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Study of The Manufacture Ofdie-Cutting Part And The Mechanical Fractureof Die Block

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Abstract:*The die processes, such as punching, bending and drawing are of unquestionable utility, as examples are the home appliances, automotive products, etc, these products have several parts produced with thestamping processeslike the ones mentioned. With the aim of facilitating the training of engineering students in the design of tools for sheet or stampingprocessing, the use of specific symbology of the die process capable of developing the required shape in the sheet is proposed, which will be used in obtaining the required piece, with, which the novice designer immediately links the necessary mechanical elements to develop the required shape and thus be able to relatively easily conceive the die,that for mass production elaborated the desired sheet part. A summary of the symbology proposal will be presented for specific punching processes. In this case, the methodology is applied to a part made of stainless steel used in refrigerators.*

Keywords:*Die, dies design, manufacturing phases.*

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I. Introduction

The processing of materials is one of the most interdisciplinary engineering activities; since, it involves the contribution of chemical, electrical, industrial, mechanical and metallurgical engineers, among others; in its broadest sense, it is defined as the conversion of raw materials into finished products, so that they possess useful shapes and properties, some examples are forged, stamped, cast and welded parts, among many others; but, this term, Processing of Materials, is restricted compared to Manufacturing Engineering. On the other hand, Manufacturing Engineering is defined as the engineering professionalspecialty, with the education and experience necessary to understand, apply and control, the procedures and methods of manufacturing, in the production of goods; the engineering professional has to possess the ability to plan the practice of manufacturing, research, development and design of tools, processes, machines and equipment, which easily integrate systems, to produce quality products with optimum expenditure. The term manufacturing process should not be confused with the term material processing[1].

Metal conforming, is defined as an operation in which the shape change of the piece, runs without removing material, as the primary method of altering its shape. Themetalpunching sometimes is not considered as a process of conformed since, it is considered as a process of divergent flow or reduction of mass; however, it shapes the flat sheet and later, if necessary, obtain a 3D part. In contrast, bending and embedded are pure processes of metal shaping, which change the shape of a flat sheet into three-dimensional shapes.

In previous congresses and papers [2,3] the design of progressive dies of different pieces has been presented; now, the focus is to facilitate the visualization of the mechanical elements necessary for a specific process of bending and punching requirements to manufacture a part of the die processes. It focuses on the bending and punching processes, in Table 1 symbology is specified for some specific phases of punching.

The processing of metal sheets, depends on the complexity of the geometry of a workpiece, this may require one or several forming tools (dies). If there are several die processes necessary to obtain a part and it is decided to make it in a progressive die the choice of a sequence of operations is the key to design a competitive tool; that is, a tool with the least number of stages of stamping and with the least possible maintenance during the useful life of the die.

The original symbols were presented at the XII Ibero-American Congress of Mechanical Engineering (CI-BEM 2017 Lisbon, Portugal) [4], which have been slightly modified for this congress and in this work will be applied to analysis of a piece called *staple*, see Fig. 2.

The modifications of the symbols have to do with the colors of the elements involved in the die processes. The sheet changes color from blue to gray and the punch remains black. When the sheet needs to be fixed to cut in the shearing or bending by pushing, the element called*presser* will be orange. For the case of "U" bending, to removing the punch, the sheet remains contained in the matrix and it must be drained by pushing, due to the elastic recovery of the sheet. Usually a solid activates a spring to push the sheet and extract it of the matrix, after having made the bend.

To show the added improvements, the die symbols shown in Fig. 1 are considered, corresponding to the bent-over process; in the part ‘a’ the initial proposal where the sheet is drawn in blue and all mechanical elements shown in black.

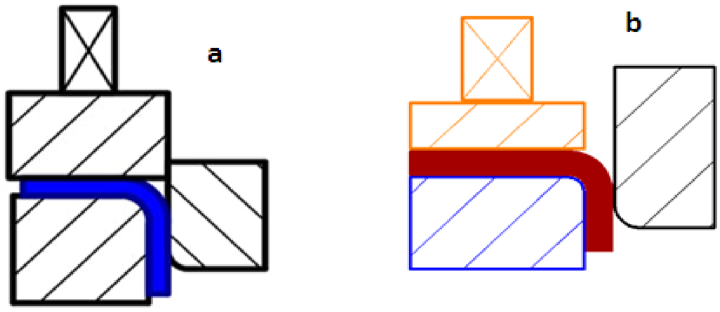


Figure 1: Symbols for the push bending processing a) initial proposal b) improved symbol

The manual of metal fabrication methods [5], recommends a methodology for manufacturing analysis where it establishes concepts such as process, phase, subphase, operation, starting surface, reference surface; which are related to the areas of work, number of tools for manufacturing, focused on parts machined by chip removal.

For this proposal, the concept of operation is recovered, which is the work executed without disassembling the piece and without changing the tool.

In Table 1, as mentioned, the symbols for basic cutting and punching process are presented. Next the symbol is shown, a photo of the process and in the last column a brief description of it.

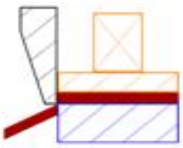
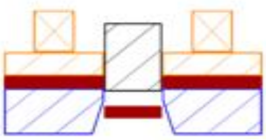
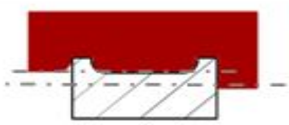
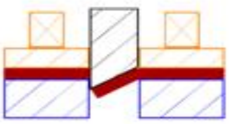
DIE PROCESS	SYMBOL	EXAMPLE	DESCRIPTION
Sheared			The shearing is not properly a punching, rather it is a simple cut of sheet in a straight line, it does not require a matrix. It is made by cutting blades that separate or divide the sheet into strips for further processing (obviously later stamping).
Punching			Considered the simplest of the processes of die-cutting, they are made with punch and matrix (female-male) where the punch fits in a matrix and the sheet is shaped with the figure of these two elements.
Cut-Punching (Advance blade)			In this process of punching, the sheet is formed with a part of the silhouette of the punch and matrix, which reduces the width of the sheet strip useful in progressive dies.
Chiseling			This is an "incomplete" punching because it does not separate the silhouette or shape of the punch. As can be seen in the photograph, the cut was made only on a line that is separated from the plane of the sheet and the other part is stretched by the action of the punch that does not completely penetrate the matrix.

Table 1: Cutting and punching process

Table 2 specifies the symbology for the specific bending phases. Follow the same sequence as for table 1, in the first column the symbol proposed for the specific bending process, followed by a photograph, and the last column, a brief description of the mechanical elements necessary to achieve the conformed of said bending process.

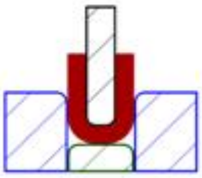
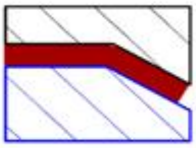
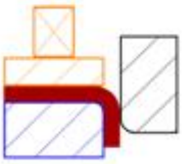
DIE PROCESS	SYMBOL	EXAMPLE	DESCRIPTION
Bendin "V"			Use a punch and mold pressing the sheet between them, obtaining the angle of the mold in the sheet. It should be anticipated that there will be an elastic recovery, and that the angle between mold and punch should be less than the desired in the sheet.
Bendin "U"			The punch pushes the sheet making two folds forming a "U". The punch pushes and the sheet are contained (and forced to bend) by a mold, whose separation is twice the thickness of the sheet plus the width of the punch. When the punch returns (rises), the elastic recovery sheet will remain contained in the mold, so an element that pushes up the bent sheet is required.
Bend by sliding			For this bend the punch pushes the sheet until it is pressed against the matrix, here it is also required to consider the elastic recovery of the sheet. As the punch goes down the blade slides on it.
Bend by pushing			Before starting the bend, the piece is held by an element called presser (yellow), then the punch pushes the sheet to achieve the bend which usually forms a 90 ° angle in the sheet, however, the elastic recovery allows get folds with half a degree and up to two degrees more.

Table 2: Bending process

II. Part to Die Analysis

2.1 Piece Description

In Fig. 2, the piece, named "support" is shown, from which the die processes necessary to manufacture it will be discriminated. In the figure is mounted on the support that will hold it, both parts are part of a refrigerator, which hold the tray where carbonated drinks (sodas) are placed.

Figure 2: "Support" piece mounted on its column

2.2 Piece Analysis

It is recommended that initially three views, frontal, lateral and superior of the piece be reviewed, in addition to an isometric perspective; which is presented in Fig 3. By simple observation the student must be estimateddie process which are used in each of the shapes, contours and elevationswere necessary for their manufacture. If the piece has not yet been manufactured, the photos will be exchanged for the same views of the drawing of the piece that is desired or needs to be formed for a need from sheet metal workparts.

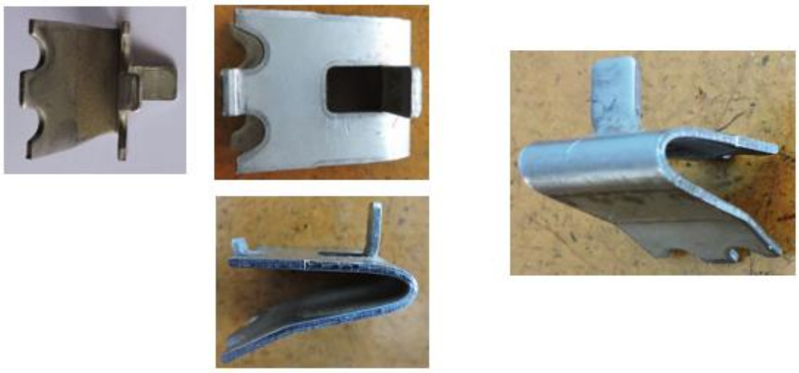


Figure 3: Front, side and top views of the piece

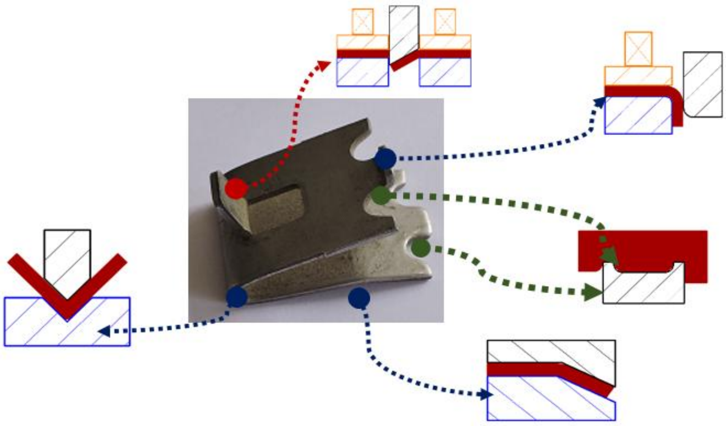


Figure 4: Piece where the die processes required for its manufacture are indicated

In figure 4, five different processes are identified, indicating with some of the symbols of tables 1 and 2, which are: chiseling, punching by advancing or external forming blade, bending by pushing, bending by sliding and bending in ‘V’.

The case of ‘V’ bending requires a deeper analysis since it cannot be done in the traditional way: punch-mold in "V", in a progressive die for the shape of the workpiece, see figure 5.

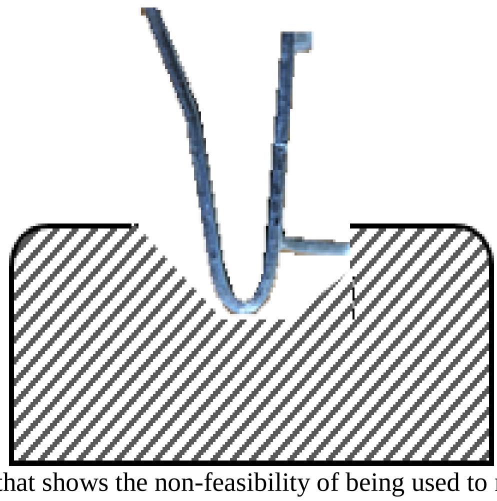


Figure 5: Folded in ‘V’ that shows the non-feasibility of being used to manufacture the "staple".

With this methodology, it is intended that the inexperienced designer of progressive dies, can visualize the mechanical elements, punches, dies, fasteners, which are necessary in the progression of the sequence of operations.

In another work presented in the same congress the steps that were followed for the design and selection of materials of the punches and molds, their thermal treatment, as well as the mechanisms used to obtain the bend in 'V' that are here presents and the way in which the piece is obtained in a progressive die which is already in operation.

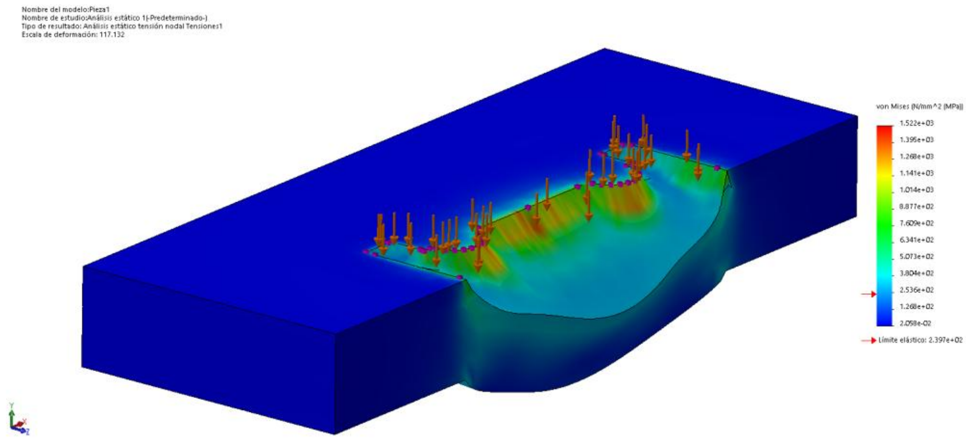


Figure 6: Fracture of the sheet.

III. Conclusions

The presented methodology facilitates the analysis of parts that can be manufactured by die processes, since it allows to visualize the disposition of the necessary elements to make a punching or bending, especially when it is necessary to manufacture pieces using a progressive die.

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