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STUDIES REGARDING THE BINDER AND THE RETAINING RIBS IN SHEET METAL FORMING

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Abstract: ***The purpose of this article is to present the results of a study regarding the binder and the retaining ribs. The study realized is a result of experiments on parts with complex and non-uniform contour using different types of ribs for binders. There were used binders with different angle slopes in relation with the direction of normal plan, in order to establish the conditions of defects appearance. The importance of angle slope and of using ribs is that of avoiding the wrinkling in the forming process. The research must be extended for different types of material used for binders and for the ribs. The study can be further developed using a preliminary numerical model. The studies presented offers useful information in avoiding wrinkle defect of products***

Keywords— ***forming process; material flow; semi-finished parts; binder force; ribs***

I. INTRODUCTION

The binder has a main role in the forming process. It supports surface of the metal sheet and restricts the material flow. The flow can be controlled by the means of ribs. When draw parts with an irregular form the deformation on the contour of the part presents a non uniform deformation degree. In order to get uniform the conditions of deforming especially in the small radius filleted areas must be foreseen retaining ribs. Ribs are not required when the material thickness is equally or more than 1.2 mm. The ribs can be in one piece when the press force is on a single plunger or in a cassette when the press force is loaded on 2 plungers.

In the process of forming it must be studied the stress conditions, the formability conditions the formability laws [15] .For the present studies the passing of the material through the retaining ribs was considered equivalent with the passing through a series of bending with stretching cycles under the flexural torque and stretching torque. The total torque is in reverse direction in relation with the elastic recovery of the material [14]. Thus the total tangential force will be added to the stretching force existent in the material. This two torques permit getting a uniform distribution of tensions in the material during the process that will not allow tension accumulation that creates slits. The main item from which is started a calculus in the plastic field is to know the characteristic curve of the material studied, that can be obtained through experimental methods. In the case of plastic forming is required to know the conditions in which the elastic deformations become permanent deformations [1]. Knowing the characteristic curve we can know the safety range in forming process, the critical area where is produce the tearing, the severity of formability, the work conditions [3].

The difficulty of calculation in the plastic field is that it cannot be written an equation of the characteristic curve to replace the Hook law. [7]. In Fig.1 is represented the characteristic curve for the material used: DC 04, for which the flowing limit is 160 N/mm^2.

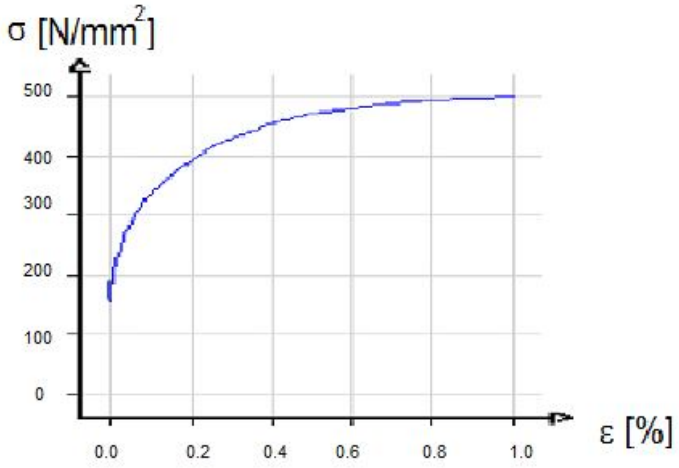

Fig.1 The characteristic curve for the material DC 04

Nowadays it can be done technical predicts with the help of simulating programs and numerical model [5]. The simulating process involve a model building for the process in order to study its behavior (output data) in different experimental conditions (input data), characterizing the structure of the real model and also the way in which the real system response to the entering data changing [12].

II. DESIGNING A BINDER CONFIGURATION

In order to assure a correct tightening it is required for the slope of retaining element surface to be no more than 30° in relation to the normal plan of forming direction, and as a main rule the length of a section must be shorter than that of the die in the same sectioning plan. A similar rule exists in the case of the entering line in the die that must be always shorter than the end line of the punch with approximately 10%.

When design a binder it is required to try to make its surface as horizontal as possible and to distribute the tightening pressure as more efficient as possible.

At the level of retaining element take place actions as:

- Stopping the sheet during the moving facilitating thus the material stretching,
- Sheet gliding on certain areas avoiding thus the splits.

The binder material is usually steel with heat treating. Having in mind the intense fretting to which the binders are subjected, these are usually built from the same material as the active elements [17]. The materials must have some properties and the common methods used to determine the properties of materials are: chemical analyses, stretching test, metallographic examination, and plasticity tests and bending tests [4].

The value of the connection radius has a great influence on the forming process. It determines the value of tensions in the semi-finished material and thus the forming force, the value of admissible forming coefficient, plies forming in the semi-finished fledges, the material thinning degree, fissuring appearance and part tearing, part quality and accuracy [19].

Reducing the connection radius of active element the forming force will increase and also the tensions. Usually $r_{pl} = k \times g$ where g is the thickness of the material and k is a coefficient depending of the deformation degree, the material and the part type.

Increasing the connection radius will determine the reducing of radial pulling tension of semi finished, thus reducing the forming force, but in the same time the possibility of forming wrinkles as a result of diminishing the semi –finished surface under the holding blank.

Because the dimension of the connection radius is limited of wrinkle appearance in the drawn part, in order to get away of this unwelcome phenomenon it can be used an additional holding element with an appropriate form that hold the semi finished pressed on the connected area of active element. [8].

III. RIBS USING

Creating the material flowing conditions in a uniform way on the entire contour during the forming process is a problem of a special importance.

In order to create the material flowing conditions in a uniform way it must be modified the way of moving of the material under the binder. The friction increasing can be done in different ways:

- increasing the pressure of the pneumatic cushion in the case of Simple Effect Press
- increasing the pressure of the exterior hammer in the case of Double Effect Press
- increasing the width of the fledge
- using"redanes" or shoulders
- using ribs (it proves to be the best method for obtaining good quality exterior parts, without wrinkles and undulations and with minimum deviations from the geometrical form (due to elastic recovery) [11] .

The number, the form, the dimension, the displacement and the material of ribs are very important for establishing the technological addition of material.

Number of ribs rows	Technological material addition
1	35-50 mm
2	65-80mm
3	90-110mm

Table 1. Technological material additions depending of the number of ribs

During the experiments there have been used different types of ribs with different dimensions: width12 mm and 16 mm, high 26 mm and 30 mm; high in the inner part of active element: 16 mm and 19 mm (in the case of a Double Effect Press); and: width16 mm and 18 mm; high 10 mm and 12mm; high in the inner part of active element: 3, 5 mm and 4,5mm (in the case of Simple Effect Press). It has also been used pressed ribs with different dimensions: breadths: 8 mm, 12 mm, 16 mm; high; 22 mm, 28 mm; high in the inner part of active element 14 mm; 20 mm depending on the part studied.

The ribs can be placed be it in the superior part of the die, be it in the inferior one; depend of the form of the part and of the desired fretting intensity. Ribs are not placed on the aspect surfaces and in the filleted areas.

It was observed that the ribs must be mounted on the lower part of the die and the slot of the rib profile to be realized in the upper part of the die. The reason for this observation is that placing them in such a way can be avoid dust or grease depositing in the slot (being in the upper part) and also can assure operational reliability and implicit the quality of the part.

When using stretch-draw "redane" there were two cases:

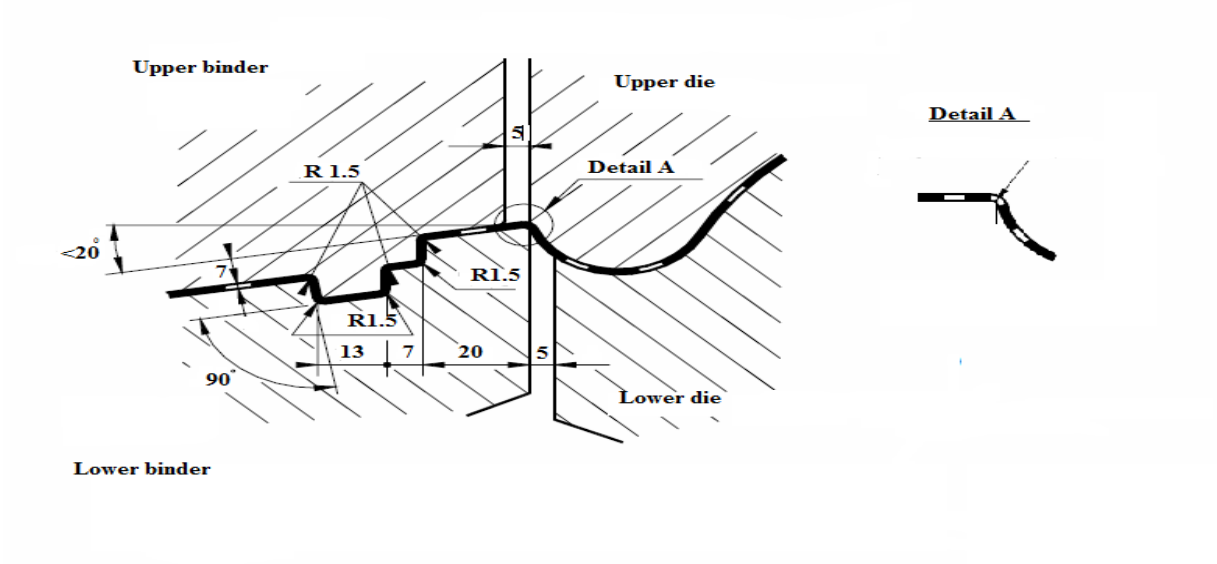

Fig.2 The case when binder surface has a slope 0° - 20°

In figure 2 is presented a"redane" that is an alternative for ribs when the binder surface has a slope between 0° - 20°.

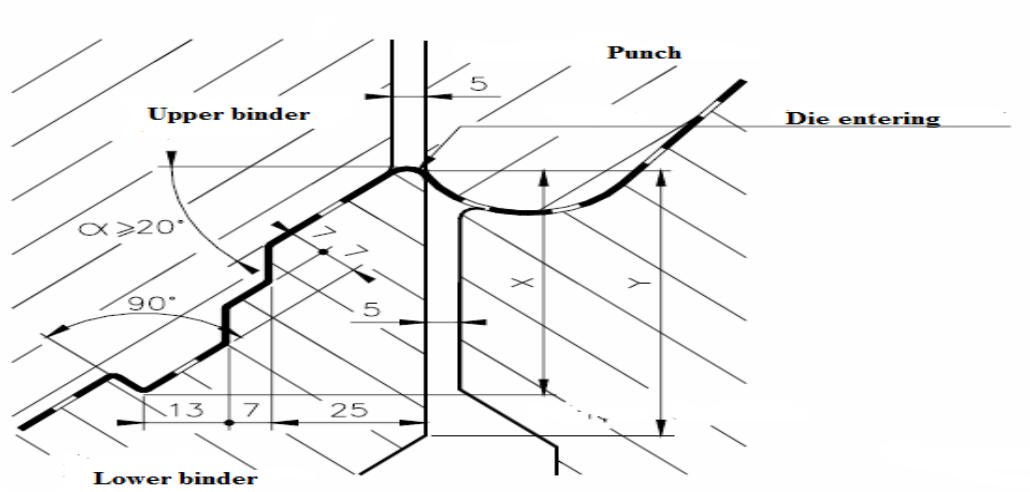

Fig.3 The case when binder surface has a slope > 20°

In fig.3 is presented a"redane" in the case in which the binder surface has a slope greater than 20 degrees.

There has also been used semi cylindrical ribs realized directly in the melted mass during the founding process.

Conclusions:

- Material cracking or tearing as a result of too longer ribs (it is required ribs shortening through polishing)
- The part has significant undulations in some areas that are caused by the shorter holding ribs or some ribs do not hold properly the material.

IV. BINDER FORCE

Usually when draw parts with great dimensions the binder force is 0.5-0.6 of the nominal force of the press (of sledge in case of double effect).

The force for the binder is calculated with the relation:

$Fs=A \times p$, relation that comes from: $Fs= (A_s - A_p) \times p = A \times p$

In the above relations the signification of terms is:

A_s– the surface of the semi-finished part; A_p – the surface of the die; A- the retaining surface of semi-finished;

p– the specific pressure (see table 2).

Material	Unit pressure on retaining surface: p [dN/mm^2]
Steel	0,25
Bronze	0,25
Copper	0,20
Brass	0,20
Hard brass	0,24
Zinc	0,15
Aluminium	0,12

Table 2 - The unit pressure and resistance to tearing for different types of materials

In table no.2 there is a list with some materials and unit pressure on retaining surface.

Another calculus for the retaining pressure is: $p = R_m C_1 ((1/m_1) - C_2) C_3 (D/100g)$ [MPa], where: g is the thickness of the material, D - the diameter of the semi-finished, Rm the connection radius, m_1 is the deformation degree, C_1 is a coefficient that for steel is: 0,78; C2 = 1, and C3 = 0,006 - 0,008, [18] .

In the case studied the binder force calculated has the value of 750 kN.

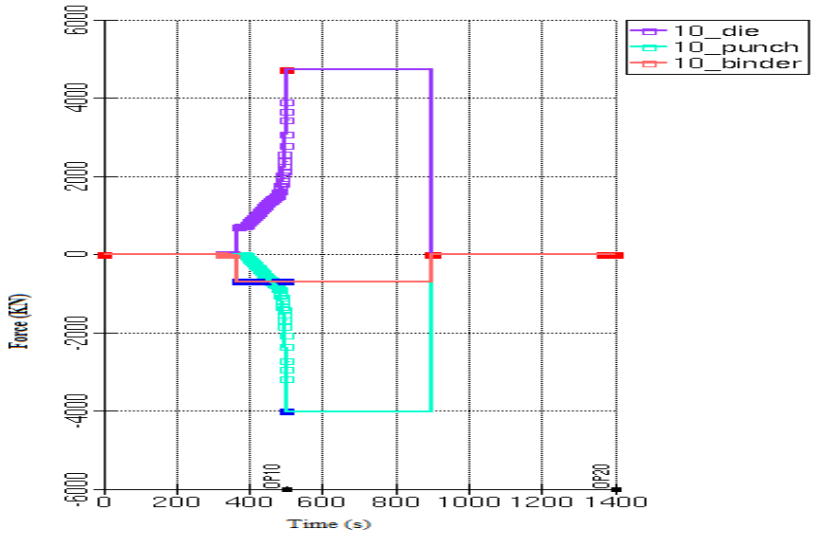

Fig.4 Diagram of forces in the forming process

In Fig.4 is presented the diagram of forces in the forming process. The values of forces for forming operation are: die force: 4773 kN, punch force: 4023 kN, binder force: 750 kN.

Other authors have used fuzzy control techniques to find the optimum sheet thickness and blank holder force in a typical mould with constant dimensions [6].

The optimum valor of pressing pressure is those to which corresponds the minimum forming force.. The forming process without binder can be done rarely and only if the difference between the diameter of semi-finished and the diameter of the part is smaller or equally with 18-22 thickness of the material [8].

Undulations and plies appear firstly because of insufficient pressing of holding element or because of a too great connection radius of the forming plate, that makes the semifinished to fall under the pressing element and to form plies [9] . In many cases these defects may be eliminated by appropriate control of the Blank Holding Force (BHF). **[10]** .

When using press with double effect the binder receives a constant force during the forming, directly from the press. Whatever the action system of the retaining rings is, these must have the active surface perfectly finished and the rounding radius to be identical with those of the forming edge and equally on the entire contour[20]. In order to reduce machining of dies and blank holder ranges, must be included a rough cast clearance at approximately 15 mm constant beyond the theoretical blank.

There are different ways of holding the material: holding with plane binder, holding with segmented binder, holding with segmented ring binder, combined holding. In the case of combined holding results an active element with a great connection radius that assures a high degree of formation of the semi finished material that allow the first two operations done with plane binders dies (for the case where is required many operations) to be cumulated in a single one, thus appearing a material and man-hours reducing with almost 50% at the first forming operation [16] .

There are known some methods of dimensional guiding such as:

- Simulating evaluation of elastic recovery and modifying the form of punch and dye in order to compensate the elastic recovery
- Reducing the elastic recovery through modifying the holding force during the process and through application of some different retaining pressures in different areas of the contact area between the semi-finished and the binder
- Dividing the punch course in two areas (one identification area where the retaining force grow under a low that is considered as reference that is used in the simulating process and one control area where the force is realized in a number of points considered as reference) [13] .

V. CONCLUSIONS

A lot of measurements were made experimentally in order to see the relation between the slope angle and the undulation appearance. In order to assure a correct tightening it is required for the slope of retaining element surface to be no more than 30° in relation to the normal plan of forming direction, and as a main rule the length of a section must be shorter than that of the die in the same sectioning plan.

It was been studied also the ways of growing the friction of the sheet under the binder through using retaining ribs. Thus was assured obtaining good quality parts, without wrinkles and undulations with little dimensional discrepancies (due to elastic recovery).

After the experiments it was seen that for the complex parts with non- uniformed contour the retaining ribs must be placed so as to assure a uniform displacing on the contour of the unit efforts especially for those of radial stretching.

In conclusion, the material cracks or tears as a result of too longer ribs (it is required ribs shortening through polishing); the part has significant undulations in some areas caused by the shorter holding ribs or because some ribs do not hold properly the material.

The new approach in this article is the study of forces using the holding system in forming process so as the process to be done without defects.

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