Contribution to a new method for deep drawing with kinetic control

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Abstract. The paper presents a new deep drawing sheet metal method in which, due to the complex geometric shape of the part, there are significant variations in the level of deformation in different areas of the piece. The method aims to improve the quality in the deep drawing process by reducing the variation of the wall thickness of the part, caused by the different degree of stretching of the sheet in different areas of it. In the proposed method the vertical movement of the punch is completed by two vertical rotational movements of it which will have the effect the increasing the flexibility of the deformation process, the active elements occupying the most favorable position dictated by the material flow in the die. It results an improved material deformability and a higher degree of deformation. Also, the new method offers a relatively simple constructive solution of the press and does not require long auxiliary times for assembly-disassembly.

Keywords: deep drawing, deformability, hydraulic presses, kinetic control

1 Introduction

Methods for reducing the variation of the degree of deformation in different areas of the part by controlling the restraint forces are known. Restraint forces are applied to the blank using blankholders which may be monobloc, segmented or elastic.

For complex parts when using monobloc blankholder, the elements that control the flow of material in the die are the drawbeads, located on these plates. Thus, in [1] is presented a model of a die provided with a drawbead that works perpendicular to the deformation direction. A multitude of successive states are generated to iteratively represent the sheet metal from the initial shape to the final shape. The drawbead is represented as a two-dimensional flat band within the stamping die model. The forces acting on the sheet metal are calculated at each state to define, successively, the next state. The calculation step includes the calculation of a pulling force acting on the drawbead, depending on the length of the sheet metal engaged in the flat strip in the respective states. The width and location of the flat strip improve the accuracy of estimating the restraint force. In [2] a method and equipment for stamping with restraint plate and segmented drawbeads along the contour of the part is proposed, so that the depth of penetration of the drawbeads is different along the contour of the part to obtain different restraint forces on the different portions of the blank.

The segmented plates [12, 13] ensure a distribution of the restraining forces, on zones, depending on the complexity of the geometry of the part to be manufactured. These plates are driven by pneumatic or hydraulic cylinders, in close correlation with the movement of the punch, and are controlled by programmable logic controllers (PLC). They allow the pressure to increase or decrease, depending on the material to be deformed. Thus, in [3], a stamping method is presented using such plates, in which the part is obtained by deforming the semi-finished product in the mold cavity, in a way that controls the position and size of the retaining forces. depending on the size of the deformations. Each segment is loaded in such a way that the force applied to it will ensure uniformity of deformation on the contour of the blank.

The elastic blankholders plates [11] have an elastic honeycomb construction. Each pin, which transmits the pressure through the network node, is hydraulically or pneumatically operated and is numerically controlled. The pressure transmitted on each of these pins ensures the change in the flow character of the material in the mold. There is a close correlation between the force applied to each pin and the corresponding surface of the retaining plate. A closed loop control system ensures so that each of the pins can be proportionally controlled by servo-valves, allowing the adaptation and individual control of the force in the retaining plate, throughout the working stroke [6, 7]. The system will react to any disturbance of the deformation process caused by the variation of the friction force, the heterogeneous properties of the material, the variations in the thickness of the sheet, the problems of centering the elements of the mold, the wear of the molds, the positioning of the blank and the elastic deformation. the press.

A solution to control the pressure exerted on the blankholder is presented in the paper [4]. A 3D servo-press is presented, in which the slide is provided with two additional degrees of freedom, so that the application of pressure on the blankholder is adaptable by tilting the slide, causing a controlled process of the blank deformation.

These types of restraint systems have the following disadvantages:

- the blankholders are not interchangeable, differing from one set of dies to another, respectively from one blank product to another;
- the shape and final dimensions of the blankholders are determined following the experimental tests on special presses intended for these tests, presses which are expensive and which benefit only the large manufacturers of body parts;
- the installation of the blankholder is done with screws or rivets, depending on its shape, the assembly time being high;
- the presence of the blankholder makes the blank product to be oversized;
- the construction of dies with elastic plates is expensive, due to their geometric complexity and drive system;
- in addition to the press, additional actuators are needed, which leads to great efforts for the design and integration of the actuator;
- in the case of hydraulic deep drawing, the control of the hydraulic drawing process is done by correlating two parameters, namely the holding force and the fluid pressure, which requires numerous experimental and / or numerical tests.

In the paper is presented a new concept for press construction in which on the slide is mounted a special die which assures a combination between vertical displacement and rotation of the punch, to accommodate with the product geometry, during the deformation process.

2 New die concept and working principle

In conventionl deep drawing, Figure 1, the punch (2) is acting toward the blank, (9), by the vertical moving of the press slide (4), thru the die (11), until the blank will contact the die plate profile, P. During the deformation process the punch does not change his position function of the blank. From (a) to (d) are represented the moving stages of the punch for material deformation. This finaly could lead to the thickness variations on the wall part, depending on the clearance between the punch and the die plate.

The new die construction is presented in Figure 2. The new deep drawing die has as the main charactersitics the possibility of superposition the vertical moving of the punch with its rotation, so an accommodation process with the different degree of deformation generated by the shape of the piece will appear.

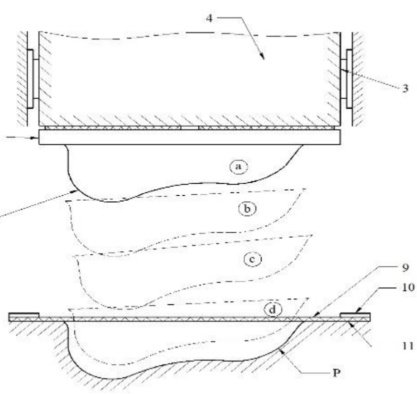

Fig. 1. Stages in conventional deep drawing

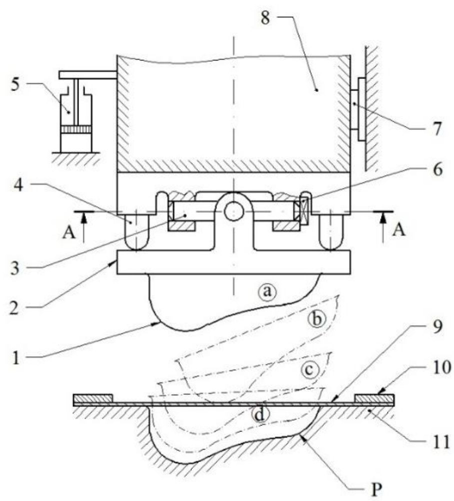

Fig. 2. Scheme of the new construction die for deep drawing [5]

The new die with kinetostatic deformation control, Figure 2, is composed of a punch (1) which is attached to the mobile punch port subassembly (2). On this subassembly is placed the cardan cross (3), the rotary transducers (6), one for each axis, and the pairs of plungers (4), driven from the hydraulic cylinder (5) by means of the distributors, Ds, Dx and Dy. On the press slide (8), it is attached the translation transducer (7), which controls its movement. The blank (9), blankhoder (10), will deform the blank in the die plate (11), until the contact with the die plate profile, P.

The patented kinetostatic deformation control die operates on the basis of data generated by dedicated software that establishes the link between the position of the

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slide and its rotation, Figure 3. The rotational movement is controlled when the value of the deformation occurred at a point on the blank, according to the drawing limit curve, exceeds the permissible value [14]. The drawing limit curve can be obtained by simulation and also by simulation the moment when this rotation is necessary can be identified, due to the value of the deformations, offering two important values namely: the size of the displacement and the rotation angle. The drawing limit curve will be, in the proposed solution, the die operation motor, Figure 3. The rotation is assured by the cardan cross (3), which is acted by the for independent hydraulic plugers (P1-P4). There are 8 positions that the plungers and so the mobile punch port subassembly (2) can occupy, Figure 4, depending on the controlled rotation.

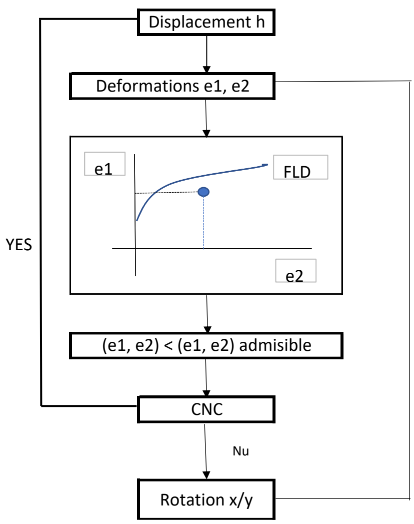
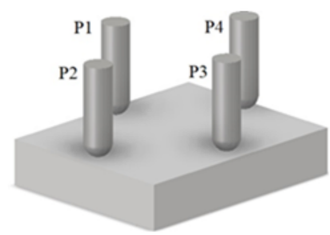


Fig. 3. Scheme of the new die control



Plunger 1	Plunger 2	Plunger 3	Plunger 4
+	0	-	0
-	0	+	0
0	+	0	-
0	-	0	+
+	+	-	-
-	-	+	+
-	+	+	-
+	-	-	+
(+) down ; (-) withdrawal (0) maintaining contact			

Fig. 4. Plunge work diagrams

The rotation control is transmitted to the plungers (4) from the hydraulic installation shown in Figure 5. The movement of the punch (1) of the stamping die, caught by the mobile subassembly punch (2), composed of the cardan cross (3) and the pairs of plungers (4), driven by the transmitted pressure, from cylinder (5), is controlled by the rotating transducers (6) and the translation transducer (7). The mobile punch holder subassembly (2), attached to the slide of the press (8), moves vertically. Upon contact with the blank (9), in the initial position a, the punch (1) will occupy the most favorable position for the deformation of the material, due to the two rotational movements.

The restraining force applied on the flange of the blank will also contribute to the size of the values of the two movements, translate and rotation.

Next, by combining the two movements of the punch (1), the blank (9), restrained by the blankholder (10), will be deformed in the die plate (11), successively occupying positions b, c, etc. until the contact with the plate profile, P.

3 Hydraulic operations of the new die

Hydraulic cylinder (5) acts as a pump, Figure 5. Cylinder (5), with double rod, is secured to the slide of the press and has one rod fixed to a plate. The cylinder has two chambers A and B. When the slide descends, the oil in chamber A of the cylinder is compressed and transmitted to the distributor Ds which has the role of selecting the axis of rotation.

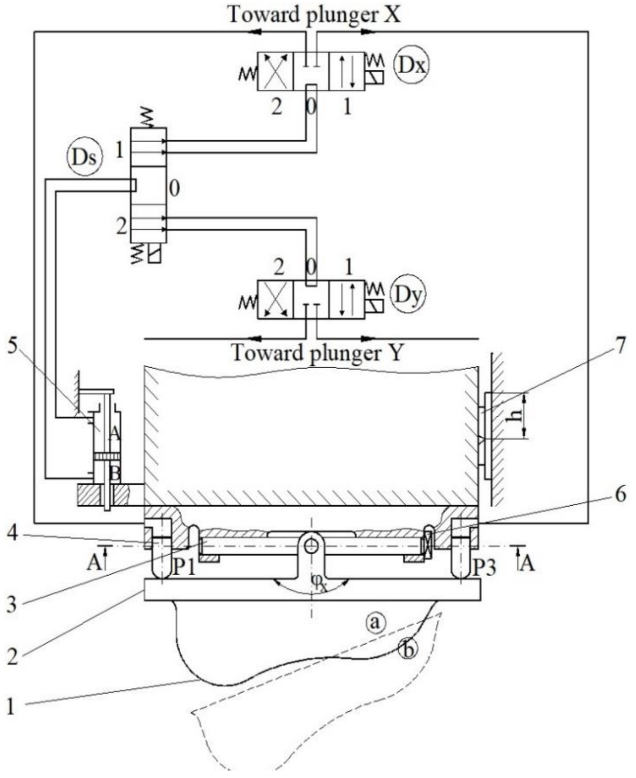


Fig. 5. Hydraulic scheme of the new die

The distributor Ds has three positions: In position 0, the oil in chamber A reaches Ds and returns to chamber B. In position (1) of the distributor Ds, the oil in the two chambers A and B of cylinder (5) reaches the distributor Dx. The y-axis is not actuated. In position (2) of the distributor Ds, the oil in the two chambers A and B of the cylinder (5), reaches the distributor Dy. The x-axis is not actuated. It is discussed below only the movement given by the distributor Dx. For the Dy distributor, the discussion is the same. In position (0) of the distributor Dx, the oil returns to the distributor Ds.

If Dx is in position (1), then the left plunger, P1, receives pressure and moves down, and the right plunger, P3, pushes back and as a result rise. This produces a rotation with an angle φ. If Dx is in position (2), then the plunger on the right, P3, receives pressure and moves down, and the plunger on the left, P1, pushes back and as a result rise. There is thus a rotation with an angle φ, in the opposite direction to the first situation. The control of the Ds, Dx and Dy distributors is established by software, using a CNC type system, according to the above. The translation transducer (7) permanently measures the vertical displacement (h), and the transducers (6), one for each axis, give information about the angle of rotation. The hydraulic scheme allows operation only after one axis, at a time.

4 Conclusions

By applying this new concept, we presume the following advantages will obtain:

- the two movements lead to the flexibility of the deformation process, the active elements occupying the most favorable position dictated by the minimum resistance to pressing;
- the reduction of the total pressing force due to the gradual action of the pressing force on the semi-finished product, which will lead to the increase of the operation period of the active elements;
- the degree of material defromation will be improved and as a result the degree of deformation will be higher;
- the solution can be applied to any hydraulic press, which provides the necessary strength and gauge;
- the vertical movement of the punch is completed by two rotational movements in the vertical plane which will have the effect of reducing the value of the shock and noise produced by the contact of the active elements with the material;
- the constructive solution is relatively simple and does not require long auxiliary times for assembly-disassembly

The future work will consider the developmnet of the solution by design and manufacturing the new die and apply then the techniques used in digital manufacturing.

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