International Journal of Religion
2024
Volume: 5| Number 11 | pp. 5109 – 5117
ISSN: 2633-352X (Print) | ISSN: 2633-3538 (Online)
ijor.co.uk
DOI: https://doi.org/10.61707/tprqfv78

The Durability of Cutting Tools in The Matting of Guadua Cane

Alfredo Cecilio Zambrano Rodríguez[1] and Francisco Lafargue Pérez[2]

Abstract

For the construction of cutting tools for wood of different species and thicknesses, it is necessary to consider some aspects such as the type of steel that should be selected for the manufacture of exclusive blades to perform cold work considering the hardness of the epidermis of the guadua cane, the objective of the research was to design, build and evaluate the durability of cutting tools used in the process of matting of guadua cane. Impact tests were carried out with the Charpy pendulum, which was used to evaluate the tenacity and resilience of the selected steels. The Statagrafhic centurion software was used to verify the process. As a result, the design and construction of the blades with different angles and degrees of hardness was obtained, obtaining that the material with the highest hardness, resistance to chipping of the cut of the matting was the AISI-D6 steel.

Keywords: *Durability, Types of Steels, Matting, Bamboo Cane, Charpy's Pendulum.*

INTRODUCTION

The province of Manabí is rich in natural guaduales, it is the one with the greatest number of species of this crop in the country, used since ancient times in the construction of houses due to its seismic resistant characteristics and its superficial hardness. Approximately 145,000 ha are cultivated in natural conditions. (Ministry of Agriculture and Livestock, 2020).

According to the MAG-2018 in the mapping of productive areas of caña guadua, both in its species of caña brava and caña mansa, 66.5% is located on the Ecuadorian coast, 10% in the highlands and 23.5% in the Amazon (Ministry of Agriculture and Livestock). In the province of Manabí, there is an area of 145,529 ha of guadua reed, with the highest percentage (24% of the total number of available guadua trees). The lack of knowledge of the physical and mechanical properties of the caña guadua of Manabí has led to the use of this material in an empirical way without taking into account the functionality of the material in the design of a structure. (Páez, De la Rosa, Verduga, & Soto, 2022).

The matting of guadua cane is done in an artisanal way with simple tools such as axe and machete with low productions that do not meet the technical requirements in housing constructions. For this reason it is necessary to study different types of tools that can perform this operation with quality and efficiency. In Manabí there is no machine to carry out the operation of matting. (Osorio, Vélez, & Ciro, 2007).

In the Andean countries it is built with guadua cane materials, in Colombia studies show that bamboo species are known as vegetable steel, for being exposed to various structural experiences, having positive results such as high tensile and compressive strength. (Edith, Nubia, Cervantes, & Gil, 2020).Bamboo is also a type of bamboo that has become an alternative to mitigate the effects caused by climate change.

Subscribe to DeepL Pro to edit this document. Visit www.DeepL.com/pro for more information. In Ecuador, the raw material needed to solve part of the housing problem is available: guadua cane or guadua angustifolia, which grows abundantly between 1800 and 3000 metres above sea level. The selection of this material for the construction of houses for the most needy, in addition to constituting the raw material for the elaboration of the same, contributes to the ecology, since it would reduce to a large extent the indiscriminate felling of trees that currently takes place. (Garzón, 2016).

[1] Carrera de ingeniería Mecánica, Universidad Técnica de Manabí, Portoviejo Ecuador, Emai: lalfredo.zambrano@utm.edu.ec

[2] Carrera de Ingeniería Mecánica, Universidad de Oriente, Santiago de Cuba, Cuba, Email: lafargue@uo.edu.cu

For the process of cutting and matting of the guadua cane, cutting tools are needed where different types of steel are used that are exclusively for cold work, such as: AISI-O1, AISID6, AISI-1045 (Balanzas, 2023).

It is proposed to design cutting tools that can be built and evaluate their durability for use in the process of matting guadua cane.

Materials and Methods

For the design of the cutting tools, the use of different steels for cold working was proposed, as well as different cutting angles and HRC ROCWELL hardness grades (Soria, Reyes, Carrillo, García, & Álvarez, 2015). (Soria, Reyes, Carrillo, García, & Álvarez, 2015).. Impact tests were performed with the Charpy pendulum, this was used to evaluate the toughness and resilience of the material of the steels, to verify the process the Statgraphics Centurion software was used. (STATGRAPHICS Centurion XVIII, 2023) was used to verify the process.. For the machining of the blades and to give them the corresponding angle, the machine tools of the workshop were used; in addition, to measure the angles, the no-pass gauges were used.

Analysis and Discussion of the Results

The blades or cutting tools are built with special steels for cold working, they are essential in the process of cane matting guadua, considering different operating factors such as applied forces, working environment, impact resistance, most of the failures are related to these mechanical causes. (bohman, 2023).

To begin the design and construction of the tools for the process of matting guadua cane, a work plan was proposed as shown in figure 1.

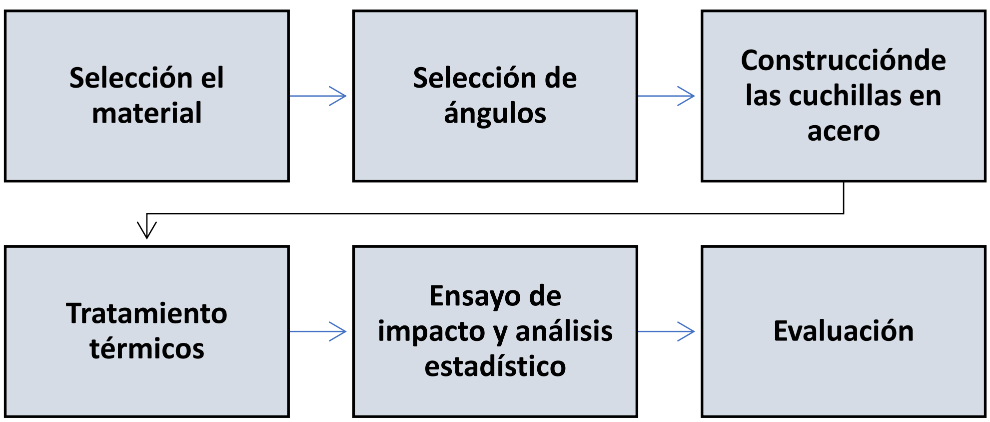

Figure 1. Planning for the design and construction of cutting tolos

As can be seen for the construction of the cutting tools, we began with the selection of the material, where the different steels to be studied were chosen, these are exclusively used in the construction and cutting for cold work AISI-O1, AISI-D6, AISI-1045. The elaboration of these cutting tools with different steels and appropriate thermal treatments should allow, simplify and optimise the work of matting guadua cane in the province of Manabí. In this region of Ecuador, there is no machine to carry out the operation of matting guadua cane, as it is carried out by hand with manual instruments such as machetes, hand axes, etc. (Rodriguez & Villacis, 2002). (Rodriguez & Villacis, 2023).. Each tool includes optimising the work in the process of matting the guadua cane for a better quality of production; there is no efficient work as desired, which meets the desired requirement since this matting process is generally a manual and artisanal work, an activity carried out by farmers who own some guadua trees in different areas of the province of Manabí.

Angle Selection

The angles of the cutting tools will be influenced by their design, construction, characteristics of the tool and the material to be cut, therefore important aspects must be considered such as: the parts of the guadua cane to be cut or processed (Stump, Basa, Over Basa), the proposed cutting angles are (15°, 20°, 25°, 30°) of the proposed angles the one selected has an impact on the resistance to wear or durability of the cutting tool with its respective hardness characteristics.

The cutting angle is related to the application that the tool is to be used for, as well as the type of casting, the tool and its thickness. In general, each tool has a cutting angle specified by the manufacturer, depending on the use to which it is to be put. For the angles of the cutting edges of the blades, a straight and a triangular point were proposed. Using a sharpness gauge (pass - fail gauge) we will check the corresponding angles of each of the blades to check the shape of the edge at the time we are performing. The sharpness gauge was made with a piece of stainless steel to which he gave the following angles (15 ° - 20° - 25° - 30°), although this gauge could also be made with a piece of cardboard, or a piece of wood. Figure 2 shows the application of the pass/fail gauge, in (A) the gauge, in (B) and (C) taking the measurements with the gauge once the corresponding angle has been completed.

Figure 2. Application of the pass/fail calibrator

As can be seen, the selected angles were calibrated in order to know if the material can be efficient in the expected cut.

Steel Blade Construction

Hard materials have been used to deform or cut other materials or metals for thousands of years. However, in the last 150 years, better materials have been invented or developed. Generally, as better materials were discovered, larger and more powerful machine tools were built and parts could be produced more quickly and economically. The cutting of materials is achieved by means of tools with the right shape and cutting edge. A tool without properly selected cutting edges or angles will result in excessive energy costs, material tearing, loss of time and money. In almost all cutting tools there are defined surfaces, angles and cutting edges: For the research of this project, 36 blades were made on the milling machine with 3 different steels, the selected steels were AISI-O1/DF-2, AISI-D6/XW-5 and AISI-1045, 20°, 25° and 30°, in turn, nine blades were made for each angle, three with each selected steel, due to the required degrees of hardness of 56, 58 and 60 HRC, achieving 36 blades, 12 of each selected steel, with different angles and different degrees of hardness.

Heat Treatment

Once the calibration test was obtained with the measuring instrument, the pass-fail calibrator, the blades were sent for the respective heat treatment, which must be given to each one of them with their different degrees of hardness, 56; 58; 60 HRC, with the different angles already known respectively. Table 1 shows the steels selected for cold working and the angles proposed for the manufacture of the blades. In addition to the heat treatment, the degrees of hardness will be obtained for each blade, with which the guadua cane will be matted.

Table 1. Cold work steels with different angles and hardness grades

Types of steels	15°	20°	25°	30°
AISI-D6/XW5	56HRC	56HRC	56HRC	56HRC
AISI-D6/XW5	58HRC	58HRC	58HRC	58HRC
AISI-D6/XW5	60HRC	60HRC	60HRC	60HRC
AISI-O1/DF2	56HRC	56HRC	56HRC	56HRC
AISI-O1/DF2	58HRC	58HRC	58HRC	58HRC
AISI-O1/DF2	60HRC	60HRC	60HRC	60HRC
AISI-1045	56HRC	56HRC	56HRC	56HRC
AISI-1045	58HRC	58HRC	58HRC	58HRC

AISI-1045	60HRC	60HRC	60HRC	60HRC

Source: Own elaboration

Impact Testing and Statistical Análisis

After having carried out the heat treatment with the proposed degrees of hardness of the 36 blades, the specimens were prepared, with which the different impact tests were carried out, using the Charpy pendulum under the ASTM-E-23 standard that describes the impact tests on notched metal specimens, to know the behaviour of Tenacity and Resilience in the specimens, under different tests according to the angle and the degree of hardness suitable for the cutting of the guadua cane, which in turn will facilitate the work of the people who are involved in the cutting process. Equation 1, allows the calculation of the absorbed energy.

$$E = WR\ (\cos\theta_{\alpha-} cos\,\theta_{\alpha)-L} \qquad (1)$$

Where:

E → Energy required for fracture (energy absorbed) (J)

W→ Hammer weight (N)

R → Distance from the centre of the hammer rotation axis to the centre of gravity of the hammer (m)

θ_β → Angle at which the hammer rotates after fracturing the test piece (°)

θ_α → Hammer elevation angle (°)

L→ Energy loss caused by friction

Table 2 shows the toughness tests on AISI-O1; AISI-D6; AISI-1045 steels using the CHARPY pendulum.

Table 2. Toughness tests of the different steels, obtained using Charpy's pendulum

HRC		Steel	Initial angle (α)	Final angle (β)	Final height (H)	Initial height (h)	kgm initial	Tenacity (J)
56	Tempering	AISI- D6/XW5	102.3	93.58	75	97	20	106,82
60		AISI-D6/XW5	102.3	87.85	72	97	20	120,54
58		AISI-D6/XW5	102.3	91.43	74	97	20	107,8
60		1045	102.3	87.13	80	97	20	117,6
56		1045	102.3	115.94	114	97	20	89,22
58		1045	102.3	112	115	97	25	107,8
56		AISI-O1/DF2	102.3	87,13	76	97	20	106,82
58		AISI-O1/DF2	102.3	79.92	77	97	20	114,66
60		AISI-O1/DF2	102.3	76.26	78	97	20	116,62
	Untempered	AISI-D6/XW5	102.3	40.54	90	97	20	84,28
		1045	102.3	64.15	92	97	20	78,4
		AISI-O1/DF2	102.3	92.86	91	97	20	83,3

Source: Own elaboration

As noted, Charpy impact tests were obtained for the selected cold work steels and the different HRC hardness grades.

It was also found that one of the most insidious types of failures that can occur in structures are brittle fractures, which are mainly due to poor quality materials or poor material selection. Brittle fractures tend to occur suddenly and without much material inelasticity, these failures often occur in situations where the material has little capacity to develop shear stresses due to three-dimensional loading conditions and the local strain concentrations are high and the designer did not provide a direct logical force path, in addition to there being no ductile behaviour of the material, local discontinuities in both the materials and the cutting tool geometry. In the case of three-dimensional stresses due to cooling, it is necessary to have a simple test that characterises the robustness of the material or fracture toughness in this sense the Charpy V-notch test, which is described as essential in this laboratory practice. The Charpy V-notch test is intended to provide a very simplistic measure of a material's ability to absorb energy when subjected to an impact load called toughness. (atusevich, Mancini, & Giudici, 2012), (Martinez, Jaimes, Serna, & Uribe, 2024).

Toughness is defined as the property of a material to absorb energy to the breaking point when subjected to shock or impact stresses. (Concept, 2024).

Resilience is the energy absorbed by the impact, calculated with equation 2.

$$\Delta Ep = mg.(H - h) \qquad (2)$$

Where:

ΔEp→ The resilience (energy absorbed by the impact)

m→ matilla mass

g→ gravity (9,8 m/seg^2

H → Charpy pendulum energy

h→ energy remaining in the pendulum

Where m is the mass of the pendulum, g is gravity, H is the initial height of the pendulum and h is the final height of the pendulum after impact.

The resilience test is a typical example of laboratory materials characterisation, which is also widely used in various manufacturing and industrial contexts. The energy expended by the pendulum to break the specimen is calculated by the difference between the energy of the Charpy pendulum before hitting the specimen and the energy remaining in the pendulum after hitting the specimen (potential energy increase).

The results of energy resilience calculations on AISI-O1; AISI-D6; AISI-1045 (by Charpy pendulum) are shown in table 3.

Table 3. Resilience tests for AISI-O1; AISI-D6; AISI-1045

Steel type	HRC	Resilience (Jul)	Speed of impact (m/seg)	Energy Kinetics (Jul)
AISI- D6/XW5	56	53,95	4,3602752	190,12
AISI-D6/XW5	60	61,31	4,3602752	190,12
AISI-D6/XW5	58	56,4	4,3602752	190,12
1045	60	41,68	4,3602752	233,12
1045	56	36,78	4,8497423	235,2
1045	58	39,78	4,9477718	234,79
AISI-O1/DF2	56	46,58	4,3602752	190,12
AISI-O1/DF2	58	49,05	4,3602752	190,12
AISI-O1/DF2	60	51,5	4,3602752	190,12
WITHOUT	TEMPLAR	WITHOUT TEMPLAR	WITHOUT TEMPLAR	WITHOUT TEMPLAR
AISI-D6/XW5		17,16	4,3602752	190,12

1045		12,26	4,3602752	190,12
AISI-O1/DF2		14,71	4,3602752	190,12

As can be seen, the Charpy impact test of cold work steels with different HRC hardness grades was obtained. Figure 3 shows the comparative graphic (resilience-HRC-ACEROS).

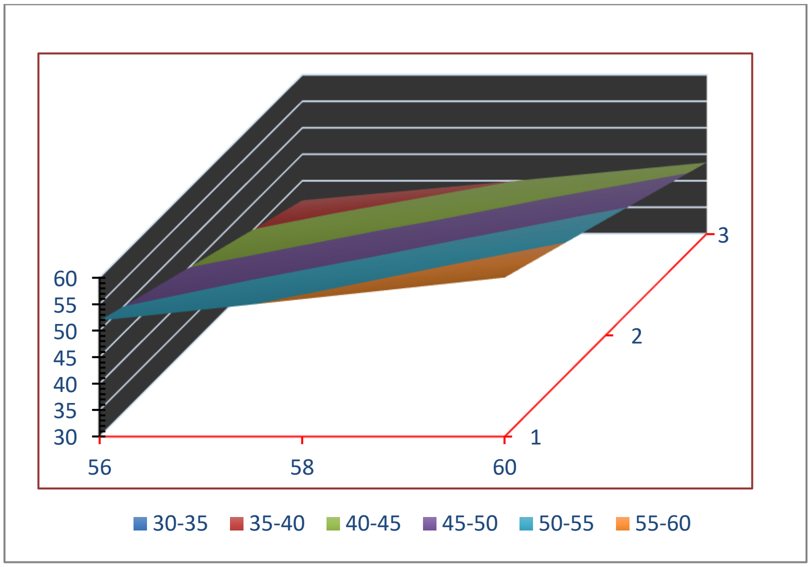

Figure 3. Comparative graph (resilience-HRC-ACEROS)

As can be seen from the equivalence of the graph, for values (56-58-60) = HRC

Where:

(1-2-3)→ Types of steels

1= AISI-D6/XW5

2= AISI-O1/DF2

3= AISI-1045

Resilience = Jul/cm²

(DE 30 A 60 range represented in the resilience graph) (Jul/cm²), according to the data obtained from the three-dimensional graph (resilience-hardness-steel) it was possible to verify the behaviour of energy consumption, with the AISI-D6/XW5 steel at 60 HRC being the most optimal for withstanding the blows of the guadua cane matting.

The graph in figure 4 shows the comparative base (Toughness-HRC-Steel).

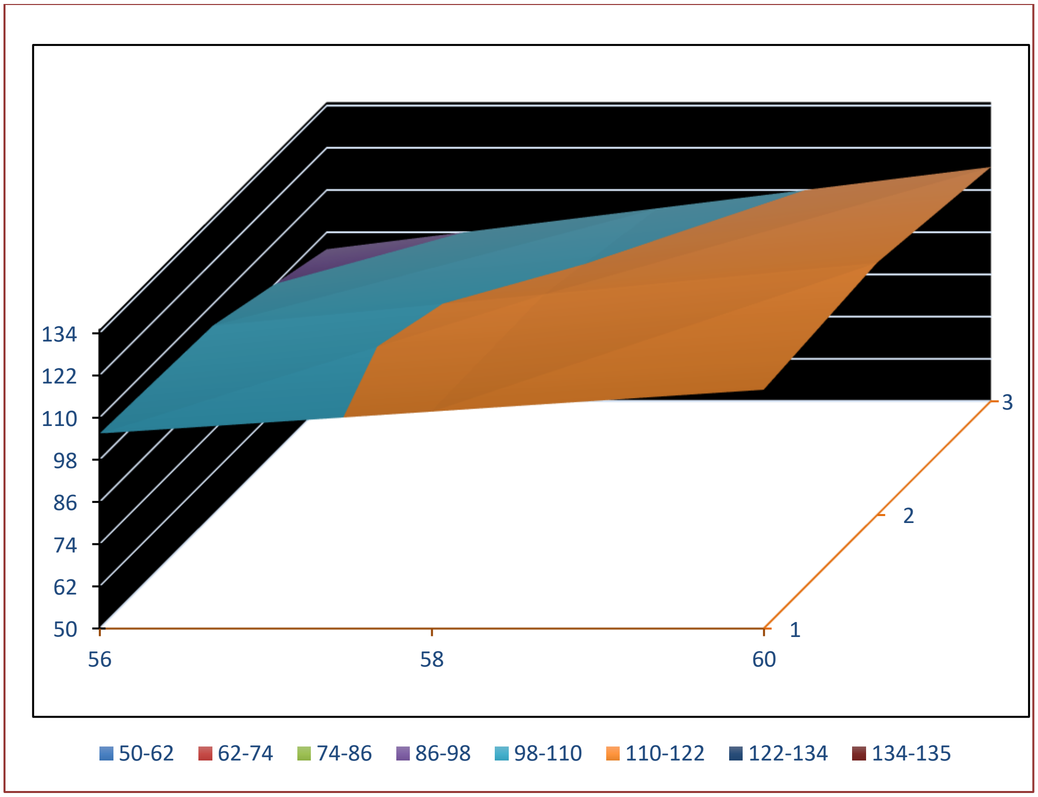

Figure 4. Comparative basis (Toughness-HRC-Steel).

Where.

(56-58-60) → HRC

(1-2-3) → Tipos de aceros

1= AISI-D6/XW5

2= AISI-O1/DF2

3= AISI-1045

TENACITY: Jul

As can be seen the toughness is in the range of (56 to 60) range represented in the toughness graph.

According to the data obtained from the three-dimensional graph (toughness-hardnesssteel) we can see that the material with the highest impact resistance and energy absorption during impact is AISI-D6/XW5 steel.

Guadua reed is a resource that grows between 16-25 cm per day, in the first six months it reaches its final height, it can be used as a mat from two years after sprouting, so it can and should be used as raw material for the manufacture of housing, and a variety of products due to its excellent properties and characteristics, such as high seismic resistance, flexibility, hardness and other properties that make it desirable in the construction of sustainable housing.

CONCLUSIONS

The efficiency of the cutting tools used in the matting of guadua cane is influenced by the type of steel AISI-D6; AISI-O1; AISI-1045 selected, these comply according to their alloys, degree of hardness that they acquire with the heat treatment applied, according to the angle that has less detachment or deposition of the material when carrying out the work of matting guadua cane.

The impact tests carried out on the Charpy pendulum to measure the toughness and strength of the different steels proposed in this project, with their different degrees of hardness (56, 58, 60) HRC, allowed the selection of the AISI-D6/XW5 steel, with 60 HRC hardness, which has the highest toughness and strength demonstrated in the tests.

For the design of the cutting tools used for the matting of guadua cane, a working model was proposed based on the statistical software Statagraffics Centurión, which corroborated the results of the impact tests carried out on the Charpy pendulum to check the Tenacity and Resilience of the different steels proposed in this project, Different cutting blades with different angles and heat treatments were constructed with them, resulting in the AISID6/XW5 steel blade, with an angle of 30° and a hardness of 60 HRC, which has the best resistance to impact, greater hardness and greater durability to chipping in the matting of guadua cane in Manabí.

REFERENCES

Acero para Trabajos en Frio. (2015). Obtenido de http://www.elacero.com.ec/pdf/aceros.pdf

Aparicio, G., & D' Armas, H. (2006). Influencia del tratamiento térmico y del trabajo en frío en el comportamiento mecánico de láminas de. Revista INGENIERÍA UC, 13(1), 43-52. Obtenido de https://www.redalyc.org/articulo.oa?id=70713106

Aprendizaje.com.mx. (s.f.). Corte de metales y caacterísticas de herramientas.

ARTESANÍAS EN CAÑA. (15 de 02 de 2007). Obtenido de http://artescana.blogspot.com/2007/02/todo-lo-que-necesitas-saber-sobre-la.html

Arturo, P. E. (2012). Energía y Salud Ambiental. Portoviejo: Grafias Zambrano.

atusevich, A. E., Mancini, R. A., & Giudici, A. J. (2012). Determinación de la tenacidad a la fractura del material de un gasoducto. Rev. LatinAm. Metal. Mater., 32(2), 253-260. Obtenido de https://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0255-69522012000200012

Avner, S. (1985). Introduccion a la Metalurgia Fisica (2da ed.). MEXICO.

Balanzas, L. (2023). Clasificación Aceros Lasart. Clasificación de los aceros según normas AISI-SAE. Obtenido de https://lasarteweboficial.com/clasificaciondeaceros.php

bohman. (2023). Aceros para trabajo en frio. Obtenido de http://bohman.com.ec/shop/category/aceros-materiales-aceros-materiales-especiales-acero-herramienta-120: http://bohman.com.ec/shop/category/aceros-materiales-aceros-materiales-especiales-acero-herramienta-120

Concepto. (2024). https://concepto.de/tenacidad/. Obtenido de https://concepto.de/tenacidad/

Cruz. (2005). Obtenido de http://repositorio.ug.edu.ec/bitstream/redug/416/1/CURADO%20Y%20PRESERVACION%20DE%20CA%C3%91A%20GUADUA%20SELECCIONANDO%20AGENTES%20Y.pdf

Cruz, J. M. (2005). Obtenido de http://repositorio.ug.edu.ec/bitstream/redug/416/1/CURADO%20Y%20PRESERVACION%20DE%20CA%C3%91A%20GUADUA%20SELECCIONANDO%20AGENTES%20Y.pdf

de Krar, O. S. (1875). Corte de metales y caracteristicas de herramientas. Obtenido de Aprendizaje.com.mx. (s.f.). Corte de metales y caacterísticas de herramientas

del Castillo Rodriguez, F. D. (2008). Materiales y sus propiedades. Cuautitlan Izcalli.

Digital, C. (2009). Digital C. En Aceros y sus clasificaciones (pág. 10). Obtenido de http://cdigital.dgb.uanl.mx/te/1020119025/1020119025_02.pdf

Eder, L. (2015). “DISEÑO Y CONSTRUCCIÓN DE UNA MÁQUINA HORIZONTAL PARA PROCESAR ESTERILLA DE CAÑA GUADUA (ANGUSTIFOLIA KUNTH)”. Obtenido de http://repositorio.uteq.edu.ec/bitstream/43000/636/1/T-UTEQ-0008.pdf

Edith, C., Nubia, J., Cervantes, L., & Gil, J. (2020). Análisis del Desarrollo Innovador para el Aprovechamiento de la (Guadua angustifolia Kunth) en la Sustitución de Cultivos Ilícitos. Ciencia en Desarrollo, 11(2), 97-109. doi:https://doi.org/10.19053/01217488.v11.n2.2020.11518

Garzón, A. F. (2016). Caracterización físico-mecánica de la guadua en el municipio de Guaduas Cundinamarca. Universidad Nacional de Colombia - Sede Bogotá. Obtenido de https://repositorio.unal.edu.co/bitstream/handle/unal/57630/1010187540.2016.pdf?sequence=1

Lasheras. (1981). En Cedel (Ed.), materiales industriales (Cedal ed., págs. 392-393). España.

Martínez, A., Jaimes, A., Serna, A., & Uribe, I. (2024). Development of a correlation to estimate the fatigue strength for steels based on low-cost test. Ciencia, Tecnología y Futuro, 4(2), 71-81. Obtenido de http://www.scielo.org.co/scielo.php?script=sci_abstract&pid=S0122-53832010000200007&lng=es&nrm=iso&tlng=es

Ministerio de agricultura y Ganadería. (2020). Caña guadúa, cultivo con potencial para un desarrollo sostenible de las naciones. Obtenido de https://www.agricultura.gob.ec/cana-guadua-cultivo-con-potencial-para-un-desarrollo-sostenible-de-las-naciones/

Oretga, Y. (2005). Prueba de impacto: ensayo Charpy. Revista Méxicana de Física, 52(1), 51–57. Obtenido de https://www.scielo.org.mx/pdf/rmfe/v52n1/v52n1a8.pdf

Osorio, J., Vélez, J. M., & Ciro, H. (2007). Estructura Interna de la caña guadua y su incidencia en las propiedades mecánicas. Dyna rev.fac.nac.minas, 74(153), 81-94. Obtenido de http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0012-73532007000300009

Páez, J. D., De la Rosa, Y. E., Verduga, G. .., & Soto, J. A. (2022). Caracterización físico-mecánica de la Guadua Angustifolia Kunth en tres cantones de la provincia de Manabí. Revista Científica Arbitrada de Posgrado y Cooperación Internacional CLAUSTRO, 5(10). doi:https://doi.org/10.56124/claustro.v5i10.0054

Rodriguez, F. D. (2008). Obtenido de http://olimpia.cuautitlan2.unam.mx/pagina_ingenieria/mecanica/mat/mat_mec/m1/materiales_1.pdf

Rodriguez, F. D. (2008). En MATERIALES Y SUS PROPIEDADES (pág. 7). Cuautitlan Izcalli.

Rodriguez, J., & Villacis, E. (2023). Diseño de una maquina para hacer latillas de caña guadua. Obtenido de https://www.dspace.espol.edu.ec/bitstream/123456789/2051/1/4100.pdf

Soria, M. d., Reyes, F., Carrillo, F. R., García, F., & Álvarez, H. G. (2015). Efecto del tratamiento térmico sobre las propiedades mecánicas y microestructura de un acero para tubería API 5CT J55. Ingeniería, investigación y tecnología, 16(4), 539-550. Obtenido de https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1405-77432015000400006

STATGRAPHICS Centurion XVIII. (2023). https://statgraphics.net/. Obtenido de statgraphics: https://statgraphics.net/

Vercell, A. (21 de JUNIO de 2012). Energia como bienes comunes. Obtenido de http://www.energias.bienescomunes.org/2012/06/21/que-es-la-energia/

Veronica, L. (2012). USO DE LA CAÑA GUADUA COMO MATERIAL DE CONSTRUCCIÓN: EVALUACIÓN MEDIOAMBIENTAL FRENTE A SISTEMAS CONSTRUCTIVOS TRADICIONALES". . Obtenido de Caracteristicas de la caña guadua: http://repositorio.educacionsuperior.gob.ec/bitstream/28000/356/1/T-SENESCYT-0126.pdf

Weldvision. (2010). El metal mas poderoso de la humanidad. "Acero,Revista tecnica de soldadura", 1- 2. Obtenido de http://www.fronius.com/cps/rde/xbcr/SID-7644D21C-60CA6F8D/fronius_poland/4000063092_ES_weldvision_24._157041_snapshot.pdf.