Article **Journal of Technological Development**
December, 2023 Vol.7 No.20 1-4

Design of a clamping device with 4 jaws for a milling machine

Diseño de fixture de 4 mordazas para fresadora

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DOI: 10.35429/JTD.2023.20.7.1.4 Received July 26, 2023; Accepted December 10, 2023

Abstract

The Unidad Profesional Interdisciplinaria de Ingeniería Campus Guanajuato is the institution where this project will be carried out, specifically in the Conventional Machinery Workshop located in the Pesados 1 building. The UPIIG belongs to the educational sector and its objective is to train competent professionals with integral preparation and specific competencies in the handling of tools and procedures involved in manufacturing. Therefore, this project proposes the design of a tooling for the milling machine that allows centering and facilitates the handling of parts during assembly. On the other hand, the tooling will have four jaws that improve the stability of the part when it is under stress during the manufacturing process. In this article, the 3D models of the tool and the details of each component of the tool are developed using CAD and FEM software. The simulation results show the behavior of the mechanical stability of the tool when it is subjected to axial load during its use considering two different materials: tool steel and A-36 tempered.

Tooling, Construction plans, Process leaves, Stress distribution, Strain distribution

Resumen

La Unidad Profesional Interdisciplinaria de Ingeniería Campus Guanajuato es la institución donde se realizará este proyecto, específicamente en el Taller de Máquinas Convencionales que se ubica en el Edificio de Pesados 1. La UPIIG pertenece al sector educativo y tiene como objetivo la formación de profesionales competentes con una preparación integral y competencias específicas en el manejo de herramentales y procedimientos involucrados durante la manufactura. Por lo que, este proyecto propone el diseño de un herramental para la máquina fresadora que permita centrar y facilitar la manipulación de las piezas en el montaje. Por otra parte, el herramental contará con cuatro mordazas que mejoran la estabilidad de la pieza al momento de someterla a las cargas que se crean durante el proceso de manufactura. En este artículo se desarrollan los modelos 3D del herramental y el detalle de cada componente de este, a través de software CAD y FEM. Los resultados de la simulación muestran el comportamiento de la estabilidad mecánica del herramental cuando se somete a una carga axial durante su uso considerando dos materiales diferentes: acero herramental y A-36-Templado.

Herramental, Planos, Hojas de Proceso, Distribución de esfuerzos, Distribución de deformaciones

Citation: MARTÍNEZ-JIRICNY, Alan, RODRÍGUEZ-DAHMLOW, Jesús Ernesto, MENDOZA-MIRANDA, Juan Manuel and PEREZ-GONZALEZ, Edgar Ernesto. Design of a clamping device with 4 jaws for a milling machine. Journal of Technological Development. 2023. 7-20: 1-4

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December, 2023 Vol.7 No.20 1-4

Introduction

The milling machine (Figure 1a) is a machining device that uses the movement of a rotating tool to machine various materials, from wood to metal. Figure 1b shows examples of parts and operations performed with a milling machine, where it is possible to create from holes to specific shapes or reliefs. However, during the milling process, it is necessary that the part to be machined is clamped to avoid movement, which is achieved by adapting different tools on the workbench or work table. Currently, the Conventional Machines Laboratory of the UPIIG-IPN does not have this type of tool "Fixture Tooling, Figure 1c", so this project proposes the design of this tool using theoretical knowledge from different fields such as modeling, manufacturing, mechanics, and materials engineering.

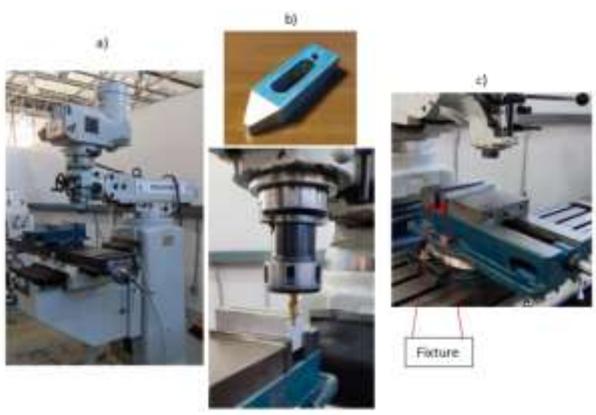

Figure 1 (a) UPIIG-IPN milling machine (b) types of machining performed with the milling machine (c) fixture type tool in the milling machine [1]

The milling machine is designed to machine different types of materials by chip removal, Figure 2 shows the main components of this 1) base, 2) column, 3) console, 4) cross slide, 5) table, 6) bridge, 7) tool holding spindle [2,3].

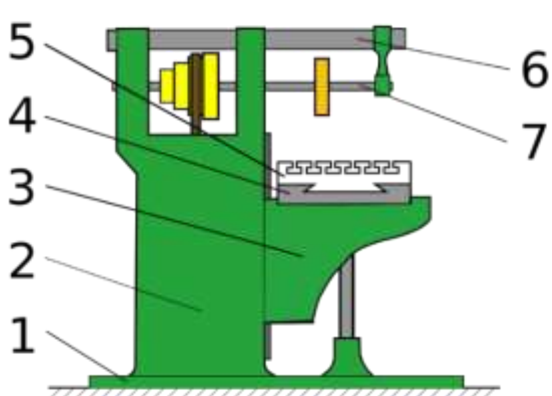

Figure 2 Diagram of the parts of a milling machine [2]

Depending on the type of machining, there are different types of movements of the tool, which rotates around its own axis. Figure 3a shows the possible axes of movement of a milling cutter (x,y,z), while Figure 3b shows the basic movements of milling, in which the cutting, feed and depth of cut movements are combined, the control of which results in the machining of the material.

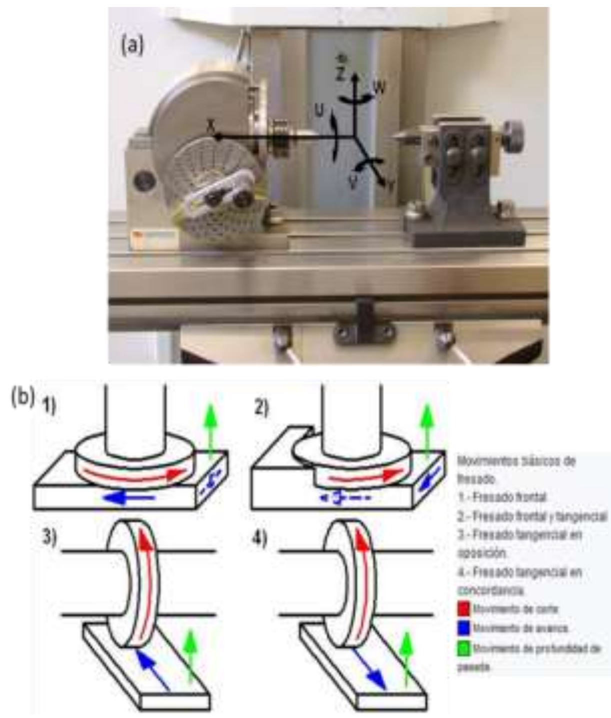

Figure 3 a) Milling cutter motion axis (b) Milling cutter basic motion [1,2]

In order to carry out the machining, the workpiece must be placed on the workbench or table and this must be clamped to prevent movement and to allow the rotating cutting tool to act perpendicularly to the material to be machined and not suffer tangential impact that causes its breakage or failure; therefore, it is necessary to use different types of tools during machining; which will be specified in the following sections of the theoretical framework [4-6].

Methodology

The design of a fixture type tooling for the milling machine is carried out considering the following development stages:

Step 1: 3D design of the tool using CAD software.

Step 2: Perform a mechanical properties analysis for different materials to select three different materials that can be used to construct the tool.

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Step 3: Simulate the mechanical behavior (stress-strain) of the tool subjected to the axial load generated by the cutting process, to determine the points where higher clamping stresses occur. The simulation considers the mechanical and physical properties of the materials selected for its construction and, after analyzing the results, the best material is proposed.

Results

Figure 4 shows the CAD design of the tool, which consists of five main parts: fixed jaws, moving jaws, guides, worm gear and base. The design of the jaws allows them to clamp square, circular or rectangular parts, which facilitates machining.

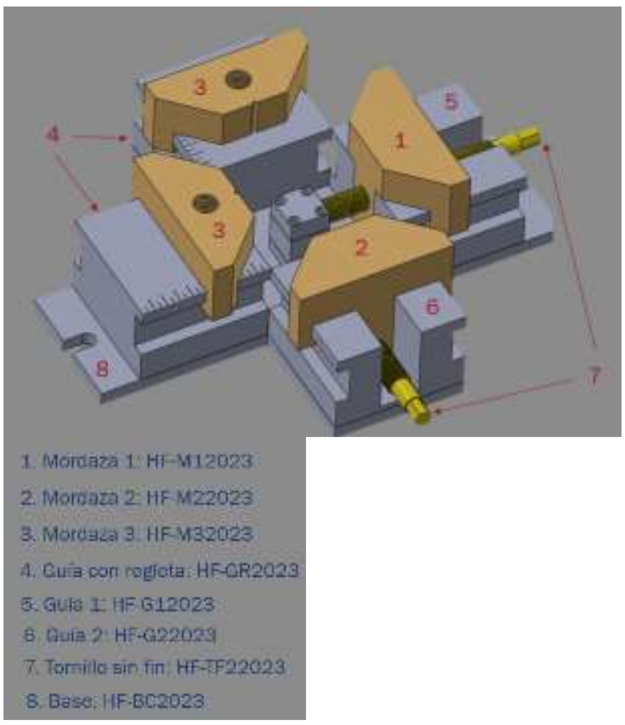

Figure 4 CAD tooling design

Figure 5 shows the design drawing for Clamp 3 (HF-M32023). It includes the following information: detailed part dimensions, dimensional tolerances, part drawing, part name, units of measure, drawing scale, maker and reviewer names and dates, fabrication material, drawing number, and finish type.

Table 1 summarizes the properties of the materials selected to simulate the mechanical behavior of the tool: A2 steel, AISI-1020 steel, and AISI-1045.

	A2 steel	AISI-1020	AISI-1045
Tensile strength; σ_u (MPa)		625	420
Yield strength; σ_y (MPa)	1275	351	530
Elastic Modulus; E (GPa)	203	200	205
Density; ρ (gcm^{-3})	7.86	7.9	7.85

Table 1 Mechanical properties required for simulation

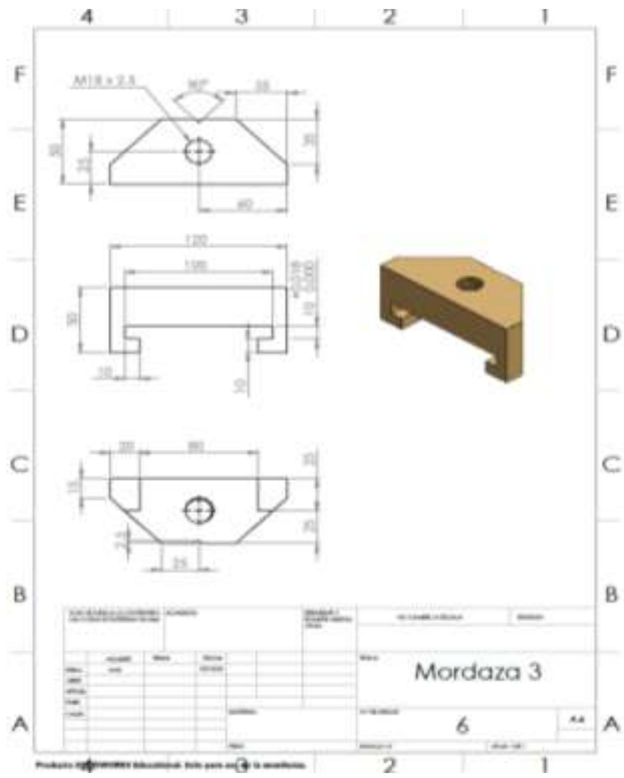

Figure 5 Design Drawing for Clamp 3: HF-M32023

Figure 6 shows a mesh sensitivity analysis, calculating the von Mises stress for AISI-1020. The load applied for this analysis was 491 N (maximum load developed during the operation of the machine in the laboratory of conventional machines of UPIIG-IPN), the mesh used was of tetrahedral geometry. The sensitized mesh consisted of $2.85x10^6$ nodes with an element size of 2.41 mm.

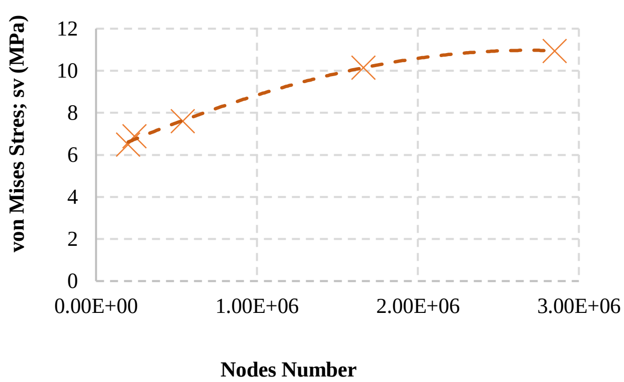

Figure 6 Mesh Sensitivity Analysis

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Table 2 shows the stress and strain profiles obtained for the three materials calculated with the 2.41 mm mesh; Table 2 shows the values obtained; obtaining a σ_v=10.15 MPa and displacements less than 1.36x10^{-3} mm.

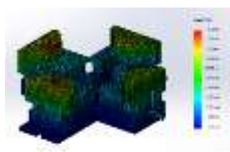
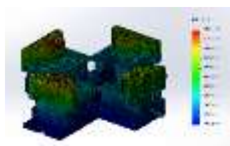
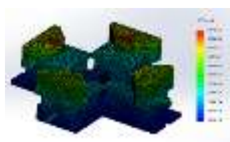
	von Mises Stress, σ_v (MPa)	Displacement, δ (mm)
AISI-1020		
AISI-1045		
Steel A2		

Table 2 Stress and strain distribution

For the load of 491 N, the stress generated is small compared to the yield strength of AISI-1020 (σ_y =351 MPa), so this steel could be used to manufacture the tool.

On the other hand, Table 2 shows the maximum load with which a σ_v=σ_y of each material would be generated; being the lowest for AISI-1020 with 15 kN (1.53 tons) and the highest for the A2 steel with a load of 60 kN (6.12 tons). This ensures that the tooling can be built using an economical steel such as AISI-1020, in accordance with the manufacturing requirements of a teaching laboratory.

	F (kN)
AISI-1020	15
AISI-1045	25
Steel A2	60

Table 2 Loads required for von Mises stress to equal the elastic limit of each material

Conclusions

The proposed tooling design allows to increase the number of practices that will be developed in the conventional machining laboratory of the UPIIG, thus facilitating the development of skills and competences of the students. On the other hand, the choice of the material with which the tool will be built will influence its life and use.

Acknowledgements

The authors thank CONACYT for the grant awarded to the student with CVU-1244894 of the Especialidad en Ingeniería para el Desarrollo de Sistemas de Manufactura de UPIIG-IPN.

References

[1] Mongrat. Montajes Industriales, Fabricación de piezas a medida a través de fresado. Recuperado 29/11/22. http://mongrat.com/fabricacion-de-piezas-a-medida-a-traves-de-fresado/

[2] DESIMA. Desarrollo de Sistemas de Manufactura Avanzada. Recuperado 29/11/22. https://desima.mx/maquinados-%2F-jigs

[3] Narayana K.L, Kannaiah P, Venkata-Ressy K (2006) Reddy Machine Drawing; New Age International Publisher; 3a Ed, New Delhi Indian.ISBN-13:978-81-224-2518-5

[4]- Metalinspec Laboratorio de Pruebas. Recuperado 29/11/22. https://www.metalinspeclaboratorios.com.mx/pruebas/pruebas-mecanicas

[5]- Murciego M, Materiales. Recuperado 29/11/22 https://sites.google.com/site/materialespormiguelmurciego/home/seleccion-de-materiales-para-una-aplicacion-determinada

[6]- GRUMEBER, ¿Cómo hacer una hoja de proceso de mecanizado?, Recuperado 29/11/22. https://grumeber.com/como-hacer-una-hoja-de-procesos-mecanizado/

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