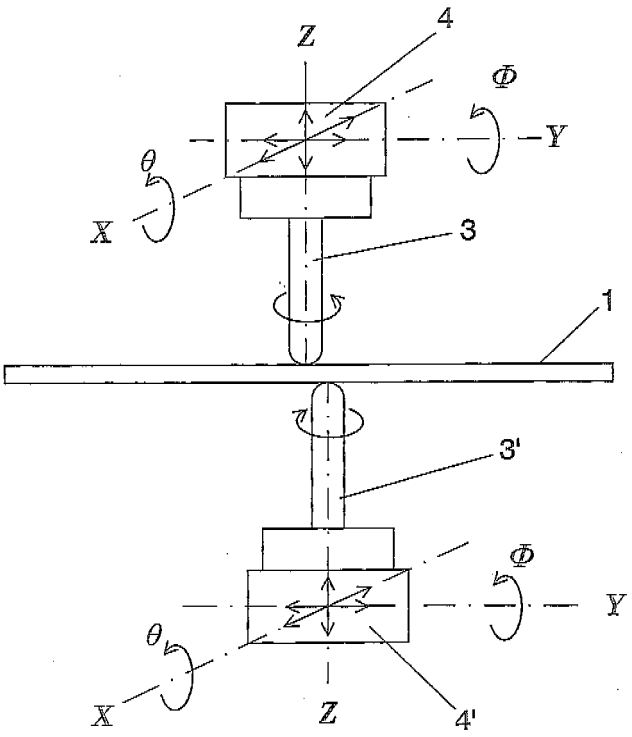

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ ES 2007/000021

A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet
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)
B21D22, B21D24

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 practicable, search terms used)

CIBEPAT,EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 9085355 A (HITACHI LTD) 31.03.1997, the whole the document. figures.	1-13 14
Y	DE 10331939 A1 (BAYERISCHE MOTOREN WERKE AG) 10.02.2005, abstract; figures.	14
A	US 6216508 B1 (MATSUBARA et al.) 17.04.2001, column 8, lines 61-64; column 10, lines 3-60; column 13, lines 37-46; column 14, lines 36-65;column 16, line 3 - column 17, line 10; figures.	1-14

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance.
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure use, exhibition, or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents , such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2007 (11.05.2007)	(22/05/2007)
Name and mailing address of the ISA/ O.E.P.M. Paseo de la Castellana, 75 28071 Madrid, España. Facsimile No. 34 91 3495304	Authorized officer M. Bescós Corral Telephone No. +34 91 349 54 92

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/ ES 2007/000021

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
JP 9085355	31.03.1997	JP 3787900 B	21.06.2006
		JP 2006021253	26.01.2006
DE10331939 9 A	10.02.2005	NONE	----------
US 6216508	17.04.2001	WO 9938627	05.08.1999
		CA 2285364	05.08.1999
		EP 0970764	12.01.2000
		EP 19990901927	29.01.1999
		CN 1255881	07.06.2000
		CN 1073895 C	31.10.2001
		TW 401329 B	11.08.2000
			11.08.2000
			11.08.2000

Form PCT/ISA/210 (patent family annex) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/ ES 2007/000021

CLASSIFICATION OF SUBJECT MATTER

B21D 22/00 (2006.01)
B21D 22/24 (2006.01)

Form PCT/ISA/210 (extra sheeet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0970764 A **[0011] [0013]**
- JP 2002102944 B **[0011]**
- JP 2003053436 B **[0012]**
- JP 7132329 B **[0013]**
- JP 2000153313 B **[0014]**
- JP 9085355 B **[0015]**
- WO 9207672 A **[0016]**