ISSN 2444-4987

Journal of Research and Development

Volume 9 Issue 24 – July – December – 2023

ECORFAN®

Journal of Research and Development, Volume 9, Number 24, December - 2023, is a sixmonthly Journal edited by ECORFAN-Spain. Matacerquillas Street 38, CP: 28411. Moralzarzal - Madrid. WEB: http://www.ecorfan.org/spain/rj_investigacion_d.php, revista@ecorfan.org. Editor in Chief: VARGAS-DELGADO, Oscar. PhD. ISSN 2444-4987. Responsible for the last update of this issue ECORFAN Computer Unit. Escamilla Bouchán-Imelda, Luna Soto-Vladimir, updated to December 31, 2023.

Journal of Research and Development

Definition of Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Humanities and Behavioral Sciences, in Subdisciplines of industrial development, project model, computer application, research production, systems development, research networks, application design, programming and development proposals.

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 - CONAHCYT Research Centers.

Scope, Coverage and Audience

Journal of Research and Development is a Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Spain, 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 of industrial development, project model, computer application, research production, systems development, research networks, application design, programming and development proposals 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 Humanities and Behavioral Sciences. 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.

Arbitration Committee

Assignment of Rights

The sending of an Article to Journal of Research and Development 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 Spain 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-CONAHCYT- 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 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 industrial development, project model, computer application, research production, systems development, research networks, application design, programming and development proposals and other topics related to Humanities and Behavioral Sciences.

Presentation of the Content

In the first article we present, *Description of the design and construction of a physical model of a dam for educational purposes,* by CANUL-TURRIZA, Román Alejandro, RODRÍGUEZ-COCOM, Leonel, VÁZQUEZ-GONZÁLEZ, Luis Ángel and CRUZ Y CRUZ, Andrea, with ascription in the Universidad Autónoma de Campeche, as the next article we present, *Effect of PANi electrodeposition methods on copper substrate*, by LERMA-GARCÍA, Martha Estela, CISNEROS-SINENCIO, Luis Fortino and PÁRAMO-GARCÍA, Ulises, with ascription in the Tecnológico Nacional de México, Instituto Tecnológico de Ciudad Madero, as the next article we present, *Use FACTS elements to improve energy exchange between countries in response to the high penetration of variable renewable energy*, by BARESKH-ONJI, Aboud, with ascription in the Istitulto Politécnico Nacional, as the last article we present, *Textile dyeing based on natural dyes*, by PONCE-CANO, Rosa Yetzira, VILLATORO-CRUZ, Tania and MEJÍA-NÁJERA, Carlos, with ascription in the Universidad Politécnica de Francisco I. Madero.

Content

Article Journal of Research and Development
December 2023, Vol.9 No.24 1-7

Description of the design and construction of a physical model of a dam for educational purposes

Descripción del diseño y construcción de un modelo físico de una presa con fines educativos

CANUL-TURRIZA, Román Alejandro†*, RODRÍGUEZ-COCOM, Leonel, VÁZQUEZ-GONZÁLEZ, Luis Ángel and CRUZ Y CRUZ, Andrea

Facultad de Ingeniería, Universidad Autónoma de Campeche

ID 1st Author: *Román Alejandro, Canul-Turriza* / **ORC ID**: 0000-0003-2081-9913, **CVU CONACHYT ID**: 546727

ID 1st Co-author: *Leonel, Rodríguez-Cocom* / **ORC ID**: 0009-0004-5919-4150

ID 2nd Co-author: *Luis Ángel, Vázquez-González* / **ORC ID**: 0009-0000-1241-353X

ID 3rd Co-author: *Andrea Cruz y Cruz* / **ORC ID**: 0000-0001-8861-1276

DOI: 10.35429/JRD.2023.24.9.1.7 Received: July 10, 2023; Accepted: December 30, 2023

Abstract

The objective of this document is to present the construction process of a physical model that resembles a dam, the use of which allows the reproduction of different hydrological and hydraulic phenomena, for example: flow, pump calculation, pipeline design, flow in open channels, among others. The built physical model has plan dimensions of 2.85 m wide by 11.50 m long, built with 15x20x40 concrete blocks and f'c=100 kg/cm^2, 150 kg/cm^2 and 200 kg/cm^2 resistance concrete, contains PVC pipes of 3” that contribute to the discharge of the flow; It will be part of the Hydraulics Laboratory facilities and impacts the academic development of the Civil Engineering and Administration, Energy Engineering and Mechanical Engineering programs of the Engineering Faculty of the Universidad Autónoma de Campeche.

Physical model, Hydraulic, Laboratory

Resumen

El objetivo del presente documento es presentar el proceso de construcción de un modelo físico que asemeje una presa, cuyo uso permita reproducir diferentes fenómenos hidrológicos e hidráulicos, por ejemplo: caudal, cálculo de bombas, diseño de tuberías, flujo en canales abiertos, entre otros. El modelo físico construido tiene dimensiones en planta de 2.85 m de ancho por 11.50 m de largo, construido con blocks de concreto de 15x20x40 y concreto de resistencia de f’c=100 kg/cm^2, 150 kg/cm^2 y 200 kg/cm^2, contiene tuberías de PVC de 3” que aportan a la descarga del flujo; formará parte de las instalaciones del Laboratorio de Hidráulica e impacta en el desarrollo académico de los programas de Ingeniería Civil y Administración, Ingeniero en Energía e Ingeniero Mecánico de la Facultad de Ingeniería de la Universidad Autónoma de Campeche.

Modelo físico, Hidráulica, Laboratorio

Citation: CANUL-TURRIZA, Román Alejandro, RODRÍGUEZ-COCOM, Leonel, VÁZQUEZ-GONZÁLEZ, Luis Ángel and CRUZ Y CRUZ, Andrea. Description of the design and construction of a physical model of a dam for educational purposes. Journal of Research and Development. 2023. 9-24:1-7.

* Author's Correspondence (E-mail: roacanul@uacam.mx)
† Researcher contributing as first author.

Introduction

The development of physical models allows to evaluate at scale the behavior of structures or the development of phenomena that by their nature are difficult to measure. At the international level, different physical models have been developed that help to understand the behavior of hydraulic structures such as dams, canals, among others. For example, Leiva Llenera (2017) develops a model to evaluate the failures of earthen dams in the world and in Cuba; o Parcero López (2016) who studies the stability of dams considering the effects of earthquakes and seepage forces through a physical model; On the other hand, Gutiérrez Gómez (2015) builds a model to demonstrate the technical feasibility for water collection; likewise, Ortiz Quizhpi & Portilla Flores (2014) analyze the stability of dam slopes. Most physical models are developed in specialized laboratories belonging to institutions for research purposes.

Universities must have adequate and optimal infrastructure for the development of their academic activities, among which are the development of laboratory practices; however, due to the socioeconomic context in which the Universities of Mexico are located, sometimes the acquisition and equipment of the laboratories becomes complicated.

The Faculty of Engineering of the Universidad Autónoma de Campeche is not exempt from the above situation, so the Hydraulics Laboratory lacks equipment that allows the correct development of activities related to the practice and teaching of the hydraulics area.

That is why, as a contribution to academic development and the implementation of knowledge offered by the Civil Engineering area, the faculty has developed projects focused on the proposed reconditioning of areas (Ice Cream Parlot of the Faculty). and preventive and corrective diagnosis of the built infrastructure (Barrera-Lao *et al*., 2017). Here we propose the design and construction of a physical model that allows the development of activities as a laboratory practice and that becomes part of the Hydraulics Laboratory equipment.

Allowing the development of practices concerning a wide variety of topics, among which stand out: flow, pump design, channel hydraulics, hydraulic jump, conduction, protection works, elements of a dam, power generation, among others.

Methodology

Once the objectives of the physical model and the hydraulic phenomena to be reproduced were defined, a pre-design was obtained in an assisted drawing software, later and after knowing the outdoor area where the model could be built, several calculations of the focused dimensions were carried out. in the speed, flow, and storage volume the final design was generated (Figure 1).

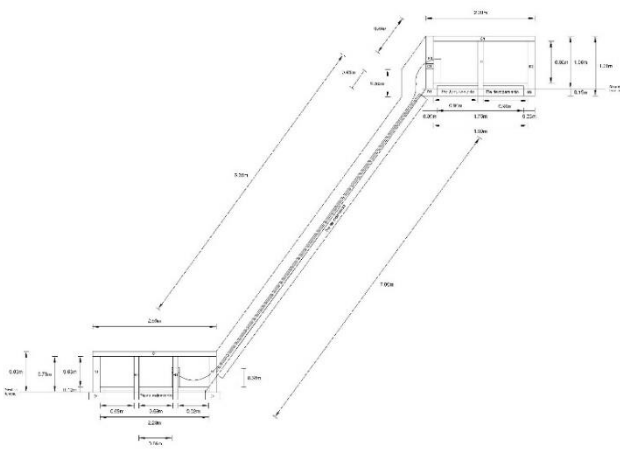


Figure 1 Schematic section of the physical model
Source: Own elaboration

It was decided to make a three-dimensional physical model, since the runoff occurs on a free surface, where the predominant force is gravity. As for the construction material, it was decided on concrete with fixed margins and initially with a fixed bottom. Likewise, within the design project, future modifications were contemplated in the configuration of the hydraulic jump and discharge.

Once the dimensions of the model, its elements and location were defined, the model was built, which can be divided into 3 stages:

1) Upper tank: Located in the highest part of the land, it includes 3 outlets with 3” pipes, which simulate intake work, diversion work and excess work. Likewise, there is a download area.

ISSN-On line: 2444-4987

2) Lower tank: Located in the lower part of the land, it includes 3 entrances with 2” pipes, here the structure that allows the hydraulic jump and the buffer tank are located.

3) Screen: allows downloading and works as an open channel, the margins are fixed.

The construction of the model can also be defined in 7 general items derived from the construction process:

1) Preliminaries: This phase comprises all the initial activities before starting the actual construction. Includes work such as plotting and leveling the land.

2) Excavations: It consists of the process of removing earth or other materials to create the necessary space where it will be built.

3) Foundations: Refers to the base or structure that is placed to transmit and distribute loads to the ground in a safe and stable manner.

4) Structures: In this phase, the main parts of the physical model are built, such as castles, dice, enclosing chains, and slabs, which provide support and stability to the construction. Different materials such as concrete and steel are used to form the structure.

5) Masonry: This stage contemplates the placement of similar blocks (masonry) for the construction of the walls.

6) Finishes: This stage implies the completion and decoration of the construction. Includes activities such as coatings and painting.

7) Hydraulic installation: It is related to the network of pipes and systems for the supply and drainage of water within the model.

These stages had to be organized sequentially, although some were carried out in parallel. Each one of them was crucial for the success of the construction and required the collaboration of different specialists and work crews.

For the construction of the physical model, the plot and leveling of the land was carried out by means of manual tools to remove the undergrowth and obstacles that prevented locating and defining the axes indicated in the project plan (Figure 2).

Figure 2 Trace and leveling of the land
Source: Own elaboration

Results

Upper tank

From a structural point of view, the upper tank is made up of three parts:

1) Bottom slab.

2) Perimeter walls.

3) Crown beam.

It also includes secondary, but no less important elements that fulfill specific functions. Among the secondary elements, the following could be mentioned: the piers and the cimacio weir, which acts as a work of excess and is built with the purpose of giving way to the volumes of water that cannot be retained in the vessel of the physical model (Figure 3).

Constructive process:

1) Outline, leveling and cleaning of the land.

2) Excavation for foundation skirting board based on 15x20x40 block and trenches for pipes.

3) Foundation skirting for piers, made of 15x20x40 hollow block filled with concrete f'c=150 kg/cm^2 with alternate reinforcement of 3/8" rods at the height of the first row of pile blocks.

4) 0.10m thick foundation slab for Upper Tank, concrete f'c=200 kg/cm^2 with reinforcing steel electro-welded mesh.

5) 15x20x40cm hollow block wall glued with a 1:6 cement-sand mixture for the Upper Tank, curtain and piers.

6) Concrete castle f'c=150 kg/cm^2 of 0.15x0.15m with armex for castle of 0.10x0.10.

7) 15x20x40cm hollow block drowned castle filled with f'c=150 kg/cm^2 concrete and 3/8" rod reinforcing steel for upper tank and buttresses.

8) Enclosure chain for piles with concrete of f'c=150 kg/cm^2 and armex reinforcing steel for half chain on ladder 0.10x0.075m

9) Chamfers in foundation slab joints based on concrete f'c=100 kg/cm^2.

10) Flattened (3 rich layers, patch, and putty) on perimeter walls and crown beam.

Figure 3 Bottom tank construction. a) Laying of electro-welded mesh, b) Construction of walls
Source: own elaboration

Lower tank

The lower tank also has a bottom slab, perimeter walls and crown beam and the structure (damping box) that allows the hydraulic jump and the pool (Figure 4).

Constructive process:

1) Outline, leveling and cleaning of the land.

2) Excavation for foundation skirting board based on 15x20x40 block and trenches for pipes.

3) Foundation skirting for piers, made of 15x20x40cm hollow block filled with concrete f'c=150 kg/cm^2 with alternate reinforcement of 3/8" rods at the height of the first row of pile blocks.

4) 0.10m thick foundation slab for the Lower Tank, concrete f'c=200 kg/cm^2 with reinforcing steel welded mesh.

5) 15x20x40cm hollow block wall glued with a 1:6 cement-sand mixture for the Lower Tank and Structure for the hydraulic jump.

6) Concrete castle f'c=150 kg/cm^2 of 0.15x0.15m with armex for castle of 0.10x0.10.

7) 15x20x40cm hollow block drowned castle filled with f'c=150 kg/cm^2 concrete and 3/8" rod reinforcing steel for upper tank and buttresses.

8) Enclosure chain for piles with concrete of f'c=150 kg/cm^2 and armex reinforcing steel for half chain on 0.10x0.075m ladder.

9) Chamfers in foundation slab joints based on concrete f'c=100 kg/cm^2.

10) Flattened (3 rich layers, patch, and putty) on perimeter walls and crown beam.

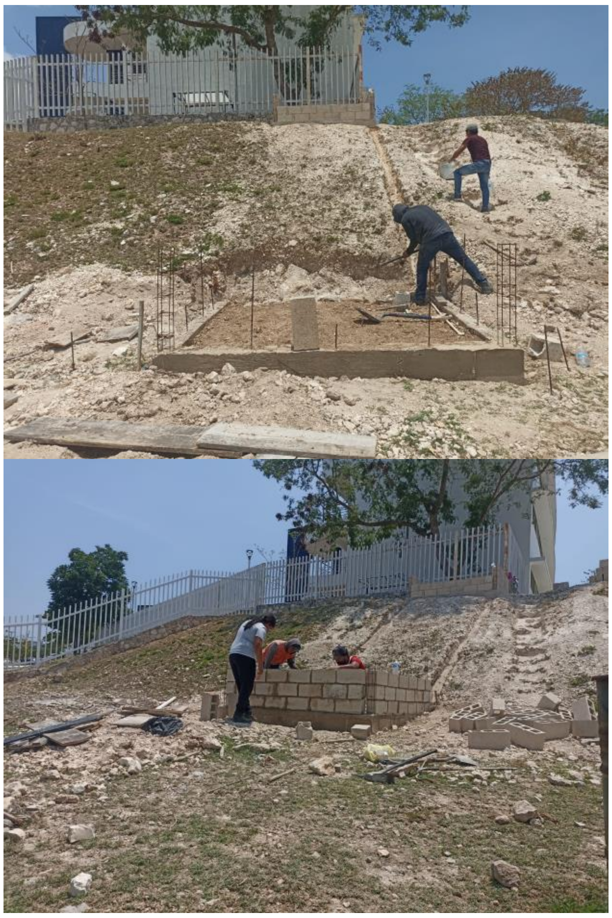


Figure 4 Bottom tank construction. a) Foundation, b) Construction of walls
Source: own elaboration

Screen:

The screen is the most important part in the physical model since this is the one that is in charge of joining the upper tank with the lower tank. The cimacio weir and the backwater box are the elements that intertwine with the screen. In addition, it works as a gravity channel (Figure 5).

Constructive process:

1) Outline, leveling and cleaning of the land.

2) Excavation for foundation skirting board based on 15x20x40 block and trenches for pipes.

3) Foundation skirting board for concrete cylinder base screen.

4) Installation of 3" pipes in the upper and lower tank outlets.

5) Filling and leveling the screen with fine and coarse aggregate to later place the electro-welded mesh.

6) Foundation slab 0.05m thick for the curtain, made of concrete f'c=100 kg/cm^2 with reinforcing steel electro-welded mesh.

7) Enclosure chain for piles of, f'c=150 kg/cm^2 and armex reinforcing steel for half chain on ladder 0.10x0.075m.

8) Elaboration of structure for hydraulic jump and cymacio.

9) Flattened (3 layers of riveting, patching and putty) on perimeter walls and crown beam.

10) Placement of intake, control, and excess works between the tanks.

11) Supply and placement of sealant and blue and white paint in the upper and lower tank and screen of the physical model.

ISSN-On line: 2444-4987

Figure 5 Screen construction. a) Laying of electro-welded mesh, b) Casting
Source: own elaboration

In Figure 6, some of the details of the constructive elements used in the physical model are presented.

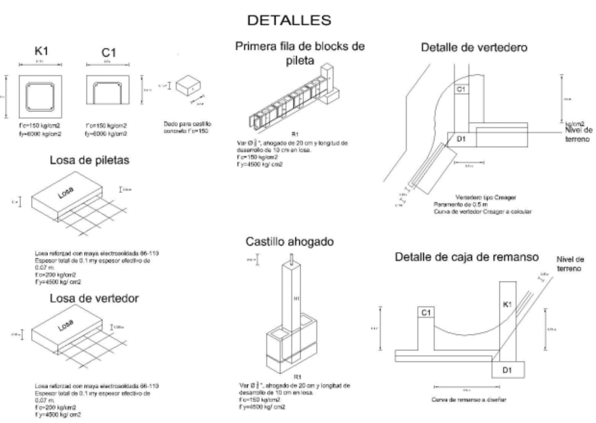


Figure 6 Constructive details
Source: Own elaboration

A three-dimensional physical model with plant dimensions of 2.85 m wide by 11.50 m long was obtained, the model has 2 storage tanks with a capacity of 3.3m^3 each that are linked through a screen (which simulates the curtain of a dam) with an effective length of 6.35 m that allows the discharge of water by means of gravity from the upper tank to the lower tank. In the upper tank, 3 3" PVC-type pipe outlets were placed, each simulating: intake work, diversion work and excess work. This pipe is connected to the lower tank, where the discharge produces a hydraulic jump and there is a damping box that reduces the speed of the flow and stores the fluid (Figure 7).

The upper tank has a Creager-type spillway, with a 0.5m facing; on the other hand, the curtain was made with a smooth finish in order to increase the discharge flow speed and the hydraulic jump to be generated; this zone is 0.62 m wide, while the buffer box is 1.53 m wide. The height in both tanks is 1.0 m, with 0.60 being the effective height. Likewise, two walls were built that simulate the buttresses, these with a rectangular section of 0.56 m high and 0.85 m long with 0.20 m thick.

Figure 7 physical model. a) Side view, b) Front view
Source: own elaboration

Thanks

The authors thank the Faculty of Engineering of the Autonomous University of Campeche for the support provided to build the physical model.

Conclusions

The model is one of the projects that will bring the greatest impact to the Hydraulics Laboratory of the Faculty of Engineering of the Autonomous University of Campeche, since it will allow the reproduction of different phenomena related to Hydrology and Hydraulics. Among the phenomena, the following stand out: a) the hydraulic behavior of the different elements that make up the structure; b) scour phenomenon at the discharge foot, c) calculation of pumps, d) Calculation of flow in pipes and open channel, among others.

Additionally, a future improvement is proposed through the installation of elements that allow the generation of electrical energy such as solar panel and wind energy; It also gives rise to new projects such as the numerical simulation of phenomena in CFD.

The construction of this model makes it possible to considerably reduce the uncertainties offered by the different mathematical formulations used to assess the physical phenomena involved in hydraulics, in addition to being a model for educational purposes that directly impacts the educational programs offered at the Faculty of Engineering from the Autonomous University of Campeche: Civil Engineer and Administration, Energy Engineer, Mechatronics Engineer, as well as a Postgraduate Degree in Engineering.

References

Barrera-Lao, F., Cruz-y Cruz, A., & Quen-Avilés, M. (2017). Diagnóstico Preventivo y Correctivo de la Infraestructura Edificada, Facultad de Ingeniería de la Universidad Autónoma de Cmpeche (Campus V) Primera Etapa, edificios B, E y F. Revista de Arquitectura y Diseño, 1(2), 41–56.

Gutiérrez Gómez, J. (2015). Pre diseño de presa de tierra en el río Piedras en la parroquia Julio Moreno, provincia de Santa Elena [Tesis para optar el grado de Ingeniero Civil]. Universidad Espíritu Santo.

Leiva Llenera, I. (2017). Tendencias actuales en el análisis de la integridad de presas de tierra. Universidad Central “Marta Abreu” de las Villas.

Ortiz Quizhpi, W., & Portilla Flores, E. (2014). Estudio de estabilidad de los taludes de las presas del proyecto Pacalori, teniendo en cuenta la acción sísmica [Tesis para optar el grado de Ingeniero Civil]. Universidad de Cuenca.

Parcero López, A. (2016). Estabilidad de taludes de presas de tierra y enrocado ante sismos y fuerzas de filtración [Tesis para optar el grado de Maestro en Ingeniería Civil - Geotecnia]. Universidad Nacional Autónoma de México

Article **Journal of Research and Development**
December 2023, Vol.9 No.24 8-14

Effect of PANi electrodeposition methods on copper substrate

Efecto del método de electrodeposición de PANi sobre sustrato de cobre

LERMA-GARCÍA, Martha Estela†, CISNEROS-SINENCIO, Luis Fortino* and PÁRAMO-GARCÍA, Ulises

Tecnológico Nacional de México, Instituto Tecnológico de Ciudad Madero, Mexico.

ID 1st Author: *Martha Estela, Lerma-García* / **ORC ID:** 0009-0003-7694-3736, **CVU CONAHCYT ID:** 1131354

ID 1st Co-author: *Luis Fortino, Cisneros-Sinencio* / **CVU CONAHCYT ID:** 102695

ID 2nd Co-author: *Ulises, Páramo-García* / **ORC ID:** 0000-0001-7682-5795, **CVU CONAHCYT ID:** 37227

DOI: 10.35429/JRD.2023.24.9.8.14 Received: July 10, 2023; Accepted: December 30, 2023

Abstract

To assess the effect of different electrochemical techniques in the synthesis of polyaniline (PANi) on copper substrates, this paper presents a comparison between cyclic voltammetry and chronoamperometry. For each technique, four synthesis processes were conducted with different potentials using a three-electrode electrochemical set-up with a neutral electrolyte (pH=7). According to the comparison, the oxidation potential sweep associated to cyclic voltammetry results in the synthesys of PANi in three different oxidation states. As synthesis by this technique results in a non-homogeneous layer conformed by different species of PANi, the characteristics of the film are difficult to determine as all three species have different electric, optic and morphologic attributes. On the other hand, selecting an appropriate oxidation potential, chronoamperometry results in the synthesis of a homogeneous layer of PANi. The use of one unique oxidation potential results in a stable process that synthetizes a homogeneous layer of pernigraniline, a stable oxidation state of PANi.

Synthesis; Substrates; Morphologic; Electrolyte; Oxidation; Electrochemical; Comparison

Resumen

Para evaluar el efecto de las diferentes técnicas electroquímicas para la síntesis de polianilina (PANi) sobre sustratos de cobre, en este trabajo se presenta una comparación entre las técnicas de voltamperometría cíclica y cronoamperometría. Para cada técnica, se realizaron cuatro procesos de síntesis con diferentes potenciales utilizando una celda electroquímica de tres electrodos con un electrolito neutro (pH=7). De acuerdo con la comparación, el barrido de potencial de oxidación asociado a la voltamperometría cíclica resulta en la síntesis de PANi en tres estados de oxidación diferentes. Al ser una capa no homogénea conformada por diferentes especies de PANi, las características de la película son difíciles de determinar debido a que las tres especies tienen diferentes atributos eléctricos, ópticos y morfológicos. Por su parte, eligiendo un potencial apropiado, la síntesis por cronoamperometría resulta en una capa homogénea de PANi; un único potencial de oxidación permite un proceso estable que sintetiza una capa homogénea de permigra-nilina, un estado de oxidación estable de la PANi.

Síntesis; Sustratos; Morfológico; Electrolito; Oxidación; Electroquímica; Comparación

Citation: LERMA-GARCÍA, Martha Estela, CISNEROS-SINENCIO, Luis Fortino and PÁRAMO-GARCÍA, Ulises. Effect of PANi electrodeposition methods on copper substrate. Journal of Research and Development. 2023. 9-24:8-14.

* Author's Correspondence (E-mail: fortino.cs@cdmadero.tecnm.mx)
† Researcher contributing as first author.

Introduction

Electrochemical synthesis of polymer films is a reliable alternative to conventional toxic corrosion inhibitors for metallic substrates (Ayalew et al., 2023; Deshpande et al., 2014; Özyilmaz et al., 2005). Coating the susceptible surface with a polymer layer, which is after enriched with chemical corrosion inhibitors, immobilizes the chemical compounds into the polymer layer minimizing their interaction with the environment (Hasanov & Bilgiç, 2009; Shabani-Nooshabadi et al., 2014; Wang et al., 2023). However, the selected process to synthetize the polymer film can tamper the benefits of this technique; it can comprise the use of hard chemicals or thermal treatments, which are harmful to the environment (Bilurbina Alter et al., 2003; Hossain et al., 2023). Synthetizing polymer-based protective layers by electrochemical process results in a sustainable effective approach to protect metals from corrosion (Zhao et al., 2023). Although several electro-chemical deposition methods for polymer coatings on conductive substrates have been reported in the literature (Aljawrneh et al., 2023; Bolaños Ch & Alvarez, 2018; Gutiérrez Pineda et al., 2016; Sebaa et al., 2013; Upreti et al., 2023), a comparison of the most common approaches is conducted in this paper: a comparison between cyclic voltammetry (CVA) and chronoamperometry (CA).

To compare both techniques, polyaniline (PANi) is synthetized on copper using a three-electrode cell with a sodium oxalate solution as electrolyte. The neutral electrolyte eliminates possible interferences due to hydrogen potential, allowing only the performance of the synthesis methods to be compared. The resulting coatings were optically characterized by bare eye inspection as well as under optic microscopy to assess homogeneity. According to the analysis, the best results were achieved under chronoamperometry using a cell potential (pE) above 1100 mV. If pE falls below this value, the aniline cannot oxidize completely in one stable specie, leading to a non-homogeneous coating. As cyclic volt-ammetry requires a repetitive sweep of pE within a selected window, the resulting coating shows different species of PANi even when the potential window was carefully selected according to the Pourbaix (pE/pH) diagrams (González Fernández, 1989; Hernández, 2012; Pedeferri, 2018).

If the oxidation potential is enough, the PANi synthetizes in all three oxidation states possible, leading to the worst results in the comparison.

Experimental details

The substrate for every case in this comparison was a copper plate with a size of 10 x 20 millimeters. To obtain these substrates, a copper sheet was sanded with a 1500 grit sandpaper to eliminate any defects on the surface. Once sanded, the copper sheet was cut into pieces of the desired size and then washed using a deionized water and degreaser mixture in a ratio of 1:1 through an ultrasonic cleaner model 8891 from Cole-Parmer. The sections were after rinsed using deionized water using the same ultrasonic cleaner and then dried by evaporation at room temperature under a bell jar to prevent any further contamination.

The electrolyte for every synthesis was a sodium oxalate (Na_2C_2O) at a concentration of 0.2 M. The solution was prepared adding 6.7 grams of sodium oxalate with a purity of 99.5% from Fagalab to a volumetric flask, adding deionized water to reach a volume of 250 milliliters. The solution was agitated manually and then mixed using an ultrasonic cleaner to assure a homogeneous result. As monomer, 0.3 milliliters of aniline with a purity of 99% (C6H5NH2 A.C.S., Fermont) were added to the cell along with 19.7 milliliters of the sodium oxalate electrolyte for a total of 20 milliliters for each synthesis.

The electrochemical cell for the synthesis processes was a 3-electrode cell. The copper substrate was the working electrode. The reference electrode was an Ag/AgCl electrode model BASMF2056 from Sigma-Aldrich. A piece of stainless steel performed as counterelectrode. The set up used in the synthesis was a potentiostat model 302 from Autolab controlled by computer. All experiments were carried out in an open cell at room temperature and conditions.

December 2023, Vol.9 No.24 8-14

Results and Discussions

The comparison between CA and CVA comprises two series of four synthesis. For the case of CVA, the experiments comprise four synthesis processes, each one consisting of 20 redox cycles performed with window potentials of: 300-900 mV, 300-1000 mV, 300-1100 mV and 300-1200 mV respectively against Ag/AgCl. The redox potentials were carefully selected according to the corresponding Pourbaix diagram. The sweep velocity for the potential was 20 mV/s. Table 1 shows the parameters used for the four synthesis using CVA.

Experiment	Reduction Potential vs Ag/AgCl	Oxidation Potential vs Ag/AgCl	Cycles	Voltage Sweep Rate
CVA-A	300 mV	900 mV	20	20 mV/s
CVA-B	300 mV	1000 mV	20	20 mV/s
CVA-C	300 mV	1100 mV	20	20 mV/s
CVA-D	300 mV	1200 mV	20	20 mV/s

Table 1 Parameters for the synthesis of PANi using Cyclyc Voltammetry.

Experiment	Fixed Potential vs Ag/AgCl	Time	Sampling interval
CA-A	900 mV	300 s	0.5 s
CA-B	1000 mV	300 s	0.5 s
CA-C	1100 mV	300 s	0.5 s
CA-D	1200 mV	300 s	0.5 s

Table 2 Parameters for the synthesis of PANi using Chronoamperometry.

The experiments to assess CA comprise four synthesis processes at a fixed potential of 900 mV, 1000 mV, 1100 mV and 1200 mV respectively against Ag/AgCl, for a period of time of 300 seconds. Table 2 shows the parameters used for the synthesis using Chronoamperometry.

Synthesis diagrams

The electrodeposition of PANi was first carried out through CVA. Figure 1 shows the volt-ammogram of the 10th cycle for all the cases. The voltammogram shows in detail the electro-chemical response of the system, providing information about the different processes involved in the synthesis.

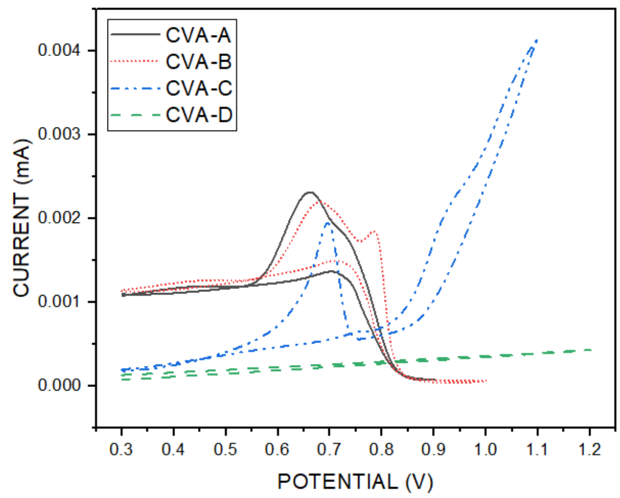


Figure 1 Cyclic voltammogram of the 10th cycle for all four cases

In all cyclic voltammograms, an initial anodic region is observed as the potential increases from 0.3 V. This region is related to the oxidation of aniline and the formation of cationic radicals, which are essential precursors for the polymerization and formation of the PANi film. As the potential increases, the current also increases, indicating a greater number of electroactive species present in the solution. When pE increases to higher regions, a change in the direction of the current occur indicating the beginning of the cathodic region. In this region, the previously generated cationic radicals reduces, building the polymeric structure on the copper substrate.

For CVA-A, current reverses from 650 mV to 900 mV, stablishing the cathodic region. Unfortunately, the potential window is too narrow, leading to the redox process to occur prior to the oxidation potential of another PANi species. Because of this, PANi can only synthetize as leucoemeraldine. Same situation occur for the case of CVA-B. The increment in pE only shifts the cathodic region between 675 mV and 1000 mV. This oxidation potential is enough to oxidize pernigraniline, however, the time the cell stays at that specific potential is not enough for pernigraniline to synthetize. As result, pernigraniline started to synthetize, but its growth rate is neglibible compared to leucoemeraldine.

ISSN-On line: 2444-4987

Article Journal of Research and Development
December 2023, Vol.9 No.24 8-14

For CVA-C, signals shows an initial anodic region related to the oxidation of the monomer. When pE rises above 1000 mV, signal reveals a significant formation of oxidative species of aniline, such as emeraldine and pernigraniline. These cell conditions persists enough time to allow the synthesis of these electroactive species on the substrate.

For CVA-D, it should be noted that there are no characteristic signals for PANi. The cell's performance due to the redox conditions causes aniline to be completely synthesized much before the tenth cycle. To validate this assumption, Figure 2 shows the voltammogram for the whole 20 cycles for CVA-D. The fist cycle shows a cathodic peak at about 725 mV, which correspond to the oxidation of aniline. After this peak, a decrement in current indicates a reduction of the radicals previously generated. At 0.8 V, the current increases again until pE reaches 1200 mV, indicating the continuation of oxidative events that results in the formation of electroactive species.

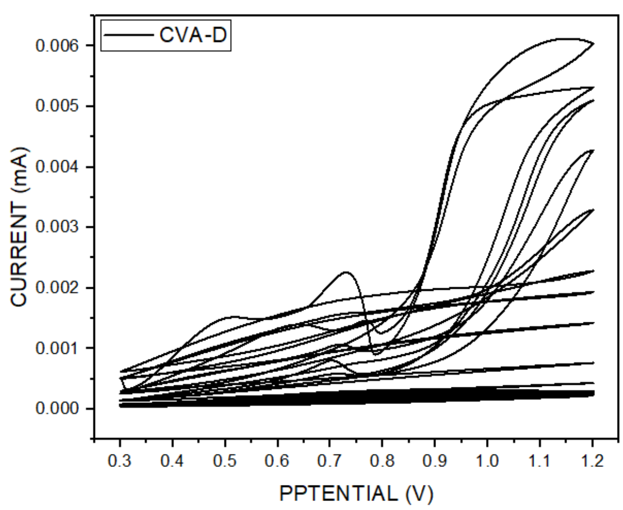


Figure 2 Cyclic voltammogram for CVA-D

For the synthesis of PANi through CA, Figure 3 shows the chronoamperograms for the four cases described in Table 2.

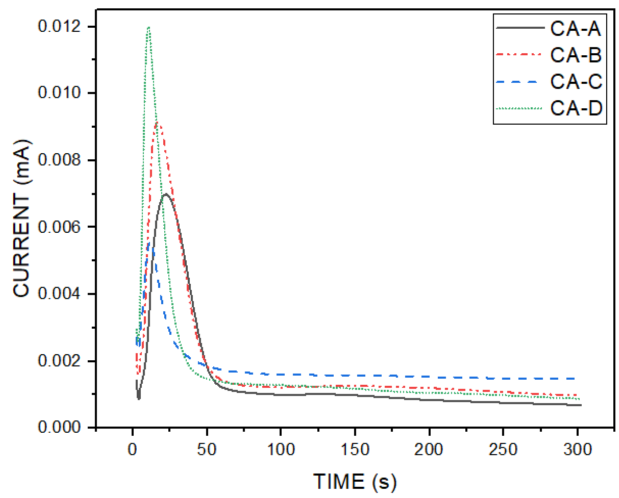


Figure 3 Chronoamperogram from the synthesis of PANi for all cases

Chronoamperograms describes the reaction rate and polymer formation over time at a fixed potential. For all cases, an initial current indicates aniline oxidation and cationic radical formation, which are the essential precursors for the synthesis. As time progresses, this current gradually decreases as the formation of cationic radicals diminishes, indicating the end of the synthesis. Graphs in the comparison shows a higher current for CA-D, suggesting a more efficient and faster generation of cationic radicals. As expected, efficiency and velocity decreases as pE decreases.

Surface Analysis

To compare the results obtained by both techniques, CVA and CA, all the coatings were optically analyzed. Initially, samples were bare eye visually inspected, also, were inspected under an optic microscope at 4X.

Table 3 shows the results for the case of cyclic voltammetry. As shown for CVA-A, the coating have large portions of the substrate uncovered. This lack of coverage is due to the redox potential is not enough to oxidize the monomer into a homogeneous film. When the oxidation potential increases to 1000 mV (CVA-B) coverage improves, but not enough to synthetize a homogeneous film; even when all the substrate is covered, film is thin enough to expose the substrate. According to the microscopy images, CVA-A and CVA-B films synthetizes as leucoemeraldine.

ISSN-On line: 2444-4987

Increasing the oxidation potential to 1100 mV (CVA-C) improve coverage and coating thickness. However, the PANi film synthetizes into different oxidation states. From the corresponding microscopy images, can be identified: white portions corresponding to leucoemeraldine; few green portions corresponding to emeraldine and large blackish areas corresponding to pernigraniline. The non-homogeneity of the film entails penicius consecuences. As known, every oxidation state has very different morphological, structural, electric, optic characteristics, therefore, the resulting film will have undeterminated characteristics even if it were possible to quantify how much of the film correspond to each oxidation state.

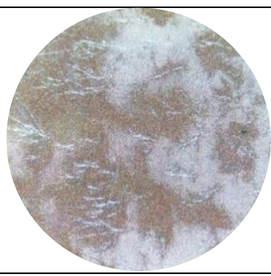
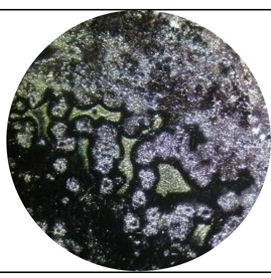
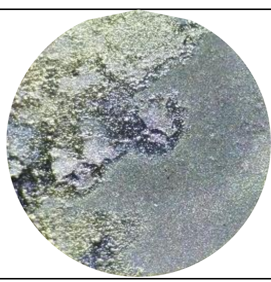
Visual Inspection	Optic Microscopy
CVA-A	
	
CVA-B	
	
CVA-C	
	
CVA-D	
	

Table 3 Analysis of the PANi coatings synthetized by cyclic voltammetry.

The homogeneity of the film seems to improve as pE increases to 1200 mV (CVS-D). Through bare eye inspection, the substrate seems fully covered by a blackish film corresponding to pernigraniline. However, by microscopy, all the three oxidation states of PANi were identified.

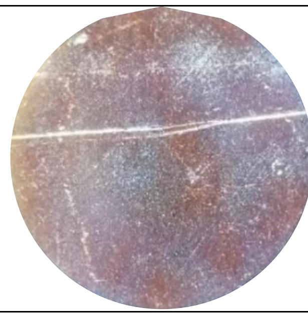
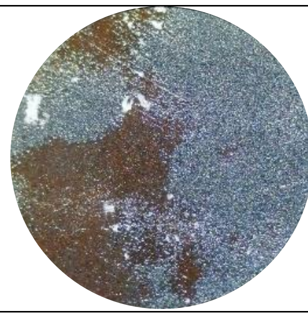
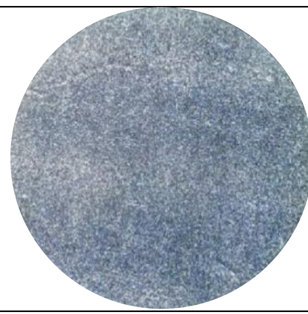
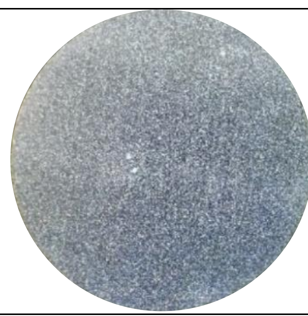
Visual Inspection	Optic Microscopy
CA-A	
	
CA-B	
	
CA-C	
	
CA-D	
	

Table 4 Analysis of the PANi coatings synthetized by chronoamperometry

Table 4 shows the results corresponding to CA under the conditions described before. For the case of CA-A the coverage seems enough to cover the whole substrate, but the resulting film is as thin that the substrate remains visible. As in CVA-A, the oxidation potential is not enough to properly oxidize the monomer into a thicker film. As the oxidation potential increases to 1000 mV, the thickness of the film increases. CA-B seems to synthetize a thick homogeneous pernigraniline coating. However, under closer inspection, even when the microscopy images confirm the presence of only pernigraniline, it can be identified sections were permigraniline was synthetized as salt, the protonated form of pernigrailine (Ji et al., 2020), while other sections were synthetized as base, the ladder form of PANi (Macdiarmid et al., 1991). These forms of pernigraniline differ specially in their optic properties, as appreciated in the visual inspection of coating CA-B in Table 4.

The last two cases show a homogeneous coating where the substrate is completely covered with a thick coat of pernigrinaline in its base form. Having only one species of PANi assures the film to have known properties useful for the user purposes.

Acknowledgements

This work has been funded by TECNM [17936.23-P]; CONAHCYT [804011].

Conclusions

In this work, PANi was synthetized on a copper substrate using two different electrochemical methods: Cyclic Voltammetry and Chronoamperometry. By setting an apropriate oxidation potential (above 1100 mV), the result is a thick film of PANi that entirely covers the substrate. However, the potential sweep inherent to cyclic voltammetry results in different species to be synthetized in the process. Using one stable sufficient potential (above 1100 mV) as done with chronoamperometry, results in a homogeneous film where only one species of PANi is synthetized.

References

Aljawrneh, B., Albiss, B. A., Abdel Rahman, M., & Ocak, Y. S. (2023). Electro-deposited halloysite nanotube/polyaniline nanocomposites for energy storage applications. *International Journal of Thermofluids*, *20*. https://doi.org/10.1016/j.ijft.2023.100469

Ayalew, A. A., Ha, X., & Sakairi, M. (2023). A critical review of additive material manufacturing through electrochemical deposition techniques. *Additive Manufacturing*, *77*, 103796. https://doi.org/https://doi.org/10.1016/j.addma.2023.103796

Bilurbina Alter, L., Lies Mestres, F., & Iribarren Laco José. (2003). *Corrosión y protección* (UPC, Vol. 150).

Bolaños Ch, L., & Alvarez, L. X. (2018). Polímeros conductores: aplicaciones en celdas fotovoltáicas y dispositivos electrónicos. *Ciencia y Tecnología*, *34*(1), 18–38. https://revistas.ucr.ac.cr/index.php/cienciaytecnologia/article/view/36405

Deshpande, P. P., Jadhav, N. G., Gelling, V. J., & Sazou, D. (2014). Conducting polymers for corrosion protection: A review. *Journal of Coatings Technology and Research*, *11*(4), 473–494. https://doi.org/10.1007/s11998-014-9586-7

González Fernández, J. A. (1989). *Control de la corrosión. Estudio y medida por técnicas electroquímicas* (CSIC-CSIC Press, Vol. 3).

Gutiérrez Pineda, E. A., Rodríguez Presa, M. J., Amalvy, J. I., & Gervasi, C. A. (2016). Síntesis y caracterización de un sistema electroestimulado. *Investigación Joven*, *3*(1). https://revistas.unlp.edu.ar/InvJov/article/view/2783

Hasanov, R., & Bilgiç, S. (2009). Monolayer and bilayer conducting polymer coatings for corrosion protection of steel in 1 M H2SO4 solution. *Progress in Organic Coatings*, *64*(4), 435–445. https://doi.org/10.1016/j.porgcoat.2008.08.004

Hernández, J. (2012). Diagramas de Pourbaix: herramienta termodinámica aplicada a los problemas de corrosión. *Revista Digital de Investigación y Postgrado*, *2*(4), 297–306. http://redip.bqto.unexpo.edu.ve7393.http://redip.bqto.unexpo.edu.ve.

Hossain, S. S., Rahman, A. F. A., Arsad, A., Basu, A., Pang, A. L., Harun, Z., Alwi, M. M. A., & Ali, S. S. (2023). Effect of Ultrasonication Parameters on the Structural, Morphological, and Electrical Properties of Polypyrrole Nanoparticles and Optimization by Response Surface Methodology. *Polymers*, *15*(6). https://doi.org/10.3390/polym15061528

Ji, X., Leng, M., Xie, H., Wang, C., Dunbar, K. R., Zou, Y., & Fang, L. (2020). Extraordinary electrochemical stability and extended polaron delocalization of ladder-type polyaniline-analogous polymers. *Chemical Science*, *11*(47), 12737–12745. https://doi.org/10.1039/d0sc03348k

Macdiarmid, A. G., Manohar, S. K., Masters, J. G., Sun, Y., Weiss, H., & Epstein, A. J. (1991). Polyaniline: synthesis and properties of pernigraniline base. *Synthetic Metals*, *41*(1–2), 621–626. https://doi.org/https://doi.org/10.1016/0379-6779(91)91145-Z

Özyilmaz, A. T., Tüken, T., Yazici, B., & Erbil, M. (2005). The electrochemical synthesis and corrosion performance of polyaniline on copper. *Progress in Organic Coatings*, *52*(2), 92–97. https://doi.org/10.1016/j.porgcoat.2004.09.003

Pedeferri, P. (2018). Pourbaix Diagrams. In *Engineering Materials* (pp. 57–72). Springer Science and Business Media B.V. https://doi.org/10.1007/978-3-319-97625-9_4

Sebaa, M. A., Dhillon, S., & Liu, H. (2013). Electrochemical deposition and evaluation of electrically conductive polymer coating on biodegradable magnesium implants for neural applications. *Journal of Materials Science: Materials in Medicine*, *24*(2), 307–316. https://doi.org/10.1007/s10856-012-4796-y

Shabani-Nooshabadi, M., Mollahoseiny, M., & Jafari, Y. (2014). Electropolymerized coatings of polyaniline on copper by using the galvanostatic method and their corrosion protection performance in HCl medium. *Surface and Interface Analysis*, *46*(7), 472–479. https://doi.org/10.1002/sia.5539

Upreti, B. B., Kamboj, N., & Dey, R. S. (2023). Laser-irradiated carbonized polyaniline-N-doped graphene heterostructure improves the cyclability of on-chip microsupercapacitor. *Nanoscala*, *15*(37), 15268–15278. https://doi.org/https://doi.org/10.1039/D3NR02862C

Wang, X., Liu, S., Yan, J., Zhang, J., Zhang, Q., & Yan, Y. (2023). Recent Progress of Polymeric Corrosion Inhibitor: Structure and Application. In *Materials* (Vol. 16, Issue 8). MDPI. https://doi.org/10.3390/ma16082954

Zhao, J., Zhao, L., Chen, X., Ye, M., & Guo, W. (2023). Highly Stable CuS Nanotrough-Networks Constructed on Arbitrate Substrate for Flexible Supercapacitor. *Advanced Engineering Materials*, *25*(17), 2300454. https://doi.org/https://doi.org/10.1002/adem.202300454

Article **Journal of Research and Development**
December 2023, Vol.9 No.24 15-23

Use FACTS elements to improve energy exchange between countries in response to the high penetration of variable renewable energy

Usar los elementos FACTS para mejorar el intercambio energético entre países como respuesta a la alta penetración de energía renovable variable

BARESKH-ONJI, Aboud†*

Istitulto Politécnico Nacional, Escuela Superior de Comercio y Administración Sto.Tomás, Ciudad de México, México.

ID 1er Autor: *Aboud, Barsekh-Onji* / **ORC ID:** 0009-0004-5440-8092, **CVU CONAHCYT ID:** 944116

DOI: 10.35429/JRD.2023.24.9.15.23 Received: July 10, 2023; Accepted: December 30, 2023

Abstract

Integrating Variable Renewable Energy sources (VRE) into Electric Power System (EPS) requires optimizing the synergy between VRE characteristics, PES flexibility elements, and local Electric Market operations. However, during advanced integration phases, where VRE accounts for a significant portion of the system's energy, and in the face of stability issues caused by energy excess, cross-border energy exchange appears to be one of the most effective solutions for Energy Management. In this investigation, to highlight the role of Flexible Alternative Current Transmission Systems (FACTS) elements to ensure the required flexibility in these energy exchange operations, a modeling strategy Methodology was implemented in MATLAB and SIMULINK to design a Static Var Compensator (SVC) and simulate its connection to a high-voltage power line between Turkey and Syria, observing its response these changes in load flow. This investigation contributes to the VRE integration strategy, identifying FACTS elements as a solution to manage excess energy and achieve efficient energy exchange.

Integration, Flexibility, Renewable energy resources

Resumen

La integración de las fuentes de Energía Renovable Variable (ERV) a los Sistemas Eléctricos de Potencia (SEP) requiere optimizar la interacción entre las propiedades de estas fuentes, los factores de flexibilidad del SEP y la operación del Mercado Eléctrico local. Sin embargo, para las fases avanzadas de integración donde la ERV forma gran parte de la energía en el sistema, y ante los problemas de estabilidad causados por excedentes de energía, el intercambio energético entre los países es una de las mejores soluciones para administrar la energía en tiempo real. En esta investigación, y para destacar el rol de los elementos FACTS (Sistemas Flexibles de Transmisión de Corriente Alterna) en garantizar la flexibilidad requerida al realizar estas operaciones de intercambio energético, se ejecutó una estrategia metodológica de modelaje en MATLAB y SIMULINK para diseñar un compensador estático de energía reactiva (SVC), y simular su conexión a una línea de alta tensión entre Turquía y Siria con la finalidad de observar su respuesta ante los cambios de flujo de energía. Esta investigación contribuye a las estrategias de integración de ERV, identificando a los elementos FACTS como una solución en la administración de los excesos de energía, logrando un eficiente intercambio energético.

Integración, Flexibilidad, Fuentes de energía renovable

Citation: BARESKH-ONJI, Aboud. Use FACTS elements to improve energy exchange between countries in response to the high penetration of variable renewable energy. Journal of Research and Development. 2023. 9-24:15-23.

* Author's Correspondence (E-mail: abarsekho2300@alumno.ipn.mx)
† Researcher contributing as first author.

Introduction

The integration of Variable Renewable Energy sources (VRE) into Electric Power Systems (EPS) has been an important research topic in recent years, aiming to integrate new technologies, specifically photovoltaic panels, and wind generators, into existing power systems. This effort also seeks to expand opportunities for extensive private sector participation in the electricity market. However, the integration strategy includes all the technical, administrative, financial, and market design changes required to enable the substantial incorporation of VRE, safely and profitably, into a country's PES.

The physical nature of electricity and the principles of electric power system stability require real-time balancing between generation and demand, underscoring the importance of adhering to the technical and operational constraints of the EPS.

In addition, it should be noted that the ease or difficulty of VRE integration into EPS depends on other factors. It is easier to integrate VRE into systems where energy demand and VRE production are positively correlated, both in normal day-to-day patterns, and where power system flexibility is crucial to facilitate VRE adoption (International Energy Agency, 2022).

In fact, to establish a strategic model for the integration of VRE, specific characteristics of the EPS assume a pivotal role in addressing this challenge. These characteristics are summarized in Table 1.

General structure and technical factors	- Geographic location of VRE sources and their main characteristics. - The demand forecast. - The correlation between demand and reproducible energy from ERV sources - The flexibility of the plants that make up the electric power system. - Interconnection, storage capacity and demand response.
Operation system, market design and regulation	- Operational decisions, and their proximity to real-time execution, for the plants that make up the electric power system and its interconnection. - The type of market design according to demand, whether long or short term. - The Network Code and the current regulation regarding the issue of VRE sources.
Fundamentals of production and demand	- The evolution of energy demand, where the growth in demand could be a reason to demand an urgent integration model for VRE sources.

Table 1 Principal characteristics of Electric Power System
Source: Own elaboration

Consequently, based on the data and experiences of several countries regarding the challenge of integrating Variable Renewable Energy (VRE), the International Energy Agency (IEA) has defined distinct phases towards achieving full integration of these sources. These phases (Table 2) were established based on the percentage of VRE penetration compared to the percentage of energy produced by the EPS in accordance with demand. (International Energy Agency, 2018).

Phase 1	The VRE sources do not have an impact on the EPS.
Phase 2	The VRE sources have a minor to moderate impact on the EPS
Phase 3	The VRE sources dictate the operational pattern of the EPS
Phase 4	The VRE sources generate most of the energy circulating in the EPS
Phase 5	The VRE sources produce surplus amounts of energy for days to weeks
Phase 6	The VRE sources produce surplus amounts of energy seasonally

Table 2 Phases off integration of VRE into EPS
Source: Own elaboration based on IEA

For years, research in the technical aspects of an integration model has focused on various areas of interest, beginning with diverse models for demand forecasting, including econometric models, regression models, or neural networks (Sambaiah & Jayabarathi, 2019), on the other hand, some researchers detailed the planning of energy storage systems to integrate high proportions of VRE (Auguarda et al., 2023).

Also, several studies can be found addressing the optimization of the location and size of VRE (Gözel & Hocaoglu, 2009) and (Ghosh et al., 2010), while other investigators have sought to optimize the aforementioned factors based on the reduction of energy losses (Gil-González et al., 2021).

Moreover, the authors of (Wang & Nehrir, 2004) employed analytical expressions based on active and reactive loads to reduce energy losses and optimize the location of VRE sources.

Similarly, the reconfiguration of electric networks has been an extensively researched topic, aimed at modifying the operating conditions of the EPS to accommodate VRE sources in a Distributed Generation (DG) system (Koutsoukis et al., 2017).

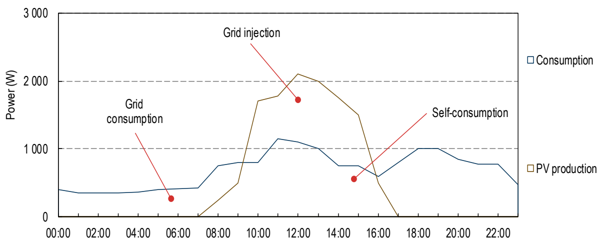


Figure 1 Excess solar PV production compared to demand
Source: IEA, 2018

Another critical point is that the production of VRE has different levels of uncertainty at different times and at different ranks within the EPS. This implies that as VRE gains a larger share in the electrical system and converts pertinent for decision-making regarding its disposition (Figure 1), whether through reserves or energy exchange.

Such as one of the most prominent examples of using interconnection to achieve efficient energy exchange during surplus hours from VRE sources was the interconnection project among the Southeast Asian countries (ASEAN) (International Energy Agency, 2019)

In response to various EPS stability challenges, the utilization of Flexible Alternative Current Transmission Systems (FACTS) has emerged. These FACTS systems, based on power electronics (Schulze et al., n.d.), enhance the controllability and stability of the electrical system, increasing its capacity to transmit energy by flexibly modulating the injected or absorbed reactive power at a specific network node (International Energy Agency, 2021).

Due to the distinctive behavior of high-voltage lines concerning voltage stability (Oliveira Da et al., n.d.) achieving control over their operation during energy exchange require a high level of real-time flexibility to ensure the stability of the Power Electric System.

Above all, this research adds significant value to the integration strategies of Variable Renewable Energy sources into EPS, highlighting the role of FACTS elements in reconfiguring the electrical grid in response to changes generated by surplus electrical energy from VRE sources, including the control of energy exchange lines between countries.

In the case of electrical systems with a high penetration percentage of VRE, the injection of excess energy can lead to voltage increases at certain nodes and result in an excess of energy that must be managed to avoid affecting the stability factors of the electrical grid.

The hypothesis of this investigation is the improvement of the stability of an interconnected Electric Power System when faced with a high level of penetration of VRE sources.

The main objective of the research is to emphasize the effect of FACTS elements in improving the flexibility of an interconnected electrical network with high ERV penetration.

The specific objectives of the research are:

- Determine the optimal locations and quantities of SVCs in the Syrian electrical grid to address excess VRE penetration, considering an energy exchange line with Turkey.

- Design a Static Var Compensator (SVC) and construct a simulation of its connection to a high-voltage line between Turkey and Syria to observe its response to changes in energy flow.

Methodology to be developed

In this paper, a program design based on the Newton-Raphson method was developed for the calculation of nonlinear differential equations representing a PES (Eltamaly et al., 2018). Additionally, the optimal placement of compensators was determined using the mathematical sensitivity theory method (Contreras Aguilar, 2005).

The Power Electric System operation is described by the following equations:

$$P_k = |V_k|.\sum_{j=1\ \&\ j\neq k}^{j=n} |Y_{kj}|.|V_j|.\cos(-\theta_{kj} - \delta_j + \delta_k) + |V_k|^2.|Y_{kk}|.\cos(\theta_{kk}) \quad (1)$$

$$Q_k = |V_k|.\sum_{j=1\ \&\ j\neq k}^{j=n} |Y_{kj}|.|V_j|.\text{sen}(-\theta_{kj} - \delta_j + \delta_k) - |V_k|^2.|Y_{kk}|.\text{sen}(\theta_{kk}) \quad (2)$$

Where: P_k is the stability equation for the active power at the node (k), Q_k is the stability equation for the reactive power at the node (k), V_j, δ_j is the length and angle of voltage at node (j), Y_{kj} , θ_{kj} is the length and angle of the admittance of the line between nodes (k) and (j). In this case, two conditions were established for the execution of the Newton-Raphson method:

- Voltage condition:

$$|V_i| = |V_i|_{spec} \quad (3)$$

Where: $|V_i|_{spec}$ is the length of voltage that a node, with reactive power controller, can achieve within its allowed limits.

- Reactive energy condition:

$$Q_i^{min} \leq Q_i \leq Q_i^{max} \quad (4)$$

Where: Q_i is the reactive energy generated in the control node, with its minimum limits (Q_i^{min}) and maximum limits (Q_i^{max}).

The method (Figure 2) was applied to the 230KV electrical grid of the Republic of Syria, consisting of 51 nodes (Alwazah et al., n.d.; Hamzeh, 2004), under the following two scenarios:

- First: without applying any reactive power compensation and considering the massive generation of renewable energy.

- Second: with the application of three points of compensation using SVC at three locations closer to the interconnection lines with Turkey. The results are presented in Graphic (1)

The system allocates the quantities in table 3 of reactive power to be generated at the three nodes.

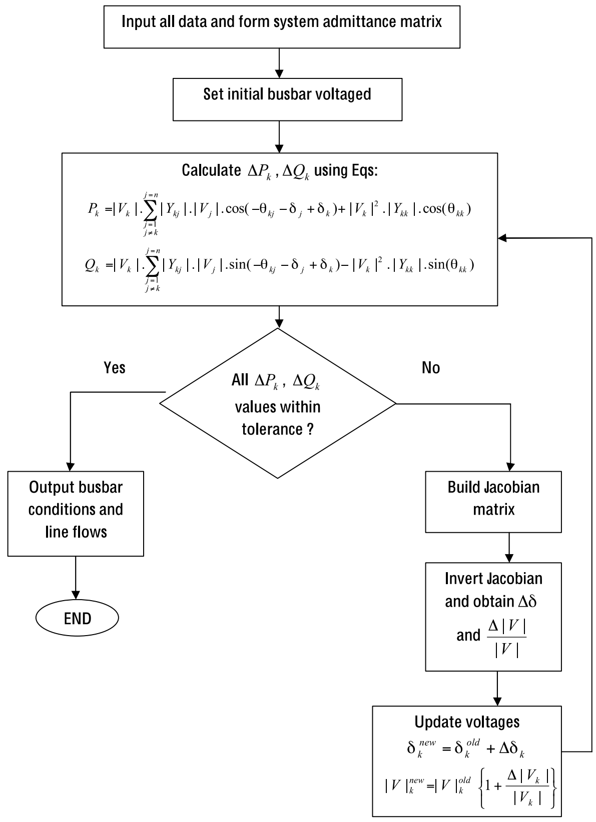
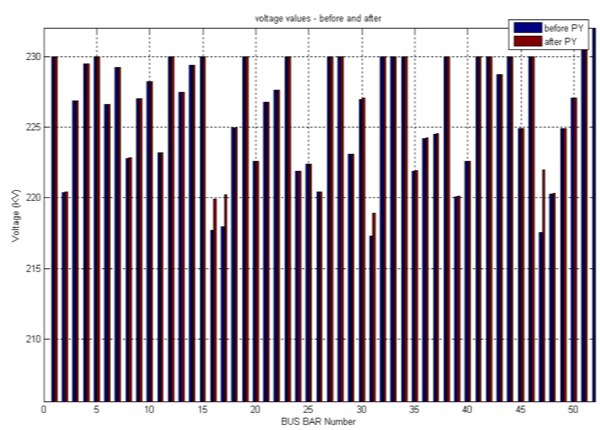


Figure 2 Newton-Raphson method applied in this investigation
Source: (Eltamaly et al., 2018)



Graphic 1 Node voltages before and after compensating for reactive power in the nodes of the Syrian 230KV power grid.
Source: Own elaboration based on results of the applied method

PY number	Node number	Q (Mvar)	Qmin (Mvar)	Qmax (Mvar)
1	16	40	-100	200
2	47	20	-100	200
3	48	160	-100	200

Table 3 Reactive power results
Source: Own elaboration based on results of the applied method

Based on the initial results, the design of the Static Var Compensator (SVC) with voltage controller, as depicted in Figure 3, and the equivalent circuit is shown in Figure 4 was undertaken, following the subsequent equations:

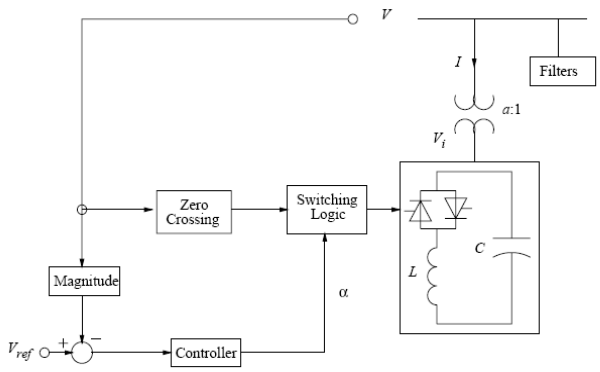


Figure 3 SVC with voltage controller
Source: (Schulze et al., n.d.)

Calculation of thyristor firing angles:

$$B_{SVC}(\alpha) = B_{TSC}(\alpha) - B_{TCR}(\alpha)\frac{X_L - \frac{X_c}{\pi}(sen(2\alpha)-(2\pi-2\alpha))}{X_c X_L} \quad (5)$$

Where:

$$X_{TCR}(\alpha) = \frac{\pi X_L}{sen(2\alpha)+(2\pi-2\alpha)} \quad (6)$$

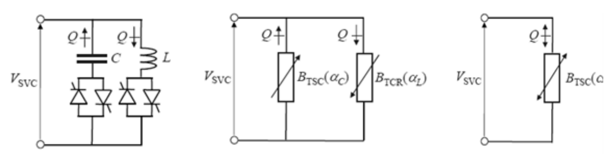


Figure 4 Equivalent Circuit of SVC with voltage controller
Source: (Schulze et al., n.d.)

Therefore, the reactive power generated by the SVC as a function of angle (α) is given in equation (7).

$$Q_{SVC}(\alpha) = -U_k^2 B_{SVC}(\alpha) = -U_k^2 \frac{X_L - \frac{X_c}{\pi}(sen(2\alpha)-(2\pi-2\alpha))}{X_c X_L} \quad (7)$$

Thus, the SVC was designed with the following reactive power values in accordance with the network requirements, considering that it will be supplied by a 300MVA, 230/66KV transformer with a reactance (XT) of 15% and a maximum voltage drop of 0.01 per unit (p.u.) for every 100VA.

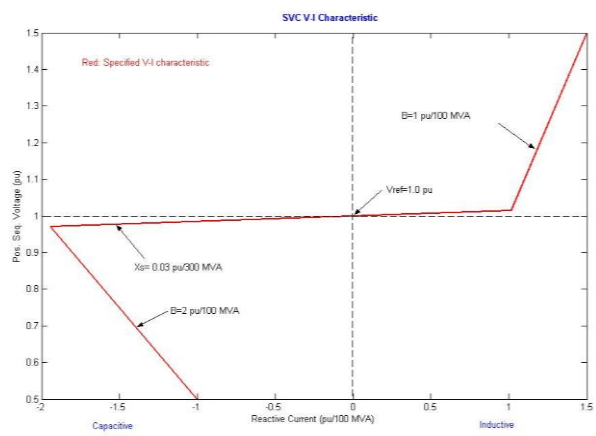
$$Q_{TSC} = 3 \times 94\ Mvar \quad (8)$$

$$Q_{TCR} = 109\ Mvar \quad (9)$$

The SVC elements calculation was supported out for the nominal voltage (230KV), maximum voltage (232.3KV), and minimum voltage (223.1KV), resulting in the technical specifications of the designed SVC (Table 4). The technical data sheet is shown in Table 5 and its V-I Characteristic in Graphic 2.

$X_{L-rated}$	$X_{Transformer}$	X_{L-TCR}
39.96 Ω	2.178 Ω	37.78 Ω
L_{TCR}	$X_{C-rated}$	C
0.36 Henri	15.44 Ω	20.606mF

Table 4 Technical specifications of the designed SVC
Source: Own elaboration based on results of the applied method

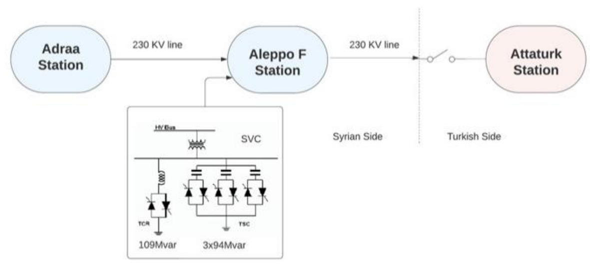


Graphic 2 SVC V-I Characteristics
Source: SVC Model output

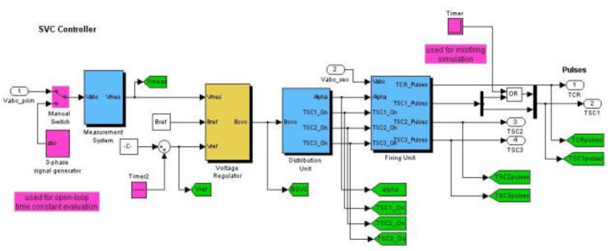
Application	230KV
Voltage Level	10KV
Type	SVC (TCR/3 & TSC)
TCR capacity	109Mvar
TSC capacity	3 x 94Mvar
Valves structure	Open
Cooling Method	Fully closed pure water cooling
Control System	Full digital
Response Time	9 msec max
Regulation range	-100% to +100%

Table 5 SVC Data sheets
Source: Own elaboration based on results of the applied method

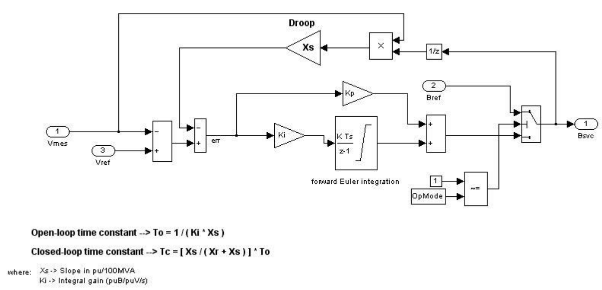
Based on the design results, a model was prepared in MATLAB SIMULINK 2022 for the installation of the SVC at the 'Aleppo F' station, where the 230KV interconnection line with Turkey originates (Graphic 3). The SVC control blocks are seen in Graphic 4, and the voltage controller in Graphic 5, with the pulse outputs assigned to each of the compensator elements. The model examined voltage variations in various scenarios at three key nodes: Aleppo F, Adraa, and Atatruck.



Graphic 3 Model connection diagram
Source: Own elaboration



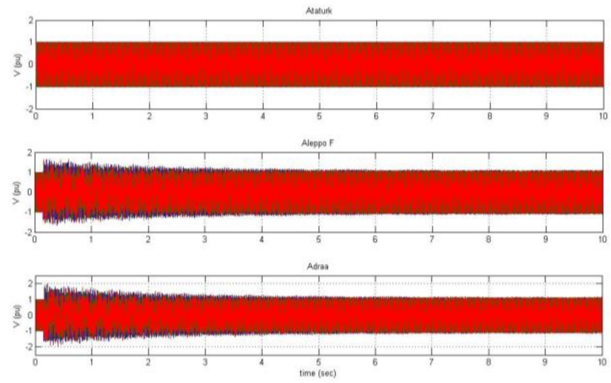
Graphic 4 SVC Controller
Source: Own elaboration on MATLAB-SIMULINK



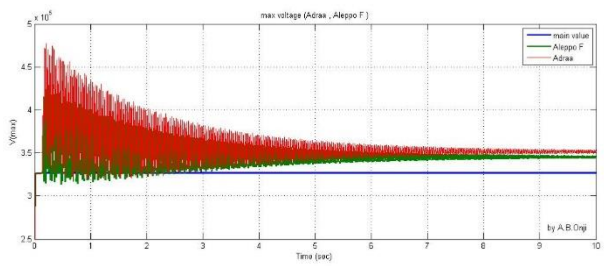
Graphic 5 SVC Voltage regulator.
Source: Own elaboration on MATLAB-SIMULINK

Results

Initially, the model of the electrical grid without activating the SVC and under normal operation was applied. To study the improvement afforded by the SVC, a drastic scenario was analyzed in which, at time 0.15 of the simulation, the line on the 'Atatürk' node side was opened, causing a voltage increase (Graphic 6) at the Aleppo F node (1.65 per unit) and the Adraa node (1.71 per unit). Furthermore, high voltage values applied to the isolating elements in both nodes were detected in this case compared to the main value (Graphic 7).

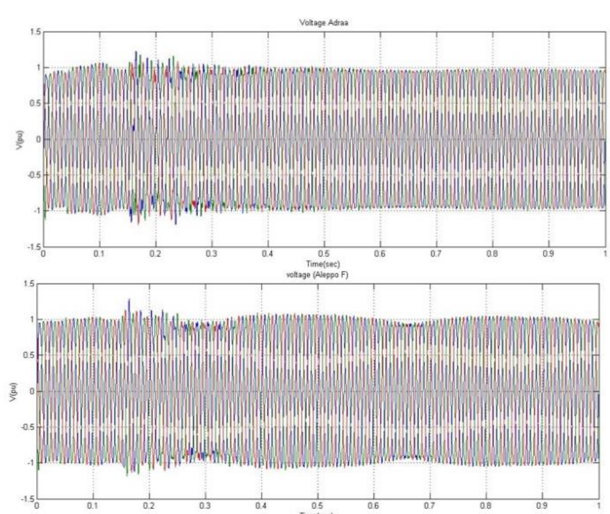


Graphic 6 Voltage variation in nodes: “Aleppo F”, “Adraa” and “Ataturk”, without SVC
Source: SVC Model output



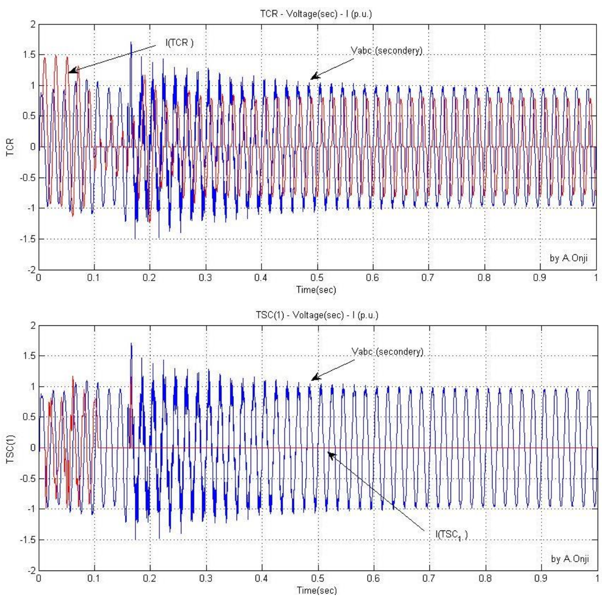
Graphic 7 High voltage values applied to the isolating elements in both nodes compared to the main value
Source: SVC Model output

In the second simulation, the SVC installed at the 'Aleppo F' node is activated, and the same procedure as before is repeated. Up on observing the results, it can be appreciated that the SVC control system operated correctly through absorbing the reactive power generated by the open line (Graphic 8), thus maintaining voltage stability at the nodes very close to nominal values. Additionally, Graphic 9 depicts the response of the currents from the TSC and TCR in comparison to the applied voltage variation.



Graphic 8 Voltage variation in nodes: “Aleppo F”, “Adraa” and “Ataturk”, with SVC
Source: SVC Model output

ISSN-On line: 2444-4987



Graphic 9 High voltage values applied to the isolating elements in both nodes compared to the main value.
Source: SVC Model output

The above results demonstrate the rapid response of FACTS elements to momentary changes in energy injected at nodes in an Electric Power System by VRE sources, even in addressing specific scenarios such as the operation in open-circuit conditions for a high-voltage line.

Financing

This work has been funded by the author.

Annexes

I. 230KV grid nodes Data

Node	Un	Q_load	P_load	O_gen.	P_gen.	Θ	V
1	230	0	0	0	0	0	230
2	230	101.4405	169.0674	0	0	0	0
3	230	67.62698	200	0	0	0	0
4	230	67.91847	113.1975	0	0	0	0
5	230	0	0	0	0	0	230
6	230	51.303	85.505	0	0	0	0
7	230	29.149	48.582	0	0	0	0
8	230	96.19355	160.3226	0	0	0	0
9	230	90.94663	151.5777	0	0	0	0
10	230	68.209	113.683	0	0	0	0
11	230	69.667	116.1124	0	0	0	0
12	230	20.75944	34.59	408.54	660	0	230
13	230	0	0	0	0	0	0
14	230	37.31144	62.18573	0	0	0	0
15	230	23.028	38.38	92.85	150	0	230
16	230	85.11672	141.8623	0	0	0	0
17	230	0	0	0	0	0	0
18	230	100.2745	167.1241	0	0	0	0
19	230	53.63519	89.39198	439.49	710	0	230
20	230	72.29091	120.4848	0	0	0	0
21	230	102.0235	170.0391	0	0	0	0
22	230	102.315	170.5249	0	0	0	0
23	230	0	0	46.425	75	0	230
24	230	103.1894	171.9824	0	0	0	0
25	230	121.2622	202.1036	0	0	0	0
26	230	110.7683	184.6139	0	0	0	0
27	230	50.13724	83.56207	371.4	600	0	230
28	230	24.48563	40.80938	55.71	90	0	230
29	230	53.63519	89.39198	0	0	0	0
30	230	94.44457	157.4076	0	0	0	0
31	230	64.12903	106.8817	0	0	0	0
32	230	34.97947	58.29912	185.7	300	0	230
33	230	46.6393	77.73216	371.4	600	0	230
34	230	51.30323	85.50538	278.55	450	0	230
35	230	82.201	137.0029	0	0	0	0
36	230	97.65	162.75	0	0	0	0
37	230	93.86	156.43	0	0	0	0
38	230	0	0	0	0	0	230
39	230	116.5982	194.3304	0	0	0	0
40	230	53.0522	88.42033	0	0	0	0
41	230	23.90264	39.83773	408.54	660	0	230
42	230	26.8176	44.69599	389.97	630	0	230
43	230	50.42874	84.0479	0	0	0	0
44	230	0	0	309.5	500	0	230
45	230	102.315	170.52	0	0	0	0
46	230	0	0	0	0	0	0
47	230	72.29091	120.4848	0	0	0	0
48	230	71.999	119.999	0	0	0	0
49	230	85.11672	141.8612	0	0	0	0
50	230	85.11672	142.8328	0	0	0	0
51	230	0	0	0	0	0	0

Table 6 230KV Syrian gird nodes data
Source: (Alwazah et al., n.d.; Hamzeh, 2004)

II. 230KV grid lines Data

Line	KT	B	G	X	R	to	from
1	1	7.7	0	0.43	0.1	2	39
2	1	396.5	0	43.84	10.95	3	2
3	1	39.7	0	4.39	1.07	8	2
4	1	80.5	0	8.88	2.18	21	2
5	1	28.8	0	3.18	0.76	48	2
6	1	225.79	0	24.96	6.125	9	3
7	1	60.48	0	6.68	1.64	22	3
8	1	55.008	0	6.08	1.49	41	3
9	1	535.39	0	59.19	14.52	5	4
10	1	51.84	0	5.76	1.4	12	4
11	1	61.945	0	6.84	1.667	22	4
12	1	560.16	0	61.92	15.2	5	4
13	1	125.4	0	13.865	2	19	4
14	1	14.62	0	1.615	0.396	41	4
15	1	388.8	0	42.98	10.54	1	4
16	1	443.52	0	49	12	6	5
17	1	247.104	0	27.32	6.7	7	5
18	1	49.598	0	5.481	1.348	10	5
19	1	63.36	0	7	1.72	23	5
20	1	48.096	0	5.31	1.3	14	6
21	1	158.4	0	17.51	4.3	1	6
22	1	28.224	0	3.18	0.76	49	6
23	1	278.496	0	30.78	7.55	14	7
24	1	59.974	0	6.629	1.622	42	7
25	1	99.36	0	10.98	2.7	21	8
26	1	22.752	0	2.515	0.615	30	8
27	1	184.32	0	20.37	5	13	9
28	1	71.136	0	5.81	1.425	19	9
29	1	482.688	0	53.36	13.1	11	10
30	1	411.84	0	45.53	11.17	18	10
31	1	39.6	0	10.34	2.54	23	10
32	1	391.68	0	43.3	10.6	15	11
33	1	374.4	0	41.39	10.15	18	11
34	1	224.64	0	24.83	6.1	29	11
35	1	20.968	0	2.316	0.566	1	14
36	1	149.76	0	16.55	4.1	51	54
37	1	250.56	0	27.7	3.46	29	15

ISSN-On line: 2444-4987

38	1	15.2	0	12.73	3.12	46	15
39	1	155.52	0	17.19	4.2	17	16
40	1	138.24	0	15.28	3.75	31	16
41	1	161.28	0	17.83	4.37	30	16
42	1	89.28	0	9.87	2.42	28	18
43	1	37.152	0	4.105	1.01	43	19
44	1	142.272	0	15.72	3.86	20	19
45	1	11.52	0	1.273	0.312	40	20
46	1	42.192	0	4.665	1.145	27	21
47	1	86.4	0	9.55	2.34	57	58
48	1	305.28	0	33.75	8.28	53	58
49	1	46.08	0	5.09	1.25	33	22
50	1	144	0	15.92	3.9	25	24
51	1	118.368	0	13.08	3.21	34	24
52	1	45.504	0	5.06	1.23	26	25
53	1	28.224	0	3.18	0.76	49	25
54	1	169.92	0	18.79	4.61	42	25
55	1	288	0	31.84	7.8	42	26
56	1	66.24	0	7.32	1.8	30	27
57	1	72	0	7.96	1.95	45	27
58	1	322.56	0	35.66	8.75	31	27
59	1	247.68	0	27.38	6.72	47	28
60	1	48.96	0	5.41	1.33	8	30
61	1	55.296	0	6.11	1.5	36	30
62	1	14.112	0	1.59	0.38	44	30
63	1	161.28	0	17.83	4.37	35	32
64	1	217.44	0	24.03	5.9	40	34
65	1	34.56	0	3.82	0.94	48	35
66	1	48.96	0	5.41	1.33	37	35
67	1	17.537	0	1.942	0.478	37	36
68	1	57.6	0	31.84	7.8	28	38
69	1	50.4	0	5.57	1.365	50	1
70	1	59.04	0	6.525	1.6	49	1
71	0.575	0	0	1.4	0.2	28	52
72	0.575	0	0	1.4	0.2	14	54
73	0.575	0	0	1.4	0.2	33	53
74	0.575	0	0	1.4	0.2	4	56
75	0.575	0	0	1.4	0.2	34	55
76	0.575	0	0	1.4	0.2	32	57
77	0.575	0	0	1.4	0.2	21	58
78	0.575	0	0	1.4	0.2	37	59
79	0.575	0	0	1.4	0.2	44	60
80	1	520	0	59.6	11.2	53	52
81	1	220	0	23.11	4.18	53	56
82	1	506	0	52.78	9.56	54	56
83	1	305.28	0	33.75	8.28	55	56
84	1	220	0	23.11	4.18	54	55
85	1	475	0	49.45	8.97	59	53
86	1	220	0	23.11	4.18	60	59
87	1	305.28	0	33.75	8.28	60	58
88	1	161.28	0	17.8	4.37	61	52
89	1	220	0	23.1	4.18	62	60
90	1	305.3	0	33.7	8.28	63	59
91	1	220	0	23.11	4.18	64	55
92	0.575	0	0	1.4	0.2	64	34

Table 7 230KV Syrian gird lines data,
Source: (Alwazah et al., n.d.; Hamzeh, 2004)

Conclusion

It is increasingly recognized that integrating renewable energy into energy systems is one of the most important challenges for the energy future of countries. Considering the high prevalence of variable renewables energy in the electricity grid, energy exchange between countries and regions is one of the most effective measures. This study specifically examines the response of SVC as one of the FACTS elements to changes in network power flows to ensure voltage stability of interstate interconnection lines as a control measure for VRE overshoot. This ensures that these FACTS elements can instantly reconfigure the grid in response to any changes. However, it should be noted that the correct operation of FACTS components depends not only on their correct design, but also on their location in the network and their characteristics. It is recommended to consider the wide possibilities of FACTS elements when reconfiguring grids in countries where VRE penetration is currently low, such as Mexico.

References

Alwazah, I., Nasyrov, R. R., & Alejendy, R. (N.D.). *Analysis Of the Performance of Syrian 400kv Electrical Network. https://acortar.link/z9eIM4*

Auguadra, M., Ribó-Pérez, D., & Gómez-Navarro, T. (2023). Planificación del despliegue de sistemas de almacenamiento de energía para integrar altas proporciones de energías renovables: el estudio de caso de España. *Energía , 264 , 126275. https://riunet.upv.es/handle/10251/193716*

Contreras Aguilar, L. A. (2005). Aplicación De La Teoría De Sensibilidades Dinámicas Para El Análisis De Estabilidad Transitoria En Sistemas Eléctricos Con Dispositivos Sifletca. *https://shre.ink/UHEJ*

Eltamaly, A. M., Sayed, Y., El-Sayed, A.-H. M., & Nasr ELGHAFFAR, A. A. (2018). *Optimum Power Flow Analysis by Newton Raphson Method, A Case Study. https://shre.ink/UHER*

Ghosh, S., Ghoshal, S. P., & Ghosh, S. (2010). Optimal Sizing and Placement of Distributed Generation in A Network System. *International Journal of Electrical Power and Energy Systems, 32(8), 849–856.https://doi.org/10.1016/j.ijepes.2010.01.029*

Gil-González, W., Garces, A., Montoya, O. D., & Hernández, J. C. (2021). A Mixed-Integer Convex Model for The Optimal Placement and Sizing of Distributed Generators in Power Distribution Networks. *Applied Sciences (Switzerland), 11(2),1–15. https://doi.org/10.3390/app11020627*

Gözel, T., & Hocaoglu, M. H. (2009). An Analytical Method for The Sizing and Siting of Distributed Generators in Radial Systems. *Electric Power Systems Research, 79(6),912–918. https://doi.org/10.1016/j.epsr.2008.12.007*

Hamzeh, A. (2004). Overview Of THE Syrian Energy Profile. *https://shre.ink/UHEu*

International Energy Agency, I. (2018). *System Integration of Renewables an Update on Best Practice. https://shre.ink/UHEc*

International Energy Agency, I. (2019). *ASEAN Renewable Energy Integration Analysis Flexibility Benefits of Cross-Border Power Trade. https://acortar.link/0wNOXO*

International Energy Agency, I. (2022). *System Integration of Renewables for Moldova: A Roadmap. https://acortar.link/mjTLwh*

International Energy Agency, I. (2021). *Conditions And Requirements for The Technical Feasibility of a Power System with A High Share of Renewables in France Towards 2050. https://acortar.link/ThVwb8*

Koutsoukis, N. C., Siagkas, Di. O., Georgilakis, P. S., & Hatziargyriou, N. D. (2017). Online Reconfiguration of Active Distribution Networks for Maximum Integration of Distributed Generation. *IEEE Transactions on Automation Science and Engineering, 14(2), 437–448. https://doi.org/10.1109/tase.2016.2628091*

Oliveira Da, S. A., Donoso-Garcia, S. P., Cortizo, P. C., & Seixas, P. F. (N.D.). *Performance Analysis of Three-Phase Line-Interactive UPS System with Active Power-Line Conditioning. https://acortar.link/tBN8DD*

Sambaiah, K. S., & Jayabarathi, T. (2019). Optimal Allocation of Renewable Distributed Generation and Capacitor Banks in Distribution Systems Using Salp Swarm Algorithm. In INTERNATIONAL JOURNAL Of RENEWABLE ENERGY RESEARCH K. S. Sambaiah and T. *Jayabarathi (Vol. 9, Issue 1).*

Schulze, H.-J., Niedernostheide, F.-J., Kellner-Werdehausen, U., Przybilla, J., & Uder, M. (N.D.). *High-Voltage Thyristors for HVDC And Other Applications: Light-Triggering Combined with Self-Protection Functions. https://acortar.link/ZGD1Qh*

Wang, C., & Nehrir, M. H. (2004). Analytical Approaches for Optimal Placement of Distributed Generation Sources in Power Systems. *IEEE Transactions on Power Systems, 19(4), 2068–2076. https://doi.org/10.1109/tpwrs.2004.836189*

ISSN-On line: 2444-4987

Article **Journal of Research and Development**
December 2023, Vol.9 No.24 15-23

Use FACTS elements to improve energy exchange between countries in response to the high penetration of variable renewable energy

Usar los elementos FACTS para mejorar el intercambio energético entre países como respuesta a la alta penetración de energía renovable variable

BARESKH-ONJI, Aboud†*

Istitulto Politécnico Nacional, Escuela Superior de Comercio y Administración Sto.Tomás, Ciudad de México, México.

ID 1[er] Autor: *Aboud, Barsekh-Onji* / **ORC ID:** 0009-0004-5440-8092, **CVU CONAHCYT ID:** 944116

DOI: 10.35429/JRD.2023.24.915.23 Received: July 10, 2023; Accepted: December 30, 2023

Abstract

Integrating Variable Renewable Energy sources (VRE) into Electric Power System (EPS) requires optimizing the synergy between VRE characteristics, PES flexibility elements, and local Electric Market operations. However, during advanced integration phases, where VRE accounts for a significant portion of the system's energy, and in the face of stability issues caused by energy excess, cross-border energy exchange appears to be one of the most effective solutions for Energy Management. In this investigation, to highlight the role of Flexible Alternative Current Transmission Systems (FACTS) elements to ensure the required flexibility in these energy exchange operations, a modeling strategy Methodology was implemented in MATLAB and SIMULINK to design a Static Var Compensator (SVC) and simulate its connection to a high-voltage power line between Turkey and Syria, observing its response these changes in load flow. This investigation contributes to the VRE integration strategy, identifying FACTS elements as a solution to manage excess energy and achieve efficient energy exchange.

Integration, Flexibility, Renewable energy resources

Resumen

La integración de las fuentes de Energía Renovable Variable (ERV) a los Sistemas Eléctricos de Potencia (SEP) requiere optimizar la interacción entre las propiedades de estas fuentes, los factores de flexibilidad del SEP y la operación del Mercado Eléctrico local. Sin embargo, para las fases avanzadas de integración donde la ERV forma gran parte de la energía en el sistema, y ante los problemas de estabilidad causados por excedentes de energía, el intercambio energético entre los países es una de las mejores soluciones para administrar la energía en tiempo real. En esta investigación, y para destacar el rol de los elementos FACTS (Sistemas Flexibles de Transmisión de Corriente Alterna) en garantizar la flexibilidad requerida al realizar estas operaciones de intercambio energético, se ejecutó una estrategia metodológica de modelaje en MATLAB y SIMULINK para diseñar un compensador estático de energía reactiva (SVC), y simular su conexión a una línea de alta tensión entre Turquía y Siria con la finalidad de observar su respuesta ante los cambios de flujo de energía. Esta investigación contribuye a las estrategias de integración de ERV, identificando a los elementos FACTS como una solución en la administración de los excesos de energía, logrando un eficiente intercambio energético.

Integración, Flexibilidad, Fuentes de energía renovable

Citation: BARESKH-ONJI, Aboud. Use FACTS elements to improve energy exchange between countries in response to the high penetration of variable renewable energy. Journal of Research and Development. 2023. 9-24:15-23.

* Author's Correspondence (E-mail: abarsekho2300@alumno.ipn.mx)
† Researcher contributing as first author.

Introduction

The integration of Variable Renewable Energy sources (VRE) into Electric Power Systems (EPS) has been an important research topic in recent years, aiming to integrate new technologies, specifically photovoltaic panels, and wind generators, into existing power systems. This effort also seeks to expand opportunities for extensive private sector participation in the electricity market. However, the integration strategy includes all the technical, administrative, financial, and market design changes required to enable the substantial incorporation of VRE, safely and profitably, into a country's PES.

The physical nature of electricity and the principles of electric power system stability require real-time balancing between generation and demand, underscoring the importance of adhering to the technical and operational constraints of the EPS.

In addition, it should be noted that the ease or difficulty of VRE integration into EPS depends on other factors. It is easier to integrate VRE into systems where energy demand and VRE production are positively correlated, both in normal day-to-day patterns, and where power system flexibility is crucial to facilitate VRE adoption (International Energy Agency, 2022).

In fact, to establish a strategic model for the integration of VRE, specific characteristics of the EPS assume a pivotal role in addressing this challenge. These characteristics are summarized in Table 1.

General structure and technical factors	- Geographic location of VRE sources and their main characteristics. - The demand forecast. - The correlation between demand and reproducible energy from ERV sources - The flexibility of the plants that make up the electric power system. - Interconnection, storage capacity and demand response.
Operation system, market design and regulation	- Operational decisions, and their proximity to real-time execution, for the plants that make up the electric power system and its interconnection. - The type of market design according to demand, whether long or short term. - The Network Code and the current regulation regarding the issue of VRE sources.
Fundamentals of production and demand	- The evolution of energy demand, where the growth in demand could be a reason to demand an urgent integration model for VRE sources.

Table 1 Principal characteristics of Electric Power System
Source: Own elaboration

Consequently, based on the data and experiences of several countries regarding the challenge of integrating Variable Renewable Energy (VRE), the International Energy Agency (IEA) has defined distinct phases towards achieving full integration of these sources. These phases (Table 2) were established based on the percentage of VRE penetration compared to the percentage of energy produced by the EPS in accordance with demand. (International Energy Agency, 2018).

Phase 1	The VRE sources do not have an impact on the EPS.
Phase 2	The VRE sources have a minor to moderate impact on the EPS
Phase 3	The VRE sources dictate the operational pattern of the EPS
Phase 4	The VRE sources generate most of the energy circulating in the EPS
Phase 5	The VRE sources produce surplus amounts of energy for days to weeks
Phase 6	The VRE sources produce surplus amounts of energy seasonally

Table 2 Phases off integration of VRE into EPS
Source: Own elaboration based on IEA

For years, research in the technical aspects of an integration model has focused on various areas of interest, beginning with diverse models for demand forecasting, including econometric models, regression models, or neural networks (Sambaiah & Jayabarathi, 2019), on the other hand, some researchers detailed the planning of energy storage systems to integrate high proportions of VRE (Auguarda et al., 2023).

Also, several studies can be found addressing the optimization of the location and size of VRE (Gözel & Hocaoglu, 2009) and (Ghosh et al., 2010), while other investigators have sought to optimize the aforementioned factors based on the reduction of energy losses (Gil-González et al., 2021).

ISSN-On line: 2444-4987

Moreover, the authors of (Wang & Nehrir, 2004) employed analytical expressions based on active and reactive loads to reduce energy losses and optimize the location of VRE sources.

Similarly, the reconfiguration of electric networks has been an extensively researched topic, aimed at modifying the operating conditions of the EPS to accommodate VRE sources in a Distributed Generation (DG) system (Koutsoukis et al., 2017).

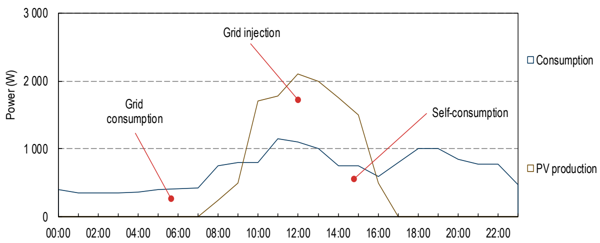


Figure 1 Excess solar PV production compared to demand
Source: IEA, 2018

Another critical point is that the production of VRE has different levels of uncertainty at different times and at different ranks within the EPS. This implies that as VRE gains a larger share in the electrical system and converts pertinent for decision-making regarding its disposition (Figure 1), whether through reserves or energy exchange.

Such as one of the most prominent examples of using interconnection to achieve efficient energy exchange during surplus hours from VRE sources was the interconnection project among the Southeast Asian countries (ASEAN) (International Energy Agency, 2019)

In response to various EPS stability challenges, the utilization of Flexible Alternative Current Transmission Systems (FACTS) has emerged. These FACTS systems, based on power electronics (Schulze et al., n.d.), enhance the controllability and stability of the electrical system, increasing its capacity to transmit energy by flexibly modulating the injected or absorbed reactive power at a specific network node (International Energy Agency, 2021).

Due to the distinctive behavior of high-voltage lines concerning voltage stability (Oliveira Da et al., n.d.) achieving control over their operation during energy exchange require a high level of real-time flexibility to ensure the stability of the Power Electric System.

Above all, this research adds significant value to the integration strategies of Variable Renewable Energy sources into EPS, highlighting the role of FACTS elements in reconfiguring the electrical grid in response to changes generated by surplus electrical energy from VRE sources, including the control of energy exchange lines between countries.

In the case of electrical systems with a high penetration percentage of VRE, the injection of excess energy can lead to voltage increases at certain nodes and result in an excess of energy that must be managed to avoid affecting the stability factors of the electrical grid.

The hypothesis of this investigation is the improvement of the stability of an interconnected Electric Power System when faced with a high level of penetration of VRE sources.

The main objective of the research is to emphasize the effect of FACTS elements in improving the flexibility of an interconnected electrical network with high ERV penetration.

The specific objectives of the research are:

- Determine the optimal locations and quantities of SVCs in the Syrian electrical grid to address excess VRE penetration, considering an energy exchange line with Turkey.

- Design a Static Var Compensator (SVC) and construct a simulation of its connection to a high-voltage line between Turkey and Syria to observe its response to changes in energy flow.

Methodology to be developed

In this paper, a program design based on the Newton-Raphson method was developed for the calculation of nonlinear differential equations representing a PES (Eltamaly et al., 2018). Additionally, the optimal placement of compensators was determined using the mathematical sensitivity theory method (Contreras Aguilar, 2005).

The Power Electric System operation is described by the following equations:

$$P_k = |V_k| . \sum_{j=1\,\&\,j\neq k}^{j=n} |Y_{kj}| . |V_j| . \cos(-\theta_{kj} - \delta_j + \delta_k) + |V_k|^2 . |Y_{kk}| . \cos(\theta_{kk}) \quad (1)$$

$$Q_k = |V_k| . \sum_{j=1\,\&\,j\neq k}^{j=n} |Y_{kj}| . |V_j| . \text{sen}(-\theta_{kj} - \delta_j + \delta_k) - |V_k|^2 . |Y_{kk}| . \text{sen}(\theta_{kk}) \quad (2)$$

Where: P_k is the stability equation for the active power at the node (k), Q_k is the stability equation for the reactive power at the node (k), V_j, δ_j is the length and angle of voltage at node (j), Y_{kj} , θ_{kj} is the length and angle of the admittance of the line between nodes (k) and (j). In this case, two conditions were established for the execution of the Newton-Raphson method:

- Voltage condition:

$$|V_i| = |V_i|_{spec} \quad (3)$$

Where: $|V_i|_{spec}$ is the length of voltage that a node, with reactive power controller, can achieve within its allowed limits.

- Reactive energy condition:

$$Q_i^{min} \leq Q_i \leq Q_i^{max} \quad (4)$$

Where: Q_i is the reactive energy generated in the control node, with its minimum limits (Q_i^{min}) and maximum limits (Q_i^{max}).

The method (Figure 2) was applied to the 230KV electrical grid of the Republic of Syria, consisting of 51 nodes (Alwazah et al., n.d.; Hamzeh, 2004), under the following two scenarios:

- First: without applying any reactive power compensation and considering the massive generation of renewable energy.

- Second: with the application of three points of compensation using SVC at three locations closer to the interconnection lines with Turkey. The results are presented in Graphic (1)

The system allocates the quantities in table 3 of reactive power to be generated at the three nodes.

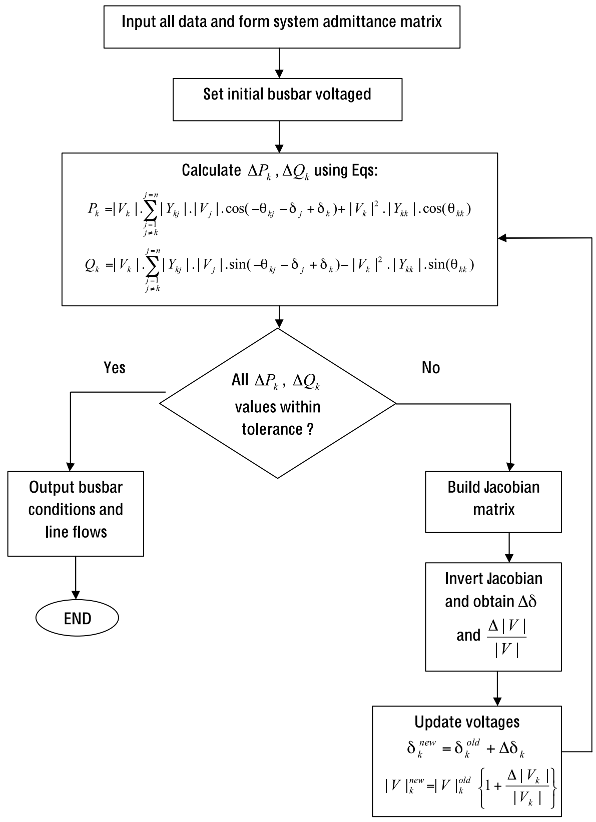
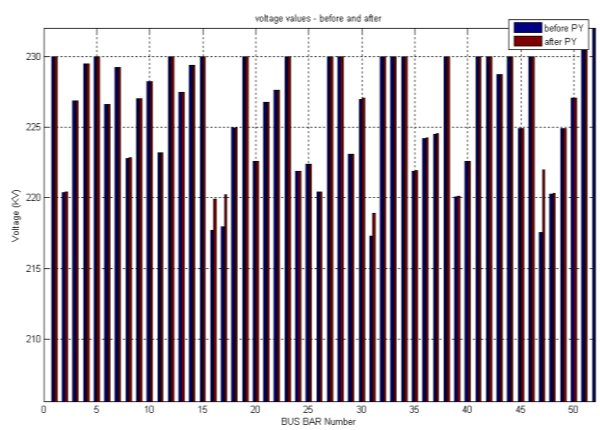


Figure 2 Newton-Raphson method applied in this investigation
Source: (Eltamaly et al., 2018)



Graphic 1 Node voltages before and after compensating for reactive power in the nodes of the Syrian 230KV power grid.
Source: Own elaboration based on results of the applied method

PY number	Node number	Q (Mvar)	Qmin (Mvar)	Qmax (Mvar)
1	16	40	-100	200
2	47	20	-100	200
3	48	160	-100	200

Table 3 Reactive power results
Source: Own elaboration based on results of the applied method

ISSN-On line: 2444-4987

Based on the initial results, the design of the Static Var Compensator (SVC) with voltage controller, as depicted in Figure 3, and the equivalent circuit is shown in Figure 4 was undertaken, following the subsequent equations:

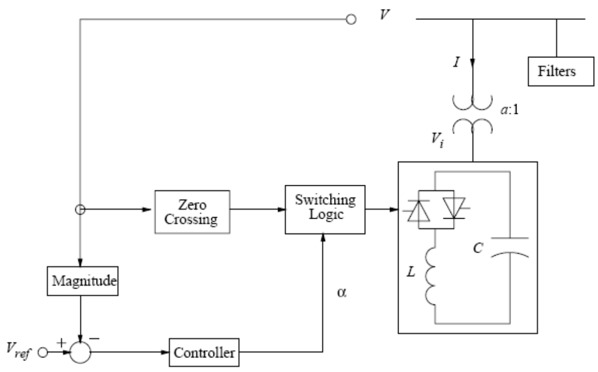


Figure 3 SVC with voltage controller
Source: (Schulze et al., n.d.)

Calculation of thyristor firing angles:

$$B_{SVC}(\alpha) = B_{TSC}(\alpha) - B_{TCR}(\alpha)\frac{X_L - \frac{X_c}{\pi}(sen(2\alpha)-(2\pi-2\alpha))}{X_c X_L} \quad (5)$$

Where:

$$X_{TCR}(\alpha) = \frac{\pi X_L}{sen(2\alpha)+(2\pi-2\alpha)} \quad (6)$$

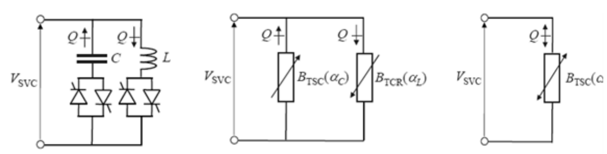


Figure 4 Equivalent Circuit of SVC with voltage controller
Source: (Schulze et al., n.d.)

Therefore, the reactive power generated by the SVC as a function of angle (α) is given in equation (7).

$$Q_{SVC}(\alpha) = -U_k^2 B_{SVC}(\alpha) = -U_k^2\frac{X_L - \frac{X_c}{\pi}(sen(2\alpha)-(2\pi-2\alpha))}{X_c X_L} \quad (7)$$

Thus, the SVC was designed with the following reactive power values in accordance with the network requirements, considering that it will be supplied by a 300MVA, 230/66KV transformer with a reactance (XT) of 15% and a maximum voltage drop of 0.01 per unit (p.u.) for every 100VA.

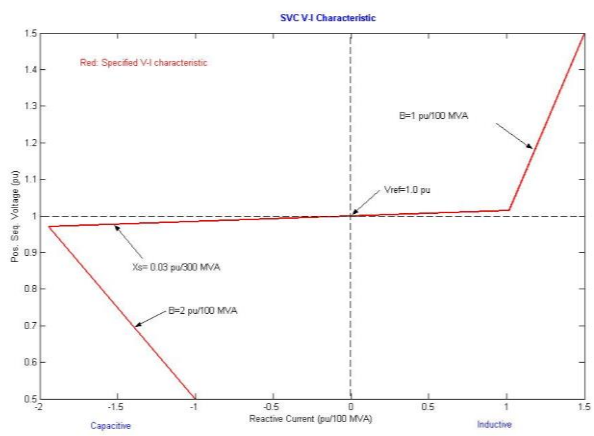
$$Q_{TSC} = 3 \times 94\ Mvar \quad (8)$$

$$Q_{TCR} = 109\ Mvar \quad (9)$$

The SVC elements calculation was supported out for the nominal voltage (230KV), maximum voltage (232.3KV), and minimum voltage (223.1KV), resulting in the technical specifications of the designed SVC (Table 4). The technical data sheet is shown in Table 5 and its V-I Characteristic in Graphic 2.

$X_{L-rated}$	$X_{Transformer}$	X_{L-TCR}
39.96 Ω	2.178 Ω	37.78 Ω
L_{TCR}	$X_{C-rated}$	C
0.36 Henri	15.44 Ω	20.606mF

Table 4 Technical specifications of the designed SVC
Source: Own elaboration based on results of the applied method



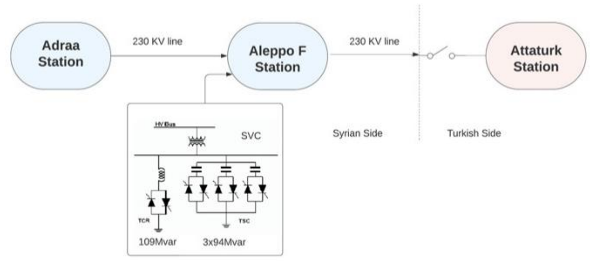
Graphic 2 SVC V-I Characteristics
Source: SVC Model output

Application	230KV
Voltage Level	10KV
Type	SVC (TCR/3 & TSC)
TCR capacity	109Mvar
TSC capacity	3 x 94Mvar
Valves structure	Open
Cooling Method	Fully closed pure water cooling
Control System	Full digital
Response Time	9 msec max
Regulation range	-100% to +100%

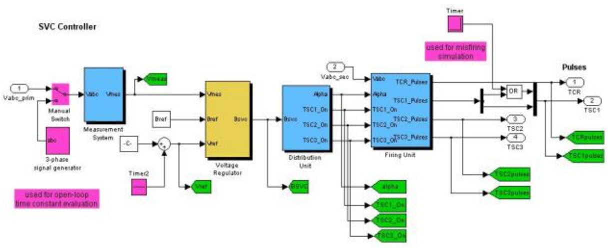
Table 5 SVC Data sheets
Source: Own elaboration based on results of the applied method

Based on the design results, a model was prepared in MATLAB SIMULINK 2022 for the installation of the SVC at the 'Aleppo F' station, where the 230KV interconnection line with Turkey originates (Graphic 3). The SVC control blocks are seen in Graphic 4, and the voltage controller in Graphic 5, with the pulse outputs assigned to each of the compensator elements. The model examined voltage variations in various scenarios at three key nodes: Aleppo F, Adraa, and Atatruck.

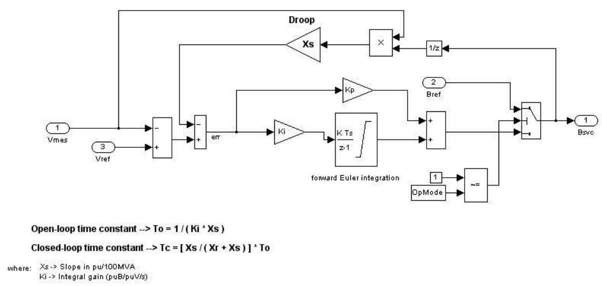
ISSN-On line: 2444-4987



Graphic 3 Model connection diagram
Source: Own elaboration



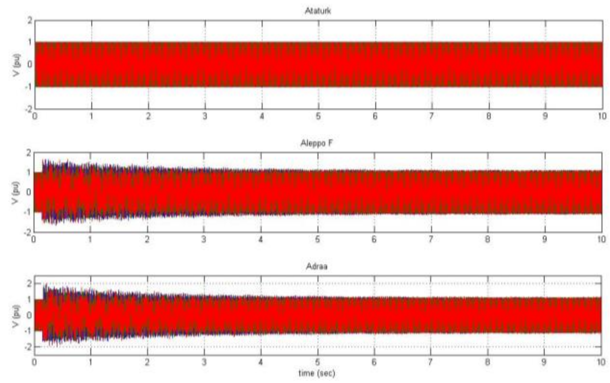
Graphic 4 SVC Controller
Source: Own elaboration on MATLAB-SIMULINK



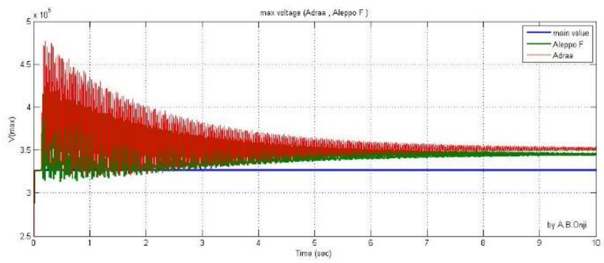
Graphic 5 SVC Voltage regulator.
Source: Own elaboration on MATLAB-SIMULINK

Results

Initially, the model of the electrical grid without activating the SVC and under normal operation was applied. To study the improvement afforded by the SVC, a drastic scenario was analyzed in which, at time 0.15 of the simulation, the line on the 'Atatürk' node side was opened, causing a voltage increase (Graphic 6) at the Aleppo F node (1.65 per unit) and the Adraa node (1.71 per unit). Furthermore, high voltage values applied to the isolating elements in both nodes were detected in this case compared to the main value (Graphic 7).

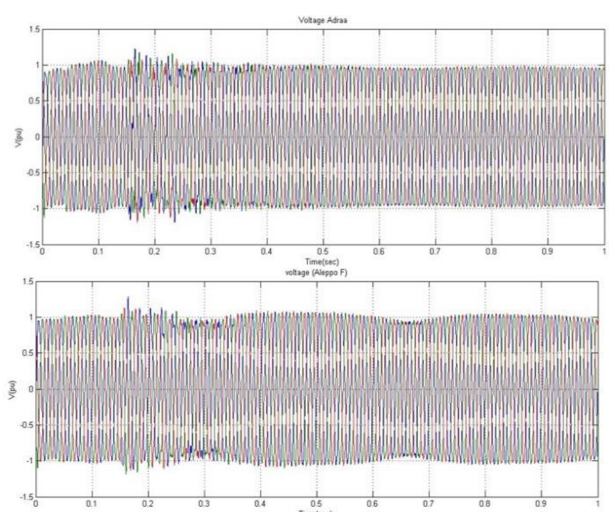


Graphic 6 Voltage variation in nodes: “Aleppo F”, “Adraa” and “Ataturk”, without SVC
Source: SVC Model output

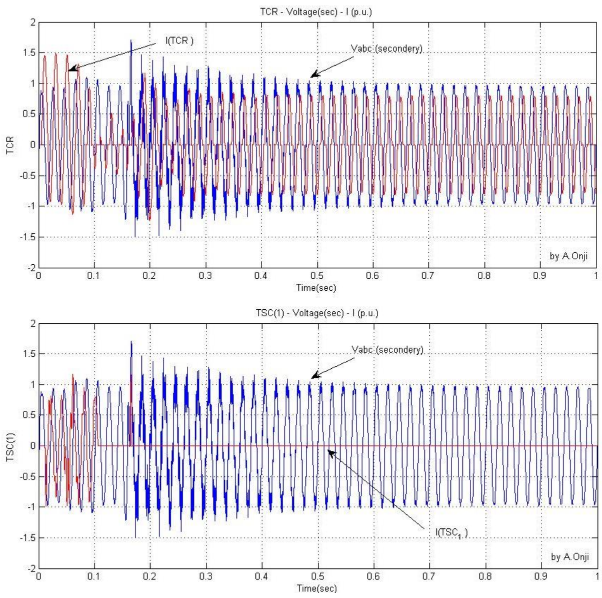


Graphic 7 High voltage values applied to the isolating elements in both nodes compared to the main value
Source: SVC Model output

In the second simulation, the SVC installed at the 'Aleppo F' node is activated, and the same procedure as before is repeated. Up on observing the results, it can be appreciated that the SVC control system operated correctly through absorbing the reactive power generated by the open line (Graphic 8), thus maintaining voltage stability at the nodes very close to nominal values. Additionally, Graphic 9 depicts the response of the currents from the TSC and TCR in comparison to the applied voltage variation.



Graphic 8 Voltage variation in nodes: “Aleppo F”, “Adraa” and “Ataturk”, with SVC
Source: SVC Model output



Graphic 9 High voltage values applied to the isolating elements in both nodes compared to the main value.
Source: SVC Model output

The above results demonstrate the rapid response of FACTS elements to momentary changes in energy injected at nodes in an Electric Power System by VRE sources, even in addressing specific scenarios such as the operation in open-circuit conditions for a high-voltage line.

Financing

This work has been funded by the author.

Annexes

I. 230KV grid nodes Data

Node	Un	Q_load	P_load	Q_gen.	P_gen.	Θ	V
1	230	0	0	0	0	0	230
2	230	101.4405	169.0674	0	0	0	0
3	230	67.62698	200	0	0	0	0
4	230	67.91847	113.1975	0	0	0	0
5	230	0	0	0	0	0	230
6	230	51.303	85.505	0	0	0	0
7	230	29.149	48.582	0	0	0	0
8	230	96.19355	160.3226	0	0	0	0
9	230	90.94663	151.5777	0	0	0	0
10	230	68.209	113.683	0	0	0	0
11	230	69.667	116.1124	0	0	0	0
12	230	20.75944	34.59	408.54	660	0	230
13	230	0	0	0	0	0	0
14	230	37.31144	62.18573	0	0	0	0
15	230	23.028	38.38	92.85	150	0	230
16	230	85.11672	141.8623	0	0	0	0
17	230	0	0	0	0	0	0
18	230	100.2745	167.1241	0	0	0	0
19	230	53.63519	89.39198	439.49	710	0	230
20	230	72.29091	120.4848	0	0	0	0
21	230	102.0235	170.0391	0	0	0	0
22	230	102.315	170.5249	0	0	0	0
23	230	0	0	46.425	75	0	230
24	230	103.1894	171.9824	0	0	0	0
25	230	121.2622	202.1036	0	0	0	0
26	230	110.7683	184.6139	0	0	0	0
27	230	50.13724	83.56207	371.4	600	0	230
28	230	24.48563	40.80938	55.71	90	0	230
29	230	53.63519	89.39198	0	0	0	0
30	230	94.44457	157.4076	0	0	0	0
31	230	64.12903	106.8817	0	0	0	0
32	230	34.97947	58.29912	185.7	300	0	230
33	230	46.6393	77.73216	371.4	600	0	230
34	230	51.30323	85.50538	278.55	450	0	230
35	230	82.201	137.0029	0	0	0	0
36	230	97.65	162.75	0	0	0	0
37	230	93.86	156.43	0	0	0	0
38	230	0	0	0	0	0	230
39	230	116.5982	194.3304	0	0	0	0
40	230	53.0522	88.42033	0	0	0	0
41	230	23.90264	39.83773	408.54	660	0	230
42	230	26.8176	44.69599	389.97	630	0	230
43	230	50.42874	84.0479	0	0	0	0
44	230	0	0	309.5	500	0	230
45	230	102.315	170.52	0	0	0	0
46	230	0	0	0	0	0	0
47	230	72.29091	120.4848	0	0	0	0
48	230	71.999	119.999	0	0	0	0
49	230	85.11672	141.8612	0	0	0	0
50	230	85.11672	142.8328	0	0	0	0
51	230	0	0	0	0	0	0

Table 6 230KV Syrian gird nodes data
Source: (Alwazah et al., n.d.; Hamzeh, 2004)

II. 230KV grid lines Data

Line	KT	B	G	X	R	to	from
1	1	7.7	0	0.43	0.1	2	39
2	1	396.5	0	43.84	10.95	3	2
3	1	39.7	0	4.39	1.07	8	2
4	1	80.5	0	8.88	2.18	21	2
5	1	28.8	0	3.18	0.76	48	2
6	1	225.79	0	24.96	6.125	9	3
7	1	60.48	0	6.68	1.64	22	3
8	1	55.008	0	6.08	1.49	41	3
9	1	535.39	0	59.19	14.52	5	4
10	1	51.84	0	5.76	1.4	12	4
11	1	61.945	0	6.84	1.667	22	4
12	1	560.16	0	61.92	15.2	5	4
13	1	125.4	0	13.865	2	19	4
14	1	14.62	0	1.615	0.396	41	4
15	1	388.8	0	42.98	10.54	1	4
16	1	443.52	0	49	12	6	5
17	1	247.104	0	27.32	6.7	7	5
18	1	49.598	0	5.481	1.348	10	5
19	1	63.36	0	7	1.72	23	5
20	1	48.096	0	5.31	1.3	14	6
21	1	158.4	0	17.51	4.3	1	6
22	1	28.224	0	3.18	0.76	49	6
23	1	278.496	0	30.78	7.55	14	7
24	1	59.974	0	6.629	1.622	42	7
25	1	99.36	0	10.98	2.7	21	8
26	1	22.752	0	2.515	0.615	30	8
27	1	184.32	0	20.37	5	13	9
28	1	71.136	0	5.81	1.425	19	9
29	1	482.688	0	53.36	13.1	11	10
30	1	411.84	0	45.53	11.17	18	10
31	1	39.6	0	10.34	2.54	23	10
32	1	391.68	0	43.3	10.6	15	11
33	1	374.4	0	41.39	10.15	18	11
34	1	224.64	0	24.83	6.1	29	11
35	1	20.968	0	2.316	0.566	1	14
36	1	149.76	0	16.55	4.1	51	54
37	1	250.56	0	27.7	3.46	29	15

ISSN-On line: 2444-4987

38	1	15.2	0	12.73	3.12	46	15
39	1	155.52	0	17.19	4.2	17	16
40	1	138.24	0	15.28	3.75	31	16
41	1	161.28	0	17.83	4.37	30	16
42	1	89.28	0	9.87	2.42	28	18
43	1	37.152	0	4.105	1.01	43	19
44	1	142.272	0	15.72	3.86	20	19
45	1	11.52	0	1.273	0.312	40	20
46	1	42.192	0	4.665	1.145	27	21
47	1	86.4	0	9.55	2.34	57	58
48	1	305.28	0	33.75	8.28	53	58
49	1	46.08	0	5.09	1.25	33	22
50	1	144	0	15.92	3.9	25	24
51	1	118.368	0	13.08	3.21	34	24
52	1	45.504	0	5.06	1.23	26	25
53	1	28.224	0	3.18	0.76	49	25
54	1	169.92	0	18.79	4.61	42	25
55	1	288	0	31.84	7.8	42	26
56	1	66.24	0	7.32	1.8	30	27
57	1	72	0	7.96	1.95	45	27
58	1	322.56	0	35.66	8.75	31	27
59	1	247.68	0	27.38	6.72	47	28
60	1	48.96	0	5.41	1.33	8	30
61	1	55.296	0	6.11	1.5	36	30
62	1	14.112	0	1.59	0.38	44	30
63	1	161.28	0	17.83	4.37	35	32
64	1	217.44	0	24.03	5.9	40	34
65	1	34.56	0	3.82	0.94	48	35
66	1	48.96	0	5.41	1.33	37	35
67	1	17.537	0	1.942	0.478	37	36
68	1	57.6	0	31.84	7.8	28	38
69	1	50.4	0	5.57	1.365	50	1
70	1	59.04	0	6.525	1.6	49	1
71	0.575	0	0	1.4	0.2	28	52
72	0.575	0	0	1.4	0.2	14	54
73	0.575	0	0	1.4	0.2	33	53
74	0.575	0	0	1.4	0.2	4	56
75	0.575	0	0	1.4	0.2	34	55
76	0.575	0	0	1.4	0.2	32	57
77	0.575	0	0	1.4	0.2	21	58
78	0.575	0	0	1.4	0.2	37	59
79	0.575	0	0	1.4	0.2	44	60
80	1	520	0	59.6	11.2	53	52
81	1	220	0	23.11	4.18	53	56
82	1	506	0	52.78	9.56	54	56
83	1	305.28	0	33.75	8.28	55	56
84	1	220	0	23.11	4.18	54	55
85	1	475	0	49.45	8.97	59	53
86	1	220	0	23.11	4.18	60	59
87	1	305.28	0	33.75	8.28	60	58
88	1	161.28	0	17.8	4.37	61	52
89	1	220	0	23.1	4.18	62	60
90	1	305.3	0	33.7	8.28	63	59
91	1	220	0	23.11	4.18	64	55
92	0.575	0	0	1.4	0.2	64	34

Table 7 230KV Syrian gird lines data,
Source: (Alwazah et al., n.d.; Hamzeh, 2004)

Conclusion

It is increasingly recognized that integrating renewable energy into energy systems is one of the most important challenges for the energy future of countries. Considering the high prevalence of variable renewables energy in the electricity grid, energy exchange between countries and regions is one of the most effective measures. This study specifically examines the response of SVC as one of the FACTS elements to changes in network power flows to ensure voltage stability of interstate interconnection lines as a control measure for VRE overshoot. This ensures that these FACTS elements can instantly reconfigure the grid in response to any changes. However, it should be noted that the correct operation of FACTS components depends not only on their correct design, but also on their location in the network and their characteristics. It is recommended to consider the wide possibilities of FACTS elements when reconfiguring grids in countries where VRE penetration is currently low, such as Mexico.

References

Alwazah, I., Nasyrov, R. R., & Alejendy, R. (N.D.). *Analysis Of the Performance of Syrian 400kv Electrical Network. https://acortar.link/z9eIM4*

Auguadra, M., Ribó-Pérez, D., & Gómez-Navarro, T. (2023). Planificación del despliegue de sistemas de almacenamiento de energía para integrar altas proporciones de energías renovables: el estudio de caso de España. *Energía , 264 , 126275. https://riunet.upv.es/handle/10251/193716*

Contreras Aguilar, L. A. (2005). Aplicación De La Teoría De Sensibilidades Dinámicas Para El Análisis De Estabilidad Transitoria En Sistemas Eléctricos Con Dispositivos Sifletca. *https://shre.ink/UHEJ*

Eltamaly, A. M., Sayed, Y., El-Sayed, A.-H. M., & Nasr ELGHAFFAR, A. A. (2018). *Optimum Power Flow Analysis by Newton Raphson Method, A Case Study. https://shre.ink/UHER*

Ghosh, S., Ghoshal, S. P., & Ghosh, S. (2010). Optimal Sizing and Placement of Distributed Generation in A Network System. *International Journal of Electrical Power and Energy Systems, 32(8), 849–856.https://doi.org/10.1016/j.ijepes.2010.01.029*

Gil-González, W., Garces, A., Montoya, O. D., & Hernández, J. C. (2021). A Mixed-Integer Convex Model for The Optimal Placement and Sizing of Distributed Generators in Power Distribution Networks. *Applied Sciences (Switzerland), 11(2),1–15. https://doi.org/10.3390/app11020627*

Gözel, T., & Hocaoglu, M. H. (2009). An Analytical Method for The Sizing and Siting of Distributed Generators in Radial Systems. *Electric Power Systems Research, 79(6),912–918. https://doi.org/10.1016/j.epsr.2008.12.007*

Hamzeh, A. (2004). Overview Of THE Syrian Energy Profile. *https://shre.ink/UHEu*

International Energy Agency, I. (2018). *System Integration of Renewables an Update on Best Practice*. *https://shre.ink/UHEc*

International Energy Agency, I. (2019). *ASEAN Renewable Energy Integration Analysis Flexibility Benefits of Cross-Border Power Trade*. *https://acortar.link/0wNOXO*

International Energy Agency, I. (2022). *System Integration of Renewables for Moldova: A Roadmap. https://acortar.link/mjTLwh*

International Energy Agency, I. (2021). *Conditions And Requirements for The Technical Feasibility of a Power System with A High Share of Renewables in France Towards 2050*. *https://acortar.link/ThVwb8*

Koutsoukis, N. C., Siagkas, Di. O., Georgilakis, P. S., & Hatziargyriou, N. D. (2017). Online Reconfiguration of Active Distribution Networks for Maximum Integration of Distributed Generation. *IEEE Transactions on Automation Science and Engineering, 14(2), 437–448. https://doi.org/10.1109/tase.2016.2628091*

Oliveira Da, S. A., Donoso-Garcia, S. P., Cortizo, P. C., & Seixas, P. F. (N.D.). *Performance Analysis of Three-Phase Line-Interactive UPS System with Active Power-Line Conditioning. https://acortar.link/tBN8DD*

Sambaiah, K. S., & Jayabarathi, T. (2019). Optimal Allocation of Renewable Distributed Generation and Capacitor Banks in Distribution Systems Using Salp Swarm Algorithm. In INTERNATIONAL JOURNAL Of RENEWABLE ENERGY RESEARCH K. S. Sambaiah and T. *Jayabarathi (Vol. 9, Issue 1).*

Schulze, H.-J., Niedernostheide, F.-J., Kellner-Werdehausen, U., Przybilla, J., & Uder, M. (N.D.). *High-Voltage Thyristors for HVDC And Other Applications: Light-Triggering Combined with Self-Protection Functions. https://acortar.link/ZGD1Qh*

Wang, C., & Nehrir, M. H. (2004). Analytical Approaches for Optimal Placement of Distributed Generation Sources in Power Systems. *IEEE Transactions on Power Systems, 19(4), 2068–2076. https://doi.org/10.1109/tpwrs.2004.836189*

ISSN-On line: 2444-4987

Article **Journal of Research and Development**
December 2023, Vol.9 No.24 24-29

Textile dyeing based on natural dyes

Teñido textil a base de colorantes naturales

PONCE-CANO, Rosa Yetzira†*, VILLATORO-CRUZ, Tania and MEJÍA-NÁJERA, Carlos

Universidad Politécnica de Francisco I. Madero, México.

ID 1st Author: *Rosa Yetzira, Ponce-Cano* / **ORC ID:** 0009-0008-2667-3365

ID 1st Co-author: *Tania, Villatoro-Cruz* / **ORC ID:** 0000-0001-7150-7923

ID 2nd Co-author: *Carlos, Mejía-Nájera* / **ORC ID:** 0009-0000-7932-4371

DOI: 10.35429/JRD.2023.24.24.29 Received: July 30, 2023; Accepted: December 30, 2023

Abstract

This study analyzes works carried out regarding the use of natural dyes in the face of the problem of toxicity due to the abuse of synthetic dyes such as chemical anilines, and also shows the first investigations of textile dyeing in fibers of natural and plant origin. (cotton and wool) with natural extracts obtained from leaves, stems and bark to find alternative solutions due to the intrinsic toxicity of the textile dyeing process towards humans and the environment due to waste that reaches the effluents. The leaves and bark of walnut, avocado pit and red onion bark have the property of producing dyes once their oxidation process is complete where it was observed that the amounts of mordants such as salt, sodium bicarbonate and alum influence the obtaining of the colors: mustard yellow, pink and brown-yellow respectively of walnut leaves and bark, avocado pit and red onion bark. The fixations of these colors satisfactorily meet tests of light fastness, wash fastness and rub fastness in cotton and wool - in high, medium and low shades.

Had, Wool, Mordants, Natural fiber, Extract, Toxicity

Resumen

Este estudio, hace un análisis de trabajos realizados referente a la utilización de colorantes naturales ante la problemática de toxicidad por el abuso de colorantes sintéticos como lo son las anilinas químicas, así mismo muestra las primeras investigaciones de teñido textil en fibras de origen natural y vegetal (algodón y lana) con extractos naturales obtenido de hojas, tallos y corteza para encontrar alternativas de solución por la toxicidad intrínseca del proceso de teñido textil hacia el ser humano y el medio ambiente por desechos que llegan a los efluentes. Las hojas y corteza de nogal, hueso de aguacate y corteza de cebolla morada poseen la propiedad de producir colorantes una vez que está completo su proceso de oxidación donde se observó que las cantidades de mordientes como sal, bicarbonato de sodio y alumbre influyen para la obtención de los colores: amarillo mostaza, rosado y café- amarillo respectivamente de hojas y corteza de nogal, hueso de aguacate y corteza de cebolla morada. Las fijaciones de estos colores satisfactoriamente cumplen pruebas de solidez a la luz, solidez al lavado y solidez al frote en algodón y lana- en tonos alto, medio y bajo.

Teñido, Lana, Mordientes, Fibra natural, Extracto, Toxicidad

Citation: PONCE-CANO, Rosa Yetzira, VILLATORO-CRUZ, Tania and MEJÍA-NÁJERA, Carlos. Textile dyeing based on natural dyes. Journal of Research and Development. 2023. 9-24:24-29.

* Author's Correspondence (E-mail: ryponce@upfim.edu.mx)
† Researcher contributing as first author.

Article **Journal of Research and Development**
December 2023, Vol.9 No.24 24-29

Introduction

Nowadays we live in a world in which ecology and environmental protection are changing many patterns of behaviour, which is why there is a great interest in using natural dyes in the textile industry because they are not harmful to humans and do not pollute the environment. In addition, they have important properties such as their stability to light and heat treatments and they are more economical. The dyeing of fibres and natural dyes is a pre-Hispanic process that we can take up again and continue to learn in order to collaborate and support the wool production sectors.

In 2016, Mexico produced 4,854 tonnes of dirty wool and a sheep generates approximately 1 to 3 kilos of fine wool and 2 to 3 kilos of coarse wool depending on the fleece (A visit to the agri-food atlas 2017. Wool another face of sheep, n.d.). Wool is a natural fibre obtained from sheep and other animals through a process called shearing (Feria de las ciencias UNAM).

The National Institute of Statistics and Geography (INEGI) and the National Chamber of the Textile Industry (CANAINTEX) through the document: Knowing the Textile and Clothing Industry provides figures regarding the Textile and Clothing Industry which contributed 3.2% of the GDP of manufacturing industries and ranked tenth among the most important manufacturing economic activities in 2019. The State of Hidalgo is also among the Entities that recorded the highest production in the textile industry, with 12.6% (as a percentage of the national total). Out of every 100 pesos of inputs used by the textile industry, 58.9 are national and 41.1 are imported; for the garment industry, 57.1 are national and 42.9 are imported. Therefore, the findings of this first stage of research show the results of the textile dyeing process with fibre of natural and vegetable origin (wool and cotton). Experiments were characterised at different concentrations of extract obtained from leaves, stems and bark, obtaining colour fixation in pink, brown and mustard tones.

Colouring in Mexico

Leticia Arroyo Ortíz, a researcher at UNAM, is a plastic artist and teacher at the National School of Plastic Arts of UNAM. She studied painting and textiles at the School of Plastic Arts in Bucharest, Romania. She has studied endemic colours of cultural, economic and historical importance. In Mexico, seven dye materials stand out among a great diversity: cempasúchitl, indigo, palo brasil, palo campeche, zacatlaxcalli, purple snail and grana cochinilla. The latter two are the only known dye animals in Mexico. With 20 years of research work, with works such as the book "Los tintes naturales mexicanos y su aplicación en algodón, henequen y lana" (Mexican natural dyes and their application in cotton, sisal and wool). In Mexico we have a great diversity of dye plants, dominated by yellow, ochre, blue, red, violet and black dyes produced from indigo, cochineal and palo Brasil (Ortíz, 2011).

The grana cochineal (Dactylopiuscoccus) is a parasitic insect of the nopal cactus (La grana cochinilla, 2001).

In some regions of Mexico, the indigenous people still use the indigo dyeing process. This is the case in Hueyapan, in the highlands of Puebla, where the preparation of the dye includes lime, elder leaves, yucca and indigo powder, all mixed in a pot. An indispensable element in indigo dyeing is the muitle, from whose leaves green or blue can be obtained, and it is always added to the indigo vat because it accentuates the colour. Indigo has within its composition some minerals. The temperature is monitored for four days in order to prevent the mixture from precipitating and the indigo from becoming insoluble in water and not adhering to the fibre. The indigo dyeing technique has been preserved from generation to generation, so the ritual is also present; in the pot, in addition to the plants, a lime cross is painted and a rolled-up doll is placed to guarantee the success of the dyeing.

ISSN-On line: 2444-4987

When dyed with indigo we can observe that, when the fabric is dipped in the dye, it acquires a green colour and when it is put to dry, the indigo comes into contact with oxygen and gives up electrons, i.e., it oxidises, then they are received by the oxygen which is reduced and this oxidation-reduction reaction becomes visible when the colour of the fabric turns blue (Ortíz, 2011).

Indigo's original habitat is not clearly defined. In Guatemala it is known as Guatemalan indigo, in Africa as wild indigo and in the United States as grass indigo (indigoferasuffruticoa). It is a shrub-like plant also known as "Jiquilite", it reaches a height of 1 to 2 metres and produces reddish flowers grouped in clusters and fruit in pods, it belongs to the leguminous family and is the original source of the dye called indigo. Indigo extract is used for dyeing fabrics, especially denim.

The ancient Mayans mixed it with some clays to produce the beautiful "Maya Blue" colour. It is still cultivated locally by a few people in some parts of the country, such as Santiago Niltepec located in the Isthmus of Tehuantepec Oaxaca, where it is grown and the dye is extracted in an artisanal way (Agro Cultura Mexicana, n.d.).

The muicle is native to Mexico and Central America and has been used since pre-Hispanic times in traditional Mexican medicine. It grows in the southeast of the country, Chiapas and Quintana Roo, as well as in the centre of the country, Morelos and in the valley of Mexico. This plant is also used for medicinal purposes (Muicle, a Mexican medicinal plant).

Regarding the Walnut tree (Juglans regia L), the walnut tree in Hidalgo, with good care, can produce up to 50 kg of walnuts and live more than 200 years. In the State of Hidalgo, 3,135 tons of walnuts were obtained, representing 1.97% of the national annual production, occupying the sixth place within the walnut producing states. The Sierra Baja region of the state of Hidalgo produces 80% of this crop, the state has approximately 900 producers for the two types of walnuts (criollo or pecan) (Government of Mexico).

Therefore, the input of walnut leaves and bark could be accessed, without considering the nut shells (pericarp and endocarp), which are currently considered as municipal solid waste and which are increasing. The aim is to make use of the dye called nogalin, which is produced when the pericarp and mesocarp of the walnut are oxidised (Monserrat, 2013).

Methodology

Textile dyeing process using fibres of natural and vegetable origin (cotton and wool, respectively). In order to carry out the dyeing technique, different concentrations of leaves, stems and bark were experimented with, obtaining the following characterisation tests, which are described below.

Optimum quantities found for the textile dyeing process with walnut bark and leaves:

	Walnut bark/leave s (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	1000	200	200	30	30	30	30
2	500	1000	200	200	30	30	30	30
3	250	1000	200	200	30	30	30	30

Table 1 Optimum quantities, tests with walnut bark and leaves

Optimum quantities found for the textile dyeing process with avocado pits.

	Stone of avocado (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	800	200	200	30	30	30	30
2	500	800	200	200	30	30	30	30
3	250	800	200	200	30	30	30	30

Table 2 Optimum quantities, tests with avocado pits

Optimum quantities found for the textile dyeing process with purple onion peel:

	Red onion peel (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	1000	200	200	30	30	30	30
2	500	1000	200	200	30	30	30	30
3	250	1000	200	200	30	30	30	30

Table 3 Optimum quantities, tests with purple onion peel

The following is a description of each of the procedures of the technique experimented with different natural extracts to obtain the textile dyeing samples.

Process of walnut bark and leaves with hanks of natural fibres of animal and vegetable origin:

1. Weigh 200 g of cotton yarn and 200 g of wool yarn. 2.

2. Cut the walnut bark and leaves into small pieces.

3. In an aluminium container, boil the bark with the water (1000 ml) for 30 minutes to obtain the extract (Note: The time is counted from the beginning of boiling).

4. Extract the liquid (pigment) using a sieve.

5. Add the mordant (30 g of salt) to the extract obtained in the previous step and boil for 30 minutes.

6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).

7. Rinse the hanks with cold water until the water runs clear.

8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 1.

Processing of avocado pits with hanks of natural fibres of animal and vegetable origin:

1. Weigh 200 g of cotton worsted and 200 g of wool worsted.

2. Cut the avocado pits in half (small pieces).

3. In an aluminium container, boil the pieces of avocado pits for 30 min. in water (1000 ml) to obtain the extract (Note: The time is counted from the beginning of boiling).

4. Extract the liquid (pigment) using a sieve.

5. Add the mordant (30 g. alum) to the extract obtained in the previous point and boil for 30 minutes.

6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).

7. Rinse the hanks with cold water until the water runs clear.

8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 2.

Process of purple onion peel with hanks of natural fibres of animal and vegetable origin:

1. Weigh 200 g of cotton worsted and 200 g of wool worsted.

2. Remove the onion peel (small pieces).

3. In an aluminium container, boil the pieces of onion peel in water (1000 ml) for 30 minutes to obtain the extract (Note: The time is counted from the beginning of boiling).

4. Extract the liquid (pigment) using a sieve.

5. Add the mordant (30 g of sodium carbonate) to the extract obtained in the previous step and boil for 30 minutes.

6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).

7. Rinse the hanks with cold water until the water runs clear.

8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 3.

ISSN-On line: 2444-4987

Results

After having carried out the different characterisation tests, tones with the following quantities were obtained:

Shades	Walnut (g)	Salt (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Yellow/ mustard	 Illustration 1. Walnut dyeing
Medium	500	30	1000	Yellow/ mustard	
Low	250	30	1000	Yellow/ mustard	

Table 4 Concentrations of walnut

Shades	Avocado pit (g)	Alumbre (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Rosé	 Illustration 2. Avocado dyeing
Medium	500	30	1000	Rosé	
Low	250	30	1000	Rosé	

Table 5 Avocado leaf concentration

Shades	Red onion peel (g)	Sodium carbonate (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Brown/ yellow	 Illustration 3. Onion Dyeing
Medium	500	30	1000	Brown/ yellow	
Low	250	30	1000	Brown/ yellow	

Table 6 Concentrations of purple onion peel

To guarantee the colour fastness results obtained in mustard yellow, pink and yellow brown, three dyeing efficiency evaluation tests were carried out: light fastness, washing fastness and rubbing fastness, according to standardised parameters. (Textiles, 2020).

Walnut bark and leaves Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
Washing fastness		
	Colour change	Colour transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Slight spotting
Rubbing fastness		
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 7 Colour fixation test on walnut bark and leaves

Red onion peel Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
Washing fastness		
	Colour change	Heat transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Light spotting
Rubbing fastness		
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 4 Colour fixation test on purple onion rind

Avocado pit Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
	Washing fastness	
	Colour change	Heat transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Light spotting
	Rubbing fastness	
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 5 Avocado pit colour fixation test

Conclusions

When textile dyeing tests were carried out with walnut bark and leaves, avocado pits and onion bark, solid colours were obtained with good colour fixation in three shades: high, medium and low, combining different mordants in animal and vegetable fibres (cotton and wool). It will be necessary to strengthen strategies for the collection of leaves, stems and bark for the raw material of the textile dyeing process. The state of Hidalgo contributes almost 2% of the national annual production of walnuts, which means that a very economical raw material is available, as its shell is considered a solid municipal waste, as well as avocado pits and onion bark. The by-product (natural dyes) resulting from the waste leaves, stems and bark are sustainable products with applications in the textile industry. Therefore, the technique should be further improved in order to achieve new and better results.

References

La grana cochinilla. (2001). México Desconocido.

Agro Cultura Mexicana. (s.f.). Obtenido de www.ago-cultura.mx

Jiménez, O. J., Meneses, E. A., García, C. M., & Durango, D. L. (2007). CARACTERIZACIÓN DE LAS PROPIEDADES Y LA ESTABILIDAD DEL COLOR DE SOLUCIONES. Revista Colombiana de Química.

Ortíz, L. A. (2011). Ciencia UNAM. DGDCUNAM Divulgación de la Ciencia. Obtenido de La diversidad tintórea de México: https://ciencia.unam.mx/leer/25/La_diversidad_tintorea_de_Mexico

COLORANTES NATURALES: UNA ALTERNATIVA EN EL TEÑIDO DE LANA. (s.f.). Obtenido de https://feriadelasciencias.unam.mx/anteriores/feria21/feria390_01_colorantes_naturales_una_alternativa_en_el_tenido_.pdf

Feria de las ciencias UNAM. (s.f.). Obtenido de https://r.search.yahoo.com/

FrequenzTherapie. (s.f.). Obtenido de https://www.frequenz-therapie.com/

Fundación Rene Quinton. (s.f.). Obtenido de https://www.fundacionrenequinton.org/blog/antocianinas-que-son-y-en-que-alimentos-estan/

Marietta Vizcaya, A. M. (2012). Revisión bibliográfica sobre la composición química y actividades farmacológicas del género Vismia (Guttiferae). Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas.

Muicle, una planta medicinal mexicana. (s.f.). México Desconocido.

Proviotek Productos y equipos Biotecnólgicos S.A. de C.V. (s.f.). Obtenido de https://www.probiotek.com/productos/reactivos/medios-de-cultivo-reactivos/caldo-luria-luria-bertani-lb/

Reveco, F. N. (s.f.). Textiles lentos y cada vez más sustentables. Tintes naturales, índigo, katazome, shibori, batik y papel en Santiago de Chile. Obtenido de https://r.search.yahoo.com/

Una visita al atlas agroalimentario 2017. La lana otra cara del ovino. (s.f.). Obtenido de https://www.gob.mx/siap/articulos/una-visita-al-atlas-agroalimentario-2017-la-lana-otra-cara-del-ovino?idiom=es

Marta Maier y María dos Santos Afonso. (2020). Química y Color en los Textiles. Facultad de Ciencias Exactas y Naturales (UBA).

ISSN-On line: 2444-4987

[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-CONAHCYT) (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

Keywords (In English)

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

Abstract (In Spanish, 150-200 words)

Objectives
Methodology
Contribution

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 Research and Development. 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

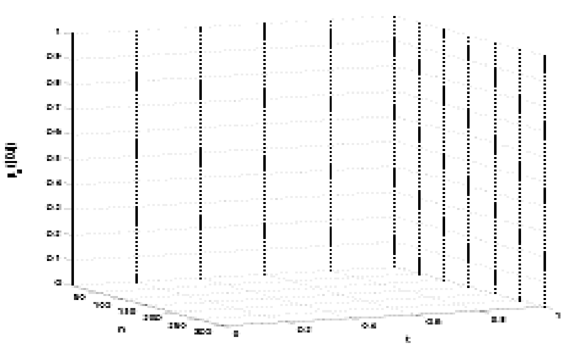
[Title No.12 in Times New Roman, single spaced and bold]

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

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.

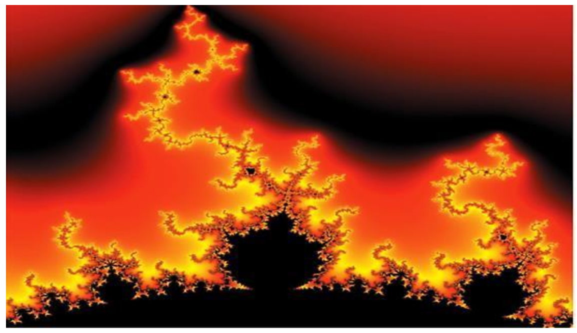


Figure 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Table 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum^{r} \beta_h X_{hij}$$

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 2444-4987

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 blue Color of the Conflict of Interest Format of Author and Co-authors.

Reservation to Editorial Policy

Journal of Research and Development reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the 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 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 Research and Development 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 Spain 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 Spain for its Journal of Research and Development, 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

LATINDEX (Scientific Journals of Latin America, Spain and Portugal)
EBSCO (Research Database - EBSCO Industries)
RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
MENDELEY (Bibliographic References Manager)

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

38 Matacerquillas, CP-28411. Moralzarzal –Madrid-España. 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

38 Matacerquillas, CP-28411. Moralzarzal –Madrid-Spain.

Journal of Research and Development

2444 4987
ISSN 2444 - 4987