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Article

Design and manufacture of a vise

Diseño y manufactura de una prensa de banco

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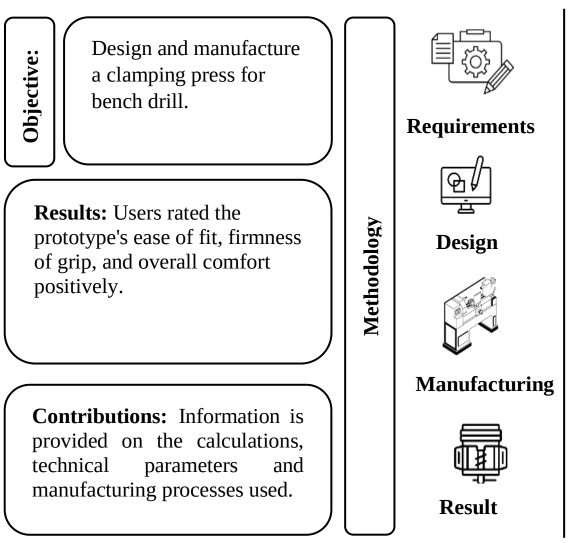
Abstract

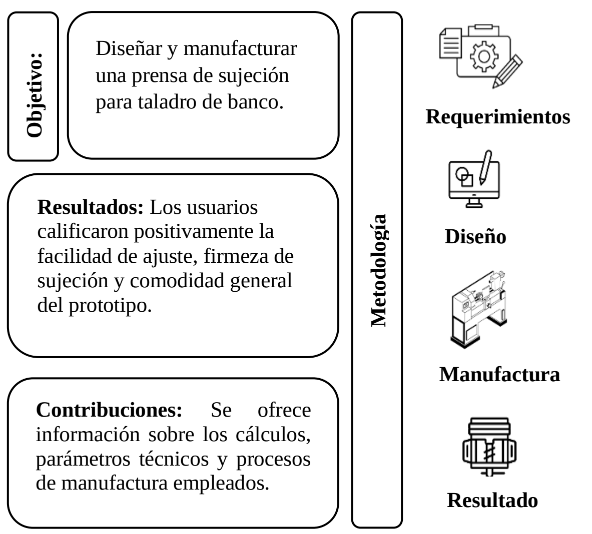
In this project, the design and manufacturing of a clamping vise is carried out, applying the knowledge acquired in key areas such as machine design, machine elements, and manufacturing processes. The objective is to meet the functional requirements of a drill press vise, ensuring its efficiency and durability. This work describes in detail the parameters and calculations used for the fabrication of the vise, which will be made from A36 steel. This material was selected due to its excellent mechanical properties, which provide significant improvements to the final design. Additionally, this material was chosen because part of the available supplies which were donated for the project, are composed of the same type of steel. Various manufacturing and assembly processes were employed for the fabrication of the different parts of the vise, such as turning, milling, drilling, threading with a tap, and electric arc welding. These processes not only allowed for the proper assembly of the vise but also provided the opportunity to gain a deeper understanding of the working parameters that depend on the specific characteristics of the material. Based on the calculations and technical parameters identified during the project, the production cost of the prototype was estimated. The final design of the vise consists of seven main parts: movable jaw, fixed jaw, spindle, guide cylinder, body, and base.



Movable jaw, Fixed jaw, Press base

Resumen

En este proyecto se lleva a cabo el diseño y manufactura de una prensa de sujeción, aplicando los conocimientos adquiridos en áreas clave como el diseño de máquinas, elementos de máquina y procesos de manufactura. El objetivo es cumplir con los requerimientos funcionales de una prensa para taladro de banco, garantizando su eficiencia y durabilidad. Este trabajo describe detalladamente los parámetros y cálculos utilizados para la fabricación de la prensa, la cual estará construida en acero A36. Este material fue seleccionado debido a sus excelentes propiedades mecánicas, las cuales aportan mejoras significativas al diseño final. Además, se optó por este material ya que parte de los insumos disponibles, fueron donados para el proyecto y están compuestos por el mismo tipo de acero. Para la fabricación de las distintas piezas de la prensa se emplearon diversos procesos de manufactura y ensamblaje, tales como el torneado, fresado, taladrado, roscado con machuelo y soldadura por arco eléctrico. Estos procedimientos no solo permitieron llevar a cabo el ensamblaje adecuado de la prensa, sino que también proporcionaron la oportunidad de comprender en profundidad los parámetros de trabajo que dependen de las características específicas del material. Basándonos en los cálculos y parámetros técnicos identificados durante el proyecto, se estimó el costo de producción del prototipo. El diseño final de la prensa está compuesto por siete piezas principales: mordaza móvil, mordaza fija, husillo, cilindro guía, cuerpo y base.



Mordaza móvil, Mordaza fija, Base de prensa

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Introduction

A vise is a general purpose clamping tool that has two jaws, which clamp the workpiece in proper position (Syahputri et al., 2021). This device is used to achieve greater fixity in the positioning of the workpiece with respect to the operation of the machine (vise).

In 1925 Josef Hever developed the forged steel vise. This press model (Hever) is known and proven all over the world. The mechanism of a vice is very similar to that of a screw and a nut. If a nut (guide cylinder) is held fixed, turning the crank rotates the screw (spindle), which generates pressure by moving the movable jaw against the fixed jaw (Budynas & Nisbett, 2015). The parts that usually break are the fixed and movable jaw supports, as well as the connector between the power screw supports (Al-Bahkali & Abbas, 2018). The clamping press we often see uses human force, which becomes a problem due to the efficiency in terms of time, energy and of course money (Badruzzaman et al., 2021); however in our case this is not important, for the time being.

In designing the prototype of a bench press, it was considered for the benefit and use of students and collaborators, who perform different manufacturing activities within the university workshops. Within the processes of drilling and cutting to mention a few, a clamping press is always very useful and provides greater safety during the operation of the equipment, facilitating the work to be carried out.

In this project, the aim is to design and manufacture a column drill press, by analysing the different types of presses that exist on the market. A design will be used to determine which of all the different types of models is most suitable for our particular needs. The design based on these characteristics allows us to determine the following: A construction that is feasible and simple, Reduced input costs, A prototype that is versatile and replaceable parts (Groover, 2014).

Figure 1 shows the different elements that make up a bench press, which are as follows (Sitepu et al., 2020):

- Movable clamp.
- Fixed clamp.
- Crank handle.
- Spindle.
- Guide.
- Base.
- Spindle nut.

Box 1

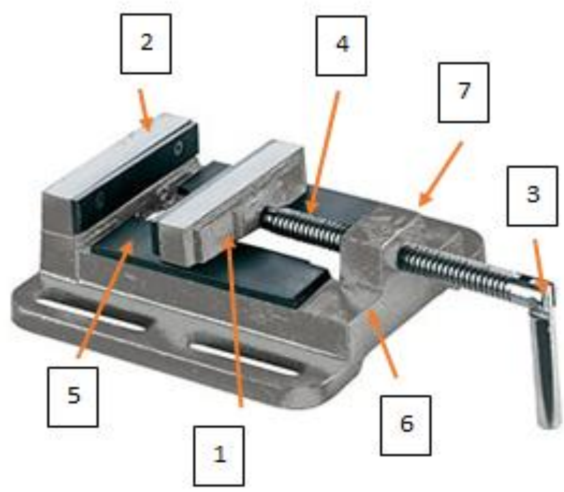

Figure 1
Elements of a column drill press

The central problem addressed by this project is to address the lack of budget for the procurement of auxiliary equipment such as these fixtures needed in shop-floor manufacturing processes. Design for Manufacturing (DFM) is a holistic approach that integrates the design process with production methods, materials, process planning, assembly, testing and quality assurance (Kalpakjian & Schmid, 2006).

The central hypothesis of this work is that a mechanical engineering student is capable of manufacturing a fastening device by employing their knowledge and demonstrating their skills through the use of existing equipment and tools.

Material to be manufactured

The processing material is A36 steel, as the materials donated for this project are made of this material. The processing materials are profile materials: Angle, C-beam, solid cylinder and sill.

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An important aspect to take into account is machinability, which is related to the ease with which a material can be machined to a good surface finish with a reasonable tool life (Mott et al., 2005).

This A36 material is considered a good choice because of its mechanical properties and also because of background information. Normally presses are made from cast steels in forging processes, however, for this project A36 steel will be worked with a different manufacturing process (machining).

Methodology

For the realisation of this prototype, a combination of theoretical-practical approaches was used; therefore, the steps to be followed were established in a simplified way and are shown in figure 2.

Box 2

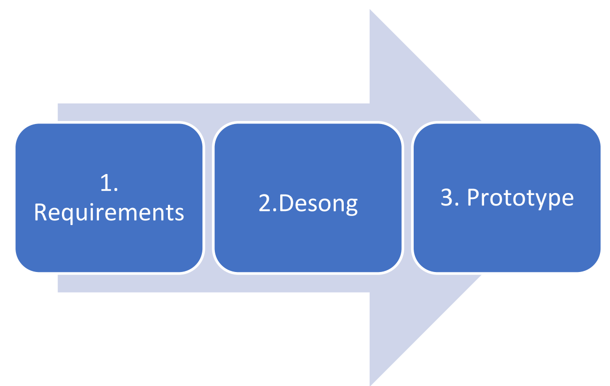

Figure 2
Flowchart for the methodology

1. Requirements

Bench press features required are: That the mounting base be compatible with the drill hole pattern of the bench drill, manually operated by means of a worm gear, having the capacity to clamp materials such as steel and aluminium.

2. Design

A hand sketch and a design in SolidWorks software is established from the geometry of the materials to be produced. See Figure 3 and Figure 4.

Box 3

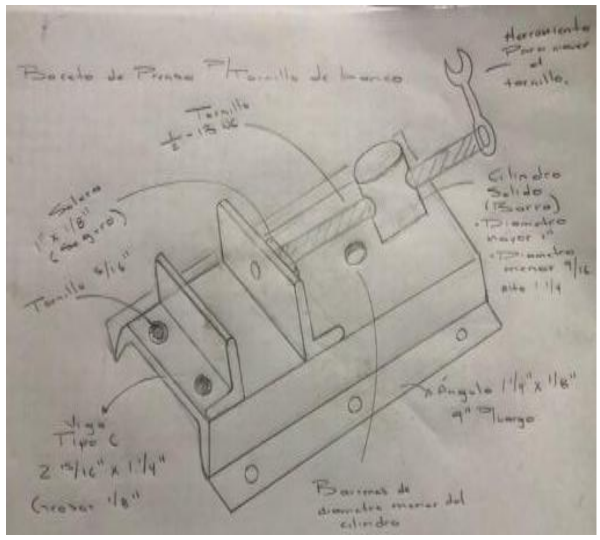

Figure 3
Hand sketch of the proposed design

Box 4

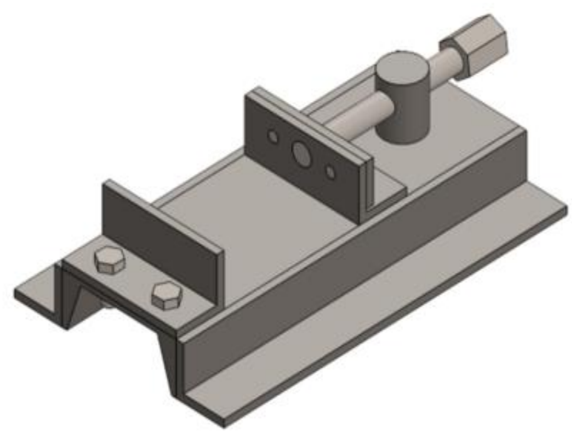

Figure 4
SolidWorks design

3. Prototype and its manufacture

Based on the plans generated in SolidWorks and the geometry of the materials to be manufactured and the experience itself, the necessary manufacturing processes are established for each of the parts, as shown in figure 5.

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Box 5

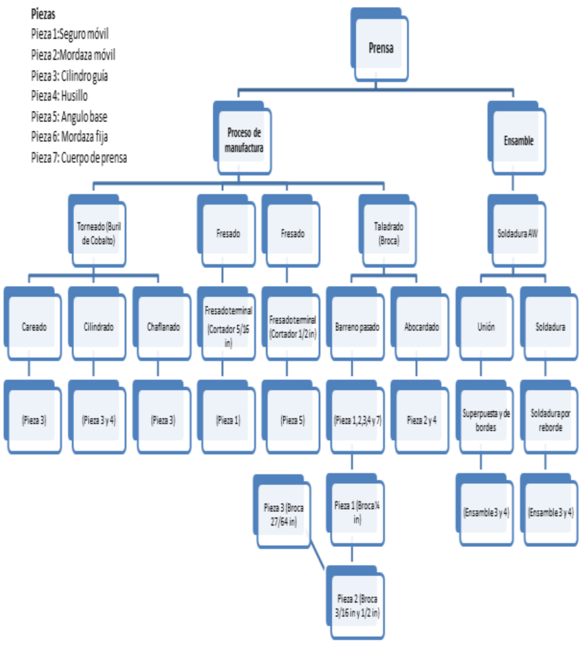

Figure 5
Diagram of parts manufacturing process

Table 1 shows the formulae used to adjust the cutting and feed parameters in the machining of the parts, both for those manufactured on the lathe and on the conventional milling machine. (Oberg et al., 2004).

Box 6

Table 1
Calculations and parameters on Lathe and Milling Machine

Lathe Calculations	Milling machine calculations
Rotational speed $N = \frac{v}{\pi D_o}$	Cutting speed. $N = \frac{v}{\pi D}$
Forward speed. $f_r = Nf$	Forward speed. $f_r = Nn_t f$
Machining time. $T_m = \frac{L}{f * N}$	Machining time. $T_m = \frac{L + A}{f_r}$
Material removal rate. $R_{MR} = vfd$	Material removal rate. $R_{MR} = wf_r d$
Electrical power $P = \frac{R_{MR} * k_C}{60000 * n}$	Electrical power $P = \frac{R_{MR} * k_C}{60000 * n}$

For machine power requirements (horsepower or kilowatts). It is often necessary to know the power requirements of the machine for a particular feed, speed and intended depth of cut for a particular material or class of materials to see if the machine is capable of maintaining the desired production rate (Walsh, 2001).

Properly determining the cutting parameters results in a part with better dimensional accuracy, surface finish, helps extend tool life and allows the process to be more efficient by reducing manufacturing costs (Walsh, 2001).

Box 7

Figure 6
Part 1) Movable locking device - Drilling and milling

Figure 6 shows the manufacture of part 1, showing the clamping of the part in a conventional milling machine and the movement of the cutting tool, as well as the drilling operation.

Box 8

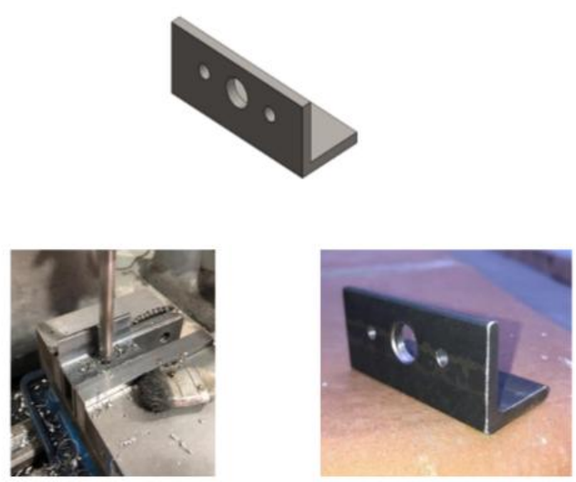

Figure 7
Part 2) Movable clamp - Drilling

In figure 7 we can see the piece clamped to make the holes of the mobile clamp.

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Box 9

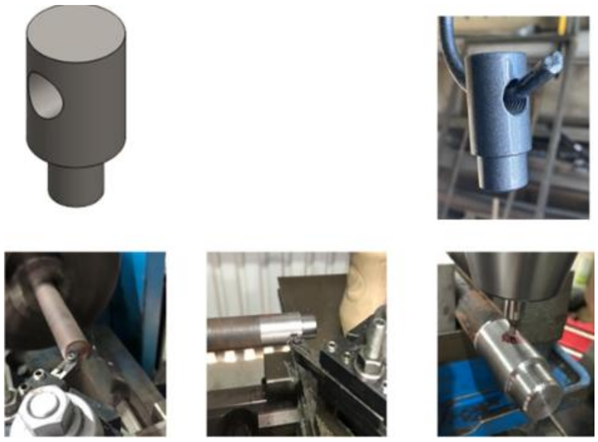

Figure 8
Part 3) Guide Cylinder-Turned, Drilled, Bored

Figure 8 shows the machining of a guide cylinder on a conventional lathe, as well as the bore that will serve as a support for tightening.

Box 10

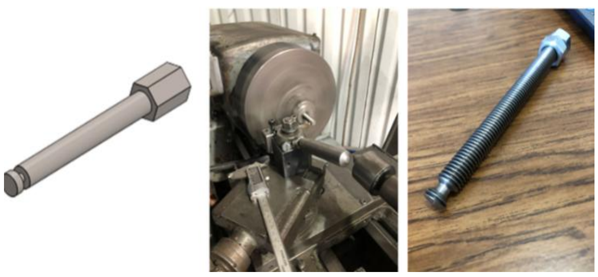

Figure 9
Part 4) Spindle-Screw

Figure 9 shows the manufacture of the spindle on a conventional lathe with its respective chord.

Box 11

Figure 10
Part 5) Base angle- Milling

Figure 10 shows the cutting of the slots in the base that will be used to hold the press, this operation is carried out on a conventional milling machine.

Box 12

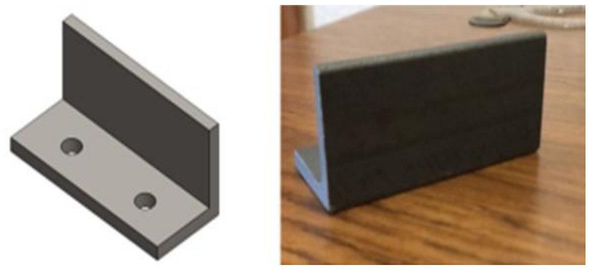

Figure 11
Part 6) Fixed clamp

Box 13

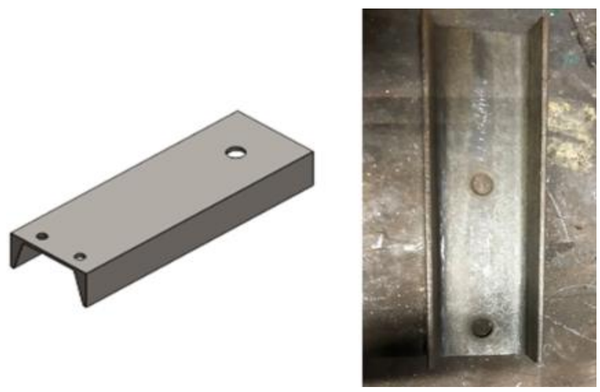

Figure 12
Part 7) Press body

Finally, figures 11 and 12 show the fixed clamp and the press body, which have already been cut to the required dimensions.

Results

Figure 13 shows the results of the design and manufacture of a press for a vertical drill. The press was evaluated in terms of clamping accuracy, ease of use and ability to clamp parts of different dimensions.

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Box 14

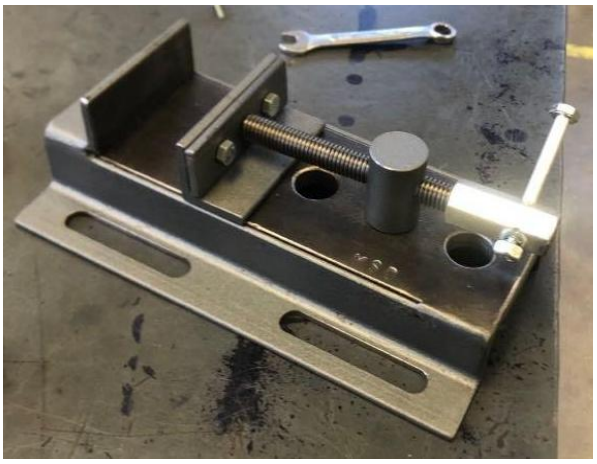

Figure 13
Finished press

During the clamping tests, a misalignment of approximately 0.02 mm was observed. The ease of use of the device was evaluated by means of a questionnaire applied to 5 students, who rated aspects such as ease of adjustment, firmness of grip and general comfort on a scale of 1 to 5 (1 Very dissatisfied, 2 Dissatisfied, 3 Neutral, 4 Satisfied, 5 Very satisfied), a summary of the results obtained can be seen in table 2.

Box 15

Table 2
Usability test results

Operator	1	2	3	4	5
How easy do you find it to adjust the movable clamp of the press?	5	4	5	5	5
How firm does the clamping of the workpiece feel when it is fully tightened in the press?	5	4	5	4	5
How comfortable do you find using the press during machining operations?	4	4	5	5	5

Conclusions

Once the manufacturing process of the prototype was finished, the desired results were obtained by verifying the calculations and finishing the assembly process. Based on the above, it can be concluded that the design and manufacturing proposal of the press was the most suitable for designing and manufacturing an A36 prototype. Based on the prototype obtained, it can be said that the press does fulfil the objective of holding parts firmly in order to carry out specific jobs in the bench drill.

The prototype of the press provides fast and high clamping of workpieces, and the base angles make it possible to easily clamp the prepared press in the vise. All this satisfies the need to clamp small parts to be drilled in the blacksmith's workshop, making the work efficient and the design feasible.

Design

The proposed design of the three holes is convenient when clamping the workpieces, as it eliminates the stroke to be travelled when turning the spindle.

Material

The choice of material for the press was initially considered for its resistance and variant properties for the best in toughness, the material used is an example of a good material to develop a press of this type, this is because it supports the pressure exerted by the spindle in the jaws, the selected material has an extensive research to determine their uses and working conditions allowing to consider it an excellent choice for use in the project or to perform the proposed manufacturing processes.

Manufacturing process

The manufacturing process allows a determined view of the different characteristics involved in the realisation of a project based on the design, it is important to have the drawings of the parts, calculations and parameters to do a good job when making use of the machine tools. It is also important to have a work order, as on some occasions manufacturing processes had to be repeated on the parts due to not considering tolerances in the machining processes. In order to be able to complement a quality work process, it is necessary to have well-defined plans for the dimensions of each part, since with this technique a correct assembly can be obtained at the end of the manufacturing processes, as well as taking into account that in all manufacturing processes there are tolerances that can slightly alter the dimensions of our machined parts. The comparison of costs in the project was also analysed to determine different processes to produce this type of press that can reduce costs by a greater amount if the project is to be retaken by evolving the design.

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Future work recommends further testing under extreme conditions and with different types of working materials to evaluate the performance and versatility of the press in a wide range of applications, as well as using the press in industrial environments to obtain additional feedback from users and make adjustments based on practical use and specific industry needs.

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have influenced the article reported in this paper.

Authors' contribution

The contribution of each researcher in each of the points developed in this research was defined on the basis of:

Delgado Hernández Alberto: Contributed to the project idea, research method and technique. He supported the design of the manufacturing process as well as writing the article.

González Vizcarra Benjamín: Conducted the background for the state of the art. He also contributed to the writing of the article.

Siqueiros Hernández Miriam: Contributed to the research design, the type of research, the approach, the method and the writing of the article.

Ana María Castañeda: Worked on the application of safety standards during manufacturing processes. She also worked on the writing of the article.

Availability of Data and Materials

The materials used for the development of the bench press prototype were A36 steel profiles, donated for the realisation of the project. The profiles used included angles, C-beams, solid cylinders and sills.

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