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Journal of Technological Development

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Presentation of the Content

In the first chapter we present, *Design of a clamping device with 4 jaws for a milling machine* by MARTÍNEZ-JIRICNY, Alan, RODRÍGUEZ-DAHMLOW, Jesús Ernesto, MENDOZA-MIRANDA, Juan Manuel and PEREZ-GONZALEZ, Edgar Ernesto, with adscription in the Instituto Politécnico Nacional, as the following article we present, *Evaluation of the photocatalytic performance of ZnO nanostructures obtained by different synthesis methods* by CANO-LÓPEZ, Axel, MELO-MÁXIMO, Lizbeth, MELO-MÁXIMO, Dulce Viridiana and GONZÁLEZ-REYES, Leonardo, with adscription in the Tecnológico Nacional de México, Instituto Tecnológico de Tlalnepantla, Tecnológico de Estudios Superiores de Monterrey-Campus Estado de México and Universidad Autónoma Metropolitana, as the following article we present, *A computational approach to predict unsaturated soil phases* by ARROYO, Hiram, GUTIÉRREZ-VILLALOBOS, José Marcelino and CHAVEZ-CARDENAS, Xavier, with adscription in the Universidad de Guanajuato Campus Celaya-Salvatierra, as the last article we present, *Solar radiation tools and analysis for grid-interconnected photovoltaic systems* by POSADAS-RODRIGUEZ, Guillermo & GUTIERREZ-CIGARROA, Dionisio Lenin, with adscription in the Tecnológico de Estudios Superiores de Chicoloapan.

Contet

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

Diseño de fixture de 4 mordazas para fresadora

MARTÍNEZ-JIRICNY, Alan*†, RODRÍGUEZ-DAHMLOW, Jesús Ernesto, MENDOZA-MIRANDA, Juan Manuel and PEREZ-GONZALEZ, Edgar Ernesto

Instituto Politécnico Nacional. Unidad Profesional Interdisciplinaria de Ingenierías Campus Guanajuato. Av. Mineral de Valenciana No. 200 Col. Fracc. Industrial Puerto Interior, C.P. 36275 Silao de la Victoria, Guanajuato, México.

ID 1st Author: *Alán, Martínez-Jiricny* / **CVU CONAHCYT ID**: 1244894

ID 1st Co-author: *Jesús Ernesto, Rodríguez- Dahmlow* / **ORC ID**: 0000-0002-5348-6898

ID 2nd Co-author: *Juan Manuel, Mendoza-Miranda* / **ORC ID**: 0000-0003-4777-767X

ID 3rd Co-author: *Edgar Ernesto, Pérez-González*

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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

* Correspondence to Author (e-mail: amartinezji@ipn.mx)
† Researcher contributing first author.

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.

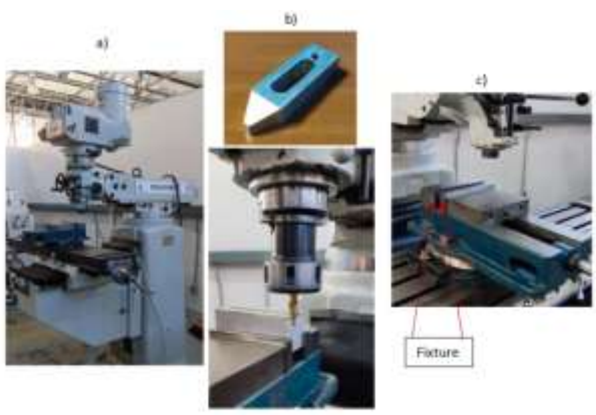


Figure 1 (a) UPIIG-IPN milling machine (b) types of machining performed with the milling machine (c) fixture type tool in the milling machine [1]

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].

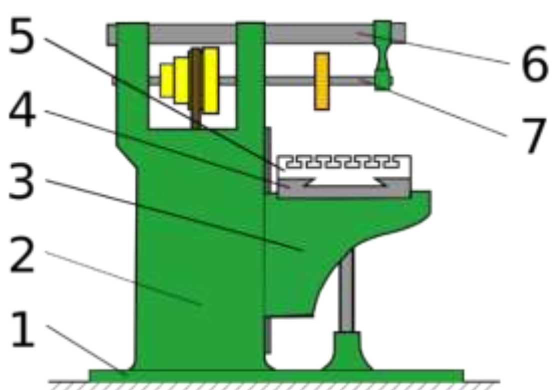


Figure 2 Diagram of the parts of a milling machine [2]

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.

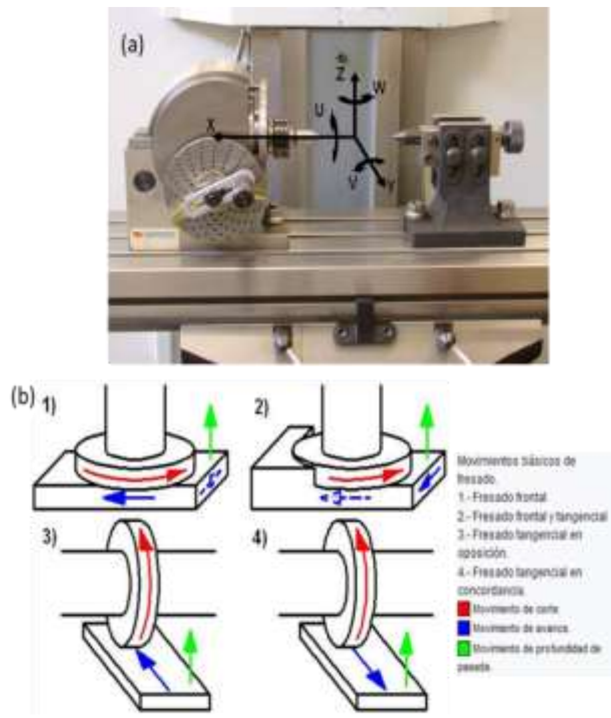


Figure 3 a) Milling cutter motion axis (b) Milling cutter basic motion [1,2]

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.

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.

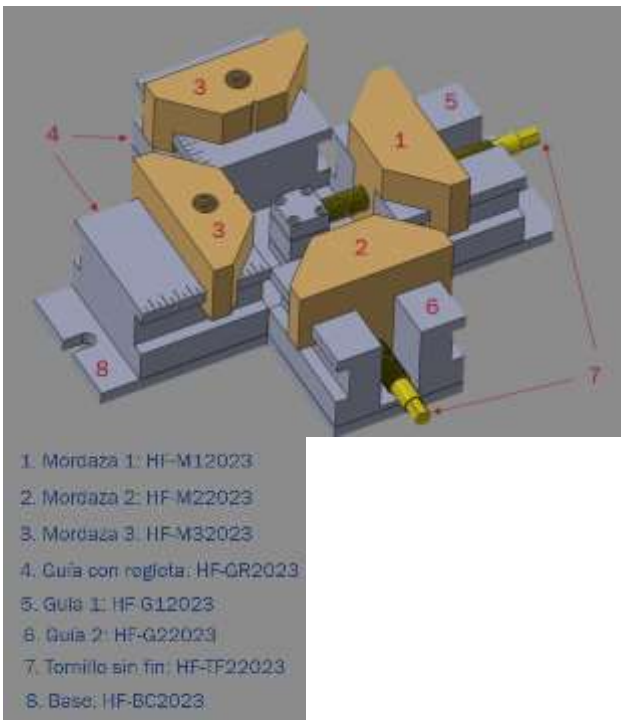


Figure 4 CAD tooling design

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

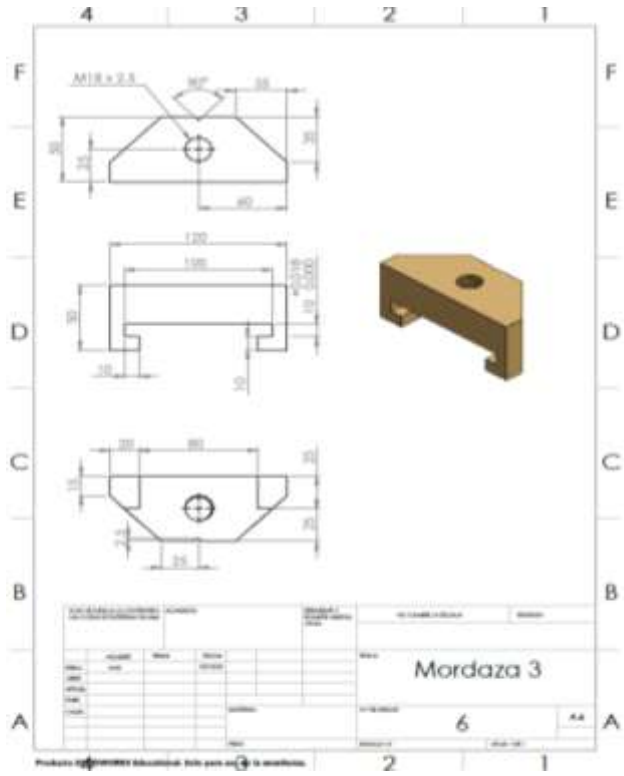


Figure 5 Design Drawing for Clamp 3: HF-M32023

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.

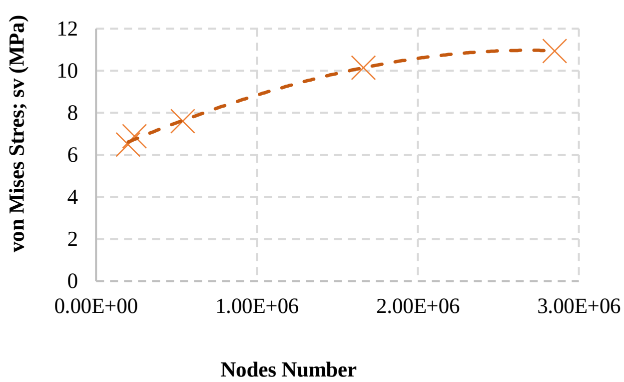


Figure 6 Mesh Sensitivity Analysis

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.

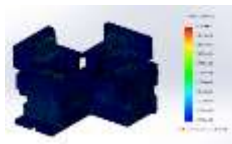
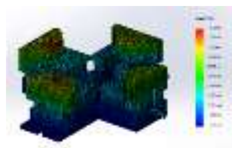
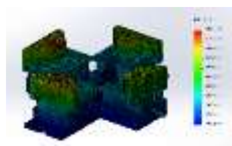
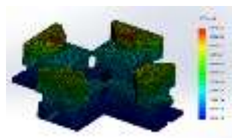
	von Mises Stress, σ_v (MPa)	Displacement, δ (mm)
AISI-1020		
AISI-1045		
Steel A2		

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

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Evaluation of the photocatalytic performance of ZnO nanostructures obtained by different synthesis methods

Evaluación del desempeño fotocatalítico de nanoestructuras de ZnO obtenidas por diferentes métodos de síntesis

CANO-LÓPEZ, Axel†, MELO-MÁXIMO, Lizbeth*, MELO-MÁXIMO, Dulce Viridiana and GONZÁLEZ-REYES, Leonardo

Tecnológico Nacional de México, Instituto Tecnológico de Tlalnepantla
Tecnológico de Estudios Superiores de Monterrey-Campus Estado de México
Universidad Autónoma Metropolitana, Departamento de Ciencias Básicas

ID 1st Author: *Axel, Cano-López* / **ORC ID**: 0009-0009-3834-5905, **CVU CONAHCYT ID**: 1187242

ID 1st Co-author: *Lizbeth, Melo-Máximo* / **ORC ID**: 0000-0002-7081-0661, **CVU CONAHCYT ID**: 299373

ID 2nd Co-author: *Dulce Viridiana, Melo-Máximo* / **ORC ID**: 0000-0001-7488-7677, **CVU CONAHCYT ID**: 170068

ID 3rd Co-author: *Leonardo, Gonzales-Reyes /* **ORC ID**: 0000-0003-3190-8911, **CVU CONAHCYT ID**: 60168

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Abstract

The industrial revolution gave way to the generation of pollutants that are harmful to the environment and that have been increasing, contaminating bodies of drinking water for this reason, solutions are currently being sought to eliminate some of these contaminants, such as dyes from the textile industry. This work describes the synthesis by different methods (physical and/or chemical) of zinc oxide nanostructures: nanopowders, nanowires and thin films, to evaluate their potential in the degradation of methyl orange in aqueous medium. The characterization of the materials was carried out by scanning electron microscopy and UV-vis spectrophotometry.

Photocatalysis, Zinc Oxide, Nanostructures

Resumen

La revolución industrial dio paso a la generación de contaminantes nocivos al medio ambiente y que han ido en aumento, contaminando cuerpos de agua potable; por esta razón actualmente se están buscando soluciones para eliminar algunos de estos contaminantes como los colorantes de la industria textil. Este trabajo describe la síntesis por diferentes métodos (físicos y/o químicos) de nanoestructuras de óxido de zinc: nanopolvos, nanocables y películas delgadas, para evaluar su potencial en la degradación del naranja de metilo en medio acuoso. La caracterización de los materiales se realizó por microscopia electrónica de barrido y espectrofotometría UV-vis.

Fotocatálisis, Óxido de Zinc, Nanoestructuras

Citation: CANO-LÓPEZ, Axel, MELO-MÁXIMO, Lizbeth, MELO-MÁXIMO, Dulce Viridiana and GONZÁLEZ-REYES, Leonardo. Evaluation of the photocatalytic performance of ZnO nanostructures obtained by different synthesis methods. Journal of Technological Development. 2023. 7-20: 5-9

* Correspondence to Author (e-mail: lizbeth.mm@tlalnepantla.tecnm.mx)
† Researcher contributing first author

1. Introduction

The industrial revolution had a major impact on many aspects of society and technology, including the textile industry, which led to the generation of pollutants and waste, such as methyl orange (MN), a synthetic dye.

As the global population continues to grow, production rates will continue to rise and with it, so will the generation of pollution, these pollutants generally end up in aquatic systems and have a detrimental effect on both the ecosystem and human health, therefore, Nanotechnology has also proven to be a versatile tool, given that throughout its history it has confirmed that it has the potential to adapt to and solve industrial problems by generating new materials with unique properties [1].

Nanotechnology offers more efficient alternatives for the degradation of pollutants through the use of different nanostructures [1]. The synthesis of these nanomaterials can be obtained by two ways, chemical and physical, however, there is also the possibility of using both for the modification of these same, one of the chemical methods is by coprecipitation, this method allows us to obtain nanomaterials and consists of the simultaneous precipitation of 2 or more chemical substances, which are mixed in a single solution, from the addition of a third reagent that generates the precipitation, for this there must be similarities between the compounds to use the growth of nanostructures depends on the type of precursor salt to use and the pH of the final solution [2].

Another chemical method is hydrothermal in which a metallic precursor is used in a solvent, which being a solvent, which being a hydrothermal process must be dissolved in water, this solution will be brought to its boiling point and maintained at a constant pressure [3].

And finally by physical means is the physical deposition of steam by reactive magnetron that allows us to obtain thin films [4] from these methods we can obtain different nanostructures, classified according to their dimensions: 0D, 1D, 2D and 3D [5].

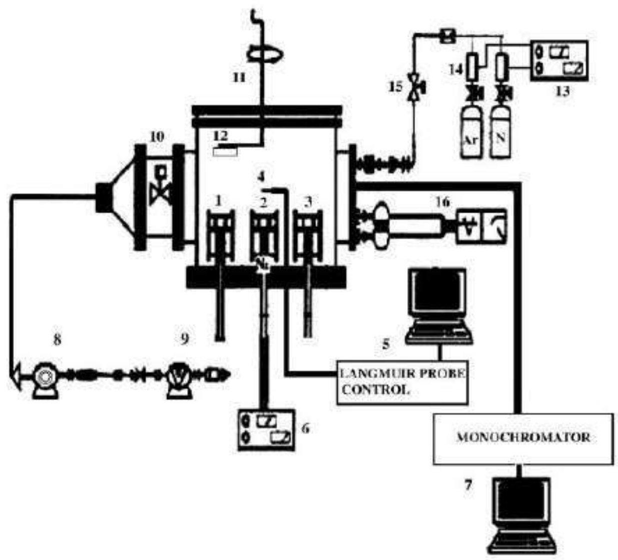

Figure 1 General schematic of the reactive magnetron sputtering equipment [4]

In addition, nanomaterials can be functionalised to achieve the decomposition of specific pollutants, since different catalytic or absorbing agents can be incorporated into their structure.Photocatalysis is a process that is based on the energy interactions between the bands (BC: valence band, gap band and BV: conduction band) and for photocatalysis, semiconductor nanomaterials are required that can act as catalysts and with the interaction of a photon can act as a photocatalyst and can be used in heterogeneous photocatalysis for the degradation of pollutants present in water. (fig. 1).

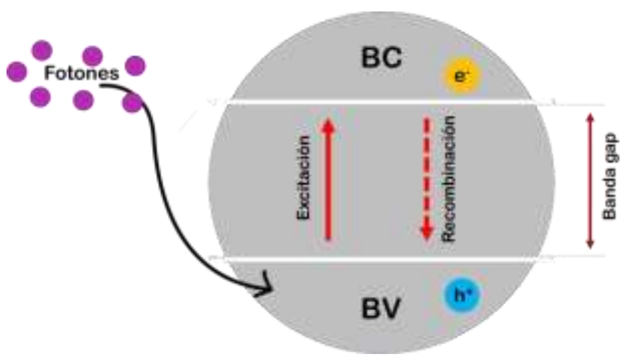

Figure 2 General mechanism of photocatalysis

Heterogeneous photocatalysis occurs when the amount received by the photon is equal to or greater than the gap band, allowing the electron to rise to the higher energy conduction band and holes in the valence band of the catalyst [6].

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Zinc oxide has proven to be an efficient nanomaterial for the degradation of organic compounds, since it is a semiconductor that has a gap band of approximately 3.36 eV, has a high stability and a good quality in thermal conductivity, these properties have allowed it to be used in various branches of technology, such as optoelectronics, cosmetics industry and since it has a low toxicity, is biodegradable and biocompatible it can be used in medicine, as well as for water treatment by having photocatalytic properties [7, 8].

2. Methodology to develop

The experimental part was carried out in 3 stages: first, synthesis of nanopowders by co-precipitation; second, synthesis of thin films by plasma-assisted physical vapour deposition (PVD) and finally, growth of zinc oxide nanostructures by hydrothermal method For the synthesis of the nanopowders (fig.2), zinc acetate dihydrate dissolved in hydrochloric acid and hydrochloric acid were used hydrochloric acid and an ammonia hydroxide solution were used for the synthesis of the nanopowders (fig.2), mixed under gentle stirring until a pH between 8-10 was obtained. The precipitates were allowed to cool to room temperature, filtered and washed with distilled water and placed in an oven at 100°C for 5 hours.

Figure 2 Nanostructured zinc oxide powders

The thin films were obtained in a PVD reactor using a high purity zinc target (99.9999%), argon gas and oxygen. An architecture with a zinc adhesion layer was generated for 10 seconds, then a zinc oxide layer was deposited for 10 seconds (fig.3).

Figure 3 Architecture of the PVD-synthesised thin film

Finally, for the growth of zinc oxide nanostructures, thin films obtained by PVD were used as seeds. For the hydrothermal method, a solution of hexamethylenetetramine and zinc nitrate was used; the seeds were immersed in this mixture and put in the oven for 6 hours at a temperature of 90°C, finally they were washed with distilled water and dried at room temperature. (fig.4).

Figure 4 Architecture for obtaining zinc oxide nanowires by PVD/hydrothermal PVD

For the photocatalytic tests, a 20 ppm solution of methyl orange was prepared and a ten-point calibration curve was performed (fig. 5). Using a 365 nm UV lamp, the samples were exposed for 30, 60 and 120 minutes. Finally, the photocatalytic performance of each of the nanostructures was evaluated by UV-vis spectrophotometry, characterised by scanning electron microscopy (SEM) and the contact angle was measured.

3. Results

Three nanostructures were obtained, figure 6 shows the powders (fig. 5a), the substrate surface with the film only (fig. 5b) and the substrate surface after the synthesis of the nanowires. (fig. 5c).

Figure 5 Nanostructures obtained. a) ZnO powders, b) ZnO thin film and c) ZnO nanowires

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The nanostructures were characterised by Uv-vis spectrophotometry, scanning electron microscopy and contact angle

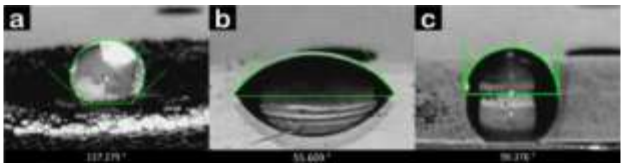


Figure 6 Contact angle of zinc oxide nanostructures. a) powders, b) thin film and c) nanowires

As can be seen in figure 6 the contact angle of the 3 nanostructures is different, two are above 90° (hydrophobic) and one is below 90° (hydrophilic).

The results of scanning electron microscopy can be seen in figure 7, that in two nanostructures there is presence of hexagonal geometries, powders and nanowires; for the case of the film on the surface, small spheres on a homogeneous layer are noticed.

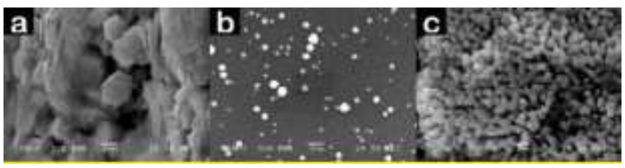
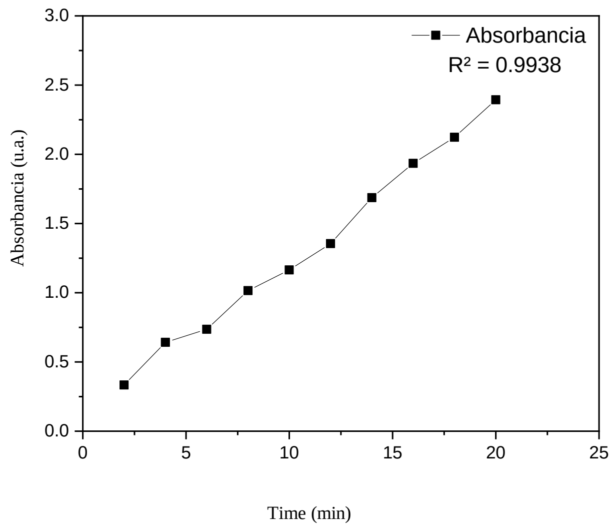


Figure 7 Scanning electron microscopy of zinc oxide nanostructures. a) powders, b) thin film and c) nanowires

The photocatalytic tests used aliquots starting from a 20ppm stock solution. It was diluted to 10 points per 10%. As shown in figure 8, the concentration changed colour as the percentage decreased.

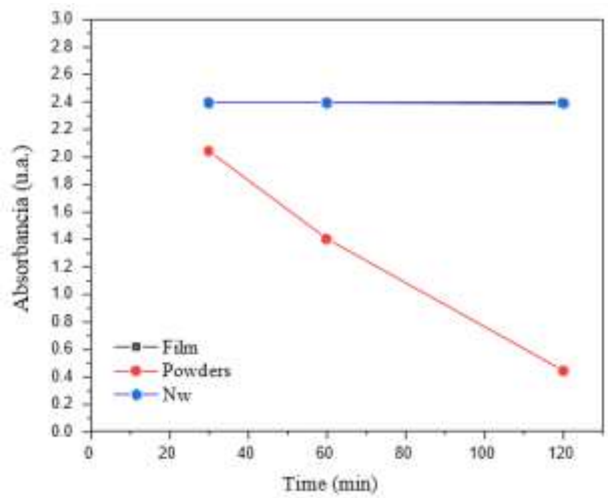
Figure 8 Aliquots taken for the calibration curve

Once the dilutions were available, they were taken to a spectrophotometer to measure the absorbance and generate the calibration curve presented in graph 1. The linear correlation coefficient the linear correlation coefficient shows a value of 0.9938, which indicates a low variation of the data following a linear trend.



Graph 1 Calibration curve of methyl orange (MN)

Graph 2 shows the degradation of methyl orange (MN) with respect to the different ZnO nanostructures exposed to irradiation under ultraviolet light.



Graph 2 Degradation of methyl orange with respect to time

The nanowires and zinc oxide films show a poor degradation of methyl orange compared to nanostructured ZnO powders.

4. Acknowledgements

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6. Conclusions

The results obtained on the photocatalytic performance of the 3 types of nanostructures show a higher performance for the zinc oxide nanopowders, being that degradations were obtained from the thin films and nanowires, while they do not present photocatalytic activity. The degradation rate of methyl orange with the zinc oxide powders increased with time.

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A computational approach to predict unsaturated soil phases

Un enfoque computacional para predecir las fracciones no saturadas de los suelos

ARROYO, Hiram†, GUTIÉRREZ-VILLALOBOS, José Marcelino* and CHAVEZ-CARDENAS, Xavier

Universidad de Guanajuato Campus Celaya-Salvatierra, Av. Javier Barros Sierra 201 Col. Ejido de Santa María del Refugio C.P. 38140 Celaya, Gto. México

ID 1st Author: *Hiram, Arroyo* / **ORC ID**: 0000-0002-8343-698X, **CVU CONAHCYT ID**: 349586

ID 1st Co-author: *José Marcelino, Gutiérrez-Villalobos* / **ORC ID**: 0000-0001-5947-1489, **CVU CONAHCYT ID**: 173461

ID 2nd Co-author: *Xavier, Chavez-Cardenas* / **ORC ID**: 0000-0001-6691-4380, **CVU CONAHCYT ID:** 269911

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Abstract

The unsaturated fractions in a porous medium such as soil are the result of the process of natural humidity changes that occur in environments where both the temperature and the relative humidity of the environment are constantly changing. These processes, important in environmental geotechnics, need to be studied to predict the resistance and permeability that the porous medium may have under various scenarios. This article allows us to establish a computational model that allows us to predict the volumes of the unsaturated fraction. The predictions of the model and its contrast with the Rojas model allow us to conclude that the model can be used on a large scale to be used in engineering applications related to water flow in soils.

Unsaturated soils, Degree of saturation, Computational algorithm

Resumen

Las fracciones no saturadas en un medio poroso como lo es un suelo, son resultado del proceso de cambios de humedad naturales que ocurren en ambientes donde tanto la temperatura, como la humedad relativa del ambiente están constantemente cambiando. Estos procesos, importantes en la geotecnia ambiental, necesitan ser estudiados parar predecir la resistencia y permeabilidad que el medio poroso puede tener bajo diversos escenarios. El presente artículo, permite establecer un modelo computacional que permite predecir los volúmenes de fracción no saturada. Las predicciones del modelo y su contraste con el modelo de Rojas, permite concluir que el modelo puede ser utilizado a gran escala para ser utilizado en aplicaciones ingenieriles relacionadas con flujo de agua en suelos.

Suelos no saturados, Grado de saturación, Algoritmo computacional

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* Correspondence to Author (e-mail: 9787@soyunaq.mx)
† Researcher contributing first author

Introduction

Soils are the most common construction material in civil engineering practice and much research is dedicated to it. Its mechanical and hydraulic behavior, unlike conventional materials such as steel or concrete, is far from being understood. This is mainly due to the heterogeneity that even the most "homogeneous" soils appertain; for example, sand materials, which are among the most homogeneous materials, classified according to the Unified Soil Classification System, as SP (poorly graded sands). These materials, commonly found in lake deposits or coastal areas, are formed by solid grains that share similarity in their sizes. That is, the particle size curve is practically a vertical line that indicates that there is a single predominant particle size.

Even so, the effects observed in civil practice for sandy soil deposits exhibit such behavior that depends on the level of applied stress, the compactness of the soil deposit, the humidity, and even the temperature of the medium. These variables are not taken into account for conventional materials such as steel or concrete, because their influence is negligible. (Fredlund & Rahardjo, 1993).

In this regard, one of the most important applications for civil engineering is to build impermeable barriers for earthen dams wich comply with preventing humidity to spread over an environment that could damage the substructure or superstructure. These barriers, also used in soil tanks to store CO_2, can be subject to changes in humidity that substantially affect the mechanical behavior of the material. (Alonso, Gens, & Josa, 1990; Laloui & Nuth, 2009; Nuth, 2009).

The flow of water in soils leads to variations in soil water content. The factors that mainly affect the flow are permeability (which in turn depends on the void ratio), the properties of the solid particles.

Development of a computational algorithm

This section describes a procedure for the placement of each solid particle, site and bond. This is a matter of utmost importance as it leads to a description of the density of the soil sample. This has important implications for various percolation properties, such as the air entry value of the soil (Hunt, 2004).

For example, solid particles of the same size, are more likely to gather, consequently producing pores of the same size around them, as indicated by several observations. (Monroy, Zdravkovic, & Ridley, 2010).

The structural geometric distribution of the porous structure, that is, the spatial distribution of sites, bonds and solids, will be carried out in a square grid of M rows and M columns. At the intersection of each row and column, there is a site, the sites are joined by bonds as shown in the following figure:

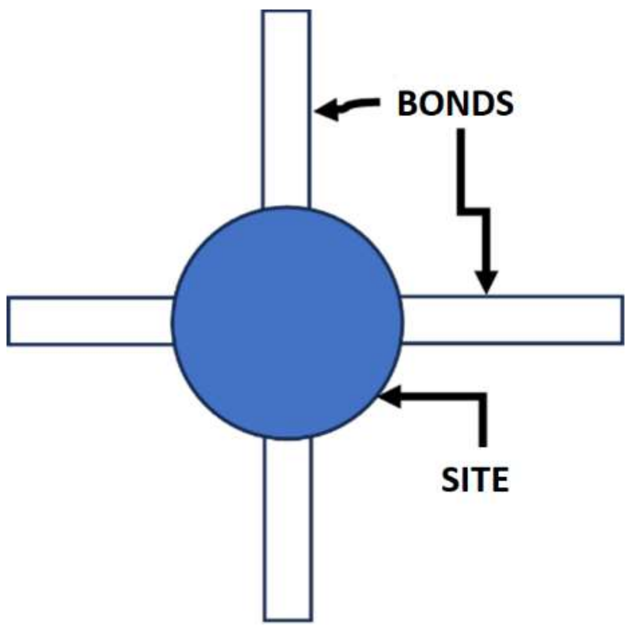

Figure 1 Interaction of sites and bonds

The number of sites and bonds will be determined by the frequency of each of them in the porous matrix. The frequency is obtained from the pore size distribution, which is commonly evaluated using the Mercury Intrussion Porosimetry technique (Kang, Watabe, & Tsuchida, 2003). The frequency distribution can be expressed considering that:

$$f = \frac{n}{\overline{n}} \quad (1)$$

Therefore, the number of required sites for a certain size will thus be:

$$n_S = \overline{n_S} f_S \quad (2)$$

Before placing the site, a random point (i.e. $Es(j)$) is scanned to see if there are already any bond connecting it. The first scenario is to find the place without bond interconnections.

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Then, completely randomly, a site is chosen from the distribution $n_S = \overline{n_S} f_S$ and placed on the empty spot $Es(j)$.

It is very important that the site-bond interconnection describes a real porous physical medium. If it is too small in figure 1, it can produce an overlap between the four bonds reaching it. To do this, it will be placed only if it is greater than the given condition to avoid for the intersection of B1 and B2:

$$R_{S\min} = \sqrt{R_{B1}{}^2 + R_{B2}{}^2} \tag{3}$$

Where R_{B1} and R_{B2} are the two concurrent perpendicular bonds.

For a given grid, the number of sites, bonds, and solid particles required is obtained based on the relative volume distribution presented earlier in this paper. Considering Equation (1), the number of each class of sites is that of $n_S = \overline{n_S} f_S$.

The construction of the solid structure is at first completely random as it occurs in nature. Then, as it progresses, the imposed restrictions give way to a real structure since the spaces and restrictions for placement of sites and bonds gradually reduce the placement possibilities.

In the first stage, sites and bonds are placed. A completely random list of empty places where the sites will be located is drawn up without repeating a single one. At first, it is a $M \times 1$ vector containing coordinates. Likewise, a list of the sites that are going to be placed in the mesh is prepared A_S. This list is actually the distribution defined for each class of sites to satisfy the volume distribution. In the same way, a list A_B of the bonds that are going to be placed in the grid is prepared. For bonds, the latter is the distribution for each class of bonds.

Before placing the site, a random point is scanned to check if there are already any connected bonds concurring to it. The first scenario is to find the place without bond interconnections. Then, completely randomly, a site is chosen from the layout and placed on the empty spot.

The described process allows the construction of a porous structure with the characteristics of the microstructural observations observed in mercury intrusion porosimetry tests, as well as in scanning electron microscopy and nitrogen adsorption technique. (Seiphoori, Ferrari, & Laloui, 2014; Simms & Yanful, 2005).

The porous network must also have solid particles; however, placement of the solid particles is performed immediately after the porous network has been established. This is because there must be a correspondence between the predicted and measured void ratios and placing the solid particles at the beginning would likely prevent the true pore network from being achieved. Regarding sites and bonds, the placement within the grid of solid particles is a random selection of a place within the grid, to place the most suitable element. Until this stage, all bonds and sites are located, leaving a free place for each of the solid particles contained in the soil.

Probabilistic model of Rojas, *et al*.

The probabilistic model used is a work developed and reported in Rojas, Zepeda, Pérez-Rea, Leal, and Gallegos (2009). It is a mathematical approach that allows us to express in probabilistic terms the distribution of pores in an infinitely large mesh. This model, developed at the Autonomous University of Querétaro, by the work group of Eduardo Rojas González, allows us to contrast the work developed for this research work. The following section contains the elements necessary to identify differences and be able to draw conclusions in terms of the parameters used.

The Rojas' model requires the porosimetry distribution of sites and bonds. The necessary parameters are the mean μ and the standard deviation σ of each element (the mean and standard deviation of the solid particles are also required, which can be obtained directly from the granulometric curve).

Contrasting Rojas *et al* model with computational approach

The previous sections have dealt with a description of the internal arrangement of solid particles and the porous structure surrounding each solid particle.

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Several assumptions have been made to produce a simple description of the pore structure. It has been argued that this model, like many others, does not represent the actual pore structure; However, the objective of this article is to propose a simple model feasible to use for engineering purposes when it comes to modeling soil drying and wetting phenomena.

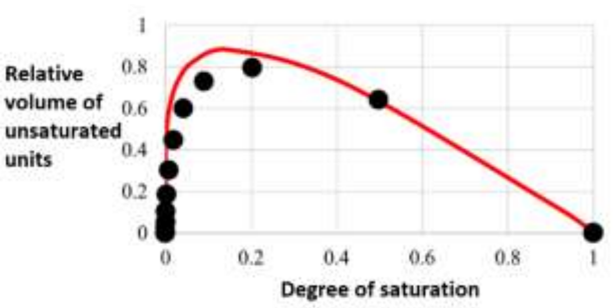
Once the porous structure is built, the evacuation of liquid water from the pores is governed by the Young-Laplace relationship:

$$R_C = 2\frac{T_S \cos\phi}{s} \quad (4)$$

Equation (4) establishes the relationship between the suction level reached during drying and the pore size that must be dried. Therefore, it allows "imposing" suction to the constructed porous matrix arrangement, correlating it with the pore size that must be dried. Only pores that are connected to dry bonds, which have the radius defined by Equation (4), will dry. The others will not. With these characteristics, a porous matrix was constructed on a square grid of 250 elements.

Model parameters					
μ_S^m	σ_S^m	μ_B^m	σ_B^m	μ_{SOL}^m	σ_{SOL}^m
-6.50	0.40	-6.85	0.40	-5.00	0.82

Table 1



Graph 1 Contrast between computational model and probabilistic model. Solid line: probabilistic model. Checkered line: computational model

With each increase in suction, the new degree of saturation is evaluated according to the equation:

$$S_r = \frac{Vw}{Vv} \quad (5)$$

Where *Vw* is the volume of the sites that remains saturated. *Vv* is the total volume of sites that make up the porous matrix.

The degree of saturation is evaluated by subtracting the relative volume of the pores that have already dried in the previous step of increasing suction. Thanks to this, it allows generating a relationship between the degree of saturation and suction, called "water retention curve".

An important property that allows the process to be analyzed is the generation of an unsaturated boundary, which means that there is a volume of material that is formed by pores that are empty, as well as pores that are saturated.

This relative volume can be analyzed in the computational model if a saturated site is considered to be exclusively surrounded by saturated sites. On the other hand, dry sites will be those that are exclusively surrounded by dry sites. In this sense, the "unsaturated" sites, which form the unsaturated units, will be the sites that are surrounded by both saturated and unsaturated sites. This allows us to identify a volume of "unsaturated" units whose evolution predicted in Graph 1 is consistent with the fact that there are no saturated units when the soil is dry (zero saturation degree), nor there exist saturated units when the soil is dry (degree of saturation equal to unity).

Graph 1 allows contrasting Rojas' probabilistic model, as well as the computational model proposed in this work, showing both consistency in their trends.

The model used in this project can be implemented in a growing grid mesh, which would allow identifying, in a computational environment, wetting times, wetting boundaries, and being able to generate useful projections for civil engineering in oil extraction projects leachate flow, etc.

Conclusions

This research work reports a computational model generated through a simple algorithm that allows simulating important characteristics of the drying process in a porous medium. The model considers the interconnection between linear bond-type elements, and elements that store water within the soil, until the two conditions necessary for them to dry are met. These conditions, established for a medium, are a function of the size of the pores that surround it, as well as the level of suction achieved.

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Solar radiation tools and analysis for grid-interconnected photovoltaic systems

Herramientas y Análisis de la radiación solar para los sistemas fotovoltaicos interconectados a la red

POSADAS-RODRIGUEZ, Guillermo†* & GUTIERREZ-CIGARROA, Dionisio Lenin

Tecnológico de Estudios Superiores de Chicoloapan

ID 1st Author*: Guillermo, Posadas-Rodriguez* / **ORC ID**: 0009-0004-5765-7107

ID 1st Co-author: *Dionisio Lenin, Gutierrez-Cigarroa* / **ORC ID**: 0009-0007-9719-7186

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Abstract

The technological tools for obtaining data allow the analysis of radiation in any part of the world, we refer us to the process with which historical data is obtained that allows determining the peak hour and the ideal geographical area for planning, design, installation, and operation. Efficient photovoltaic systems. This analysis justifies the measurement of solar radiation in the study region for the implementation and improvement of renewable energy systems, which play a fundamental role in the performance of photovoltaic systems. These technological tools are essential to guarantee that the systems make the most of the sun's energy and are a profitable investment in the generation of sustainable energy, contrasting with the costs recorded in electricity bills, the feasibility of establishing this modality of energy generation is projected electrical energy, contributes to the improvement of the environment as well as the benefit in the economy of the population.

Photovoltaics, Radiation, Solar

Resumen

Las herramientas tecnológicas para la obtención de datos permiten el análisis de la radiación en cualquier parte del mundo, referimos al proceso con el que se obtienen datos históricos que permite determinar la hora pico y la zona geográfica idónea para la planificación, diseño, instalación y operación eficiente de sistemas fotovoltaicos. Este análisis justifica la medición de la radiación solar en la región de estudio para la implementación y mejora de los sistemas de energías renovables, desempeñan un papel fundamental en el rendimiento de sistemas fotovoltaicos. Estas herramientas tecnológicas son esenciales para garantizar que los sistemas aprovechen al máximo la energía del sol y sean una inversión rentable en la generación de energía sostenible, contrastando con los costos registrados en recibos de luz, se proyecta la factibilidad de establecer esta modalidad de generación de energía eléctrica, contribuye a la mejora del medio ambiente y se refleja en beneficio de la economía de la población.

Fotovoltaicos, Radiación, Solar

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* Correspondence to Author (e-mail: memoposadas@gmail.com)
† Researcher contributing first author

1. Introduction

The growing demand for sustainable energy has driven the exploration of renewable sources, with solar energy being a promising and environmentally friendly option. In this context, the efficiency of photovoltaic systems plays a crucial role in the transition towards a cleaner energy matrix. This study focuses on the collection and analysis of solar radiation data, which is essential for determining the peak time and optimal geographical location, thus facilitating the planning, design, installation and efficient operation of these systems.

The collection and analysis of solar radiation data is essential in the current transition to renewable energy sources. Solar radiation is the driving force behind photovoltaic systems, and a thorough understanding of it is essential to optimise the efficiency of these systems. This research is presented as a strategic tool for informed decision making in the implementation of solar technologies, highlighting their importance in sustainable energy generation.

What distinguishes this research from other existing techniques is its focus on obtaining historical global solar radiation data. The selected technological tools allow not only the collection of point-in-time information, but also the analysis of patterns over time and across geographic locations. This global approach provides a holistic view, allowing for more accurate and efficient planning in the implementation of photovoltaic systems.

Description of the solar peak hour (SPH)

The unit of measurement of solar irradiance referring to the energy per unit of a constant surface area that will be received with an assumed constant solar irradiance of 1000 W/m^2.

A peak solar hour is equivalent to 3.6 MJ/m^2 or 1 kWh/m^2.

85% of the Mexican territory has optimal solar radiation conditions, making it one of the most privileged countries in the world in terms of solar resources.

Mexico is almost six times larger than Germany, and due to its location, it has five times more solar radiation capture.

Despite this, the Teutonic country generates 42 times more energy than California (USA).

Generates 42 times more energy, and is one of the powers in terms of solar panels and renewable energies. If the comparison is made with Denmark, another leading nation in the sector, the equivalent of what Mexico generates corresponds to only 0.1% to 0.23% of the energy produced by the European country. This indicates that Mexico has a better location than many countries, and therefore a greater unexploited solar catchment.

Country	Distributed generation penetration (%)
Germany	48
California (USA)	5
Chile	10
Denmark	55
Spain	31
México	0.23

Table 1 Percentage in countries with excellent PV generation
Source: Prepared by CIEP, with data from SENER 2017

Solar energy in Mexico has grown steadily in recent years. Thanks to the trust placed in the main technology for harnessing it: solar panels.

Important physical elements for peak solar time (HSP):

- Solar Radiation
- Direct Radiation
- Diffuse Radiation
- Reflected Radiation
- Energy Flow
- Check feasibility

Solar radiation

The flow of energy we receive from the Sun in the form of electromagnetic waves that enables the transfer of energy.

Direct Radiation

Radiation received directly from the sun in a straight line, without being deflected as it passes through the atmosphere. It is the largest and most important in photovoltaic applications.

Diffuse radiation

Radiation received from the sun after being deflected by atmospheric scattering. Diffuse radiation is the radiation that is received through clouds, as well as that which comes from the blue sky. If there were no diffuse radiation, the sky would be black even during the day, as is the case, for example, with the moon.

Reflected radiation

This is the direct and diffuse radiation that is received by reflection from the ground or other nearby surfaces. Global irradiance is the total incident radiation on a surface.

Energy flux

Radiation quantities are generally expressed in terms of radiant exposure or irradiance, the latter being a measure of the flux of energy received per unit area instantaneously as:

energy/area-time and whose unit is Watt per square metre (W/m^2).

Check feasibility

The feasibility of the solar resource must be verified in order to design and implement a photovoltaic system capable of meeting society's electricity consumption needs.

Key Characteristics for Solar Radiation Analysis for photovoltaic systems:

1. Global Accessibility: The ability of this technology platform to provide solar radiation data anywhere in the world significantly expands the scope and applicability of the research.

2. Historical Analysis: The ability to provide and analyse historical data allows for the identification of seasonal patterns and trends over time, improving accuracy in decision making.

3. Photovoltaic System Efficiency: The focus on determining the peak time and ideal geographic location directly aims to improve the efficiency of photovoltaic systems, thus maximising energy generation.

Problem statement

The central problem addressed, is the scarce dissemination of technological platforms that serve as specific tools for obtaining and analysing detailed solar radiation data on a global level. The implementation of these technological tools would support more accurate and efficient planning of photovoltaic systems by identifying the optimal peak time and geographical location.

Current State of Photovoltaic Technology

Photovoltaic technology has seen significant progress in recent years, driven by advances in solar cell efficiency, reduced production costs and increased generation capacity. Recent research has highlighted developments in semiconductor materials, solar cell structures and manufacturing methods that improve the conversion of solar radiation into electricity more efficiently. In addition, current trends in the integration of energy storage systems to overcome challenges related to the intermittency of solar generation will be explored.

The Solar Resource

The sun is an inexhaustible source of energy due to the nuclear reactions occurring at its centre. A large part of this energy reaches the Earth in the form of electromagnetic radiation, the sunlight that we can perceive by sight is in the spectral range from 400 to 750 µm in wavelength.

The sun's path

In addition to atmospheric conditions, there is another parameter that radically affects the incidence of radiation on a solar collector: the apparent movement of the sun throughout the day and throughout the year. We say "apparent" because in reality it is the Earth that is rotating and not the Sun. The Earth has two types of motion: one is around its own axis (called rotational motion) which gives rise to day and night and the other is around the sun (called translational motion) following an elliptical path, which gives rise to the seasons of the year.

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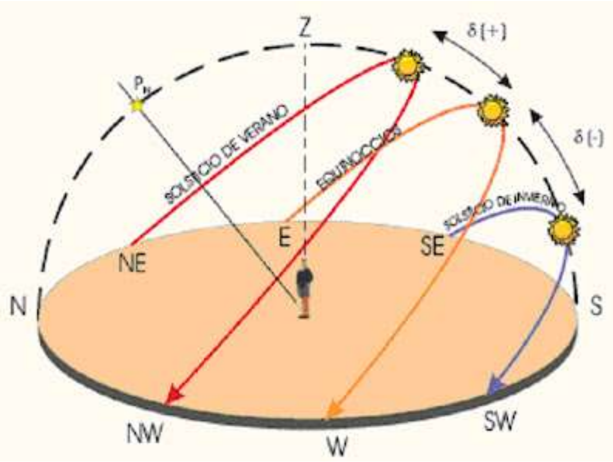

Figure 1 Angle formed by the Sun's rays with the equatorial plane
Source: https://maestrosenciencias.blogspot.com/2010/12/el-cielo-visto-desde-la-tierra-los.html?m=1

Tilt of the photovoltaic array

Maximum energy is obtained when the sun's rays are perpendicular to the collector surface. In the case of PV arrays, perpendicularity between the module surfaces and the sun's rays can only be achieved if the array mounting structures move in line with the sun. There are array support structures that automatically adjust the azimuth and/or elevation. These mounting structures are called trackers. Usually the elevation angle of the array is fixed. In some cases azimuthal trackers are used. Depending on the latitude of the site, these trackers can increase the average annual insolation by 15-25%.

Selection of Technological Tools

Exploration and evaluation of available technology tools, highlighting selection criteria.

The technology tool selection stage is crucial to ensure the effectiveness and applicability of the research. A thorough exploration of the available tools will be carried out, followed by an evaluation based on specific criteria to select the most suitable tools for the study of solar radiation and photovoltaic systems in the region of interest.

Exploration of Available Tools

A full exploration of existing technological tools for obtaining solar radiation data will be undertaken. This will include a review of commercial platforms, open source software and emerging technologies in the field.

The diversity of approaches, from weather stations to geospatial analysis platforms, will be considered to ensure an informed selection.

A table with solar radiation values per state of the Mexican Republic was made, in each state the peak solar hour per month and the annual count for each of them is denoted with information based directly from a NASA page from the year 2021, as it is the most current information found in that platform, the process was performed as follows:

Figure 2 Image Virtual Platform, NASA Projection
Source: POWER | Data Access Viewer (nasa.gov)

Figure 3 Image Approach to geolocation input
Source: POWER | Data Access Viewer (nasa.gov)

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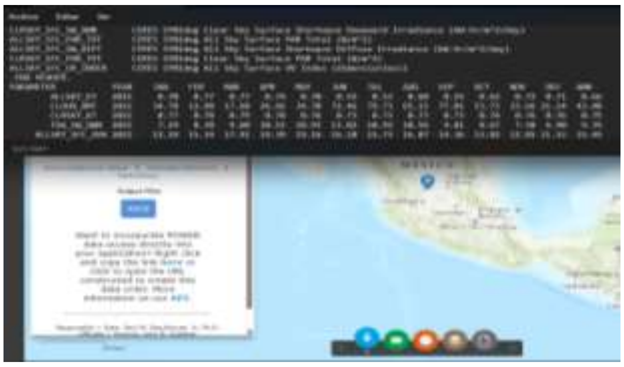

Figure 4 Image with parameterised values
Source: POWER | Data Access Viewer (nasa.gov)

NASA POWER Selection Criteria

Evaluation of these tools will be based on specific criteria designed to meet the research objectives. Some key criteria include:

a. Measurement Accuracy: Priority will be given to tools that provide accurate solar radiation measurements, ensuring reliable data for decision making.

b. Data Update Frequency: Tools with higher update frequencies will allow for more detailed analysis of temporal patterns, being beneficial for peak time identification.

c. Accessibility and Ease of Use: Data accessibility and ease of implementation will be key considerations, as a user-friendly tool will facilitate integration into the study.

d. Historical Analysis Capability: The ability to perform historical analysis at different time scales will be essential to understand long-term patterns and optimise the efficiency of PV systems.

e. Integration with Design and Planning Systems: Tools that integrate seamlessly with PV project design and planning systems will be preferred for efficient implementation.

f. Geographical Applicability: The ability of tools to adapt to the specific geographical characteristics of the study region will be a crucial criterion.

Regulatory

We verified that through the analysis of the information provided by NASA POWER POWER Data Access Viewer Official NASA Source, corresponding to the maximum irradiance in units of KW/h/m^2, as well as the amount of Peak Solar Hours (PSH), we corroborate that it is feasible to integrate a project of this type which will have sufficient solar resource to be optimal and also comply with the regulations (NOM-001-SEDE-2012).

Figure 5 Image created by AI

Conclusions

We corroborate that it is feasible to use NASA POWER tools to integrate a project with sufficient solar resource to be able to be optimal in its operation.

As with the integration of this solar photovoltaic system, it will be possible to generate an awareness of the use of technological tools prior to the installation of solar energy.

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Hora Solar Pico: Profesor Sarmiento: Titular del Centro de Estudio de Tecnologías Energéticas Renovables (CETER). Miembro de CUBASOLAR.

NASA POWER | Data Access Viewer

NORMA Oficial Mexicana NOM-001-SEDE-2005, Instalaciones Eléctricas (utilización).

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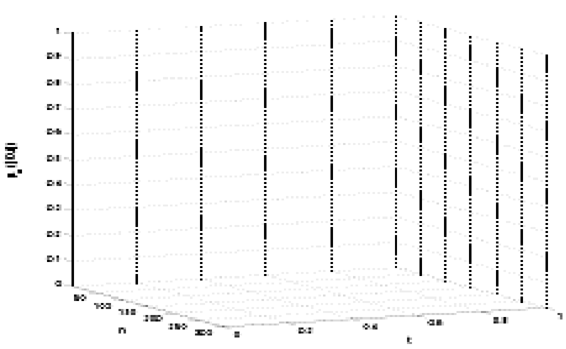

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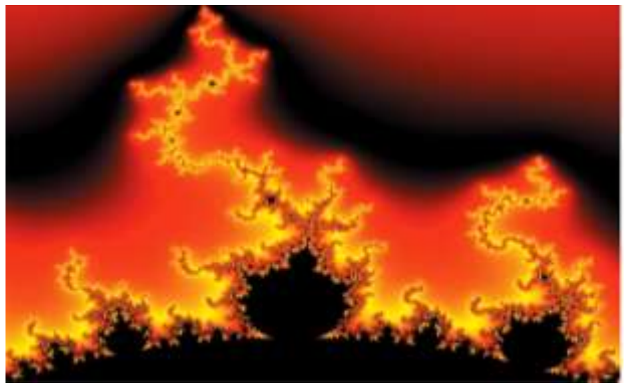

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