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Design and construction of a knife sharpening machine

Diseño y construcción de máquina afiladora de cuchillas

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Abstract

The objective of this project was to design and build a blade sharpening machine for bagging and sleeve machines from the Excel Nobleza company, with a capacity of up to 66 cm, to reduce the costs of the blade sharpening service and also eliminate shipping costs. First, an investigation on sharpeners and sharpening methods was carried out, then mechanical, structural and electrical calculations were carried out. The design of the machine depended absolutely on the materials obtained during the process of searching for materials within the company, adjusting them to the proposed calculation and design. Subsequently, the assembly of the machine, the assembly and programming of the electrical and electronic components, as well as the functional tests, were carried out. The design and manufacture of the sharpening machine was successfully completed, optimizing the sharpening process and saving monetary resources. The machine was manufactured with parts that the company already had in stock or were machined with existing resources, consequently, the investment was zero or minimal.

Capacity, Functional, Optimizing

Resumen

El objetivo del presente proyecto fue diseñar y construir una máquina afiladora de cuchillas para máquinas de bolseo y mangas de la empresa Excel Nobleza, con capacidad de hasta 66 cm, para reducir los costos del servicio de afilado de cuchillas y además eliminar los costos por envío. Primero se realizó una investigación sobre afiladores y métodos de afilado, después se realizaron los cálculos mecánicos, estructurales y eléctricos. El diseño de la máquina dependió absolutamente de los materiales obtenidos durante el proceso de la búsqueda de materiales dentro de la empresa, ajustándolos al cálculo y diseño propuestos. Posteriormente se realizó el ensamble de la máquina, el montaje y programación de los componentes eléctricos y electrónicos, así como las pruebas de funcionamiento. Se culminó con éxito el diseño y fabricación de la máquina afiladora, optimizando el proceso de afilado y ahorrando recursos monetarios. La máquina se fabricó con partes que ya tenía la empresa en existencia o se maquinaron con recursos existentes, en consecuencia, la inversión fue nula o mínima.

Capacidad, Funcional, Optimizando

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June 2023, Vol.10 No.26 7-15

Introduction

This project was developed at the company Excel Nobleza, dedicated to the co-extrusion of plastic films and their conversion into labels, bags and printed and laminated wrappers of the highest quality. It has various machines such as flexographic presses, laminators, coaters, sealers, formers and cutters, among others, to provide comprehensive solutions in printing and flexible packaging.

Figure 1 Example of Excel Nobleza machines
Source: EXCEL NOBLEZA. (s. f.). media.cylex.mx. https://media.cylex.mx/companies/1123/7678/uploadedfiles/11237678_635101146670756514_EXCEL_NOBLEZA.pdf

Inside the Bolseo y Mangas line there was a problem regarding the blades that the machines need to carry out their daily activities. The problem mainly consisted in the fact that it was necessary to acquire the specialized services of an external company to sharpen the blades, also said company is located in the State of Mexico. Consequently, in addition to acquiring an expense for the service of sharpening the blades, it was necessary to pay an extra cost for the services of sending said material. The monthly cost for sharpening was 10,000 pesos and for transportation 1,500 pesos, giving a total of 11,500 each month, which gave an annual cost of 138,000 pesos.

That is why the workers of the maintenance department, in collaboration with the machine and tool shop of the plant, as well as the intern Efrén Hernández Rosas, who developed this project together with his adviser from the Technological University of Tecamachalco, M.C. Manuel Pérez Villegas, the decision was made to work on the project for the design and manufacture of a blade sharpening machine, a machine that will be delivered to the maintenance department, with the aim that they themselves would be able to carry out this blade maintenance process. and later, avoid unnecessary expenses for the acquisition of an external service and transport.

The main challenge of this project was to manufacture a functional machine from existing material in the machine and tool workshop, in addition to the company's warehouse. With this project, the company Excel Nobleza SAPI de C.V. will be able to implement the knife sharpening process. This project will equip the company with a machine with a minimum monetary cost, and most importantly, it will completely or largely eliminate the costs for the acquisition of the sharpening service and the transport of blades, thus contributing to growth and company success.

General objective

Design and manufacture a blade sharpening machine for bagging and sleeve machines from the company Excel Nobleza, with a capacity of up to 66 cm.

Specific objectives

- Reduce knife sharpening service costs, plus eliminate shipping costs.

- Enable the maintenance department of a specialized machine to carry out corrective maintenance tasks on the blades.

- Reuse existing equipment in the warehouse and optimize it to carry out the construction of the machine.

ISSN: 2410-3993

Theoretical framework

According to Shigley, J. E., et al (2019), designing is formulating a plan to satisfy a specific need or solve a problem. If the plan results in the creation of something physically real, then the product must be functional, safe, reliable, competitive, useful, manufacturable, and marketable. Design is also a decision-making process, which must be made with very little information, or with just the right amount and sometimes with an excess of partially contradictory information. Sometimes decisions are made on a tentative basis, so reserve the right to make adjustments as more data becomes available. What is important is that the designer must be personally comfortable in exercising the decision-making and problem-solving function in order to achieve the goal of designing and subsequently building the required equipment.

Within an industrial plant there are a number of different needs to cover, many of these needs can be covered through the services of the different departments that the company has, for example, maintenance services for machinery and facilities, others without However, they require the hiring of an external provider, (electricity, gas and drinking water services, for example), but there are certain activities that only companies specialized in the subject can grant, (automation of certain lines, transport of dangerous substances, etc.) one of these services is the sharpening of knives.

General information on cutting blades

Blades are single-edged cutting tools. The typical shape of a cutting blade comprises three main faces (see Figure 2); the front face of the blade is called a mirror; the opposite side is called the spine; the skewed face of the blade is called the bevel. The edge or edge that forms the bevel and the mirror is the edge (Hernández Hernández, et al, 2017).

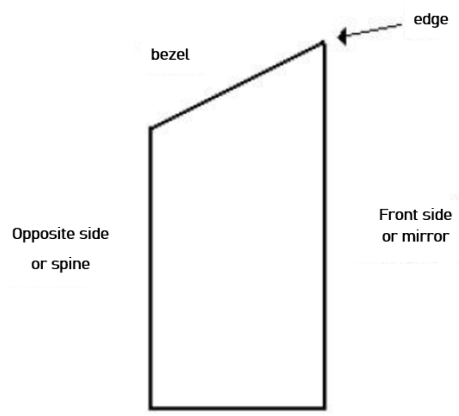

Figure 2 Typical profile of a cutting blade
Source: Hernández Hernández, et al (2017), pp. 6.

The characteristics that a cutting blade must have to achieve the longest useful edge life are a combination of wear resistance and toughness, characteristics that the material from which they are made must have.

Sharpener definition

The main function of sharpening machines, also called grinding machines, is to create or rectify the cutting surface of instruments or elements used in the cutting operation (Claudio Guerrero, 2013). It is a machine tool, used to carry out abrasion machining, with high dimensional precision and a high surface finish, that is, with lower roughness than in chip removal machining. Commonly one of these artifacts is made up of one or several emery stones (also called emery wheels) mounted on a rotating shaft or shaft that rotates at considerable speed, commonly supported on a table that allows the user to comfortably maneuver the shape. of the sharp

The parts that are ground are mainly steel hardened by heat treatment. For this reason it is very important to control the speed of rotation of the grinding wheel and the feed, to avoid damaging the blade. Manufacturers' tables or specialized machine tool manuals indicate the proper turning speed and feed.

Blade sharpening

The mission of sharpening machines is to create for the first time, or to regenerate the cutting edges of a tool. The tool used in sharpening is called a grinding wheel and the operation that is carried out with the sharpener is called sharpening (Claudio Guerrero, 2013).

ISSN: 2410-3993

June 2023, Vol.10 No.26 7-15

Sharpening is always done on the bevel side, with a fine-grained grinding wheel, with the three main movements shown in figure 2.

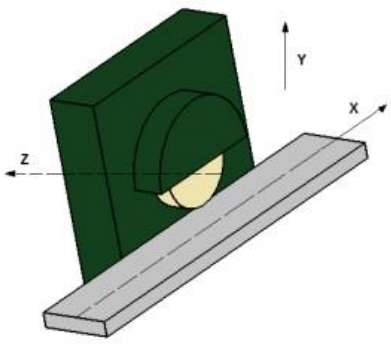

Figure 3 Main movements of the sharpening machine
Source: Claudio Guerrero, 2013, pp.7

- **Z axis of cutting movement:** This axis has the cutting power and the abrasive wheel is mounted on it.

- **X axis of feed movement**: This axis is horizontal and parallel to the clamping surface of the part. It is perpendicular to the Z axis.

- **Y axis of penetration movement**: This axis is vertical, perpendicular to the X axis and provides the movement of approach or penetration of the grinding wheel in the piece, until reaching the required dimension or until obtaining the necessary edge.

Tangential speed of the grinding wheel

It is the speed of the points of the piece that are in contact with the tool, it is measured in m/s, and it is represented by the following formula:

$$Vc = \frac{\pi * d * n}{1000} \quad (1)$$

Where:

Vc = Cutting speed (m/s).

d = Diameter of the tool (mm).

n = Rotational speed (rpm).

Type of grinding wheel	Vitrified and silicate binder Hardness			Synthetic resin and rubber binder Hardness		
	Soft	Half	Hard	Soft	Half	Hard
Disc	25	30	33	33	40	60
Annular, cup, conical	23	25	28	25	30	40
Disc for cutting					50	60
Special disc for cutting						60-80

Table 1 Tangential speed of the grinding wheels in m/seg
Source: ROSSI, MARIO; Máquinas-Herramientas Modernas, editorial Hopeli, Barcelona, 1971; pág. 1004

Longitudinal feed rate

In the sharpening of flat knives, the term longitudinal feed refers to the path in millimeters, according to which the tool or the piece moves relative to each other, this feed rate is indicated in millimeters per minute.

According to Bohórquez Suárez, G. R. (2011), the speed of the grinding wheel, the longitudinal and transversal feed speed, are values that depend on the following factors: quality of the material to be sharpened, surface condition, dimensions, degree of finish required, quality of the abrasive and its grain, quality of the binder and lubrication.

Material	Type of work	Type of grinding wheel Of cup	Of segments	Tangential
Mild steel	Roughing	8--10	10--12	10 a 15
	Finishing	1--8	6--10	6 a 10
Tool steel	roughing	8--12	10--14	10 a 15
	Finishing	1--8	6--10	6 a 10
Foundry	roughing	8--0	10--12	10 a 15
	Finishing	1--8	6--10	6 a 10
light metals	roughing	…	….	20 a 30
	Finishing	….	….	10 a 20
Copper and alloys	roughing	…	….	15 a 20
	Finishing	….	……	10 a 15

Table 2 Feed rate in m/min in flat grinding
Source: http://www.produccion.cps.unizar.es/info/tec_fab/.../mec%20abrasivos.pps

Methodology for the design of the machine

The design of the machine (the sharpener) absolutely depended on the materials obtained during the process of searching for materials within the company, with the aim of not acquiring external elements. In other words, this machine will not have an extra cost for the company, only labor in the design, research, machining, adaptation, optimization and assembly of the sharpener components.

The methodology followed for the development of the project was the following:

- Research on sharpeners and sharpening methods.

- Manual sharpener design and approval.

- Software design of the sharpener.

- Mechanical, structural, and electrical calculations.

- Search for the mechanical and structural components of the sharpener.

- Table assembly by welding with 6013 coated electrode.

- Assembly and programming of electrical and electronic components, as well as functional tests.

- Final delivery of the project in the company.

Manual and computerized design

Once the project was approved in the company, the activities were planned and different designs were made, thinking about the possibilities of obtaining the materials. Initially, a fully automated machine model was proposed, which would include stepper motors, CNC machine spindles and guide axes, similar to the Metal Blade Sharpening Machine, developed by Sierra Garriga, C. (2022). However, the design had to be changed considering that only parts existing in the company would be used and those that would be manufactured would be made with the machine tools available in the plant and the experience of the workers.

According to the bibliographical research carried out, a great variety of sharpening machines were found on the market, among which there were some differences, from the position of the motor or sharpening head to the way of advancement, both of the head and of the blade (moving only the sharpening head in some cases while in other cases what moved was the blade) and the advance being both manual and automatic, using in some cases only guides and in others, a combination of spindle, guide axes and endless screw.

Finally, based on all the information collected, an own design was developed and presented to the project coordinator, the head of the maintenance area and the master turners, who after analyzing the initial proposal (figure 4) suggested changes in the design. , according to the materials that were available in the warehouse, the necessary machining operations and the sharpening needs.

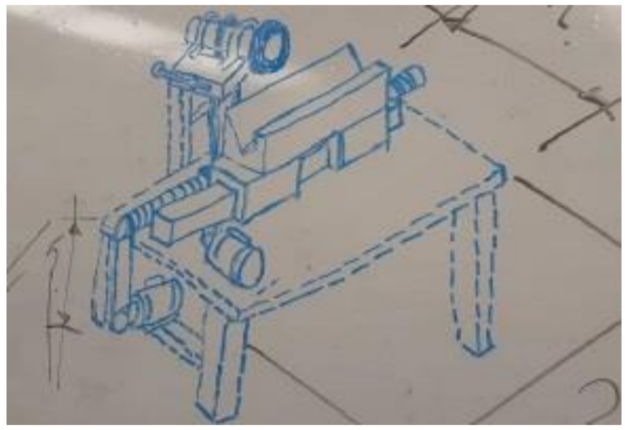

Figure 4 Sharpening machine design proposal
Source: Own elaboration

The final design was carried out with the help of specialized software, both for the mechanical and structural design. AutoCAD and SolidWorks were used (figure 5). Various calculations were also made to determine where it would be optimal to place the mechanical and electrical elements.

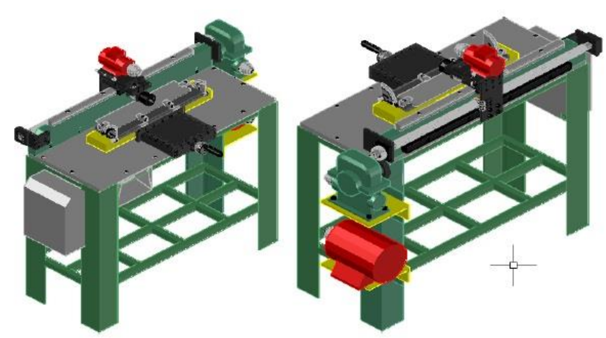

Figure 5 Final design of sharpening machine
Source: Own elaboration

Mechanical calculations

The mechanical calculations made for the design of the machine are mentioned: It is necessary to clarify that it refers to the transmission of force and speed between the motors and the mechanical components that will carry out the work of movement and load, with the following results:

ISSN: 2410-3993

1. Calculation of the dimensions of the worm and spindle. ACME triple entry thread, 24mm pitch, 3/4” internal diameter, 1” external diameter, 1/8” thread height.

2. Advance calculations. Since the sharpening process is necessarily fast, it was established that the sharpening head should travel a distance of 1100 mm in 10 seconds or 110 mm/s, with a rotation speed of 275 RPM.

3. Calculation of pulleys. In this case, this transmission system is only to transmit the movement, with a 1:1 ratio.

Electrical calculations

1. Electric motors. An ASEA 220 volt AC three-phase motor was selected, with a speed of 3410 RPM, 0.5 HP, AMP. 0.85/1.7, for continuous operation, this in order to ensure good machining (sharpening) and avoid burning the blade or reducing its resistance or the effectiveness of its mechanical properties. A SIEMENS brand three-phase motor of 230/460 volts AC, type GP100, 2 HP, 1740 RPM, AMP 5.6/2.8 was also selected.

2. Motor wiring. TW 4x12 AWG wire (4 wires, 12 gauge) was used.

3. Control devices. To control the movement of the sharpener, the intervention of a MOELLER® brand PLC, model EASY 412-DC-TC, was necessary, which had the advantage of its compact size, its inputs and outputs more than enough to be able to operate the machine and Above all, the fact that it does not need software and a computer to be able to be programmed, this being its greatest advantage. A start button (NA), a stop button (NC), a button for turning the lead screw motor in the normal direction (NA) and a button for the reverse direction of the lead screw motor (NA) were programmed.

Machine manufacturing

Ten detailed plans were made for the manufacture of the machine in AutoCAD, in figure 6 and figure 7 two examples of plans are shown.

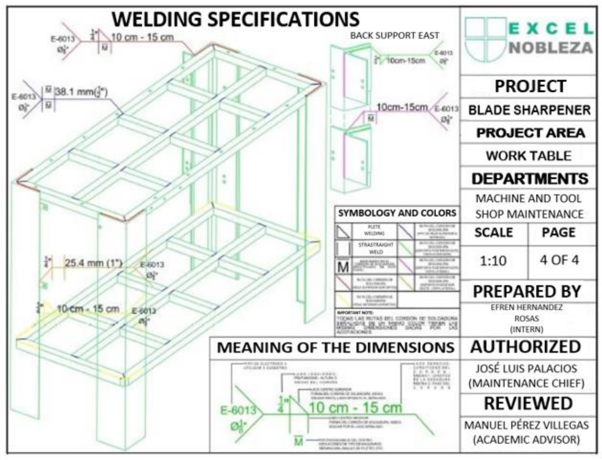

Figure 6 Work table design for the sharpening machine
Source: Own design

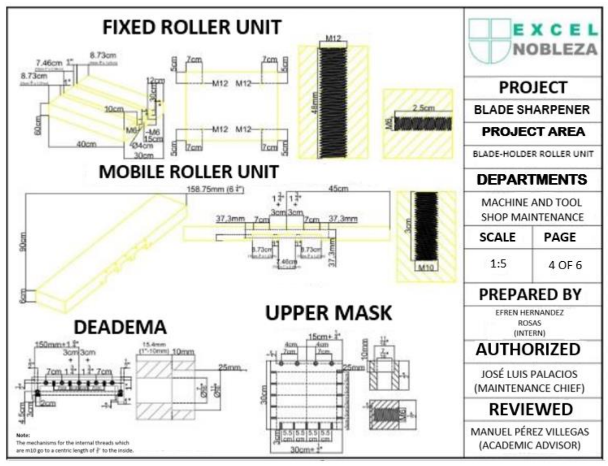

Figure 7 Design of fixed advance carriage, mobile advance carriage, deadema and upper mask for the grinder
Source: Own design

The materials used to make the machine were the following:

- SIEMENS GPS100 engine.
- ASEA MBT 48(71B)-2 motor with base for mounting on horizontal and transversal guides.
- MOELLER® EASY 412-DC-TC PLC.
- 1½ *11/2 PTR Tubular Profile, 4mm thick.
- Angular profile 6´´x 6´´, 1/8´´ thick.
- 2kg. 6013 stick electrode welder.
- Worm and spindle (manufactured in the company's machine tool shop).
- 2 CNC linear guides 120 cm long.
- Steel plate (front part of a sharpener).

- 6 ¼ ´´ x 6 cm x 1.5 m steel plate.
- 2 skids for CNC linear guide.
- 1 m screed of 6´´x ½´´.
- ½” round Cold-Rolled.
- 1” square Cold-Rolled

Once the necessary materials for the manufacture of the equipment were obtained, the material cutting processes began. The first of the steps was to adjust the angle and the cutting line both in the PTR material and in the angular profile in the cutting machine, counting at all times with the support of the company's specialized machine tool personnel. After proceeded to weld the table, as shown in figure 8.

Once the table was made, the components that would make up the mechanical part of the sharpener were assembled, starting with the design of the head, for which a steel plate (front part of a sharpener) and a 6-inch steel plate were needed. ¼ ´´ x 6 cm x 1.5 m.

Figure 8. Table welded process
Source: Own design.

However, since they had been stored for a long time, the paint and the surface of these pieces were filling with rust, it was necessary to clean the pieces with the help of sandpaper and a manual polisher or grinder, to which a brush was adapted (emery brush) 5" diameter cup.

Figure 9. Plate drilling
Source: Own design

At the end of the cleaning process, we proceeded to verify if the surface was completely straight, and to the surprise of the workers in the machine and tool shop, the surface had a 1/8-inch buckling, so it was necessary to a rectification to this piece. For the process, the services of a milling machine were required, the same one found in the machine and tool shop. In the workshop bench drill, the plate that would be used to support the rest of the components was drilled.

Once the drilling process was finished, we proceeded to place the plate on the table, align and finally make the same perforations in the corresponding place, this time on the table, a couple of type c presses were used to fix our plate to the table and a drill to make these holes.

On the other hand, grooves were machined (figure 9) to function as guides in some metal pieces, pieces that would serve to make an advance carriage. Once the grooving process was finished, drilling was carried out and later another internal threading or tapping process was carried out, with 4 millimeter threads made with M10 taps, in order to fix this "feed carriage" to the table plate.

Figure 10 Moving part grooving process
Source: Own design.

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It is important to mention that, at the suggestion of the head of the machine and tool shop, the machine was assembled and disassembled each time a new element was added or a process or procedure was completed, that is, the progress of the project was "presented" in question. Apart from being the basis for verifying progress, this was used to better visualize both mechanical and structural elements that could be added to or removed from the project.

In order to solve the problem of the advance of the sharpening head and the advance carriage, the option of manufacturing an endless screw with its respective spindle was chosen, an element that would hold the mobile part (head or advance carriage) and slide or would advance along the screw and would help move these elements. For this, the same workers from the machine and tool workshop fully supported us in the manufacture of these elements, essential for the operation of the machine. It should be noted that these elements were made based on the calculations made and the plans that were made at the beginning of the project.

After the mechanical assembly, the electrical and electronic systems for the operation and control of the knife sharpener were installed and connected.

Figure 11 Machine assembly
Source: Own design.

As an initial step, an empty control cabinet that had not been used for a long time was chosen. Said cabinet belonged to a bagging machine and already had DIN rails installed inside it.

Once the cabinet was found, we proceeded to look for the contactors and the PLC that would be used to control the motors, however, it was found that both the available contactors and the PLC worked with 24V DC, therefore that a power source had to be found, which was not a problem, since there was also a power source available in stock. After this, it was necessary to look for THW-12X4 cable and 12 AWG cable to connect the control and power system of the machine, also available in the company's warehouse, and finally, it was necessary to look for 40mm x 40mm slotted conduit, which is would be used to protect the cable, in addition to the NO and NC pushbuttons to control the machine.

Results

Finally, and as part of the final quality control, the knife sharpening machine was subjected to functional tests, it was possible to verify the correct operation of the electrical components, making different measurements. Tests were carried out on the advance carriages, to verify that they could advance without any difficulty along their trajectory, likewise, by means of the buttons, the correct functioning of the program installed in the PLC was verified.

To test the machine, blades of different sizes were taken and fitted into the blade holder system, one at a time, the angle of inclination was adjusted and the sharpening process proceeded. With satisfaction, both the maintenance department staff, as well as the machine tool workshop and the trainees, observed the optimal result of the sharpening process with the new machine. Finally, the machine was transferred with the help of a forklift to the Maintenance Department Workshop and put into operation, thus achieving the main objective of this project, which was to provide the maintenance department and the company with a blade sharpening machine.

Financing

This work has been financed by the company Excel Nobleza SAPI de C.V.

Conclusions

The design and manufacture of a knife sharpening machine for the company Excel Nobleza was successfully completed, optimizing the sharpening process and saving monetary resources. The machine was manufactured with parts that the company already had in stock or were machined with existing resources, for this reason, the investment was zero or minimal. In summary, the project was completed successfully.

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