ISSN 2410-3950

Volume 10, Issue 28 – January – June – 2023

Journal of Experimental Systems

ECORFAN®

Journal of Experimental Systems, Volume 10, Issue 28, January – June 2023, is a journal edited sixmonthly by ECORFAN-Bolivia. Loa 1179, Cd. Sucre. Chuquisaca, Bolivia. WEB: www.ecorfan.org/bolivia, journal@ecorfan.org. Editor in Chief: VALDIVIA - BARRERO-ROSALES, José Luis. PhD. ISSN On line: 2410-3950. Responsible for the latest update of this number ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN, Imelda. PhD, LUNA-SOTO, Vladimir. PhD, last updated June 30, 2023.

Journal of Experimental Systems

Definition of Research Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Biology and Chemistry, in Subdisciplines Logical Methods, Research methods, Hypothetical-deductive method, Scientific observation method, Measuring method, Scientific experimentation, Climatology, Geology, Geochemistry, Acoustics.

ECORFAN-Mexico SC is a Scientific and Technological Company in contribution to the Human Resource training focused on the continuity in the critical analysis of International Research and is attached to CONAHCYT-RENIECYT number 1702902, its commitment is to disseminate research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S & T Councils - CONACYT Research Centers.

Scope, Coverage and Audience

Journal of Experimental Systems is a Research Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Bolivia, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice Logical Methods, Research methods, Hypothetical-deductive method, Scientific observation method, Measuring method, Scientific experimentation, Climatology, Geology, Geochemistry, Acoustics with diverse approaches and perspectives , That contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Biology and Chemistry. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

Editorial Board

Arbitration Committee

Assignment of Rights

The sending of an Article to Journal of Experimental Systems emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Bolivia considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONACYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONAHCYT for the chapters of America-Europe-Asia- Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Research Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board- Allocation of the pair of Expert Arbitrators-Notification of Arbitration -Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of Logical Methods, Research methods, Hypothetical-deductive method, Scientific observation method, Measuring method, Scientific experimentation, Climatology, Geology, Geochemistry, Acoustics and other topics related to Biology and Chemistry.

Presentation of Content

In the first article we present, *System for personnel access control based on image processing*, by LÁRRAGA-ALTAMIRANO, Hugo René, ESPINOSA-GUERRA, Omar, SEBASTIAN-LÓPEZ, Jonathan and FLORES-HERNÁNDEZ, Omar, with adscription in the Tecnológico Nacional de México, Campus Ciudad Valles; as next article we present, *Energy efficiency manager for electrical installations at home*, by GONZÁLEZ-CARRILLO, Gamaliel, ORDOÑEZ-FLORES, Rafael, NAVARRETE-ESCALANTE, Marcela Monserrat and MORALES-CAPORAL, Roberto, with adscription in the Instituto Tecnológico de Apizaco and Instituto Tecnológico de Ciudad Guzmán, Ciudad Guzmán; as next article we present, *Analysis of hazards and risks in drawing machines*, by PÉREZ-GALINDO, Liliana Eloisa, TORRES-VALLE, José Bernardo, HERNÁNDEZ-BORJA, Carlos and PEZA-ORTÍZ, Edebaldo, with adscription in the Universidad Tecnológica Fidel Velázquez; as final article we present, *Design and experimental study of systems for the regeneration of aqueous CaCl2 solutions using solar energy*, by CARRERA-ARELLANO, Ethson Uriel, PILATOWSKY-FIGUEROA, Isaac, HERNÁNDEZ-RUÍZ, María A. and GARCÍA-GONZÁLEZ, Juan Manuel, with adscription in the Universidad Autónoma de Zacatecas.

Content

Article **Journal of Experimental Systems**
June 2023, Vol.10 No.28 1-8

System for personnel access control based on image processing

Sistema para control de acceso de personal basado en procesamiento de imágenes

LÁRRAGA-ALTAMIRANO, Hugo René†*, ESPINOSA-GUERRA, Omar, SEBASTIAN-LÓPEZ, Jonathan and FLORES-HERNÁNDEZ, Omar

Tecnológico Nacional de México, Campus Ciudad Valles, México.

ID 1st Author: *Hugo René, Lárraga-Altamirano* / **ORC ID:** 0000-0001-8258-9418, **Researcher ID Thomson:** T-2296-2018, **arXiv Author ID:** Hugo_Larraga, **CVU CONACYT ID:** 626539

ID 1st Co-author: *Omar, Espinosa-Guerra* / **ORC ID:** 0000-0002-5787-226X, **Researcher ID Thomson:** W-7585-2019, **arXivAuthor ID:** omar_espinosa, **CVU CONACYT ID:** 37672

ID 2nd Co-author: *Jonathan, Sebastian-López* / **ORC ID** 0000-0002-5607-4389, **Researcher ID Thomson:** HJH-7546-2023, **arXiv Author ID:** Jonathan_Sebastian, **CVU CONACYT ID:** 1265066

ID 3rd Co-author: *Omar, Flores-Hernández* / **ORC ID:** 0000-0001-9157-3338, **Researcher ID Thomson:** HJH-7600-2023, **arXiv Author ID:** Omar_Flores, **CVU CONACYT ID:** 1265062

DOI: 10.35429/ JOES.2023.28.10.1.8 Received: January 10, 2023; Accepted: June 30, 2023

Abstract

Access control in organizations has been an important logistic process that allows verifying the identity of those who transit in a company. It gives security management certainty, but it is also a control point for additional information, for example, the health status of those who access it. This study proposes a software and hardware prototype to implement access control to an institution using various technologies within the framework of industry 4.0. It consists of an image processing system for validating QR codes, through an Arduino hardware module, as well as a web application for managing the information generated during the logistics process.

Arduino, Image processing, Access control, Vaccination status, Logistics

Resumen

El control de acceso en las organizaciones ha sido un proceso logístico de importancia que permite verificar la identidad de aquellos quienes transitan en una empresa. Da certeza a la gestión de la seguridad, pero también es un punto de control de información adicional, por ejemplo, el estado de salud de quienes acceden. El presente estudio propone un prototipo de software y hardware para implementar un control de acceso a una institución usando diversas tecnologías dentro del marco de la industria 4.0. Consiste en un sistema de procesamiento de imágenes para validación de códigos QR, a través de un módulo de hardware Arduino, además de una aplicación web para la gestión de la información que se genera durante el proceso logístico.

Arduino, Procesamiento de imágenes, Control de acceso, Estado de vacunación, Logística

Citation: LÁRRAGA-ALTAMIRANO, Hugo René, ESPINOSA-GUERRA, Omar, SEBASTIAN-LÓPEZ, Jonathan and FLORES-HERNÁNDEZ, Omar. System for personnel access control based on image processing. Journal of Experimental Systems. 2023. 10-28:1-8.

* Correspondence to Author: (E-mail: hugo.larraga@tecvalles.mx).
† Researcher contributed as first author.

Introduction

Globalization has made the logistics sector a very important part of business processes given the need to comply with the required organizational models, for example, the entry and exit of personnel or merchandise (Lora & Garcés, 2020). Access control for personnel helps to manage compliance with regulations imposed by an organization such as: the security of the facilities, maintaining adequate capacity in the face of the health emergency caused by the covid-19 pandemic, or restricting access to sensitive areas of a hospital or a student space, to mention a few (Tapia, 2020). Another application of access verification mechanisms is in the area of product logistics. Throughout the supply chain, it is necessary to know a sufficient amount of information about each merchandise to ensure its storage, transportation, distribution, and acquisition (Guedes, 2021).

For its part, industry 4.0 has been a catalyst for access control to play a relevant role within the organization, since it gives certainty to the safety management of personnel and/or products, but it is also a point of generation of information that can be used to build statistical models that support decision-making (Guerra & Ortiz, 2020). Currently there are technologies dedicated to access control based on biometrics such as facial recognition or fingerprint, however, these mechanisms are limited to personnel control. Another technology widely used in this sector is called Quick Response (QR), unlike the previous ones, it can be used in other industrial fields by storing encrypted information, in addition to reducing operating costs by not requiring highly specialized equipment (Henríquez, 2021).

There are many possibilities offered by the QR code, not only as access control but also to provide more information about the personnel or product that is verified. The advantages of using this technology are extensive: it is possible to generate a URL, a smartphone or tablet can be used to read it, it facilitates the construction of SMS messages, making calls or writing emails, among others, (Sánchez, 2021). In addition to cards, the QR code can be present on many other surfaces, such as a smartphone or tablet touch screen.

As an access verification control, it can be read by a device such as those mentioned above, recover the encrypted information and thus determine the entry or exit, generating a precise record of the movement of personnel, dates, times or any sensitive data for the organization (Chung et al. to, 2022).

The technology that offers benefits similar to those of QR are those based on cards with a built-in magnetic stripe, they have an integrated circuit that connects to an antenna and is inserted into a plastic. They use RFID (Radio Frequency Identification) which is a wireless technology for communication between electronic devices. A card reader is necessary, which detects the integrated card at a certain distance, recovering the information it stores (Baque, 2020). Unlike the QR that only needs to be printed or in image format, these cards normally use plastic, vinyl and polycarbonate, so a specialized printer should be considered for the design on the chosen material, as well as the information stored within the circuit. . These factors raise the cost of operating an access control system based on electromagnetic cards (Lluen, 2022).

Therefore, this study proposes a software and hardware prototype to implement access control to an organization or institution, using various information and communication technologies within the framework of industry 4.0. The main idea consists in the construction of an artificial vision system for reading and validation of QR codes, in addition to implementing a web application for the management of the information that is generated during the logistics process. The use of open source technology allows reducing manufacturing costs, making this solution accessible to small organizations, promoting growth and adherence to industry 4.0 paradigms. As a consequence of the global events caused by COVID-19 where organizations monitor access to their facilities with greater caution, this prototype proposes to validate two aspects of interest, the vaccination status in addition to verifying the identity of the personnel, their functions main are:

- Streamline the input-output process avoiding crowds.
- Reduce investment in security personnel.

ISSN 2410-3950

- Reduce investment in expensive equipment for access control operation.
- Avoid printing certificates, identification copies, CURPs or other documents that were required.
- Propose a more sustainable solution avoiding the use of plastics and RFID chips.

Methodology

The Tecnológico Nacional de México Campus Ciudad Valles, located in the state of San Luis Potosí with a student population of more than 2,000 and more than 120 workers, was considered as the subject of the case study. The campus requirements for access control consisted of:

- Expedite admission to the Institute.
- Do not use physical documentation such as: vaccination certificate and official identification.
- Have a process as independent as possible from human supervisión.
- Determine the following with the information generated in the access validation process:
- Time when more students enter the institution.
- Average entrance to the Institution of the students.
- Number of students who enter the Institution per day, week or month.
- Students with updated COVID-19 vaccination status

Hardware module

For the construction of the physical part of the prototype, various components are required that are described below:

Web camera as a data entry device, which remains active while the equipment is running. This camera will be programmed to enter a power saving mode as long as it does not detect a QR code, when it detects one it will return to its active state to read the QR code (Coronado et al., 2021). See figure 1.

Figure 1 Logitech c920 webcam Fountain
Source: https://resource.logitech.com/w_692

PCB (“Printed Circuit Board”, “Placa de Circuito Impreso” in Spanish) is the most compact and stable way to build an electronic circuit. The Arduino board is nothing more than a PCB that implements a certain internal circuitry design. You should not worry about the electrical connections that the microcontroller needs to work (González, 2021). Manages the electronic components used such as the ethernet module, leds, horn, etc. figure 2.

Figure 2 Arduino Uno
Source: https://arduino.cl/wp-content/uploads/2019/01/Arduino-UNO-1.png

Ethernet module, complements the Arduino board, designed to facilitate internet connectivity without the need for an operating system. It incorporates Jack RJ45, reset button and microSD memory reader, where it is possible to store the files to use or share them as if it were a server, figure 3.

ISSN 2410-3950

Figure 3 Network module (Ethernet) Ard-351. Fountain
Source: https://m.media-amazon.com/images/I/51D4V-aLRdS._AC_SX522_.jpg

LEDs, used to notify the user of access to the institution, as a reference the green color allows access, the red access denied and the yellow as a warning that something has not gone well during the process, figure 4.

Figure 4 10mm LEDs. Fountain
Source: https://uelectronics.com/wp-content/uploads/2018/10/Led-10mm-Grande-V1-550x550.jpg

Speaker, is a horn whose function is to produce a sound indicating that the QR code was read, accepted or denied. The sounds will be programmed on the Arduino board, figure 5.

Figure 5 Horn 8 ohm 0.5w Diameter 3.5 cm. Fountain
Source: https://http2.mlstatic.com/D_NQ_NP_987976-MLM43431820224_092020-W.jpg

Necessary box to protect the electronic equipment from blows, humidity or direct sunlight. It will have inside the Arduino and ethernet module, with holes for the exit of the cables that will carry the necessary connections, figure 6.

Figure 6 Safe. Fountain
Source: https://http2.mlstatic.com/D_NQ_NP_816836-MLM49214783006_022022-V.jpg

Software module

There are two software components developed for this module, the artificial vision system implemented in the Python programming language, embedded in the Arduino integrated whose function is the decoding by image processing of the QR code captured through the webcam. This information is temporarily stored in the integrated circuit to later be sent to a database on a remote server, in this way, access to information in real time and be used for statistical analysis, which support the decision. organizational decisions (Carrillo & Ronny, 2022).

The second software component is a web application implemented under client-server architecture with technologies such as JavaScript and PHP, where there are two submodules, one for users and the other for the person responsible for the system. While users access the QR verification module, the administrator has access to the application settings (Tircio, 2022).

Results

Hardware module

The integration of the hardware elements takes the Arduino integrated circuit as its core. The webcam that allows the reading of the QR image, whether printed or in digital format, is a visible element of the prototype with which the user interacts directly. This device remains active waiting to receive new information, however, when it does not process a QR for a certain time, it enters a suspended state to avoid unnecessary processing.

ISSN 2410-3950

Once the personnel identification number is obtained, the Arduino through the ethernet board that has been configured to establish a connection to the institution's network and thus be able to execute http requests, sends the identification information to the remote server which maintains Communication with the system database.

Finally, the application designed to verify the status determines the condition of the personnel, sending a signal back to the Arduino to allow access (green light), or deny it (red light), in case of any anomaly during the process it lights up. yellow light, figure 7.

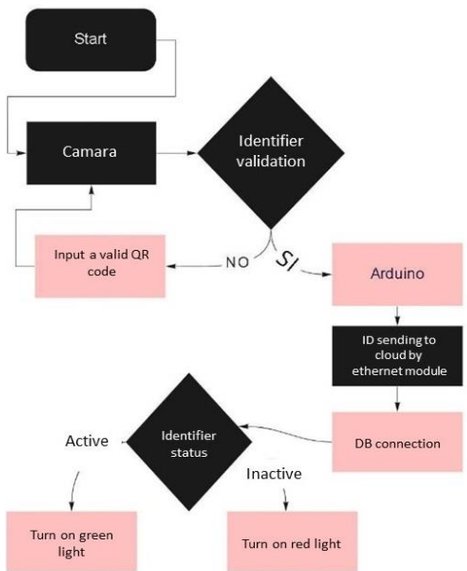


Figure 7 Hardware module operation flow
Source: Own elaboration

Software module

The application developed in Python for image processing and which resides in the microcontroller, has as its first task the identification of a valid QR code through the webcam. This function requires the CV2 library used to perform operations on images, such as reading, segmentation, among others. The decoding of the information contained in the QR image is carried out by the Pyzbar library, whose interpretation function allows extracting the personnel identifier.

The developed web application provides two submodules: Administrator and Users. The tasks that each role will do both as the user and the administrator are shown in figure 8.

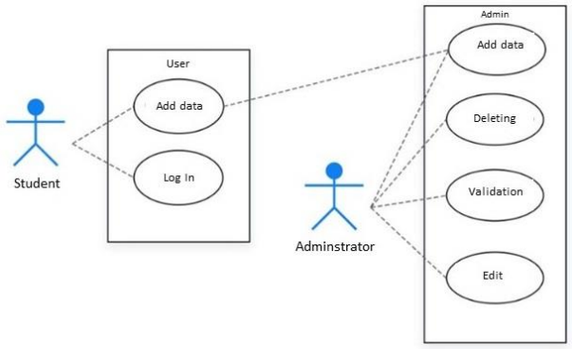


Figure 8 User/Student and Administrator module of the web application
Source: Own elaboration

The user module oriented to the personnel that accesses the institution and where it is possible to enter general information through a form on any device with an Internet connection, and thus, carry out the registration and generation of the QR code. All records will be stored in a database connected to the server.

The data flow in the software section is represented through figure 9, where it can be seen that the entry of correct data must be necessary for the generation of the QR, otherwise the user is notified to review and correct their information.

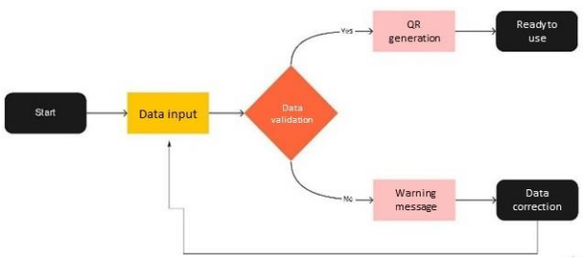


Figure 9 QR code generation operation flow
Source: Own elaboration

This module requires information such as: Name, Control Number, Specialty, Current Semester and Files in PDF format (Certificate of vaccination and official identification), figure 10.

ISSN 2410-3950

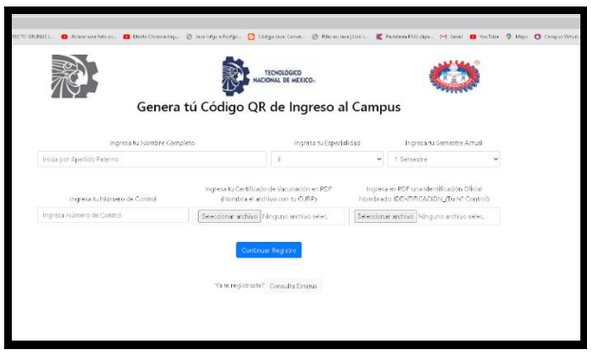


Figure 10 Interface for QR code generation
Source: Own elaboration

The QR code activation process does not end with the capture of the information, it is the responsibility of the System Administrator to validate the data and activate those requests that actually proceed, in this way the staff will be able to use the QR code to access the institution. To know the status of the request, a consultation module was designed where the user can continuously monitor if his request has been accepted, figure 11.

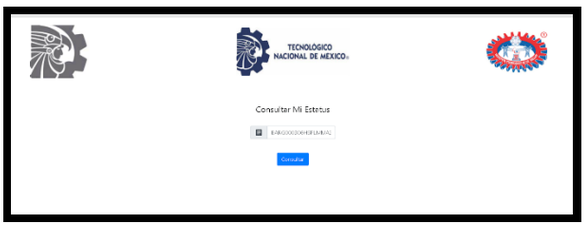


Figure 11 Interface for QR code generation
Source: Own elaboration

The result of the query generates two types of messages, when the request has not been accepted by the administrator, inactive status, figure 12.

Figure 12 Request inactive message
Source: Own elaboration

When the administrator has validated the user's information and has accepted the request, the option to generate their code will be enabled, figure 13.

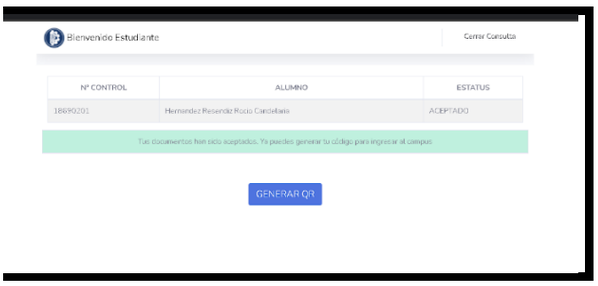


Figure 13 Request accepted message
Source: Own elaboration

To finish the QR code generation process, a security system is established that consists of checking the user's identification number, once this is done, the QR is created available to download and store in the desired format, figure 14.

Figure 14 QR code generation
Source: Own elaboration

The module for the Administrator provides an interface to review the requests made by users, consult and edit said records.

The status of the requests is easily identified by the assigned color, yellow for PENDING users, green for ACCEPTED users, red for INACTIVE users, figure 15.

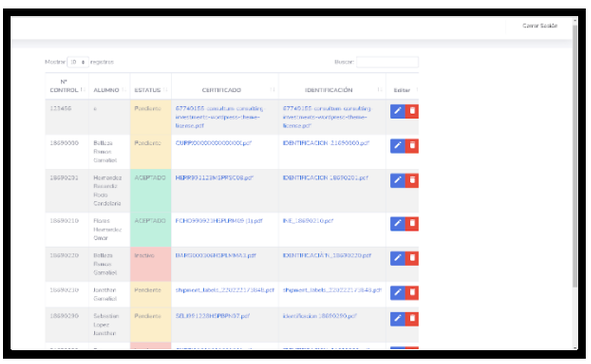


Figure 15 Web application administrator module
Source: Own elaboration

The data dictionary is integrated by the student table, which stores the data that each user entered in the registration module. For its part, the Admin table stores the data of the Administrator account to be able to log in and allow entry to the administrator module. The Income table keeps track of the QR and the time it was used, this table stores a large amount of data since it will be constantly growing, it is described in figure 16.

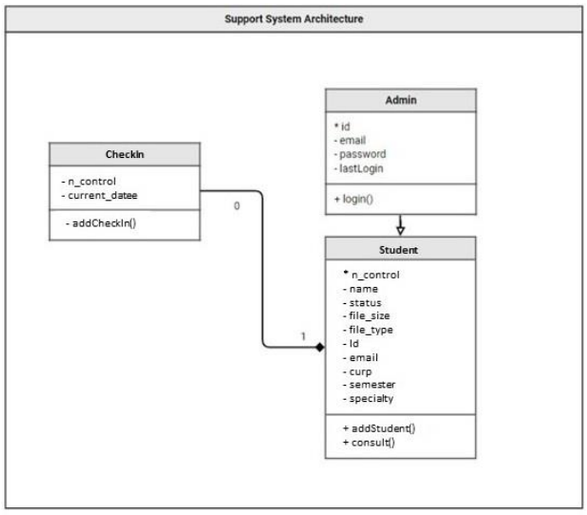


Figure 16 Access system data dictionary
Source: Own elaboration

The resulting prototype is shown in figure 17, it was tested in the access of the TecNM / Technological Institute of Ciudad Valles with a group of 185 students in a period of 5 business days, the operation of the device met the company's requirements.

Figure 17 Access control system
Source: Own elaboration

Conclusions

The proposed access control system solves the problem of entering a complex in an efficient and safe way, considering the global health contingency COVID-19 through the validation of the vaccination status of the personnel. Also, it significantly reduces the operational costs that would be generated with manual access protocols, or if compared to other similar access systems on the market. The benefits were:

- Promotes sustainability by avoiding the use of plastic material or magnetic tapes that are normally used in control systems based on radio frequency, additionally.
- Avoid printing physical documents by having everything stored in a digital BD.
- Reduces access control personnel in charge of verifying documentation.
- Avoid crowds at access points, through a continuous flow of entry-exit.
- Reduces the investment in the implementation, since it does not require high cost sophisticated hardware.

References

Baque Jaramillo, a. L. (2020). *Estudio de factibilidad de un sistema de control de acceso con tecnología RFID de la sala inteligente con tecnología digital en la unidad de bienestar estudiantil de la universidad estatal del sur de Manabí* (bachelor's thesis, jipijapa. Unesum).

Chung, C. K. K., Galeano, S. M. T., Duarte, D. L. B., Girett, V. A. R., & Sanchez, D. D. D. (2022). Adopción del código QR en el sector de servicios. Caso de locales gastronómicos en los shoppings del Paraguay, 2022. *Ciencia Latina Revista Científica Multidisciplinar*, *6*(3), 4191-4205.

Carrillo, R., & Ronny, J. (2022). Diseño e implementación de un sistema de acceso vía móvil, web y escritorio para el control de reservas y aforos usando Bots de Telegram y códigos QR.

ISSN 2410-3950

Coronado Ramírez, R. E., Juárez Olaya, J. M., Quiroga Antón, S. R., & Tocto Domínguez, J. C. (2021). Módulo de registro para mejorar el sistema de control de asistencia mediante la incorporación de código QR en Interamericana Norte SAC.

González Castillo, G. A. (2021). *Implementación de sistema de seguridad para el control de acceso a aulas del bloque 1 de la Facultad de Sistemas y Telecomunicaciones mediante el uso de lectores QR y Arduino* (Bachelor's thesis, La Libertad: Universidad Estatal Península de Santa Elena, 2021).

Guedes Estupiñán, V. J. (2021). Diseño de la ampliación de una cadena de suministro de bebidas alcohólicas y su sistema logístico para servir al sector hotelero en un archipiélago.

Guerra, R. P., & Ortiz, G. A. (2020). La industria 4.0 y su relación con la Gestión de los Recursos Humanos. *Revista Daena (International Journal of Good Conscience)*, *15*(3).

Henríquez González, E. E. (2021). Aplicación de la tecnología QR en dispositivos móviles para mejorar el control de ingreso del personal en los fundos de Chao de la Empresa Tal SA.

Lluen Ramos, S. C. (2022). Propuesta de un sistema de trazabilidad de la cadena de suministro para mejorar la inocuidad alimentaria del programa Qali Warma.

Lora-Guzmán, H. S., & Garcés-Henao, L. G. (2020). Análisis de los procesos logísticos de una organización mediante el modelo Donald Bowersox. *Revista científica anfibios*, *3*(1), 52-59.

Sánchez Páez, G. S. (2021). Aplicación del código qr como solución para un registro eficiente de las revistas de seguridad en un complejo militar.

Tapia, E. E. C. (2020). Impacto económico de la logística en el Ecuador y su afectación en la pandemia. *Dominio de las Ciencias*, *6*(4), 1610-1625.

Tircio Perero, G. V. (2022). *Desarrollo de una aplicación web para la generación de códigos QR y control de acceso a aulas para docentes y estudiantes en la UPSE–Facultad de Sistemas y Telecomunicaciones* (Bachelor's thesis, La Libertad: Universidad Estatal Península de Santa Elena, 2022).

ISSN 2410-3950

Article **Journal of Experimental Systems**
June 2023, Vol.10 No.28 9-15

Energy efficiency manager for electrical installations at home

Diseño de un medidor y gestor de consumo eléctrico

GONZÁLEZ-CARRILLO, Gamaliel†*´, ORDOÑEZ-FLORES, Rafael´´, NAVARRETE-ESCALANTE, Marcela Monserrat´´ and MORALES-CAPORAL, Roberto

´ *Instituto Tecnológico de Apizaco, s/n, Col. Centro, Apdo. Postal N° 19. Tlaxcala, México*
´´ *Instituto Tecnológico de Ciudad Guzmán, Ciudad Guzmán, Jalisco, México.*

ID 1st Author: *Gamaliel, González-Carrillo* / **ORC ID:** 0009-0000-5109-2484, **CVU CONAHCYT ID:** 1154024

ID 1st Co-author: *Rafael, Ordoñez-Flores* / **ORC ID:** 0000-0001-9831-9316, **Open ID:** 252169

ID 2nd Co-author: *Marcela Monserrat, Navarrete-Escalante* / **ORC ID:** 0009-0001-3067-4677, **CVU CONAHCYT ID:** 764134

ID 3rd Co-author: *Roberto, Morales-Caporal* / **ORC ID:** 0000-0002-6115-0454, **Open ID:** 93093

DOI: 10.35429/JOES.2023.28.10.9.15 Received: January 15, 2023; Accepted: June 30, 2023

Abstract

The enormous energy consumption in homes, offices and schools that is increasing day by day requires taking the use of Smart Grid and IoT to a higher level for the optimization of smart meters, whose function is data extraction and statistical generation of energy consumption. Next, a prototype of visualization and energy management is proposed through an Android mobile application, focused on domestic electrical networks where daily and historical energy consumption can be visualized, as well as warnings of statistics outside the average, monitoring peaks of consumption physically and remotely from the mobile application. This prototype is designed with LoRa and Arduino technology, it must be installed in parallel to the original CFE meter, the collection of readings is acquired through the PZEM 004T sensor, with the help of the RTC DS3231 Module, the exact date and time are assigned, and these readings are saved in the micro-SD of the H95 Reader Module to transmit data via LoRa and Bluetooth through LILYGO TTGO LoRa32. Thus, this prototype makes it possible to optimize consumption in domestic electrical networks.

Energy consumption, Home networks, Monitoring and optimization

Resumen

El descomunal consumo energético en las casas habitación, oficinas y escuelas que día a día va en aumento, exige llevar a un nivel superior el uso de Smart Grid y el IoT para la optimización de medidores inteligentes, cuya función es la extracción de datos y la generación estadística del consumo energético. A continuación, se propone un prototipo de visualización y gestión energético por medio de una aplicación móvil Android, enfocado en redes eléctricas domésticas, donde se puede visualizar el consumo energético cotidiano e histórico, así como advertencias de una estadística fuera del promedio, monitoreando los picos de consumo de manera física y remota desde la aplicación móvil. Este prototipo está diseñado con tecnología LoRa y Arduino, se instala de manera paralela al medidor original de CFE, la recopilación de lecturas se adquiere por medio del sensor PZEM 004T, con ayuda del Módulo RTC DS3231 se les asigna la fecha y hora exacta, y dichas lecturas se guardan en la micro SD del Módulo lector H95 para transmitir los datos mediante LoRa y Bluetooth a través de TTGO LoRa32. Así pues, este prototipo permite optimizar el consumo en redes eléctricas domésticas.

Consumo energético, Redes domésticas, Monitoreo y optimización

Citation: GONZÁLEZ-CARRILLO, Gamaliel, ORDOÑEZ-FLORES, Rafael, NAVARRETE-ESCALANTE, Marcela Monserrat and MORALES-CAPORAL, Roberto. Energy efficiency manager for electrical installations at home. Journal of Experimental Systems. 2023. 10-28:9-15.

* Correspondence to Author: (E-mail: gamaliel-gonzalez@utem.edu.mx).
† Researcher contributed as first author.

Introduction

High electricity demand, bad consumption habits, high costs, complaints to the electricity supplier [8] are caused by the lack of use of Smart Grid or technological products within the household for monitoring electricity consumption.

Improving electricity management and metering arises from two main parts; generation and demand.

In terms of energy generation, based on obtaining energy from fossil fuels and alternative energies, in 2018 Mexico had a gross consumption of 318,236GWh, of which 15.8% (50,285GWh) corresponds to the Central East Zone [9]. In terms of demand, there are several factors that influence its consumption, such as climate changes and users' consumption habits, to name a few, which easily lead to complaints about high and inexplicable energy consumption. In 2020, the Central East Zone of Mexico registered 891 complaints about electricity consumption [8]. Unfortunately, investment projections for 2018-2022, it is planned to acquire 2. 7 million electronic self-management meters to achieve some AMI features, and 3 million meters with radio frequency cards will be installed [10], which lack the ability to manipulate and restrict energy consumption on their own, but offer the end user real-time energy consumption information about their home, giving little opportunity for the consumer and energy supplier to manage and measure energy use and behaviour, depriving the former of establishing and planning energy savings and the latter of having feedback to make changes in energy generation [11].

Therefore, the need arises to implement solutions to these circumstances by creating new technologies in the home, such as the creation of a prototype for real-time monitoring and visualisation of consumption behaviour by hour, day, week and month, as well as alarms and warnings related to consumption, for example; offers the option of control over the activation and deactivation of the power supply due to a low or high voltage in the electrical grid, warning when there is a jump in consumption level over the tariffs imposed by CFE; and forecasting energy based on the stored energy history giving the latter as an added value to many other existing research and/or products.

By managing energy thanks to warnings, alarms, forecasts and the daily energy rhythm, users could be convinced and made aware of the need to reduce their consumption, thus protecting the environment by reducing excessive energy generation and avoiding huge CO_2 emissions into the atmosphere. [9].

Development

In order to fulfil the optimal performance simulation of this prototype, a descriptive methodology [2] is used, which is implemented in an electrical service at 127VAC, i.e., a single-phase service.

The general structure of the proposed design is shown in figure 1, in it the CFE supply (1) that supplies energy to the house is observed, which in turn is delivered to the main meter (2), which provides as the only data the historical consumption in KWh, highlighting that this information is little understood by the user, the reading is generally outside the house and the consumption data are delivered with the charge included, which prevents the opportunity to have control over consumption, while it lacks energy monitoring at all times. However, the CFE meter will always be present. Given this situation, the prototype (3) is connected after the main meter but inside the house to visualize the consumption readings at any time by means of the local display (4) of the prototype, also locally all the events occurred are stored in a SD card (5) thanks to the LoRa module located inside the cabinet. In addition to this, remote data transmission via Bluetooth to an Android mobile device (6) is included, and finally the data is sent to the software via serial communication. (7).

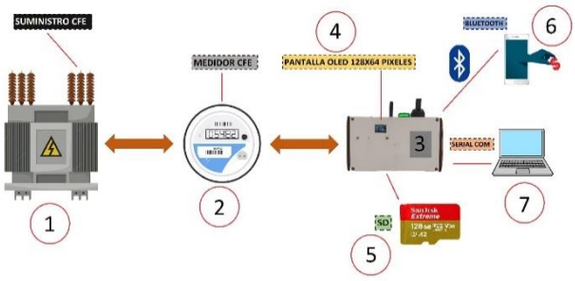


Figure 1 Overall project architecture

ISSN 2410-3950

Architecture

The construction of this prototype (figure 2) is made up of four important blocks: the first one is made up of the PZEM 004T V3 module, which provides the way to acquire information directly from the energy consumption that is obtained from the sockets and controlled with the switches; the second block is made up of the RTC module that provides the precise time and date recording of each event sample delivered to TTGO LoRa ESP32, which is the IoT board that carries out the processing, analysis and data acquisition to perform the calculations and predictions of energy consumption; In the third block, with the support of the voltage booster and the H-bridge, the control signal is transferred on the high or low voltage peaks so that the relay protects the domestic electrical network and cuts the power; finally in the fourth block is the OLED display, the SD slot and serial port, to deliver the display of the information, in parallel the Bluetooth transmits this information to the Android App.

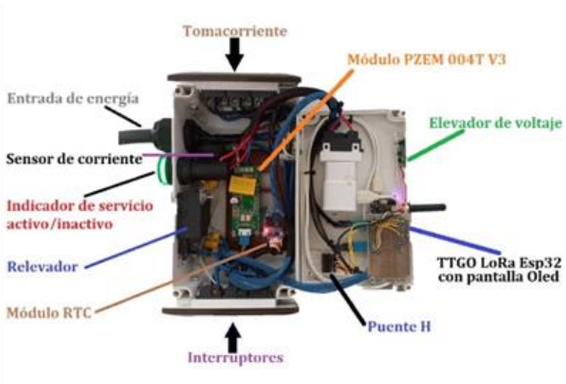


Figure 2 Smart meter design system

Data acquisition

By means of the PZEM 004T V3 sensor (figure 3) the electrical parameters of voltage, current, frequency, power factor, active power and consumption are obtained, friendly with voltages of 127/220VAC so it is not necessary to make any modification to the sensor as it has characteristics and parameters (table 1) suitable for its direct study [3].

Figure 3 PZEM 004T V3

Characteristic	Range	Resolution	Accuracy
Voltage	80-260v	0.1v	0.50%
Current	0-100A	0.001A	0.50%
Active Power	0-23KW	0.1W	0.50%
Power Factor	0-1	0.01	1%
Frequency	45-65Hz	0.1Hz	0.50%
Consumption	0-9999KWh	1Wh	0.50%

Table 1 Electrical characteristics and parameters of PZEM 004T

Data Processing

In this project, to perform the prediction calculations on the sensor readings, we started with the active power, which is transformed into useful energy either in mechanical work or in the form of heat. This energy is measured in watts (W) and is the energy consumed by mixed loads [5], which optimally reflects the energy being consumed in the home. Given the uninterrupted energy use in households, the standard unit of measurement used by the CFE to measure energy consumption is the kilowatt-hour (kWh, equivalent to one thousand watt-hours).

The basis for the prediction of instantaneous energy consumption, which allowed the values to be determined, is set out in formula 1 with the rational analysis of the behaviour of the power demanded over time.

$$\text{prediction} = \frac{P*t}{1\,000} \qquad (1)$$

P= Power demand (W)

t=Time lag to be predicted(hours)

Once the initial prediction has been extracted, it is used to obtain the predictions per minute, hour, day, week and month elapsed.

We work in parallel with a second option of prediction by event (minute, hour, day or month) to offer another way of predicting consumption, obtaining the equation 2.

ISSN 2410-3950

$$pronos_t = \Delta 2et_f - et_o \quad (2)$$

where:

$pronos_t$ = Energy forecast for the following event.

et_o= Energy with respect to event start.

et_f= Energy with respect to the final time of the event.

Equation 2 is also used to obtain the predictions of any event.

Control

The power cut-off occurs when a voltage deficit is detected below 105.3VAC and when an excess voltage is detected above 139.7VAC, this power cut-off is done by the microcontroller with two electrical pulses with a pulse width of 10ms to the L293D, which is responsible for amplifying and switching the weak signal of the microcontroller LoRa.

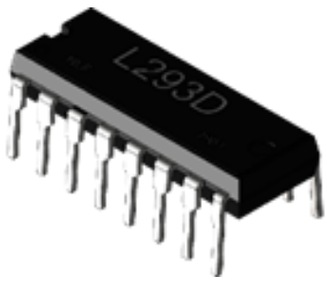


Figure 4 L293D

And finally the amplified signal reaches the KG-K125 relay (figure 5) which uses the magnetic principle to control the on/off switching of the power supply.

Figure 5 Relay KG-K125

Display and storage of data

In order to display and store data about the sensor readings locally, it was necessary to implement the DS3231 RTC module (figure 6) to date and time each event, which is a high-precision clock with a temperature-compensated crystal oscillator (TCXO). The integration of the crystal oscillator into the integrated circuit itself, in conjunction with the temperature compensation, ensures long-term accuracy. [7]

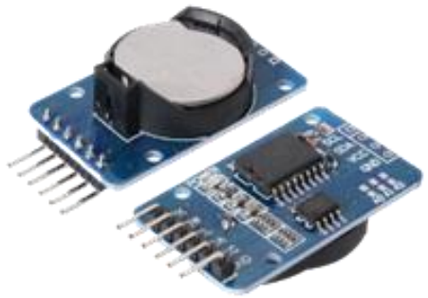


Figure 6 RTC module DS3231

TTGO LoRa32 915Mhz V1.6.1 was also used which features an OLED display, microSD memory slot, bluetooth, as well as connection to the serial monitoring port.

As broken down below; TTGO LoRa32 is a development board based on the ESP32 family, which incorporates a LoRa 868 / 915 MHz module allowing bi-directional data transmission over long distances (approx. 300m), it incorporates an OLED display and a 915Mhz V1.6.1 V1.6.1 V1.6.1 V1.6.1 OLED display.), incorporates an OLED display of 128×64 pixels, which is connected internally to the ESP32 in the pins: GPIO 21, GPIO 22 and GPIO 16, which correspond to the SDA, SCL and RST (OLED) pins of the display as shown in the figure and communicate through the I2C communication protocol. [5]

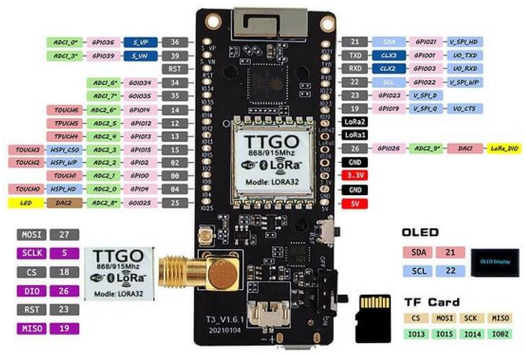


Figure 7 TTGO LoRa32 TTGO board pin layout

The way in communicating to the Arduino IDE platform to display the data on the serial monitor is through its micro USB connector which also supplies power for the overall module operation. [6]

And the display wirelessly for prediction and power consumption, bluetooth module was used which will send data packets to the Android device as seen in figure 8.

Figure 8 Android App

The collection of data obtained by the PZEM 004T sensor, which the TTGO LoRa ESP32 module processes and analyses, samples voltage, current, power, frequency, power factor and historical consumption in kWh, as well as the prediction and trend of consumption in the next minute, hour and day, to send them via Bluetooth to the Android device and in parallel to the SD memory placed in the slot of the microcontroller as shown in figure 9.

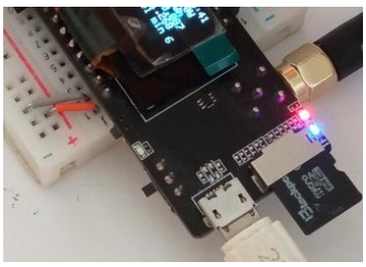


Figure 9 SD slot

Results

A user-friendly prototype with a clean and aesthetically pleasing external design (figure 10) was achieved, showing: A) contacts for the control of the sockets to be measured; B) the voltage cut-off indicator light and the display with the most important parameters for the user; and C) three sockets controlled by the contacts for a more controlled and efficient testing system.

Figure 10 External design of the prototype

Considering in the internal part (figure 11) top quality materials such as, rigid casing, use of Bakelite, electrical connectors and harnesses together with cable mesh, resulted in a solid and tidy internal structure capable of being a heavy duty design.

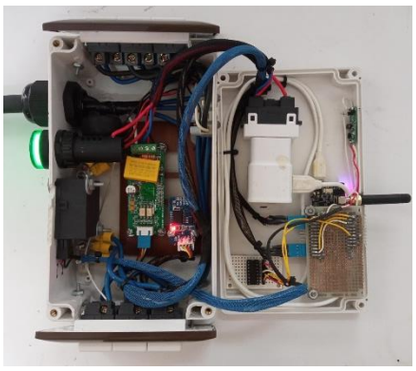


Figure 11 Internal prototype design

Complementing the prototype with a user-friendly and simple application for mobile devices (figure 12) where the user monitors consumption and clearly visualises energy predictions.

Figure 12 Application on mobile device

The voltage, current, power, stored energy in KWh, as well as the frequency and power factor measured by the PZEM004T sensor were read and recorded, as shown in lines two to seven of figure 13, having a consumption storage capacity of 9999.99kWh [3] or three years of regular consumption of an average house [1]. The prediction was calculated and recorded based on time, i.e. the consumption of the next minute, hour, day, week and month, as shown in lines eight to twelve of figure 13.

ISSN 2410-3950

And the margin of error of less than 5% on the estimated consumption predictions was calculated by recording this information in line 15 of figure 13.

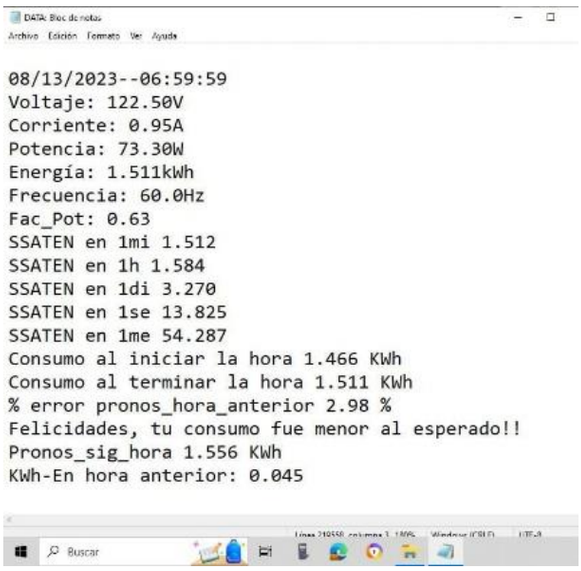


Figure 13 Energy consumption readings and forecasts

In all statistical, non-exact events such as prediction, error is inevitable. Below is a graph (figure 14) made with data taken at random from multiple samples from one day of an event. Good results were obtained by having a maximum error of 3.71% with respect to predicted consumption (yellow) vs. actual consumption (green) at the end of each event (hours). The other predictions were even better with an error of even less than 1%. Making the calculation of the error of the predicted vs. actual consumption reliable.

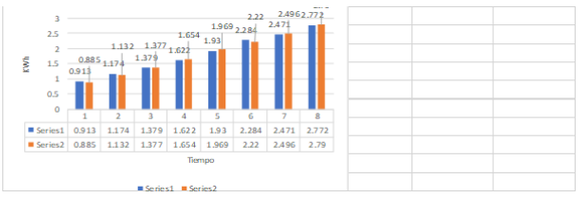


Figure 14 Prediction error statistics.

The most relevant data such as date and time, real time power sensed every second, accumulated consumption and instantaneous power predictions for the next hour and the next day based on real power consumption were also recorded on the screen as shown in figure 15.

Figure 15 Data on Display

Finally, power control was achieved as a preventive measure against damage to the electrical installations of the house and the electrical appliances connected to it, by cutting off the power supply with the help of the KG-K125 contactor activated by high and low voltages, warning the user that the power supply was cut off due to high or low voltage as shown in figure 16.

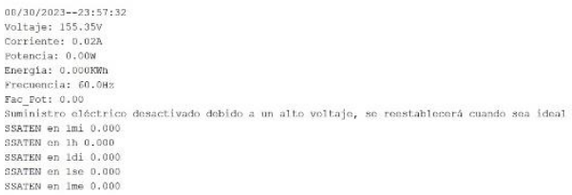


Figure 16 High voltage power control

Acknowledgement

To the Consejo Nacional de Ciencia y Tecnología (CONACYT) for their valuable support for this research.

Conclusions

Nowadays it is essential to be aware of the effects of energy consumption, as well as the care of the environment, this design contributes to consumers, making decisions about their daily energy consumption, in this project the design and implementation of a smart meter based on LoRA and Arduino technology was broken down in detail.

ISSN 2410-3950

The module calculates the electrical energy used in the home based on the power demand provided by the PZEM004T sensor, allowing the user to view daily, weekly and monthly consumption readings on the prototype's screen and on their mobile device, as well as warnings about tariff changes due to consumption, the management of high and low voltage power cuts, as well as short and long term consumption predictions and forecasts, providing the user to identify what, when and where excess energy consumption is created and its behaviour, reducing the user's financial burden, while contributing to the care of the environment.

References

[1] Guzmán, R. (2023, febrero 7). Cuántos kilowatts por hora consume una casa. Recibodeluzcfe.mx. https://recibodeluzcfe.mx/blog/cuantos-kilowatts-por-hora-consume-una-casa/?expand_article=1

[2] R. Hernández Sampieri, C. Fernández Collado y M. d. P. Baptista Lucio, Metodología de la Investigación, México D.F.: Mexicana, 2014.

[3] Mandula, J. (s/f). PZEM-004T-v30: Arduino library for the Updated PZEM-004T v3.0 Power and Energy meter.

[4] Santos, S. (2019, octubre 19). TTGO LoRa32 SX1276 OLED with Arduino IDE. Random Nerd Tutorials. [En línea] Available: https://randomnerdtutorials.com/ttgo-lora32-sx1276-arduino-ide/

[5] John J. Grainger y William D. Stevenson Jr. Análisis de Sistemas de Potencia. McGRAWHILL, S.A., México, primera edición, 1996.

[6] Joffe S.(2021, Agosto 11) what is a lora module. Mokolora.com. [En línea] Available: https://www.mokolora.com/es/what-is-a-lora-module/

[7] Thorpe, E. (2019). Arduino para principiantes: Guía completa para principiantes Aprende la programación Arduino paso a paso (Libro En español/ Arduino Spanish Book Version). Publicado de forma independiente.

[8] Olivares-Rojas, J. C., Reyes-Archundia, E., Gutiérrez-Gnecchi, J. A., Molina-Moreno, I., Ramos-Díaz, J. G., & González-Serna, J. G. (2020). Towards human-computer interaction on smart metering systems. Avances En Interacción Humano-Computadora,0(1),90. https://doi.org/10.47756/aihc.y5i1.58

[9] Coldwell p. (2016). Evaluación rápida del uso de la energía Huamantla Tlaxcala México [En línea, PDF] Available:https://www.gob.mx/cms/uploads/attachment/file/171263/15__Huamantla.pdf

[10] Fulk, C., Hobar, G., Olsen, K., El-Tawab, S., Rahman, F., & Ghazizadeh, P. (2019). Cloud-based low-cost energy monitoring system through internet of things. 2019 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), 322–327.

ISSN 2410-3950

Article **Journal of Experimental Systems**
June 23, Vol.10 No.28 16-20

Analysis of hazards and risks in drawing machines

Análisis de peligros y riesgos en máquinas trefiladoras

PÉREZ-GALINDO, Liliana Eloisa†, TORRES-VALLE, José Bernardo, HERNÁNDEZ-BORJA, Carlos and PEZA-ORTÍZ, Edebaldo

Universidad Tecnológica Fidel Velázquez, Mantenimiento Industrial y Mecatrónica, México.

ID 1st Author: *Liliana Eloisa, Pérez-Galindo* / **ORC ID:** 0000-0001-6016-2595

ID 1st Co-author: *José Bernardo, Torres-Valle* / **ORC ID:** 0000-0002-4302-1640

ID 2nd Co-author: *Carlos, Hernández-Borja* / **ORC ID:** 0000-0002-8138-9016

ID 3rd Co-author: *Edebaldo, Peza-Ortíz* / **ORC ID:** 0000-0003-0236-883X

DOI: 10.35429/JOES.2023.28.10.16.20 Received: January 20, 2023; Accepted: June 30, 2023

Abstract

This work aims to identify the degree of risks based on the dangers to which wire drawing machine operators are exposed. An evaluation is also carried out with the purpose of reducing accidents when workers operate this type of machine. The methodology used for this analysis is carried out using a tool called Operation, Risks Corrective Actions (ORCA). This type of tool is a format implemented by the company and compatible with most of the risks that may exist in each area that makes up the company. Carrying out this risk and hazard analysis will help control and prevent accidents, help implement and improve safety protocols, as well as improve learning to carry out efficient control in preventing accidents that could occur. present and identify the level of risk.

Danger, Risks, Wire drawing machine

Resumen

Este trabajo tiene como objetivo identificar el grado de los riesgos a partir de los peligros a los que se encuentran expuestos los operadores de las máquinas trefiladoras. También se realiza una evaluación con el propósito de reducir los accidentes al momento de operar este tipo de máquinas por los trabajadores. La metodología utilizada para este análisis se realiza mediante la utilización de una herramienta llamada Operation, Risks Corrective Actions (ORCA). Este tipo de herramienta es un formato implementado por la empresa y compatible con la mayoría de los riesgos que puedan existir en cada área que integra la empresa. Con la realización de este análisis de riesgos y peligros se contribuirá a controlar y prevenir accidentes, se ayudará a implementar y mejorar protocolos de seguridad, así como también mejorar el aprendizaje de para llevar a cabo un control eficiente en la prevención de accidentes que se pudieran presentar e identificar el nivel de riesgo.

Peligro, Riesgos, Trefiladora

Citation: PÉREZ-GALINDO, Liliana Eloisa, TORRES-VALLE, José Bernardo, HERNÁNDEZ-BORJA, Carlos and PEZA-ORTÍZ, Edebaldo. Analysis of hazards and risks in drawing machines. Journal of Experimental Systems. 2023. 10-28:16-20.

* Correspondence to Author: (E-mail: liliana.perez@utfv.edu.mx).
† Researcher contributed as first author.

Introduction

Drawing is the process used for the reduction of a wire from a given diameter to a smaller one, (MARIO FRIGERIO S.p.a., 2007).

The wire is passed through a conical hole. And from the other side it is pulled with force causing a stretching of the material. This can be done continuously by using a drum which rotates constantly pulling wire and coiling it. This drum may be connected to another drawing die with an even smaller orifice. This, too, is pulled by another drawing drum, and so on constantly until the desired diameter is obtained, (Aceros Torices S.A. de C.V., 2023).

For the wire drawing process, some of the following operations are carried out in the machining process:

- Load the raw material through a spool.
- To arrange the wire by the pulleys in the wire drawing machine.
- Designate the diameter for the first dies of the wire drawing machine.
- Join the two ends of the wire with solder.
- Grind the soldering solder at the junction of the two wires.
- Attach the drag dog to the block at the other end of the wire rod tip until the block is 3/4 of its maximum capacity.
- Pass the wire onto the reel by passing its tip through the hole.
- Start the wire drawing machine.
- Exit of the reel and weighing.

During the wire drawing process, there are risks such as the following:

- Mechanical risks.
- Electrical risks.
- Thermal risks.
- Radioactive risks.
- Hygiene and safety risks.
- Ergonomic risks.

In this work, an analysis and study is carried out to determine the degree of risk involved in each of the processes carried out during wire drawing.

Risk Matrix

The risk matrix is a document that allows the identification of the activities carried out by a company, the risks inherent to them and the probability of these risks materialising. It is a tool for documenting processes and assessing the overall risk of an organisation, (Romero, S., 2022).

RISK MATRIX
JOB HAZARD ANALYSIS

Probabilidad	¿Puede Ocurrir?	¿Frecuente?	Ocurrencia Observada			Severidad				
						Seguridad Salud	No hay efectos adversos	Lesiones ligeras	Lesiones menores y días perdidos a uno o varios trabajadores	Largo tiempo de ausencia a uno o varios trabajadores	Fatalidad
						Medio Ambiente / Área Afectada Pérdida Económica / Remediación	Puntual < 1000 € < $16000 MXP	Planta < 10.000 € < $160000 MXP	Sitio < 100.000 € > $1600000 MXP	Área Industrial con Vecinos < 1.000.000 € < $16000000 MXP	Vecindad con Área Residencial > 1.000.000 € > $16000000 MXP
							Insignificante 1	Moderado 2	Serio 3	Critico 4	Muy Critico 5
	Seguro	Constantemente Diariamente	Observada con frecuencia	Muy Probable	5	51	52	53	54	55
	Muy Probable	Frecuente Semanalmente	Ha ocurrido a menudo	Probable	4	41	42	43	44	45
	Probable	Ocasionalmente Mensualmente	Ha ocurrido en nuestra área	Posible	3	31	32	33	34	35
	Poco probable	Pocas veces Anualmente	Ha ocurrido en otro lugar	Remoto	2	21	22	23	24	25
	Muy Poco probable	Muy pocas veces Dentro de algunos Años	Nunca se ha oído que ocurra	Poco Probable	1	11	12	13	14	15

Figure 1 Risk matrix

The above matrix considers the severity of the consequences of the causes for a hazardous situation, and the probability of the hazardous situation happening.

The risk class is formed by the number of the severity level (first digit) and the number of the probability level (second digit).

ISSN 2410-3950

Severity level

1. Insignificant	No adverse effects on worker safety or health. No impact on the environment. Economic loss due to damage < 1,000 € (< $16,000 MXP).
2. Moderate	Minor injuries to the worker. An injured person. Injuries that can be treated with First Aid. Contained spill of hazardous substances. Emergency response with no injuries. No impact on the population. Damage causing negligible inoperability of equipment. Spills or discharges of hazardous materials on site or minor damage to the environment on site or remediation costs < 10,000 € (< $160,000 MXP). Negligible material or energy consumption, Easily reversible impact.
3. Serious	Worker lost time due to injury or minor injuries to several workers. One disabling accident. Multiple injured Small spill not containing hazardous substances. Inoperability of equipment for 1 to 10 days. Off-site spill or discharge of hazardous materials in industrial area or moderate environmental damage or remediation costs < 100,000 € (< $1,600,000 MXP). The severity of the impact depends on the hazardousness of the pollutants, or the availability of natural resources.
4. Critic	Severe injuries. Long absence of one or more workers, serious injuries to several workers or external personnel. Disabling accident or hospitalisation Affection of the industrial area. Spillage of uncontained hazardous material Inoperability of equipment for more than 10 and less than 90 days. Permanent damage to a localised section of the process or construction. Off-site spill or discharge of hazardous materials in a mixed area or extensive damage to the environment or remediation costs < 1,000,000 € (< $16,000,000 MXP). Medium reversible impact
5. Highly critical	One or more fatalities. Community affected. Injuries or fatalities in the community. Equipment downtime greater than 90 days. Off-site spills or discharges of hazardous materials in a residential area or extensive environmental damage or remediation costs of > 1,000,000 € (> $16,000,000 MXP). Hardly reversible impact

Table 1 Risk class by severity

Probability level

1. Unlikely	Never heard of it happening. Occurs between 100 and 1000 years. Imaginable to happen over a period of several generations. Very rare. Within a few years. Very unlikely to occur. Coincidence or sequence virtually impossible, a "one in a million" chance.
2. Remote	Has occurred elsewhere. Occurs between 10 to 100 years. On average once during the operational lifetime of the plant. Rarely, from once per month to once per year. Unlikely to occur. Would be a remotely possible or very unusual coincidence.
3. Possible	Has happened in our area. Known to have happened. Occurs between 1 to 10 years. Likely to occur several times during the operational lifetime of the plant. Occasional, once a week to once a month. Likely to occur. It would be a rare or unusual but possible sequence or coincidence..
4. Likely	Occurred often, once a day. Occurs within one year. Likely to reoccur within 3-5 years. Likely to occur frequently during the operational life of the plant. Frequent. Weekly Very likely to occur. Very likely, not uncommon to have a 50/50 chance.
5. very likely	Frequently observed occurrence. Occurs more than once a year. Likely to occur within the next year. Constantly, or several times a day. It is certain to occur. It is the most likely and expected outcome if the event occurs.

Table 2 Risk class by probability

The Steps of a JSA (Job Safety Analysis)

1. Selecting the job to analyse

An effective JSA programme chooses and prioritises the jobs to be analysed. Categorise each job according to as many hazards as possible. The most hazardous jobs are analysed first. The following factors need to be considered:

- The frequency of accidents.
- The severity of the accident.
- New jobs, non-routine jobs or changes of duties.

ISSN 2410-3950

- Repeated exposure.

Note: remember that experienced workers can help identify potential hazards associated with a job.

2. Break the job down into basic steps

The analysis should not be so detailed that it results in a large number of steps, nor so generalised that basic steps are omitted.

Preferably an experienced worker should help divide the work into steps. The purpose and practicalities of a JSA should be explained to the workers, and once broken down, the list should be reviewed and approved by everyone involved.

Note: if there are more than 15 steps, the work should be divided into more than one JSA.

3. Identify the hazards within each step

Each step is analysed for existing and potential hazards, the hazard should be noted.

Consider these notations when evaluating each step of the job:

- Struck against.
- Struck by.
- Contact with.
- Being touched by.
- Caught in.
- Caught in.
- Caught between.
- Falling from the same level.
- Fall from another level.
- Overexertion.
- Exposure.

4. Control each hazard

In this step the control measures for each hazard are identified and noted, the control measure recommends a work procedure to eliminate or reduce accidents or potential hazards.

Consider these five points for each hazard identified:

- Change the work procedure.
- Change physical conditions.
- Change work procedures.
- Reduce frequency.
- Use personal protective equipment.

5. Review the Job Safety Analysis

The JSA is effective only if it is re-examined periodically or after an accident occurs to determine if new work procedures or protective measures are needed, (Texas Department of Insurance. Government Agency, 2023).

Considering the risk matrix and the steps to develop a job hazard analysis, a risk analysis was performed for a wire drawing machine called MT-106, where the following figure 2 shows the observed operation, the type of hazard it represents, the risk that could occur, the severity score and probability of occurrence, the type of evaluation and the action to be taken to mitigate or eliminate the risk.

Secuencia de operación	Peligros potenciales (SHEQ)				Acción correctiva
Operación	*Peligros*	*¿Qué pude suceder?*	*Riesgo*	*Evaluación*	*¿Cómo se puede evitar o eliminar?*
Carga de materia prima por medio de un carrete		El alambre que se utiliza como materia prima viene embobinado en un carrete y se coloca en una base especial para evitar que se mueva a la hora de girar y pasarlo a la trefiladora.	42	Probable	Se debe de usar el montacargas con precaución para poner el carrete en la base y se debe de evitar el contacto con el carrete si no se usan herramientas de trabajo.
Acomodo del alambre por las poleas de la trefiladora		En este proceso el operador puede sufrir de un piquete con el alambre o de un machucón con los dados.	42	Probable	El operador debe de utilizar guantes al momento de pasar el alambre por las poleas para evitar machucones y también cuando se colocan los dados, para evitar
Designación del diámetro para los primeros dados de la trefiladora		Se le hace un desbaste a la punta del alambre para que pueda entrar en los dados y se pueda unir con el alambre restante de carrete anterior.	32	Insignificante	El esmeril con el que se hace el desbaste tiene que tener guarda y el operador debe de usar guantes.
Unir las dos puntas del alambre con soldadura		El operador puede sufrir de alguna quemadura al estar soldando.	42	Probable	Se debe de usar equipo de protección adicional como lo es la careta de soldador y guantes que sean resistentes al calor.

El operador esmerila la soldadura que puedo en la unión de los dos alambres.		En esta parte el operador puede sufrir de quemaduras por parte de las chispas que crea el alambre y si no se tiene cuidado se podría raspar o cortar con la esmeriladora.	43	Importante	Se debe de usar el equipo de protección adecuado para este proceso como lo es una careta y guantes de soldador.
Fijar el perro de arrastre al block en el otro extremo de la punta del alambrón hasta llenar 3/4 su capacidad máxima del block		Al realizar todo este proceso pueden suceder accidentes, al colocar el alambre en los pasos a pueden haber machucones, se puede romper el alambre y herir al personal, se pueden picar con los amarradores de alambre y lesionar si los pasos se activan automáticamente.	43	Importante	La medida de seguridad principal es usar el equipo de protección personal completo y de la manera adecuada. Se recomienda que se usen las herramientas especiales para el manejo del alambre y no herramientas que los mismos operadores puedan crear y les sean funcionales.
Pasar el alambre al carrete pasando su punta por el barreno		Una vez que se colocó el alambre en las poleas es muy importante tener el control absoluto del alambrón porque este podría generar cortaduras o picaduras al momento de manipular el material.	42	Probable	Es importe que se utilicen guantes, casco y careta para evitar los riesgos.
Poner en marcha la máquina		Al dejar trabajando las trefiladoras con las guardas abajo, los operadores se exponen a que el alambre se rompa y le pegue a alguno de ellos, además que se pueden machucar si ponen la mano en alguno de los pasos de la trefiladora.	43	Importante	Es obligatorio que las trefiladoras trabajen con las guardas abajo y que las puertas donde está el carrete del producto final este completamente cerrada.
Salida del carrete y pesaje		Cuando sale el carrete de la máquina puede rodar y golpear a un operador, al pesarlo este también se puede balancear y golpear a un operador.	32	Insignificante	El operador debe de verificar que el carrete salga con poca fuerza de la máquina y que a la hora de levantarlo con el polipasto sea en una dirección recta para evitar que se pueda balancear.

Figure 2 Risk analysis for MT-106 wire drawing machine

Acknowledgements

We are grateful for the support provided by the Universidad Tecnológica Fidel Velázquez for this work.

Funding

Funding: The following work does not have any type of funding.

Conclusions

As a result of the risk analysis carried out, shortcomings were identified in the personal protective equipment, as well as in the tools used by the operators to handle this type of machine.

Various hazards or risks that were present in the plant were identified and measures were taken to minimise them.

The following figure shows the reduction of accidents caused by the risks detected:

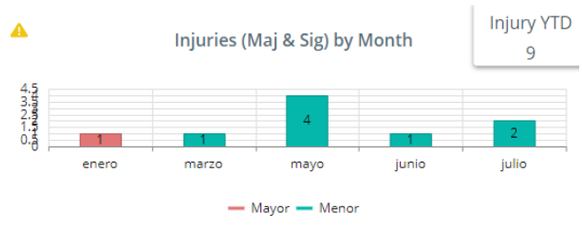


Figure 3 Accident reporting from January to July

References

MARIO FRIGERIO S.p.a. (2007). *La tecnología del trefilado y la maquinaria para dicho proceso.* THE DRAWING TECHNOLOGY (E) Sep-07. Retrieved from: https://antaac.org.mx/catalogos/9.--trefiladoras-y-velocidades.pdf

Aceros Torices S.A. de C.V. (2023). *¿Cómo es el proceso de trefilado?* Descubre ¿Qué función cumplen las trefiladoras de alambre? Retrieved from: https://acerostorices.com.mx/blog/trefiladoras-de-alambre/

Romero, S. (2022). *La matriz de riesgos según la norma ISO 45001*. El portal de la coordinación empresarial.com GRUPO CTAIMA. Retrieved from: https://www.coordinacionempresarial.com/la-matriz-de-riesgos-segun-la-norma-iso-45001/

Departamento de Seguros de Texas. Agencia de gobierno (2023). *Análisis de Seguridad en el Trabajo*. Retrieved from: https://www.tdi.texas.gov/pubs/videoresourcesp/spstpjobsafetana.pdf

Article **Journal of Experimental Systems**
June 2023, Vol.10 No.28 21-28

Design and experimental study of systems for the regeneration of aqueous $CaCl_2$ solutions using solar energy

Diseño y estudio experimental de sistemas de regeneración de soluciones acuosas de $CaCl_2$ mediante energía solar

CARRERA-ARELLANO, Ethson Uriel†, PILATOWSKY-FIGUEROA, Isaac, HERNÁNDEZ-RUÍZ, María A. and GARCÍA-GONZÁLEZ, Juan Manuel*

Universidad Autónoma de Zacatecas, Unidad Académica de Ciencias Químicas, Maestría en Ciencias y Tecnología Química

ID 1st Author: *Ethson Uriel, Carrera-Arellano* / **ORC ID:** 0000-0002-5323-6047

ID 1st Co-author: *Isaac, Pilatowsky-Figueroa* / **ORC ID:** 0000-0002-6492-2456

ID 2nd Co-author: *María A., Hernández-Ruíz* / **ORC ID:** 0000-0003-3369-6676

ID 3rd Co-author: *Juan Manuel, García-González* / **ORC ID:** 0000-0001-7259-5021

DOI: 10.35429/ JOES.2023.28.10.21.28 Received: January 30, 2023; Accepted: June 30, 2023

Abstract

Desiccants are capable of extracting or releasing water vapor from the air, in relatively large quantities. It is important from the economic point of view the recovery by thermal regeneration of these desiccants. Therefore, the development of a technique for the regeneration of this type of substance is of technical and economic interest. For this reason, in the present work, two equipments for the regeneration of calcium chloride in aqueous solutions were designed, built and experimented with, one with a flat surface and the other with a stepped surface assisted by solar energy as a heating medium. This process was monitored through various temperature and humidity sensors to know the operating conditions inside the regenerators, as well as the environmental conditions throughout the experiments through a climatic and solarimetric station. During the study it was observed that the materials and dimensioning of both equipment are adequate. When comparing the temperatures and amount of water evaporated during the test period, a better performance was obtained in the regenerator with an inclined plane, than in the stepped type, which was corroborated by evaluating the relative density of the solutions.

Aqueous desiccant, Variable monitoring, Regeneration

Resumen

Los desecantes son capaces de extraer o liberar vapor de agua del aire, en cantidades relativamente grandes. Es importante desde el punto de vista económico la recuperación por regeneración térmica de estos desecantes. Por lo anterior, el desarrollo de una técnica para la regeneración de este tipo de sustancias resulta de interés técnico y económico. Por ello, en el presente trabajo se diseñaron, construyeron y se experimentó con dos equipos para la regeneración de cloruro de calcio en soluciones acuosas, uno de superficie plana y otro escalonado asistidos por energía solar como medio de calentamiento. Este proceso fue monitoreado mediante diversos sensores de temperatura y humedad para conocer las condiciones de operación dentro de los regeneradores, así como las condiciones ambientales a lo largo de los experimentos mediante una estación climática y solarimétrica. Durante el estudio se pudo observar que los materiales y el dimensionamiento de ambos equipos son adecuados. Al comparar las temperaturas y cantidad de agua evaporada durante el periodo de pruebas se obtuvo un mejor desempeño en el regenerador con plano inclinado, que en el tipo escalonado, lo cual se corroboró mediante la evaluación de la densidad relativa de las soluciones.

Desecante acuoso, Monitoreo de variables, Regeneración

Citation: CARRERA-ARELLANO, Ethson Uriel, PILATOWSKY-FIGUEROA, Isaac, HERNÁNDEZ-RUÍZ, María A. and GARCÍA-GONZÁLEZ, Juan Manuel. Design and experimental study of systems for the regeneration of aqueous $CaCl_2$ solutions using solar energy. Journal of Experimental Systems. 2023. 10-29:21-28.

* Corresponde to author (E-mail: jmgarcia@uaz.edu.mx)
† Researcher contributed as first author.

Introduction

In the last decades, in the field of air conditioning of spaces, the industrial sector has focused on the control of environmental humidity, this due to the repercussions that it has on the industrial processes of pharmaceuticals, food drying, among others, and air conditioning. of spaces, such as hotels, houses and shopping malls. This has caused a growing demand for air conditioning equipment which in turn generates a greater demand for primary energy resources.

The air conditioning equipment operates under heat transfer mechanisms, carrying out operations of evaporation and condensation of water from the ambient air, in such a way that they can control the temperature, air quality and humidity in closed environments.

This is how the need to partially or totally eliminate water vapor from the air (a process called dehumidification) is created, in order to achieve optimal operating conditions. Currently there are several methods for dehumidification, among which are mainly dehumidification by cooling and dehumidification using desiccants. The first method consists of bringing humid air below its dew point temperature, which causes condensation of water in the air, simultaneously obtaining cooling and dehumidification. The second method is based on the use of absorbent or adsorbent desiccant materials in solid and liquid state (absorbents and adsorbents), which retain a certain amount when they come into contact with water vapor, increasing their temperature due to the heat of dissolution. Currently, there are several systems that operate with this method (desiccant dehumidification). Which have great potential for improvement in the dehumidification process, since under the right conditions they could increase the speed and facilitate the process of moisture retention.

Within the absorbers and adsorbers used for these processes, silica, alumina, zeolites, activated carbon, etc. are used as solid materials, and for liquid absorbents, solutions of inorganic salts are used, such as LiCl and $CaCl_2$, among others. These desiccants can be regenerated through conductive and/or convective and radiative heating processes derived from conventional energy sources (electrical and from fossil fuels) and renewable energies such as solar energy, geothermal energy and biomass.

In recent years, several techniques have emerged where solid and liquid salts are regenerated using conductive and convective heating, both for conventional heating systems and for systems that operate with renewable energies, however, it is unknown if the solar energy available in the Central- Northern Mexico is sufficient to carry out regeneration processes of hygroscopic salts in a liquid state with the climatic conditions of the state of Zacatecas.

At present, a large part of the industrial processes such as the manufacture of medicines, pharmaceuticals, the treatment and preservation of wood, textiles, the storage of post-harvest products and the drying of food depend on environmental conditions, mainly on temperatura and environmental humidity, whose high values favor the generation of molds, the decomposition of products, the corrosion of metals or simply achieving an undesirable climatic environment [I].

Mexico is a country with a wide diversity of climatic conditions with areas where the weather varies throughout the year. This highly changing environment generates environments with high humidity contents in most of the country, especially in the April-August season, which makes it difficult to control the conditions in the processes. Figure 1 shows two maps of the national territory that show: a) the annual maximum relative humidity and b) the maximum relative humidity values for the month of July [II].

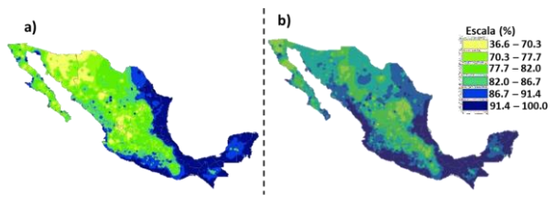


Figure 1 Relative humidity: a) annual average 2018, b) maximum month of July 2018

Therefore, it is important to achieve air conditioning in the processes to facilitate and optimize the processes by reducing the moisture content and controlling the temperature. There are air conditioning systems that cover these needs, such as mechanical vapor compression (SCV) systems that, according to research carried out by the International Institute of Refrigeration in Paris, present a problem due to their high energy consumption.

ISSN 2410-3950

According to this study, the proportion of energy used by air conditioning systems in homes and buildings represents almost 45% of the electricity consumption in this sector, which represents almost 15% of the total energy consumption in the world [III]. In addition, in developing countries, refrigerants with a high environmental impact such as chlorofluorocarbons (CFCs) are still used, which deplete the ozone layer and equipment that generates large amounts of CO_2, being a problem for the environment [V]. Hence, the need arises to look for new alternatives to satisfy the air conditioning conditions and reduce the environmental impact due to the high electrical consumption of the equipment. As well as new alternatives to recycle and regenerate the chemical substances involved in said air conditioning equipment.

Kyshore et al (2013), conducted an experimental analysis of a hybrid liquid desiccant dehumidifier system. Air dehumidification is performed in a randomly packed packed column in which air and desiccant solution flow countercurrently to exchange heat and moisture and after heating and mass transfer is circulated through the regenerator where it is reconcentrated. The desiccant chosen for the analysis is aqueous calcium chloride solution [VI].

Seenivasan et al. (2018), studied the effects of input parameters on the performance of liquid desiccant dehumidifiers with and without an indirect evaporative cooler or intercooler (IDEC) between one and two stage dehumidifier. They conclude that the double stage desiccant dehumidifier with indirect evaporative cooler has a better performance [VII].

Cho et al. (2019), found that in a liquid desiccant desiccant desiccant, the direction of airflow to the solution plays an important role in desiccant performance and the physical size of the desiccant tower. The assertion was with the results when using the liquid desiccant in counterflow and crossflow. They concluded that the crossflow liquid desiccant dehumidifier would provide relatively stable dehumidification performance, regardless of changes in operating parameters [VIII].

Chen et al (2020), in their article, present a bibliographic review of air conditioning and dehumidification systems using liquid desiccants. In addition, they present various types of dehumidifiers and their integration with the liquid desiccant dehumidification system. They have also grouped and compared the combination of liquid desiccant dehumidification system with solar collector, vapor compression systems, heat pump systems, CHP systems, etc. [IX].

Bhowmik (2021), proposed a hybrid method by combining solar evacuated tube collectors as a regeneration source to drive the liquid desiccant system in a closed loop. They made the overall energy balance between the ambient air and the liquid desiccant. Similarly, they analyzed the effects of independent parameters on the performance parameters of the dehumidifier-regenerator. In addition, they developed Adaptive Neurofuzzy Inference System (ANFIS) prediction models to predict system performance based on system-independent parameters. The model results exhibited good agreement with the experimental results [X].

Sarukasan et al. (2022), carried out a theoretical-experimental analysis of $CaCl_2$ regeneration using solar energy. The dehumidifier used was a vertical film connected to a flat collector. Among their results, they verified that the regeneration performance increases as the temperature of the solution increases, the massive evaporation increases by 50%. Since solar energy is used, the total energy of the system is reduced and the emissions are also reduced [XI].

Passamani et al. (2023), used concentrated $CaCl_2$ solutions for the dehumidification of humid air. The work carried out was in order to acquire the necessary experience for the design of systems of this type, they built an experimental prototype lighting artificially, in order to collect information on the parameters that define the evaporation process and obtain experience on construction details and materials to use [IV].

ISSN 2410-3950

Gado et al. (2023), comprehensively present the operating principles of atmospheric water collection technology. Subsequently, they carry out a detailed evaluation of state-of-the-art sorption materials, such as activated carbon fiber, zeolite, silica gel, organometallic structures, calcium chloride with various host materials and hydrogels, where their isotherms and adsorption kinetics are examined. They also summarize and classify numerous solar-powered atmospheric water collector designs, including fixed and mobile installations. They demonstrated the viability of these systems is also demonstrated in different weather conditions. Finally, the obstacles and limitations that hinder its use and future research directions are explored [XIII].

Kumar et al (2023), their study offers an overview of the advances associated with the incorporation of liquid desiccant technologies in VCS units to date. Various dehumidifier configurations and hybrid technology. This review article is beneficial. to researchers as it identifies research gaps and explores prospective future research techniques to further improve the performance of hybrid vapor compression-liquid desiccant systems [XIV].

Shah et al. (2023), evaluated the advantages of providing internal cooling and the effect of LD concentration, as well as environmental conditions. They proposed two new efficiencies, one based on ambient wet bulb temperature and the other on LD crystallization temperature to give due credit to the higher moisture removal potential available in the internally cooled dehumidifier. At 40% LD concentration, dehumidifier effectiveness at wet bulb temperature was 67% for the adiabatic dehumidifier, but could be increased to 95% using an internally cooled dehumidifier [XV].

Xie et al. (2023), comprehensively reviewed and compared the state of the research on several different adsorbents, such as zeolite, silica gel, and organometallic structures. They conducted in-depth research on the synthesis processes, characterization, and adsorption characteristics of various adsorption composite materials. The purpose of this study was to provide a reference for researchers engaged in the development of new adsorption materials in various applications and conditions [XVI].

Methodology

The current design methodology in terms of spatial dimensions of the equipment was raised based on a bibliographic review, in addition, parameters such as environmental conditions and properties of the chemical substances involved such as corrosivity, density and solubility were taken into account.

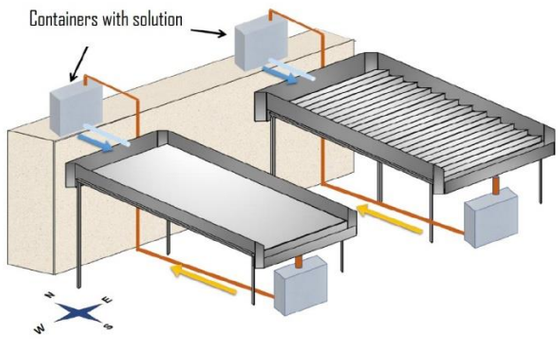


Figure 2 Equipment assembly diagram

For the climatic parameters of the place of installation, the climatological database registered by the UNAM was used as: "Database are Meteorological Information (Irradiation, Ambient Temperature, Relative Humidity and Wind Speed) for all the populations of Mexico of more than of 10,000 inhabitants registered in 2011", with registration number 03-2012-112811530700-01. Obtained with the FORDECYT 190603 project. And to the Zacatecas_04 Solarimetric Station of the National Solarimetry System located in the E6 building of the Siglo XXI campus at the Autonomous University of Zacatecas (Latitude: 22.77 ° N, Longitude: 102.64 ° W, Height: 2,440 snm) Figure 3, from which the historical data recorded in this area were obtained and processed, which are reported in Table 1. And based on which it was decided to carry out experimentation in the third quarter of the year since historically it is where the most suitable conditions for the operation of the regeneration systems are recorded.

ISSN 2410-3950

Month	T_a (°C)	$T_{mín}$ (°C)	$T_{máx}$ (°C)	HR (%)	V_{air} (m/s)	Radiation (MJ/m^2 day)
January	11.1	4.8	17.3	52.9	4.33	15.35
February	12.2	5.5	19.0	45.5	4.36	18.46
March	14.6	7.5	21.7	33.8	4.51	21.52
April	16.8	9.7	23.8	32.6	4.16	22.57
May	19.1	12.0	26.2	38.1	3.44	24.03
June	19.0	12.5	25.4	62.3	2.78	22.30
July	17.2	11.5	23.0	71.6	2.77	21.52
August	17.2	11.5	23.0	69.7	2.54	21.16
September	16.8	11.2	22.3	72.8	3.12	18.23
October	15.7	9.6	21.8	69.0	3.42	16.84
November	13.9	7.4	20.4	63.4	3.86	16.93
December	11.9	5.8	18.1	56.5	4.08	14.16

Table 1 Averaged historical climatological data for Zacatecas

Figure 3 Zacatecas_04 Solarimetric Station of the National Solarimetry System

Results

Preliminary tests were carried out to know the behavior of the solutions, the regeneration equipment and the monitoring during the dehumidification process. The qualitative results that were found were used to improve the previously established methodology. The aspects analyzed correspond to the flow velocity in the solution, the orientation of the equipment and its elevation angle with respect to the sun, the monitoring data recording intervals, as well as the optimal intervals for the recirculation of the solutions.

Regarding the flow of the solution, it started with low values between 0.5-0.75 l/min, observing the formation of canals in certain areas in the regeneration equipment, which indicates a waste of the available heat exchange area of the equipment.

In flows equal to or greater than 2 liters/min, low and insufficient temperature increases in the solution were observed due to the short residence time of the solution in the equipment. In addition, it was necessary to recirculate the solution many times.

The results indicated the need to operate the generators in a flow domain between 0.8 and 1.8 l/min to reduce the effect of the canalizations, a more adequate recirculation and have a better use of the available area.

In addition, a test was carried out in the staggered equipment with an inlet flow of 1.0 l/min, where different inclinations were tested with 5° increments with respect to the floor starting at 23°, this to determine the influence of the inclination with respect to the increase in temperature by the angle in which the equipment receives solar radiation, in addition to determining the variation of the velocity of the fluid throughout the equipment, from which it was observed that inclinations greater than 45° contact time of the solution with the plate which is reflected in low temperature increases. It was possible to verify that the optimal range of inclination is from 23° to 38° of inclination, which depends on the solar declination, that is, on the day of the test. During this test the recording intervals on the loggers were set to 0.5 seconds for the arduino. Regarding recirculation, in order to protect the equipment from damage due to an operation without flow, it was decided to recirculate the solutions until all the solution had circulated through the regeneration equipment. Regeneration of salts and calculations of solar and thermal energy used

For the first regeneration test, 50 liters of solution were prepared with $CaCl_2$ whose mass fraction was 0.20. The solution was distributed in two 25-liter drums and was taken to the experimental site after evaluating its properties (temperature, relative density, and weight and volume). Prior to the regeneration test, the solar declination and solar noon were calculated and the equipment was tilted at the appropriate angle and operated with a flow of 1.2 l/min. Measurements began and every minute was monitored with the help of sensors and arduino.

According to the data obtained by processing the information from the data collectors, the environmental temperature was plotted, the temperatures of the saline solution as a function of time both in the overflow and at the end at the end of the equipment and the profiles of the temperature increases in the solution for the flat type equipment and the stepped one (Figure 4).

ISSN 2410-3950

The temperatures reached by the solution at the beginning and end of its passage through the equipment throughout the regeneration test, in addition to the solar radiation received. The solution that reached the highest temperature is the one treated in the inclined plane equipment, with a value of up to 52.12 °C registered at 1:50 p.m., in contrast to the solution treated by the stepped equipment, the maximum temperature was 40.47 °C registered at 13:46 civil time.

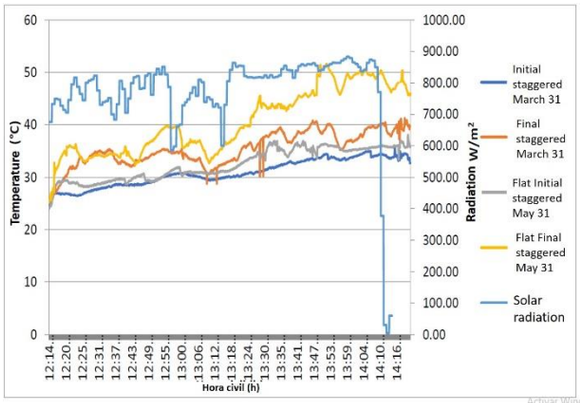


Figure 4 Temperature increase in $CaCl_2$ regeneration equipment

Regarding the amount of water removed, the relative density at the beginning and that obtained at the end of the test was recorded.

For the determination of the change of the concentration of the solutions, the mass fraction of $CaCl_2$ in the solutions was calculated.

The solute-solvent ratio was 0.28 and considering that the loss of mass is due solely to the loss of H_2O in the solution, the volume of water at the end of the experimentation is calculated, which for both teams in the test represents a loss of 0.37 liters of water.

The data obtained from the regeneration of the salt are presented in the Table 2, where they are expressed as a function of the initial and final relative density of $CaCl_2$-H2O at room temperature (22-25 °C), where the masses of water are presented removed for each case. Of which a superior performance is observed by the "Flat Team" achieving water losses of up to 2.5 liters and in contrast to the "Staggered Team" a loss of 2 liters was obtained.

Equipment Configuration	Test date	Relative density		Water mass (kg)		
		Start	After regeneration	Initial	Final	Lost
Staggered	31 May	1.18	1.19	20	19.63	0.37
	3 June	1.18	1.21	20	19.3	0.6
	6 June	1.175	1.275	20	17.96	2.04
	7 June	1.175	1.27	20	18.6	1.4
	15 August	1.18	1.26	20	18.93	1.07
Flat	31 May	1.18	1.19	20	19.6	0.4
	3 June	1.18	1.27	20	18.6	1.4
	6 June	1.175	1.29	20	17.35	2.56
	7 June	1.175	1.28	20	17.6	2.4
	15 August	1.18	1.265	20	18.8	1.2

Table 2 Regeneration data table

Regarding the temperature of the solution, it is observed that the temperature was up to 72 °C, which supports the salt regeneration data.

Although the global energy data received by the equipment gives a coherent relationship between the temperature, the regeneration of the saline solution and the solar radiation in the environment of the equipment, that is, there is a greater regeneration of salt when they are registered, higher temperatures and higher solar radiation, we have to take into account that this energy is not 100% used by the equipment. However, an estimate of energy use can be made from the volume of water evaporated by the regenerators.

For this, it is necessary to know the sensible and latent heats of the solution and from them, obtain the total energy necessary. There was a greater use of energy from the flat equipment. This can be attributed to the geometry of the equipment, where the stepped equipment makes less use of solar energy, due to the fact that the temperature on the plate is not homogeneous in the height and width of its steps.

The energy required by the average Flat and Stepped Equipment was 161.41 and 149.61 kJ respectively. For the process to be viable, the values must be greater than the energy required by the fluid recirculation pumps and thus be able to have a positive saved energy balance. For this, the electrical consumption was measured in each recirculation cycle during the tests with a multimeter according to the methodology suggested by Venables M. [XIII]. According to the results obtained, it was found that 7.2% of the solar energy used for the staggered equipment and 5.4% for the Flat Equipment. This shows a positive balance in energy saved for the regeneration of salts.

ISSN 2410-3950

Conclusions

The inclined plane type regenerator performed better than the stepped equipment, achieving solution temperatures of up to 72 °C in contrast to the stepped equipment whose maximum temperature was 58 °C.

The design of both equipments turned out to be adequate since it was shown to be able to regenerate $CaCl_2$ solutions.

The design and implementation of a monitoring system for climatic and physical conditions of fluids with low-cost and accessible sensors was achieved.

The regeneration of aqueous $CaCl_2$ solutions was achieved, reaching values in the mass fraction of the salt of 0.25.

The performance of the staggered equipment did not meet expectations, despite having a longer residence time of the solution in the equipment, the temperatures reached by the latter were lower than those of the flat equipment.

The configuration of the staggered equipment avoids having a homogeneous temperature on the plate due to the angle of incidence of solar radiation.

The use of solar energy by the equipment in the regeneration of salts denotes the achievement in the implementation of renewable energy in the evaporation of chemical solutions.

References

[I] Dina, S. F. (2015). Study on effectiveness of continuous solar dryer integrated with desiccant thermal storage for drying cocoa beans. *Case Studies in Thermal Engineering, 5*, 32–40.

[II] CONAGUA, (2014). *Resumen anual de Temperaturas y Lluvia*. Obtenido de http://smn.cna.gob.mx/es/climatologia/temperaturas-y-lluvias/resumenes-mensuales-de-temperaturas-y-lluvias.

[III] LaNGIF, (2018). *Monitoreo de precipitación en México para el año de 2017*. Obtenido de http://langif.uaslp.mx/HR_Historico.php

[IV] Passamai & L. Sarabia., (2023). Ensayos de deshumidificación solar de soluciones de CaCl2. *Avances en Energías Renovables y Medio Ambiente – AVERMA. No. 2*.

[V] Evans J.A., F. A. (2014). Rendimiento energético del almacenamiento en frío. *Frío Calor Aire acondicionado, Vol 42, No. 471*, 3-12.

[VI] Nanda, K. P. (2013). Experimental analysis of a liquid desiccant dehumidifier using aqueous calcium chloride solution. *International Journal of Innovative Research in Science, Engineering and Technology Volume 2, Special Issue 1*.

[VII] Seenivasan, D. S. (2018). Experimental studies on the performance of dehumidifier using calcium chloride as a liquid desiccant. *International Journal of Energy Technology and Policy, 14(1)*, 49-63.

[VIII] Cho, H. J. (2019). Experimental analysis of dehumidification performance of counter and cross-flow liquid desiccant dehumidifiers. *Applied Thermal Engineering, 150*, 210-223.

[IX] Xiangjie Chen, S. R. (2020). Recent progress in liquid desiccant dehumidification and air-conditioning: A review. *Energy and Built Environment 1*, 106–130.

[X] Bhowmik, M. M. (2021). Experimental study of coupled heat and mass transfer phenomena between air and desiccant in a solar assisted thermal liquid desiccant system. *International Journal of Thermal Sciences, 162*.

[XI] D. Sarukasan, S. S. (2022). Experimental and Theoretical Analysis of CaCl2 Liquid Desiccant System with Solar Regeneration. *Conference paper. First Online: 30 September 2022. Part of the Lecture Notes in Mechanical Engineering book series (LNME)*.

[XII] Bouzenada, S. K. (2016). Estudio comparativo experimental sobre cloruro de litio y desecantes de cloruro de calcio. *Procedia*.

ISSN 2410-3950

[XIII] Gado, M.G., Nasser, M., Hassan, H. (2023). Solar Adsorption-Based Atmospheric Water Harvesting Systems: Materials and Technologies. In: Fosso-Kankeu, E., Al Alili, A., Mittal, H., Mamba, B. (eds) Atmospheric Water Harvesting Development and Challenges. Water Science and Technology Library, vol 122. Springer, Cham. https://doi.org/10.1007/978-3-031-21746-3_5

[XIV] Kumar K., Singh A, Chaurasiya P. K., Patthnak K. K., Pandey V., (2023) Progressive development in hybrid liquid desiccant-vapour compression cooling system: A review, *Sustainable Energy Technologies and Assessments*, Volume 55, 2023, 102960, ISSN 2213-1388 https://doi.org/10.1016/j.seta.2022.102960.

[XV] Shah N. M., Mehta J. R., Sharma S. (2023), Parametric investigations on a novel bubble column liquid desiccant dehumidifier with internal cooling, *Energy and Buildings*, Volume 285, 112913, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2023.112913.

[XVI] Xie W., Hua W, and Zhang X. (2023), Research Progress on Synthesis and Adsorption Properties of Porous Composite Adsorbents for Adsorption Cooling and Desalination Systems: A Mini-review *Energy Fuels* 2023, 37, 7, 4751–4768, Publication Date:March 27, https://doi.org/10.1021/acs.energyfuels.2c03700

ISSN 2410-3950

[Title in Times New Roman and Bold No. 14 in English and Spanish]

Surname (IN UPPERCASE), Name 1st Author†*, Surname (IN UPPERCASE), Name 1st Coauthor, Surname (IN UPPERCASE), Name 2nd Coauthor and Surname (IN UPPERCASE), Name 3rd Coauthor

Institutional Affiliation of Author including Dependency (No.10 Times New Roman and Italic)

International Identification of Science - Technology and Innovation

ID 1st Author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st author: (Scholar-PNPC or SNI-CONACYT) (No.10 Times New Roman)

ID 1st Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st coauthor: (Scholar or SNI) (No.10 Times New Roman)

ID 2nd Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 2nd coauthor: (Scholar or SNI) (No.10 Times New Roman)

ID 3rd Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 3rd coauthor: (Scholar or SNI) (No.10 Times New Roman)

(Report Submission Date: Month, Day, and Year); Accepted (Insert date of Acceptance: Use Only ECORFAN)

Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Abstract (In Spanish, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

Indicate 3 keywords in Times New Roman and Bold No. 10

Keywords (In Spanish)

Indicate 3 keywords in Times New Roman and Bold No. 10

Citation: Surname (IN UPPERCASE), Name 1st Author, Surname (IN UPPERCASE), Name 1st Coauthor, Surname (IN UPPERCASE), Name 2nd Coauthor and Surname (IN UPPERCASE), Name 3rd Coauthor. Paper Title. Journal of Experimental Systems. Year 1-1: 1-11 [Times New Roman No.10]

* Correspondence to Author (example@example.org)
† Researcher contributing as first author.

Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

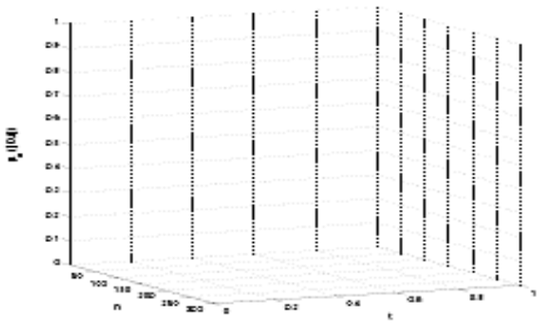
[Title No.12 in Times New Roman, single spaced and bold]

Products in development No.12 Times New Roman, single spaced.

Including graphs, figures and tables-Editable

In the article content any graphic, table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]



Graphic 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

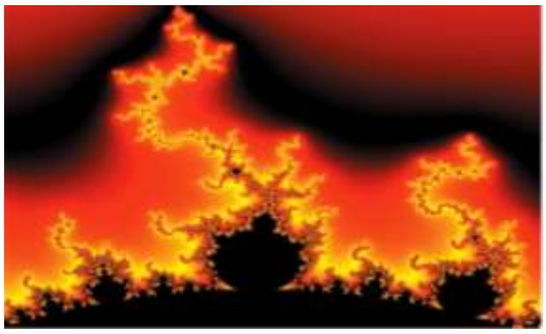


Figure 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Table 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Each article shall present separately in **3 folders**: a) Figures, b) Charts and c) Tables in .JPG format, indicating the number and sequential Bold Title.

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad (1)$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Annexes

Tables and adequate sources

Thanks

Indicate if they were financed by any institution, University or company.

Conclusions

Explain clearly the results and possibilities of improvement.

ISSN 2410-3950

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use Roman Alphabet, all references you have used must be in the Roman Alphabet, even if you have quoted an Article, book in any of the official languages of the United Nations (English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic), you must write the reference in Roman script and not in any of the official languages.

Technical Specifications

Each article must submit your dates into a Word document (.docx):

Journal Name
Article title
Abstract
Keywords
Article sections, for example:

1. Introduction
2. Description of the method
3. Analysis from the regression demand curve
4. Results
5. Thanks
6. Conclusions
7. References

Author Name (s)
Email Correspondence to Author
References

Intellectual Property Requirements for editing:

-Authentic Signature in Color of Originality Format Author and Coauthors

-Authentic Signature in Color of the Acceptance Format of Author and Coauthors

-Authentic Signature in Color of the Conflict of Interest Format of Author and Co-authors.

ISSN 2410-3950

Reservation to Editorial Policy

Journal of Experimental Systems reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Research Journal. Once the Article is accepted in its final version, the Research Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Research Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution

The ECORFAN-Mexico, S.C Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

– The sending of an Article to Journal of Experimental Systems emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

– None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

– References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

– The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Bolivia considers pertinent for disclosure and diffusion of its Article its Rights of Work.

– Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

– The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

– No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

– The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, SC in its Holding Bolivia for it Journal of Experimental Systems, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Coauthors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
MENDELEY (Bibliographic References Manager)
DULCINEA (Spanish scientific journals)
UNIVERSIA (University Library-Madrid)
SHERPA (University of Nottingham - England)

Publishing Services

Citation and Index Identification H
Management of Originality Format and Authorization
Testing Article with PLAGSCAN
Article Evaluation
Certificate of Double-Blind Review
Article Edition
Web layout
Indexing and Repository
ArticleTranslation
Article Publication
Certificate of Article
Service Billing

Editorial Policy and Management

21 Santa Lucía, CP-5220. Libertadores -Sucre – Bolivia. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org

Site Licences

03-2010-032610094200-01-For printed material ,03-2010-031613323600-01-For Electronic material,03-2010-032610105200-01-For Photographic material,03-2010-032610115700-14-For the facts Compilation,04-2010-031613323600-01-For its Web page,19502-For the Iberoamerican and Caribbean Indexation,20-281 HB9-For its indexation in Latin-American in Social Sciences and Humanities,671-For its indexing in Electronic Scientific Journals Spanish and Latin-America,7045008-For its divulgation and edition in the Ministry of Education and Culture-Spain,25409-For its repository in the Biblioteca Universitaria-Madrid,16258-For its indexing in the Dialnet,20589-For its indexing in the edited Journals in the countries of Iberian-America and the Caribbean, 15048-For the international registration of Congress and Colloquiums. financingprograms@ecorfan.org

Management Offices

21 Santa Lucía, CP-5220. Libertadores -Sucre–Bolivia.

Journal of Experimental Systems

"System for personnel access control based on image processing"
LÁRRAGA-ALTAMIRANO, Hugo René, ESPINOSA-GUERRA, Omar, SEBASTIAN-LÓPEZ, Jonathan and FLORES-HERNÁNDEZ, Omar
Tecnológico Nacional de México, Campus Ciudad Valles

"Energy efficiency manager for electrical installations at home"
GONZÁLEZ-CARRILLO, Gamaliel, ORDOÑEZ-FLORES, Rafael, NAVARRETE-ESCALANTE, Marcela Monserrat and MORALES-CAPORAL, Roberto
Instituto Tecnológico de Apizaco
Instituto Tecnológico de Ciudad Guzmán, Ciudad Guzmán

"Analysis of hazards and risks in drawing machines"
PÉREZ-GALINDO, Liliana Eloisa, TORRES-VALLE, José Bernardo, HERNÁNDEZ-BORJA, Carlos and PEZA-ORTÍZ, Edebaldo
Universidad Tecnológica Fidel Velázquez

"Design and experimental study of systems for the regeneration of aqueous CaCl2 solutions using solar energy"
CAR**RERA-ARELLANO, Ethson Uriel, PILATOWSKY-FIGUEROA, Isaac, HERNÁNDEZ-RUÍZ, María A. and GARCÍA-GONZÁLEZ, Juan Manuel**
Universidad Autónoma de Zacatecas

2410 3950
ISSN 2410 - 3950
www.ecorfan.org