

Design proposal for a progressive die**Propuesta de diseño de un troquel progresivo**

TUDÓN-MARTÍNEZ, Alberto†*, ZÚÑIGA-MARTÍNEZ, Marco Antonio, GARCÍA-CASTILLO, Ilse Nallely and ROSALES-GALLEGOS, Israel Atzin

Universidad Tecnológica de San Luis Potosí, Prol. Av. Dr. Arturo Nava Jaimes, Rancho Nuevo, Soledad de Graciano Sánchez, S. L. P.

ID 1st Author: *Alberto, Tudón-Martínez* / ORC ID: 0000-0003-1689-1250, CVU CONACYT ID: 411753

ID 1st Co-author: *Marco Antonio, Zúñiga- Martínez* / ORC ID: 0000-0003-2736-9177, CVU CONACYT ID: 94933

ID 2nd Co-author: *Ilse Nallely García-Castillo* / ORC ID: 0000-0001-9602-2869, arXiv Author ID: IlseGarcia, CVU CONACYT ID: 668657

ID 3rd Co-author: *Israel Atzin, Rosales-Gallegos* / ORC ID: 0000-0003-1485-9601, Researcher ID Thomson: AAR-7809-2021, CVU CONACYT ID: 372002

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Abstract

The objective of this project is to elaborate a design proposal for a progressive die to help reduce the manufacturing cycle time of a metal part in a die-cutting machine and contribute to increasing the number of parts produced. The methodology used to prepare the progressive die design proposal is concurrent engineering, also known as simultaneous engineering or total engineering; it consists of a methodology where the design of the product is integrated into all the necessary processes to manufacture it. (F, 2003); It is the guide of each one of the phases that have been set in the design, such as conceptual and functional design and retail design; all this in order to take into account the requirements, parts, functions, manufacturing and construction to materialize the ideas that are proposed in this.

Proposal, Design, Machine**Resumen**

El objetivo del presente proyecto es la elaboración de una propuesta de diseño de un troquel progresivo para contribuir a reducir el tiempo de ciclo de fabricación de una pieza metálica en una máquina de troquelado y contribuir al incremento del número de piezas producidas. La metodología que se utiliza para la elaboración de la propuesta de diseño del troquel progresivo es la ingeniería concurrente, también conocida como ingeniería simultánea o ingeniería total; consiste en una metodología donde el diseño del producto está integrado en todos los procesos necesarios para fabricarlo. (F, 2003); es la guía en cada una de las fases que se han fijado en el diseño, como lo son el diseño conceptual y funcional y diseño de detalle; todo esto con el fin de que se tengan en cuenta los requerimientos, piezas, funciones, fabricación y la construcción para materializar las ideas que en este se proponen.

Propuesta, Diseño, Máquina

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*Correspondence to the Author (e-mail: atudon@utslp.edu.mx)

† Researcher contributing as first author.

Introduction

There is a constant need for companies to continuously improve production processes and develop products that meet customer needs in terms of service, cost and delivery.

A company dedicated to the manufacturing sector has the need to make improvements in the production process, because in recent years the demand for its products by its customers has increased. The manufacturing process that it uses consists of several operations that are carried out independently in several die-cutting machines to bend and cut, consuming long times in the elaboration of metal parts, for this reason it is considered necessary to make improvements in the production process.

The hypothesis of the project is that by carrying out the necessary operations for the elaboration of the metal part with a single die, the cycle time will be reduced, since it will not be necessary to carry out die changes to carry out each operation that is required in the process of manufacture of the piece, in this way it will contribute to time reduction for elaboration of the piece and contribute to the increasement of production keeping the company in a competitive market.

Development of Sections and Sections of the Article with subsequent numbering.

In the die design methodology, the reference of the engineering design process is considered (Victorino, 2003), which contemplates the stages shown in Figure 1.

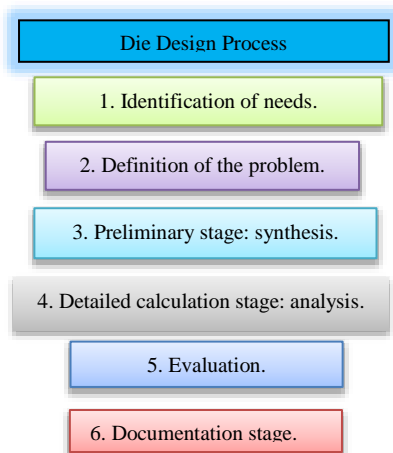


Figure 1 Design methodology
Source (project contribution, unpublished)

1. Identification of needs

A list of specifications is drawn up in a concise and not so extensive way, which is presented in table 1, where a sketch of only two of the machine concepts is shown in one format (Riba, 2006)], in where the specifications are: for design C: Customer; I: Engineer; A: Required; D: Desired

Universidad Tecnológica de San Luis Potosí		Date:		Product: Design of a die for the manufacture of part 317B8422P002	
Business:		Revision:			
Initial specifications					
Concept	C/I	R/D	Description		
Function	I	R	Reliable for implementation and reduction of production times.		
	I	R	Consume fewer resources		
	I	D	Produce the part in a shorter time than the current process.		
Necessary operations	I	R	Carry out the cut of the piece with the same die.		
	I	D	Reduce cycle time by 50%		
	I	R	Use only one press		
	I	R	Produce one part for each die stroke		
Precision	I	R	The first precision inspection is done with materials, dimensions and cycle times.		

Table 1 Machine concepts
Source (project contribution, unpublished)

2. Definition of the problem

It is important to consider the main characteristics of the part to be manufactured, which are determined at this stage, such as material, tolerances, in addition to the required production.

1. Material: galvanized steel B8A26G5 0.060" +/- 0.002" [1.524 +/- 0.051].
2. All holes in the part should have a tolerance of + 0.001" - 0.003" [+0.025 - 0.076]
3. Annual production 90,000 pieces.

3. Preliminary stage: synthesis

The part to be manufactured is analyzed to determine the necessary operations for the manufacture of the part, which are considered to define the types of elements that the progressive die must contain and be able to satisfy the client's needs.

In this analysis, three types of operations will be determined, which are: Planes (P), Punching (PZ) and bends (D), which are shown in Figure 2.

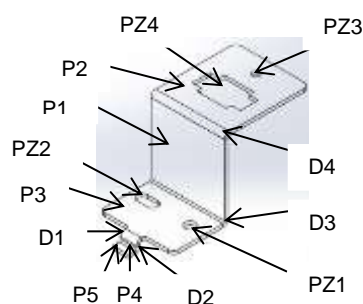


Figure 2 Necessary operations.
Source (project contribution, unpublished)

Table 2 shows the components nomenclature of the part, which are defined according to each element of the part.

Elements	Nomenclature	
Planes	P1	Intermediate plane
	P2	Upper horizontal plane
	P3	Lower horizontal plane
	P4	Lower vertical plane located at P3
	P5	Lower horizontal plane located at P3
Punching	PZ1	Punching located at P3
	PZ2	Punching located at P3
	PZ3	Punching located in the P2
	PZ4	Punching located in the P2
Folds	D1	Fold linking P4 and P5
	D2	Fold linking P4 and P3
	D3	Fold linking P1 and P3
	D4	Fold linking P1 and P4

Table 2 Nomenclature of the components of the part
Source (project contribution, unpublished)

Elaboration of a relational diagram of the support, which is shown in figure 3, with the main elements of the piece used to visualize the number of necessary operations in the die design.

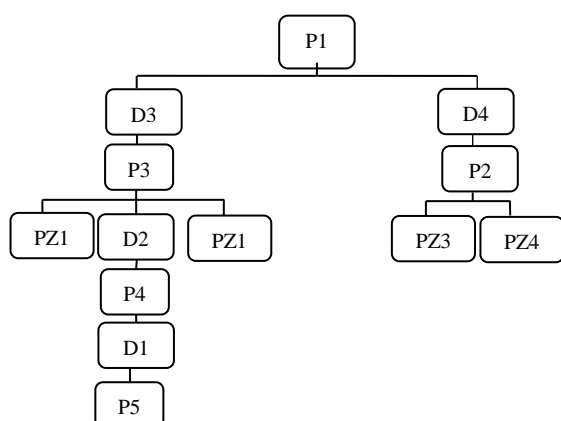


Figure 3 Relational diagram of the support.
Source (project contribution, unpublished)

Figure 4 shows the steps in a schematic form of the strip of material required to obtain the product, the steps indicated are related to the operations diagram. (Enrique, 2013)

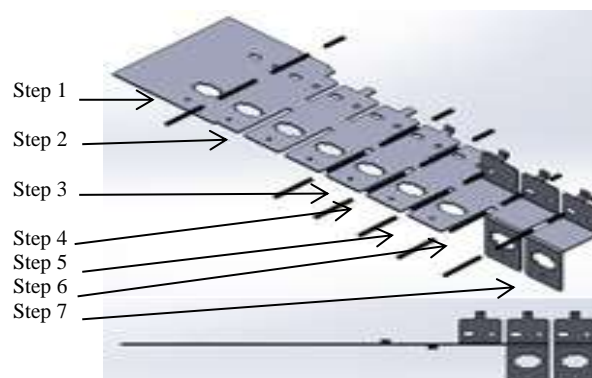


Figure 4 Steps in schematic form
Source (project contribution, unpublished)

4. Detailed calculation stage: analysis

In this stage, the element's shear and extraction force calculations are made, using the following equations:

For the calculation of shear force, equation 1 was used.

$$F = (S)(t)(K) \tag{1}$$

And for the calculation of the extraction force of the element, equation 2 is used (Eugene A. Avallone, 2008)

$$F_a = (F)(0.8) \tag{2}$$

Table 3 shows the results of the calculations of the forces of the planes elements operations.

Force calculations in planes		
Elements	Results	
	Cutting force (Kg.)	Extraction force (Kg.)
P1	3441.28	275.302
P2, P3, P4, P5	21932.7984	1754.623872

Table 3 Results of the calculation of the force of the planes
Source (project contribution, unpublished)

Table 4 shows the results of the calculations of the forces of the punching elements operations.

Punching force calculations		
Elements	Resultados	
	Cutting force (Kg.)	Extraction force (Kg.)
PZ1	1219.2	97.536
PZ2	1993.4	159.472
PZ3	851.154	68.09232
PZ4	5600.7	448.056

Table 4 Results of calculations of punching forces.
Source (project contribution, unpublished)

Equation 3 is used to calculate the force necessary to make the "L" bends.

$$P = \frac{(t)(K)(length)}{3} \tag{3}$$

And for the calculation of the extraction force of the element, equation 2 is used.

Table 5 shows the results of the calculations of the bending forces operations.

"L" Bend Force Calculations		
Elements	Results	
	Bending force (Kg.)	Extraction force (Kg.)
D1	193.548	15.48384
D2	193.548	15.48384
D3	903.224	72.25792
D4	903.224	72.25792

Table 5 Results of calculations of bending forces
Source (project contribution, unpublished)

The calculation of the total force is carried out using equation 4, which is the sum of all the punching, bending and planes.

$$F_{Total} = \sum_1^4 PZ + \sum_1^4 D + \sum_1^5 P \tag{4}$$

$F_{Total} = 37232.0764 \text{Kg.}$

An additional factor of 10% is increased; this percentage is an experimental value to overcome the resistance of the springs and the clamp.

Once the add factor is added, a safety factor of 1 to 5 recommended by some designers is also added.

Then:

$$F_{final} = 37232.0764 \text{ kg} (0.1) + 37232.0764 \text{ kg} = 40955.28404 \text{ kg} (1.2) = 49146.3408 \text{ kg.}$$

$F_{final} = 49 \text{ tons.}$

According to the total value of the forces, a press greater than 49 tons should be used

The calculation of the number of springs required for the extraction force is carried out.

In calculating the number of springs, equation 5 is used.

$$N_r = \frac{F_a}{F_r} \tag{5}$$

For the Fa Total calculation, equation 6 is used, where the sum of all extraction forces, both for punching, as well as for bends and planes, are considered.

$$F_{a\ Total} = \sum_1^4 PZ + \sum_1^4 D + \sum_1^5 P \tag{6}$$

$$F_{a\ Total} = 2.9 \text{ ton} \approx 3 \text{ ton} = 3000 \text{ Kg}$$

Springs

The characteristics of the spring to be used are established, which are:

- Spring outer diameter = 1.240"
- Rod diameter = 0.625"
- Free height = 3"
- Maximum load = 1027 lb = 465.75 Kg

Substituting the values of the total extraction force and the maximum spring load in equation 5, the number of springs to be used is obtained.

$$N_r = 6 \text{ springs.}$$

Elaboration of drawings

Shop drawings and die part simulations are made using Solid Works software. (Gómez, 2014), which are shown in figures 5, 6, and 7.

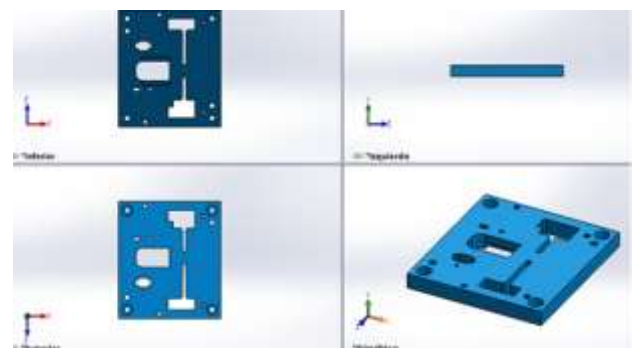


Figure 5 Cutting matrix.
Source (project contribution, unpublished)

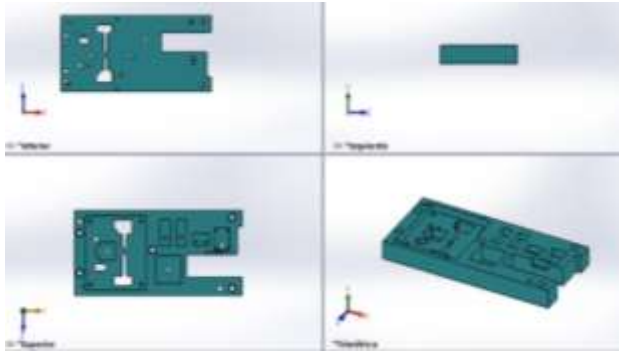


Figure 6 Lower Suffering.
Source (project contribution, unpublished)

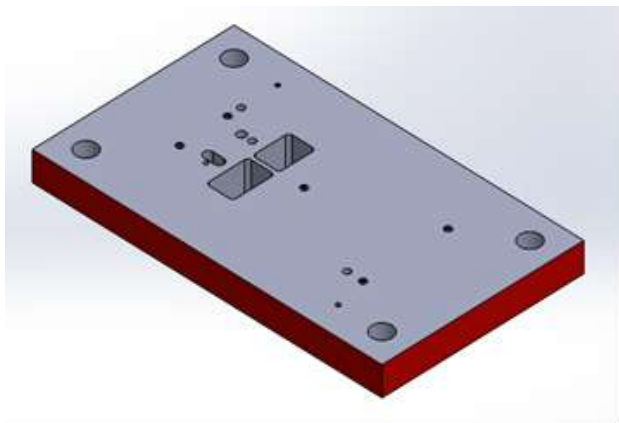


Figure 7 Lower die platen
Source (project contribution, unpublished)

5. Evaluation Stage

This stage is based on the dimensional part, for which a verification of its operation of the die was carried out in order to review possible interferences, part positioning errors or incorrect clearances.

This evaluation is carried out by preparing the assembly drawing in the Solid works simulator, which is shown in figure 8, performing the opening and closing of the die, executing the interference analysis between the elements that make up the die.

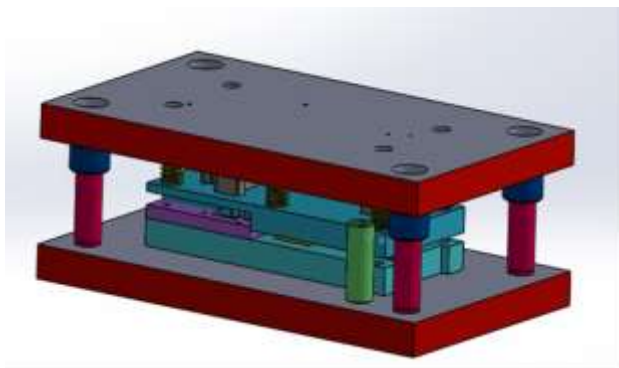


Figure 8 Complete assembly of the progressive die
Source (project contribution, unpublished)

6. Documentation stage

Documentation is developed that identifies the main operating characteristics of the progressive die and the workpiece.

1. Tooling ID: L1221
2. Part No.: 317B8422P001
3. Die free height: 9.125"
4. Width and length of the tooling: 26" x 15"
5. Minimum working load: 49 tons.
6. Material: Galvanized Steel.
7. Material thickness: 0.060"
8. Material width: 4.565"
9. Plumb: 0.050"

Results

With this project, the objective of developing a proposal for the design of a progressive die was achieved, for the elaboration of a metallic piece (with the part number 317B8422P002), with this proposal it is intended to eliminate a cost of 99.1% of the cutting process in laser and avoid the use of more than one press for the elaboration of the bends, at the same time reducing to 90.6% of the time to obtain the first piece within the specifications of the client.

Conclusions

It is concluded that it was necessary to prepare this project, which will be possible to satisfy the needs established by the company such as:

1. Design a die with the necessary elements for the part process.
2. The general dimensions of the die will allow it to be installed in a 250-ton press existing in the company.
3. When the die is manufactured, more than 90% of the resources currently used to manufacture the part will be eliminated.
4. The design of the die includes limiting stop systems for fine tuning.
5. With the elaboration of the data sheet a good functioning and optimal operation of the die is guaranteed.

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