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The works must be unpublished and refer to topics of logical methods, research methods, hypothetical-deductive method, scientific observation method, measuring method, scientific experimentation and other topics related to Physical Sciences Mathematics and Earth sciences.

Presentation of content

In volume seven, issue nineteen as the first article we present, *Transient angular stability on medium voltage distribution systems with distributed generation*, by CISNEROS-VILLALOBOS, Luis, VERA-DIMAS, José Gerardo, AGUILAR-MARIN, Jorge Luis and VERGARA-VÁZQUEZ, Julio Cesar, with secondment at the Universidad Autónoma del Estado de Morelos and Centro Nacional de Investigación y Desarrollo Tecnológico, as a second article we present, *Disposable diapers problem and its regulations in Mexico*, by SERRANO-FARFÁN, Angélica Rocío & NIVÓN-PELLÓN, Alejandra, with an appointment at Universidad Autónoma de Querétaro, as a third article we present, *Computational program to evaluate local defects type Chalmers Test on a reflective optical surface*, by CANALES-PACHECO, Benito, RUEDA-SORIANO, Esteban, RUIZ-AGUILAR, Luis Alberto and NORIEGA-LOREDO, Raymundo Sergio, with secondment at the Universidad Tecnológica de la Sierra Hidalguense, Cuerpo Académico UTSH-CA-6 and Universidad Autónoma del Estado de Hidalgo, as fourth article we present, *Comparative study of P25/BiOCl mixtures as photocatalysts in Acid Orange 7 degradation*, by MENDEZ-ALVARADO, Lorena, RIVERA-FLORES, Miguel A., SANDOVAL, Miguel A. and FUENTES, Rosalba, with secondment Universidad de Guanajuato and Universidad de Santiago de Chile.

Content

Article **Journal of Scientific and Technical Applications**
June 2021, Vol.7 No.19 1-8

Transient angular stability on medium voltage distribution systems with distributed generation

Estabilidad angular transitoria en sistemas de distribución de media tensión con generación distribuida

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Abstract

The dynamic behaviour of a 32 MW gas-turbine generating unit, connected to the 23 kV main busbar of a substation, is analysed in this article. The study is focused on the representative faults occurring in an electrical system and allows the determination of the maximum times in with a fault must be delivered to maintain the stability of generator. A three-phase power network is modelled with the Alternative Transients Program (ATP). Simulation results are reported and analysed for typical variables of interest such as machine rotor angle, frequency, and power. According to the study results, machine stability is greatly affected by three-phase faults, as compared to the dynamic behaviour under single-phase faults. The analysis carried out is useful to improve and maintain the security of operation of the electrical grid and in aligned to the current regulations and recent reforms of the Mexican electric sector. The fact that the performed study was usually not mandatory but has been pending since the commissioning of distributed generation plants in the Central Mexican Region is emphasized.

Distributed generation, Distribution sub-station, Medium voltage, Transient stability

Resumen

En este artículo se analiza el comportamiento dinámico de una unidad generadora de turbina de gas de 32 MW, conectada a la barra principal de 23 kV de una subestación. El estudio se centra en las fallas representativas que ocurren en un sistema eléctrico y permite determinar los tiempos máximos en los que se debe entregar una falla para mantener la estabilidad del generador. Una red de energía trifásica se modela con el software Alternative Transients Program (ATP). Los resultados de la simulación se informan y analizan para las variables típicas de interés, como el ángulo, la frecuencia y la potencia del rotor de la máquina. Según los resultados del estudio, la estabilidad de la máquina se ve muy afectada por fallas trifásicas, en comparación con el comportamiento dinámico en fallas monofásicas. El análisis realizado es útil para mejorar y mantener la seguridad de operación de la red eléctrica y está alineado con la normativa vigente y las recientes reformas del sector eléctrico mexicano. Se destaca el hecho de que el estudio realizado generalmente no era obligatorio, pero se encuentra pendiente desde la puesta en servicio de plantas de generación distribuida en la Región Centro México.

Generación distribuida, Subestación de distribución, Media tensión, Estabilidad transitoria

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June 2021, Vol.7 No.19 1-8

Introduction

With the entry of the Wholesale Electricity Market in Mexico, where the short-term market was put into operation in January 2016 and its current regulations (CRE, 2016), a new diversity of studies of the electricity networks is required. The deregulation of the electricity markets has allowed the generation capacity to be increased not only in the power grid but also in the distribution networks. This has created an interest on the part of energy trading companies to interconnect with public electricity networks (Rosales et al 2000) complying with various technical requirements.

An option to meet the growing demand for electricity from public networks considers adding sources of generation as close as possible to charging centers at certain points in the network (Paine, 2002). These energy sources are known as distributed generation and can use renewable energy or non-renewable energy. By properly selecting the insertion points of the generation, it is possible to recover a certain amount of the transmission and transformation capacity of the electricity grid and thus obtain a better quality of the electrical energy used because there is better voltage support, harmonic components and energy losses are reduced (Shilling, 1997). Moreover, by recovering the capacity of the system there is more time to budget, plan, schedule and conclude projects that alleviate or strengthen the electricity network (Dommen & Kohler, 1995).

The design and planning of electrical networks involve topics as short circuit, power flow, protection coordination and some others such as electromagnetic transients, insulation coordination, motor starting and electric arc studies (IEEE, 1997). Recently the study of transient stability has considered new conditions about the operation of a grid that may represent a risk in the electric system (CRE, 2016). Transient stability is important because it relates directly to energy sources that are included in an electrical system (Dunki & Davis, 1994).

Historically, the study of transient stability was handled by specialized personnel, this study was developed specifically when generators connected to the backbone power networks.

In Mexico, the public distribution network includes the generation of electricity with various technologies and one of them is through the use of conventional synchronous machines. It must be taken on account that the disturbances due to short circuits in the aerial distribution networks are frequent (CFE, 2017), these disturbances cause a dynamic behavior between the generators and the electrical network that largely determines the successful operation of the electrical system. Thus, in this document, the classical stability of a synchronous generator connected to a public medium voltage network is evaluated due to disturbances caused by short circuits. (Dunki & Davis, 1994) presents some reasons why the studies of transient stability were not so frequent.

Currently, aspects such as operational flexibility, inclusion of new processes in the medium voltage networks and the applicable regulations (CRE, 2016) require attending transient stability studies in power and distribution systems.

It is important to notice that the conventional distributed generation reduces losses, has a complete availability and can withstand with the voltage of the network through the injection of reactive power, compared to the plants based on unconventional energies, whose main limitations are incomplete availability and null reactive power delivery.

It should be noticed that the planning of the national electricity network in the short and medium-term suggests the care and availability of its generation technologies, the use and greater efficiency of the current resources available (PRODESEN, 2019).

Angular transitory stability in electrical systems

The continuity and quality of the electricity supply in medium voltage distribution systems that have distributed generation, are strongly related to studies of transient stability (Orellana, González & Abreu, 2020).

It is always desirable for electric power supply companies and their users that the voltage and frequency parameters are always within the defined and controllable operating ranges (CRE, 2017).

ISSN 2444-4928

June 2021, Vol.7 No.19 1-8

For example, maintaining an adequate plant factor without outputs due to external network failure; increases the quality, efficiency, and reliability of the network, but if unnecessary machine outputs occur, this implies a synchronization procedure that demands time and money, in addition to negatively impact on the user and the environment.

The ability of an electrical system to be synchronized when subjected to a disturbance or disbalance is called stability (Anderson & Fouad, 2003). The disturbances may be of different kinds; such as short circuits, load losses, load connections, etc. These can be classified as large or small. Generally, small disturbances are due to a moderate variation in the load and generation of the system and, those of great magnitude normally implies the presence of short circuits, severe load-generation imbalance as well as the loss of important elements in the power grid. The behavior of an Electric Power System changes continuously and might be expressed with mathematical expressions that contain nonlinear characteristics (Kimbark, 2015).

If after a disbalance or disturbance the transient oscillatory response of an electric energy system is damped and the system reaches in a finite time to a new stable operating condition, we say that the system is stable (Kundur, 1994).

This implies that voltage and frequency oscillations must be damped to reach an acceptable operating condition. The stability of a system depends largely on the magnitude and location of the disturbance, and its operational condition before the disturbance. If stability is not maintained, the generator loses its synchronism with the network.

It is possible to analyze the transient stability of a system by formulating two sets of equations, the first one includes differential equations that describe or include the dynamics of mathematical modeling of the generators and their components such as excitation system, speed regulators and loads. The second set consists of algebraic equations that describe the behavior of the power grid to which the generator is connected (Anderson & Fouad, 2003).

To observe the dynamic behavior of an electrical system and carry out the analysis of its transient stability, a system of equations must be solved in the way shown in equation (1). Where it represents the state of variables related to the generators and their controls (for example, rotor angle and speed, excitation voltage) and is a vector of input signals (for example, voltages and currents in different nodes of the system). This equation represents a differential simultaneous system of nonlinear equations. The solution of (1) can be done in the time domain through numerical methods techniques.

$$\dot{x} = f(x, u, t) \tag{1}$$

The method consists of solving in the time domain the oscillation equation of the system in this case represented by two first-order expressions, equations (2) and (3). For further details of the treatment and analysis of equations (1), (2) and (3) see references (Kimbark, 2015), (Anderson & Fouad, 2003).

$$\dot{\delta} = w(t) + w_R \tag{2}$$

$$\dot{w} = \left(\frac{w_R}{2H}\right)\left(P_m - P_e(t)\right) \tag{3}$$

By solving equations (2) and (3), the behavior of the electromechanical oscillations inherent in the system can be analyzed and the dependence of the electrical power delivered by the generator based on the angular position of its rotor can be known.

When the generator operates in a steady state, it delivers an energy (determined by a mechanical torque applied to its shaft) to the power grid with a voltage at its terminals and at a rotor speed that determines its frequency. During a short circuit, in a network where the inductive effect dominates, the balance between the mechanical torque and the electrical torque of the generator can be lost. The machine starts a gradual acceleration until the fault is isolated and its rotor accumulates kinetic energy determined by the acceleration area A_1 indicated in Figure 1. The deceleration area A_2 is responsible for restoring the synchronous speed of the generator. Figure 1 shows the behavior of the real power as a function of the internal angle of the machine for the pre-fault state, during the failure and post-fault state.

ISSN 2444-4928

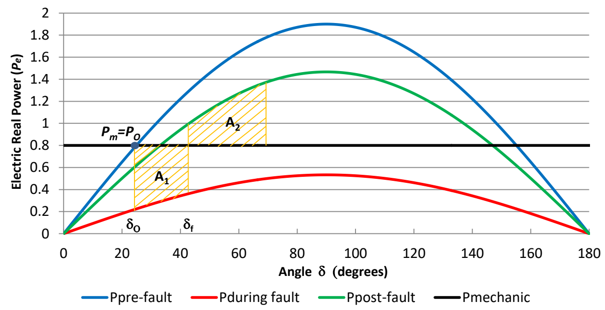

Figure 1 Power-angle feature
Source: Own elaboration

In a distribution system, the post-fault curve can be very similar to the pre-fault curve since by eliminating the fault the magnitude of the Thevenin impedance at the point of the short circuit has a greater change when a transmission circuit is lost than when one of the distribution circuits is lost. Figure 1 graphically describes the criteria of equal areas for transient stability, which can be widely addressed in (Kundur, 1994).

Description of the electrical network

The Mexico City Metropolitan Zone (ZMCM), located in the Central Region of the country, demands about 24% of the energy nationwide in approximately 1% of the national territory and 70% of it comes from the eastern, western and southeast regions (PROSEDEN, 2019). The demand for electricity in the Central Region has an average annual growth rate of 2.6% (PROSEDEN, 2019), special actions have been implemented in that particular area, mainly focused on satisfying the energy supply and maintaining voltage stability. These actions include the insertion of generation, reactive power compensation and increased capacity of transformation from high to medium voltage through mobile substations (CRE, 2017).

Therefore, to reduce the generation deficit in the Central Region and the ZMCM, since 2008 a total of 15 turbogenerators distributed in the substations of Iztapalapa, Magdalena, Santa Cruz, Aragón, Coapa, Atenco, Cuautitlán, Ecatepec, Villa de las Flores, Remedios, Coyotepec (2 generators), Valle de México and Victoria are in service. Each generator has the nominal values of 40 MVA and 13.8 kV and natural gas is its primary source of energy.

The system discussed here corresponds to the Coapa substation located in the southern part of Mexico City. It is a medium voltage aerial distribution electrical system that feeds most of its load with the transmission network of 230 kV through the links it has with the Topilejo and Xochimilco substations. Arrangements in 230 kV and 23 kV are of the conventional type, see Figure 2. The generator is directly connected to the 23 kV bus A and is connected to the transmission network through the T1 power transformer. In the 23 kV network arrangement of the substation, the link switches are kept open. That is, the power transformers are not connected in parallel. The energy provided by the turbogenerator can be consumed by loads of the distribution network of the substation and the surplus can be injected into the distribution and transmission networks.

The generator's operating policy prevents it from working when there is no link to the transmission system (it does not include the "isochronous" option). The machine speed regulation system operates in the "regulation" option when the medium voltage network is interconnected with the 230 kV system.

Operating the turbogenerator isolated of the network is not a real problem if the load and the generation are balanced. However, when the load exceeds generation, there are stability problems that might lead to a total loss of the electricity supply (IEEE, 2008). It should be noticed that the installed capacity of the substation is 87% full and the T1 transformer handles a maximum demand of 59.9 MW. Therefore, if demand conditions and operational policies allow it, the generator could only be on the island supplying the demand for only two 23 kV feeders.

Also, in the case of a gas turbine generator, its main advantages are the availability and the speed of its synchronization.

Analysis and simulation of the electrical network

There are two general operating scenarios presented in this work which relate to the types of representative failures in the network and the critical points of their application, considering always the interconnection of the substation with the 230 kV network:

Journal of Scientific and Technical Applications
June 2021, Vol.7 No.19 1-8

1. A fault occurs in the output conductor of a 23 kV feeder.

2. A fault occurs in the output conductor of the 93180 230 kV circuit.

These two scenarios have been selected because they represent the most severe short-circuit conditions that jeopardize the normal operation of the system and are located near the busbar. Also, the simulation includes the switch opening corresponding to the failed circuit.

The variables of interest in the simulations related to the generator are the rotor angle, frequency, terminal voltage, and power delivered.

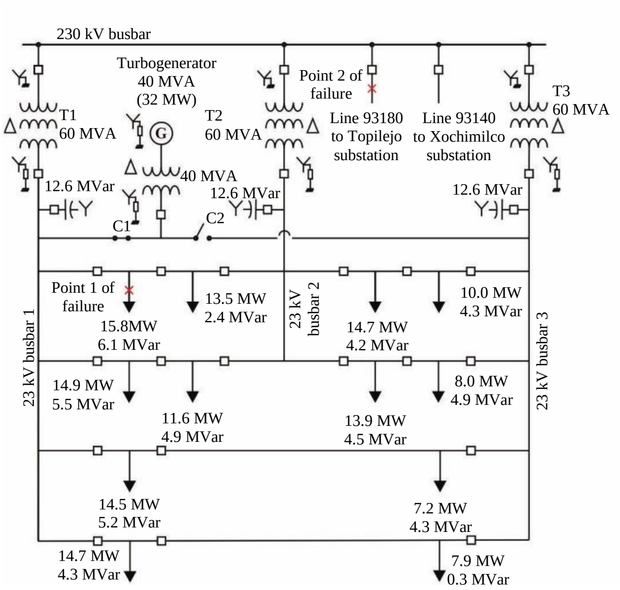

Figure 2 Simplified single-line diagram of the system under study

Figure 2 shows that the machine has the possibility of connecting to bar 1 or bar 3 through the closing of switches C1 or C2, respectively. The study considers that the machine is connected to bar 1 and provides a generation of 32 MW to the distribution network, while the capacitor bank of bar 1 remains connected. The usual values of power generated from the Coapa substation generator are 29 MW, however, the maximum power value that can be delivered is 32 MW.

Thus, the following is obtained for the first operation scenario:

Figure 3 shows the behavior of the rotor angle during the presence and clearance of the three-phase (123F3) and single-phase (223F1) faults at point 1.

It has been assumed that the fault occurs at the output of one of the distribution feeders, therefore when the fault is cleared, the circuit load is lost. The maximum clearing time for the three-phase fault that allows the generator to be synchronized is 131 ms. While the release time for a single-phase fault does not affect the generator's synchronism, it is shown that even maintaining the single-phase fault for a time of 500 ms the system turns out to be stable. The angle of the rotor is measured concerning a reference frame that rotates synchronously.

Figure 4 shows the frequency of the generator for the single-phase and three-phase fault events shown in Figure 3. During the three-phase fault, the frequency reaches a maximum value of 61.6 Hz and a minimum of 58.2 Hz, the frequency has positive damping and tends to stabilization. The single-phase fault causes the machine frequency to have a dampened oscillation between 60.3 and 59.75 Hz. The natural oscillation frequency of the electromechanical system is 3 Hz.

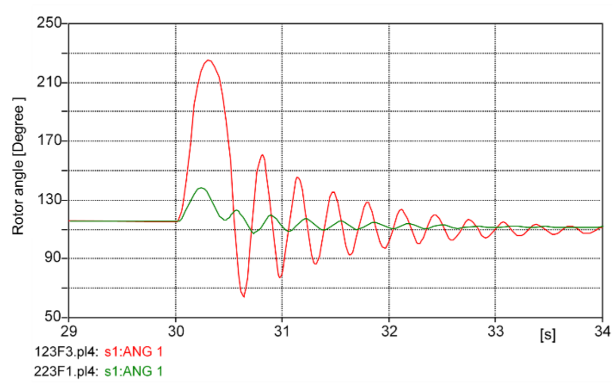

Figure 3 Rotor angle with presence and release of three-phase and single-phase faults in 23 kV

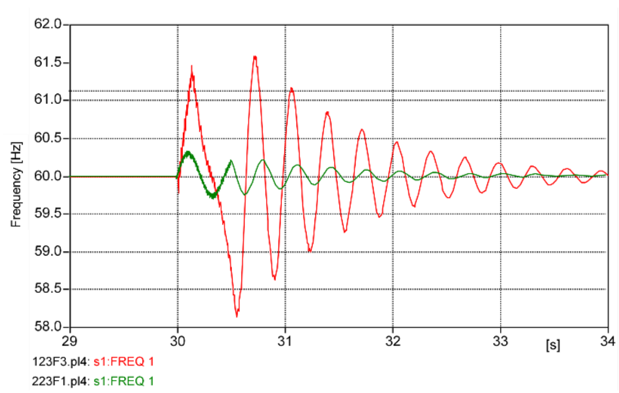

Figure 4 Frequency of the generator with presence and release of three-phase and single-phase faults in 23 kV

Figure 5 shows the apparent three-phase power output of the generator when the faults are applied at 23 kV.

June 2021, Vol.7 No.19 1-8

The generator contributes with 145 MVA to the three-phase fault, once the fault is cleared, positive damping reaches 110 MVA. The single-phase fault demands 68 MVA and after its release, there is also a damped oscillation.

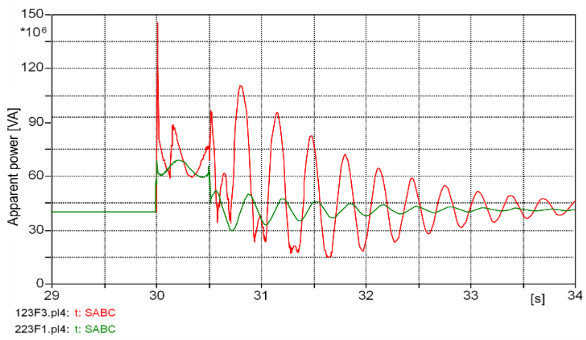

Figure 5 Generator output power due to three-phase and single-phase faults in 23 kV

The voltage behavior at the generator terminals for single-phase and three-phase faults in 23 kV is presented in Figure 6 and 7, respectively. In the event of the three-phase fault, as shown in Figure 6, the lowest voltage depression occurs in phase B with an effective phase-to-earth value of 1.8 kV. The event corresponding to the single-phase fault shows that the effectiveness phase-to-earth voltage of phase A is reduced to 4.7 kV, see Figure 7. In both cases, the voltage stabilizes in approximately 4 seconds.

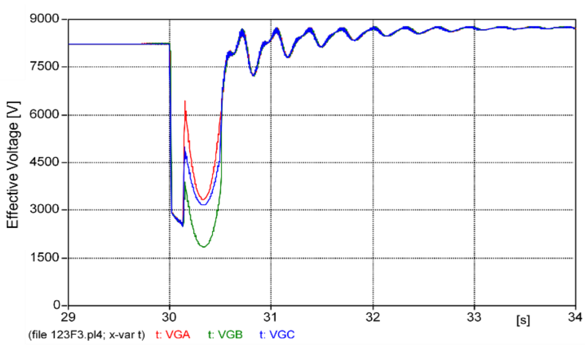

Figure 6 Behavior of the terminal voltage of the generator with presence and clearing of the three-phase faults in 23 kV

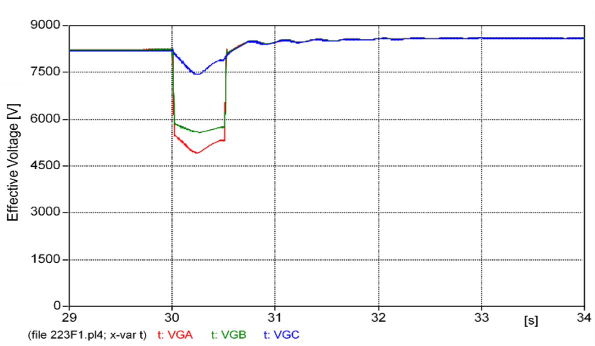

Figure 7 Behavior of the terminal voltage of the generator with presence and clearing of the single-phase faults in 23 kV

The second scenario considers that the fault occurs in the output conductor of the 93180 230 kV circuit:

The maximum clearing time of the three-phase fault (3230F3) that allows maintaining the synchronism of the generator is 150 ms, while the release time of the single-phase fault (4230F1) does not determine the stability of the system, that is, a single-phase fault can last more than 500 ms and still the machine will reach a steady state without losing synchronism with the network. This can be verified by observing the behavior of the rotor angle shown in Figure 8. Although the transient stability is not lost, this relatively high fault clearing time may cause the operation of some over-current or over-voltage protection.

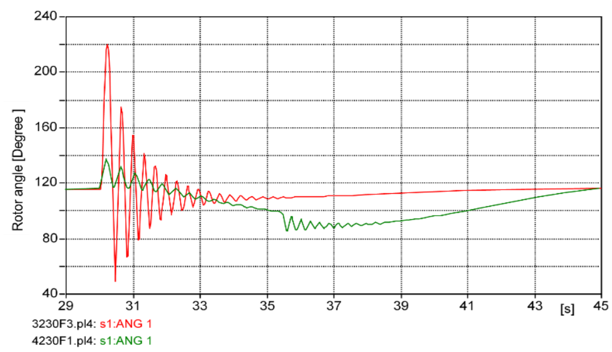

Figure 8 Rotor angle behavior with presence and clearing of three-phase faults in 23 kV

Figure 9 shows the generator frequency. The three-phase fault appears in the second 30 and is released in time 30.15 s. If the fault clearing time is less than 150 ms, the machine does not lose synchronism with the network.

The single-phase fault is applied in the second 30 and is cleared in the second 30.5, despite the relatively long duration of the failure the generator does not lose its synchronism with the network.

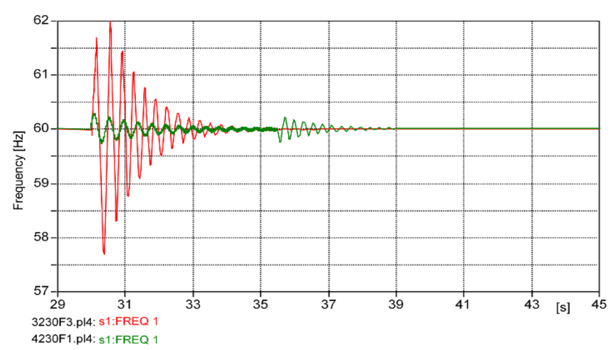

Figure 9 Frequency behavior with presence and leaning of three-phase and single-phase faults in 23 kV

The apparent three-phase power output of the generator when the failures are applied at 230 kV can be seen in Figure 10. The three-phase fault is fed by 109 MVA provided by the generator, once the fault is cleared there is positive damping that reaches 115 MVA. The single-phase fault demands 56 MVA and after its release its oscillation is damped, and its value increases gradually.

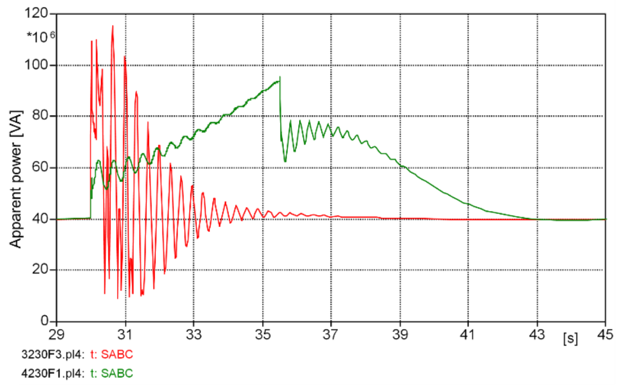

Figure 10 Generator output power due to three-phase and single-phase failures at 230 kV

Figure 11 shows the behavior of the phase voltages at the terminals of the machine before, during and after the three-phase fault, they have positive damping and reach their stable state in approximately 4 s. During the fault, the voltage in the three phases decreases to 3.9 kV.

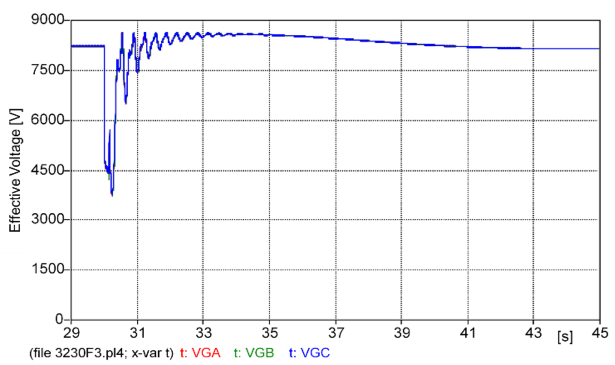

Figure 11 Behavior of the terminal voltage of the generator with presence and cleaning of the three-phase fault at 230 kV.

Figure 12 shows that 500 ms after the three-phase fault has been cleared, the voltage at the generator terminals tends to a steady state but, the increase in its value during the fault reaches values that are no longer operational in the power grid.

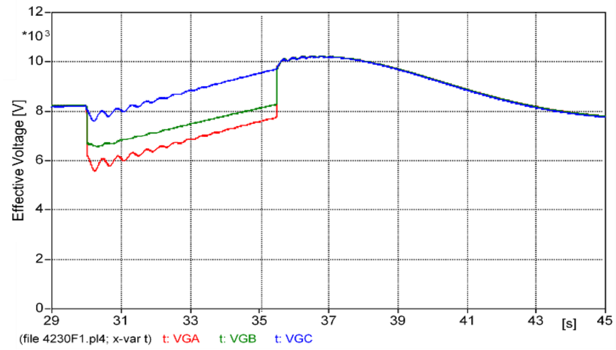

Figure 12 Behavior of the terminal voltage of the generator with presence and cleaning of the single-phase fault at 230 kV.

In Figure 13 the rotor's angle behavior and the generator frequency related to the presence and release event of the three-phase fault in 230 kV have been plotted. The fault is cleared in a time of 160 ms, so the system loses stability.

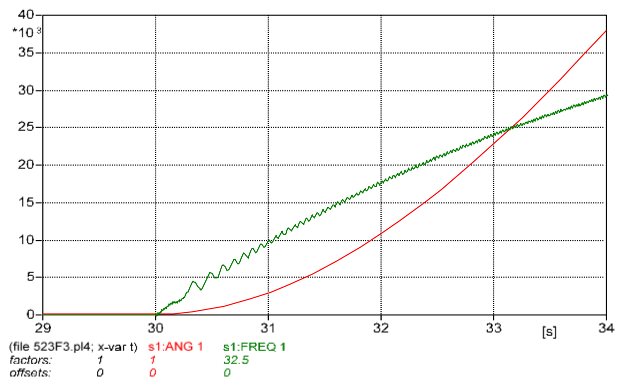

Figure 13 Rotor angle and generator frequency showing loss of stability

The results of this study are useful to define the times of adjustment of the protections of the system to improve its reliability and the correct functioning of the protection schemes which at the time did not take into account the information from a study of transient stability.

The machine does not lose stability with single-phase failures due to the magnitude of these, the neutral reactance helps to maintain stability.

Conclusions

This study always considers the link with the transmission network, so the information obtained from the scenarios presented does not have a high dependence on the electrical equivalents of the transmission and distribution networks.

The results of the scenarios presented in this article allow us to conclude that the presence of a three-phase fault near the 23 kV busbar of the Coapa substation with a duration greater than 131 ms causes the turbo generator to lose synchronism with the power grid. If the three-phase fault is applied near the 230 kV busbar and is not cleared in less than 150 ms, the system is also unstable. The application of the single-phase fault at 23 kV or 230 kV does not cause the generator to lose stability, however, the voltages and currents handled by the machine in its stable state will no longer be within the permitted operating ranges. The study of transient stability performed here is unpublished and the data obtained can be used to establish design criteria and determine corrective actions at the critical time of clearing of the large number of failures that occur in the distribution system, to favor the quality and continuity of the electricity supply of the public distribution network.

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Disposable diapers problem and its regulations in Mexico

Problema de pañales desechables y sus regulaciones en México

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Abstract

Disposable diapers are the modern solution to keep babies' skin dry and clean since they are efficient, a single diaper can keep a baby clean and dry for up to eight hours and they are effective due to the manufacturing materials that are waterproof, flexible, resistant and highly absorbent. While these are advantages to the layered design of the disposable diaper, they become barriers that prevent degradation. In Mexico, 14% of the solid waste generated corresponds to this waste. In the present work, a systematic and exhaustive review is made of the trends, regulations, and regulations that govern the commercialization and possible improvements to the disposable diaper considered a product whose usability is highly accepted and disseminated. The foregoing to prospect the development of this product and orient it towards a more sustainable future to manage the relevant innovations and changes in the regulations that correspond to disposable diapers in the framework of development: social, economic, and environmental that raises the 2030 agenda.

Disposable diapers, Ecolabelling, LCA

Resumen

Los pañales desechables son la solución moderna para mantener la piel de los bebés seca y limpia ya que son eficientes, un solo pañal puede mantener limpio y seco a un bebé hasta por ocho horas y son eficaces debido a los materiales de fabricación que son impermeables, flexibles, resistentes y altamente absorbentes. Si bien estas son ventajas para el diseño de capas del pañal desechable, éstas se convierten en barreras que impiden su degradación. En México el 14 % de los de los residuos sólidos generados corresponden a este residuo. En el presente trabajo se hace una revisión sistemática y exhaustiva de las tendencias, regulaciones y normativa que rigen la comercialización y posibles mejoras al pañal desechable considerado un producto cuya usabilidad es altamente aceptada y difundida. Lo anterior con la finalidad de prospectar el desarrollo de este producto y orientarlo hacia un futuro más sostenible para gestionar las innovaciones pertinentes y cambios en la normativa que corresponda a los pañales desechables en el marco del desarrollo: social, económico y ambiental que plantea la agenda 2030.

Pañales desechables, Ecoetiquetas, Análisis de ciclo de vida

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Introduction

The current design of the disposable diaper is the result of an engineering process that has managed to develop from the hourglass-shaped design to the implementation of superabsorbent polymers, making each diaper more efficient for up to twelve hours (Sotelo Navarro, 2017). As is already known, the main objectives of disposable diapers are to absorb and retain the waste that the baby's body eliminates.

For more than eight decades the diaper industry has developed material technology so that disposable diapers are lighter, compact, highly absorbent, leak-resistant, and easier to use, due to this it has been adopted as an effective way to keep babies dry and clean daily (EDANA, 2019). Due to its efficiency and effectiveness, it has been adopted by 95% of parents in developed countries as the solution to keep babies' skin healthy. The benefits that disposable diapers offer to modern society are extensive, although the most important and the reason why it has been widely accepted in the market is that it does not require maintenance before or after use (SEMARNAT, 2016).

Due to the aforementioned importance of disposable diapers for today's society, a systematic review of scientific references and regulations governing this highly distributed product is carried out, to make an analysis and propose a prospective by making visible the standards that regulate the commercialization and introduction of new products to the Mexican market. The foregoing, to make a strategic approach that establishes the guidelines and requirements when projecting pertinent and desirable changes to a product of proven and extended usability to be sustainable within the framework of the economic, environmental, and social development objectives of the 2030 agenda.

Innovation in disposable baby diapers

The baby's skin is especially sensitive and is susceptible to irritability, spots, dryness, and rashes, this due to the maturity in which the baby is born since it is five times thinner than that of an adult. "Thanks to the advent of disposable cellulose diapers, the prevalence of diaper rash has dramatically decreased compared to the era of woven diapers." (Muñoz, 2003).

Dermatitis caused by the use of diapers is related to the excessive hydration of the skin, the damage generated by the friction of the materials with the baby's skin, and the increase in the PH level of the mixture of urine with feces. These are the factors that trigger inflammation, which is a natural mechanism that tries to repair the skin, but by not stopping the process, this generates dermatitis and/or severe dermatitis (Blume-Peytavi & Kanti, 2018). Because of this, diaper innovation has focused on improving absorption and reducing moisture return. Increased technology development to design lighter and more absorbent materials that can be used in disposable diapers (Mendoza J. M., D´Aponte, Gualtieri, & Azapagic, 2018). However, the implementation of biomaterials to the layering of disposable diapers has not been carried out. The innovation and development of highly biodegradable materials are prevalent when it is known that the United Nations Environment Program (2016) indicates that 14% of the solid waste generated in Mexico corresponds to disposable diapers.

Babies use about 4 diapers a day, on average, therefore, in one year it will use 1,460 pieces, and in two years 2,920 (Procuraduría Federal del Consumidor, 2019). If we consider that in 2018 more than 2 million girls and boys were born (Conaco and Servytur México, 2018) and in Mexico, this product has a market penetration of 68%, it is estimated that, in 12 months, more than 5 billion diapers were discarded (Vázquez Morillas, Espinosa Valdemar, Beltrán Villavicencio, & Velasco Pérez, 2016).

The disposable diaper makes resources more efficient, increasing its absorption capacity and effectively eliminating runoffs and leaks, as well as improving the quality of life of babies, but as it is a product that responds to the demand of a mass-market segment, which consumes and discards in a short time, the materials are not suitable since they are highly polluting and not very degradable, being incoherent to the environmental crisis that humanity faces, for this it is necessary to regulate their life cycle, materials and create certifications dictated from of a normative framework.

Reducing the negative environmental impact of cities, focusing efforts on improving air quality and municipal waste management is part of the objectives of the 2030 agenda, as well as reducing waste generation through prevention, reduction, recycling, and reuse. The Sustainable Development Goals were raised in an appeal to the Members of the United Nations in 2015 due to the environmental crisis faced worldwide (Government of Mexico, 2020). For the aforementioned reasons, it is important and pertinent to make regulations and prospect regulatory options or certifications that help Mexico to guarantee sustainable consumption and production modalities for this type of disposable products.

Methodology

A systematic review of scientific articles, Mexican Official Standards, and indexed journals as an exploratory and analytical technique was carried out to obtain relevant information on diaper production, product design, materials used, environmental impact, regulations, and standards that must be met for them to be commercialized in the Mexican territory and thus be able to make visible the regulations that regulate the environmental impact of this type of waste in Mexico and prospect for certifications and standards that comply with the objectives of sustainable development.

Results

Components and materials of a disposable diaper for babies

As part of the methodology, a review of the literature on layer design and the materials used in disposable diapers is presented.

The design of disposable diapers is very similar among the representative brands in the market, so the layers and components of the diapers can be well-identified.

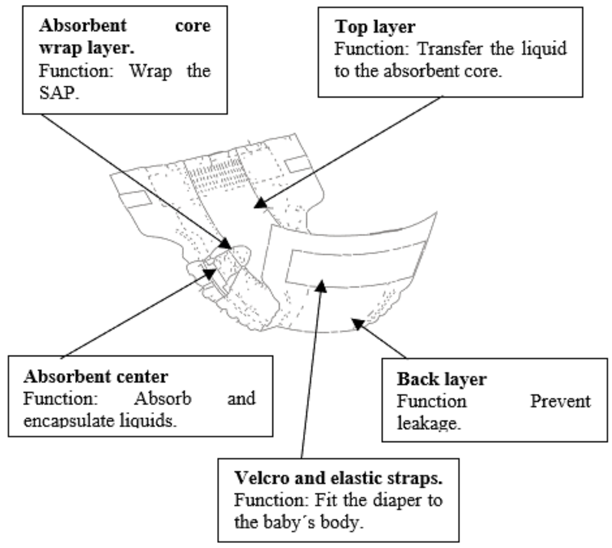

Figure 1 Layers and elements of a disposable baby diaper
Source: Own elaboration, with information from EDANA (2019).

In Figure 1, the main layers of a disposable baby diaper are identified: the upper layer, which is in contact with the baby's skin, its function is to allow the passage of fluids to the next layer, which is the layer of distribution that allows the superabsorbent polymer to saturate evenly; the third layer is the absorbent center made from a polymer that can absorb 300 times its dry weight (Pozos Vázquez, Blanco Padilla, Mercado González, & Vélez Martínez, 2018), the fourth layer is waterproof, which prevents liquids leak out of the diaper (Sotelo Navarro, 2017).

As EDANA (2019) indicates, the layers that make up disposable baby diapers are made from polyethylene and polypropylene, which can take up to 500 years to decompose (Vázquez Morillas, Espinosa Valdemar, Beltrán Villavicencio, & Velasco Pérez, 2016).

The development of synthetic polymers is one of the great advances of the 20th century and due to their characteristics, they make them very versatile. However, the fact that this material comes from non-renewable sources and is highly resistant to corrosion, oxidation, and bacterial decomposition makes it a material that is not very friendly to the environment, forcing the industry to look for new biopolymer proposals that satisfy the requirements of the design of each product (Vázquez Morillas, Espinosa Valdemar, Beltrán Villavicencio, & Velasco Pérez, 2016).

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The need to replace polymers with biopolymers or materials that come from renewable sources is becoming a priority for the industries that manufacture disposable products. This is due to the consumption strategy on the part of companies since there is a growing interest of consumers to seek new alternatives that keep babies clean and dry (Mirabella, Castellani, & Sala, 2013).

Life Cycle Assessment of disposable diapers

The life cycle analysis (LCA, for its acronym in English) should be projected before marketing any product, especially in those, whose useful life is short as in the case of disposable diapers for babies (Cordella, Bauer, Lehmann, Schulz, & Wolf, 2015).

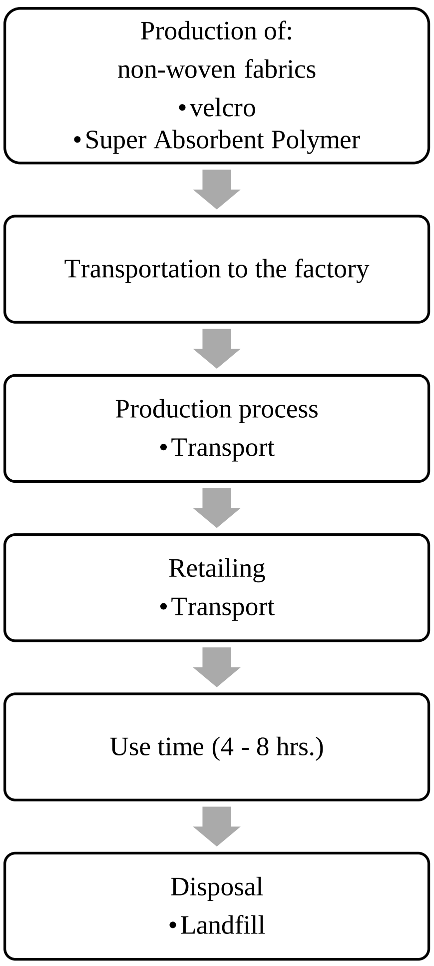

Figure 2 Diagram of the life cycle analysis of a disposable baby diaper
Source: Own elaboration

In Figure 2, the life cycle (LCA) of a disposable baby diaper is described, which begins in the extraction and processing of the raw materials that are: the superabsorbent polymer, polypropylene, and polyethylene, which are used in the manufacture of non-woven fabrics, elastics, velcro, and glues. Subsequently, these materials are taken to the production plants of each company, so that the layers are finally assembled and cut to size and manufacturing design. For their distribution, they are packaged in polyethylene bags that are packed in cardboard boxes that will be distributed at points of sale in the Mexican territory. The use time of the product, on average for each disposable diaper, is six hours, which, upon completion, is discarded to be taken to landfills.

The linear model of use and disposal of products known as Cradle to Grave (C2G), is unsustainable because the materials used in the design of disposable diapers are not recovered or recycled. and are taken to landfills without generating value, while the circular model, Cradle-to-Cradle (C2C) proposes economic growth that can be achieved sustainably through the design and manufacture of products within a closed cycle of materials, that ultimately, at the end of their life cycle, they return to be considered raw materials. The technology of these products linearly reaches the consumer, in which companies generate innovative products (trainees, pull-ups, ultra-dry, among others) with resources from different parts of the world, launching globalized products that are generated from the exploitation of natural resources in an excessive way (Gavito, *et al*., 2017).

Designing C2C disposable products from their planning phase, useful life and the end of their life is imperative for the design of disposable products such as diapers (Hauschild, Rosenbaum, & Olsen, 2018).

The Public Waste Agency of Fland, Belgium, developed a tool called Ecolizer 2.0, employing points it evaluates the environmental load of the designed products, to identify which stage of the product's life cycle has the greatest impact. There are more than one hundred and five ways to analyze the life cycle of products. These tools are strategies that designers and industries should use to reduce an environmental load of their products and produce under the C2C Cradle to Cradle model (OVAM, 2020).

An eco-efficiency and circular economy life cycle analysis study has shown that by eliminating an element of the design of disposable diapers such as glue, it could reduce their environmental impact, increasing their eco-efficiency from 7% to 170% (capital/impact), this is because the extraction, manufacturing, processing, and transportation of an element of the diaper design would be eliminated, thus reducing the environmental burden and increasing the economic efficiency of the product (Mendoza J., D´ Aponte, Gualtieri, & Azapagic, 2018).

The technologies developed for disposable diapers have been highly polluting: they generate sanitary risks, erode biological and cultural diversity, deplete natural resources and, consequently, do not conserve resources, do not improve the quality of life, nor are they sustainable (Gavito *et al.*, 2017). The seriousness of the problem is the lack of communication of these aspects to the consumer, excluding him from the responsibility of consuming disposable products.

> Well-informed purchasing decisions by consumers can guide the industry to generate more and better products and services that are responsible for the environment and society. According to the International Organization for Standardization, consumers are increasingly interested in the less tangible attributes of products, such as ethical and environmental aspects. " (Pacific Alliance. Chile Mexico Cooperation Fund, 2017)

Well-informed purchase affects the amount of waste generated. If the consumer is educated about the products, they consume and the processes that are required for their manufacture, as well as their treatment and disposal, they could change their consumption habits, in such a way that they have a lower environmental burden (Mahecha Bustos & Romero Venegas, 2021). Taking into account the above, pertinent and desirable is the design of a regulation that regulates and evaluates the life cycle analysis (LCA) and evaluates the environmental impact of the products marketed within the Mexican territory, instead of allowing certain levels of pollutants. in the air when incinerating solid waste such as NOM-098-SEMARNAT-2002 (Ministry of the environment and natural resources, 2004), (Pacific Alliance. Chile Mexico Cooperation Fund, 2017) (Hauschild, Rosenbaum, & Olsen, 2018).

Disposable diapers regulations

The Official Mexican Standards (NOM) that regulate trade within Mexican territory pertinent to disposable diapers are related to the information that the manufacturer provides on its packaging (Ministry of Economy, 2019). The Official Mexican Standards are listed below:

- NOM-002-SCFI-2011 "Prepackaged Products - Net Content - Tolerances and Verification Methods."

- NOM-030-SCF-2006 "Commercial information - Declaration of quantity on the label - Specifications."

- NOM-050-CFI-2004 “Commercial information - General provisions for products".

In addition to the Official Mexican Standards, the Mexican Standards (NMX) can also be analyzed, which are issued by the National Institute for Textile Standardization, which is in charge of designing, distributing, and selling the pertinent standards for diapers and urine absorbent aids. (National Institute of Textile Standardization, A.C., 2020).

The Mexican Standards (NMX) are laboratory test methods that measure the maximum liquid absorption capacity that it retains inside when the absorbent material of the diapers is saturated, the moisture regression when absorbing a certain amount of liquid and the speed of absorption, however, these are not mandatory for their commercialization in the country. The companies that use these standards are those that produce disposable diapers and use them to verify the quality of the diaper they are marketing (Secretaria de Economía, 2016). Below is a list of Mexican Standards according to the characteristics of disposable diapers.

- NMX-A-024-INNTEX-2012 "Textile Industry-Non-Woven - Diapers - Determination of moisture return and absorption rate in disposable baby diapers-Test method."

- NMX-A-049/1-INNTEX-2009 "Textile Industry - Urine absorbent auxiliaries - Part 1 - full product test."

ISSN 2444-4928

June 2021, Vol.7 No.19 9-17

- NMX-A-259/2-INNTEX-2009 "Textile Industry - Determination of the pH of the aqueous extract Part 2- pH of diapers and disposable sanitary napkins - Test method."

Ecolabelling

Ecolabels are a type of ecological certification that validates a quality process. It is awarded to products or services that are less harmful to the environment than their competitors. It is a certified authority that grants the ecolabel and does so by analyzing the life cycle of the product, from extraction to disposal and treatment (OVAM, 2020). The objective of eco-labels is that products that comply with these environmentally friendly processes are recognized with a special logo on the packaging and can be identified by the consumer. Ecolabels are a strategy that countries are implementing to promote products whose life cycle has a lower environmental impact than their competitors. Around the world, these are beginning to take on the importance for consumers, such as the Nordic Ecolabel, which is recognized by 95% of consumers in the Nordic countries (Martínez Rodrígez, Mayorga-Pérez, Vera-Martínez, & García Morales, 2018).

Ecolabels in Mexico

Mexico has its certifications and eco-labels that are relevant to the environment such as the Organic SAGARPA Mexico label, certified by the Organic Products Law, and the Monarch Butterfly eco-label, based on the Mexican Standard NMX-N-107-SCFI-2010 that establishes the minimum content of recycled fiber for the manufacture of paper that varies between 50% and 80% (Alianza del Pacífico & Chile-Mexico Cooperation Fund, 2017).

These eco-labels are a precedent of certifications based on Official Mexican Standards and Laws that regulate products marketed within Mexican territory, which could be used in disposable products. Mexico has eco-labels for sustainable consumption in six consumer segments:

- Food and drinks.
- Cosmetics and personal care.
- Cleaning.
- Paper, furniture, and construction.
- Energy and electronics.
- Labels for companies.

However, disposable products such as diapers are not considered in any of these classifications, when this type of product generates a significant percentage of solid waste as previously discussed. The extraction of raw materials from non-renewable sources, their transport, their useful life, and their way of disposal have a great environmental burden.

Prospective of ecolabels on disposable diapers

The sustainable development objectives of the 2030 agenda indicate that scientific and technological capacity must be strengthened to reduce the generation of waste, therefore, the life cycle analysis and regulations should be a strategy to defend the resources of future generations that are currently being consumed in disposable products. Promoting the knowledge of this type of indicator to consumers would result in responsible consumption (Government of Mexico, 2020).

The design of the disposable diaper, the way it is produced, transported, and disposed of is not sustainable. Obtaining raw material from non-renewable sources to use in products whose useful life is six hours, has resulted in the environmental crisis that afflicts humanity.

The layers of disposable diapers are manufactured from polyethylene and polypropylene (polymers), which should be degradable to recover organic matter, as indicated in NMX-E-273-NYCE-2019, which establishes the minimum specifications of plastics that are suitable for organic recovery through aerobic composting.

There are four characteristics that the Mexican Standard evaluates so that plastics can be classified as compostable:

1) Biodegradation.
2) Disintegration during composting.
3) Negative effects on the composting process.

ISSN 2444-4928

4) Negative effects on the quality of the compost, including the presence of high levels of regulated metals and other harmful components (Normalization and Certification NYCE, S.C., 2020).

The standard applies to all compostable plastic products and materials that are manufactured, marketed, and distributed in the Mexican national territory, this could be the basis for designing a label for disposable products such as diapers, due to the volume that is produced and disposed of. This would force companies to design products with a short useful life with highly biodegradable materials, which would generate a valued waste such as compost.

The objective of labels for sustainable consumption is to use marketing as a tool to highlight products whose production process is friendly to the environment and that represent a lower burden on the environment.

The use of eco-labels as an educational strategy would work to inform the consumer of the products that have a lower load, reducing the use of products with a greater environmental load, as mentioned in the "Educate Me Program." If the consumer is instucted in the management and treatment of waste, urban waste could decrease significantly (Alvarado Pereda, 2021)

Discussion of Results

The objective of this review is to make visible the existing regulations to market disposable diapers in the Mexican territory and prospect a regulation that regulates and establishes the guidelines and requirements for disposable diapers to achieve the sustainable development objectives of the 2030 agenda.

It was found in this study that the Official Mexican Standards do not regulate:

- Materials for the design of disposable products.
- The life cycle analysis (LCA) of the products.
- Management of this waste.
- Indicators apply to products of this type that reflect the environmental damage caused by production processes.

The Mexican Standard NMX-E-273-NYCE-2019 indicates the characteristics that the materials must have so that they can be classified as suitable for organic recovery through aerobic composting, generating a valued waste, which could help another sector to reduce its environmental impact and closing the product life cycle from cradle to cradle, being an eco-efficiency indicator that functions as a strategy to regulate the impact of Mexican companies, obtaining benefits by making their processes and resources more efficient (Martínez Rodrígez, Mayorga- Pérez, Vera-Martínez, & García Morales, 2018).

Conclusions

The disposable diaper is a product that has helped improve the quality of life of modern families, however, the consumption of this product is causing air and soil pollution because:

- Extract the materials for the manufacture of this product is from non-renewable sources.
- The materials used for manufacturing are virgin, none is recycled or reused.
- The short shelf life of the product (six hours).
- Materials are resistant to degradation.

Mexico is a country that is interested in safeguarding natural resources and for this reason it has implemented norms and laws that support eco-labels, which indicates that it is possible to design a government agent based on environmentally friendly norms and processes that certify and regulate the disposal of disposable products that are generated from commercial activity.

On the other hand, Mexico is one of the countries that committed to achieving the objectives of the 2030 agenda, a great advance in the development of sustainable cities and communities would be achieved if this type of disposable products were regularized and scientific and technology of companies to develop materials suitable for the useful life of the product.

ISSN 2444-4928

If eco-labels are promoted based on the Official Mexican Standards, the companies that manufacture disposable products would advance towards the development of clean processes, achieving products whose life cycle would have less impact than the current ones that are marketed, and could significantly reduce the quantity of solid waste generated.

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Computational program to evaluate local defects type Chalmers Test on a reflective optical surface

Programa Computacional para evaluar defectos locales tipo Prueba de Chalmers en una superficie óptica reflectiva

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Abstract

A computational tool is developed to measure the local deformations in optical surfaces from the interference patterns obtained by the Chalmers test principle and from the analysis of a reflective optical surface using a commercial Fizeau interferometer of the ZYGO. The tests were made on a concave spherical mirror with a radius of curvature of 60 cm and a diameter of 13 cm. To obtain the measurements of local deformations, a computational tool proposed for the localization of dark fringes is used by evaluating the maximum and minimum of the image obtained in the interference patterns. The results obtained show that the computational tool allows locating fringes within an interference pattern, allowing faster inter-fringe measurements and assigning an error on the surface in terms of wavelength.

Interferogram analysis, Chalmer's test, Young's experiment, Optical tests, Reflective spatial light modulator, Reflective spatial light modulator

Resumen

Se desarrolla una herramienta computacional que permite medir las deformaciones locales en superficies ópticas a partir de los patrones de interferencia obtenidos por el principio de la prueba de Chalmers y del análisis de una superficie óptica reflectiva utilizando un interferómetro comercial de Fizeau de la marca ZYGO™. Las pruebas se realizaron sobre un espejo esférico cóncavo con radio de curvatura de 60 cm y diámetro de 13 cm. Para obtener las mediciones de las deformaciones locales, se usa una herramienta computacional propuesta para la localización de franjas obscuras mediante la evaluación de máximos y mínimos de la imagen, obtenida en los patrones de interferencia. Los resultados obtenidos muestran que la herramienta computacional permite localizar las franjas dentro de un patrón de interferencia, permitiendo de una forma más rápida las mediciones entre franjas y asignar un error en la superficie en términos de la longitud de onda.

Análisis de interferogramas, Prueba de Chalmers, Experimento de Young, Pruebas ópticas, Modulador espacial de luz reflectivo

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June 2021, Vol. 7 No.19 18-24

Introduction

In optics workshops, different test techniques are used for the measurement of optical surfaces, such as Ronchi, Hartman, Fizeau and Newton, as mentioned by (Malacara, 1999), among others. Most of these tests perform global measurements on the surfaces, there are other tests that determine measurements in specific locations, and these tests are usually difficult to perform so their use is limited. One of these techniques is the Chalmers test described by (Martin, 1959), where he evaluates the local deformations of a biconvex lens, using an extended light source that is placed at a distance of $2f$ from the lens under test, then a screen called Chalmers is placed in the exit pupil of the lens, which contains a set of holes that are perpendicular to the optical axis forming a line, two holes are manually selected with the help of a selector template so that it covers the remaining ones, letting the light pass only in the selected holes, these act as two secondary light sources that are propagated and superimposed at a distance $2f$ posterior to the lens, where a pattern of inference fringes can be observed.

In particular, the Chalmers test has had several modifications as expressed by (Zuloaga, 1994), where the same principle is used, the significant difference is in the screen called Chalmers, the author uses the lithography technique to improve the distribution of the holes of the screen while retaining the idea of the original proposal. A recent work is presented by the authors (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012), where they retain the principle of the test to analyze the local defects of a concave spherical mirror. The proposed technique is based on using a Reflective Spatial Light Modulator (RSLM), to simulate a Chalmer screen, this is possible by projecting two holes on the optical modulator using a computer. The use of this device provides a flexible way to select two holes from a particular area of the mirror to be dynamically tested, instead of using a rigid screen as traditionally done. The main advantage in this work is the way to select a pair of holes to perform the test in real time, for any area, with different sizes and orientation of the holes, the latter being of great importance to select the optimum size and distance between them.

This work describes a computational algorithm that allows to evaluate the maximum profiles of the image of an interferogram with local deformations, a similar work is presented by (Canales Pacheco, Toto Arellano, & Austria González, Analysis of the local defects of a concave spherical surface using three measurement techniques, 2018), the authors use the commercial interferometry software DURANGO™ (Diffraction, 2014), which is based on the algorithms of (Hariharan, 1987), which according to his theory; is a method of temporal phase changes that is analyzed from the resulting intensity pattern, likewise it is mentioned that they use a commercial Fizeau type interferometer of the ZYGO™ brand and in the exit pupil of this instrument a piezoelectric transducer is placed, which allows to perform phase changes. It is possible to record 9 interferograms, each one displaced with a phase difference of $\pi/4$ and using the commercial software, the wavefront of the mirror under test is reconstructed, where the local deformations of the mirror in terms of wavelengths are obtained.

Proposal of a Computational Algorithm for the analysis of an Interferogram with local deformations

There are several commercial computational methods that analyze interferograms to determine deformations contained in an optical surface, however most of them fail to quantify local deformations, generally they obtain an average value of the whole interferogram. Therefore, this paper describes the development of a computational algorithm that allows measuring local errors in a concave spherical mirror in terms of wavelength, from analyzing a corresponding interferogram as explained by the authors (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012). For the development of the algorithm and explanation of the proposal, the four phases shown in Figure 1 are used, it is very important to mention that the first two are explained in more detail in the works already mentioned by (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012) and (Canales Pacheco, Toto Arellano, & Austria González, Analysis of the local defects of a concave spherical surface using three measurement techniques, 2018).

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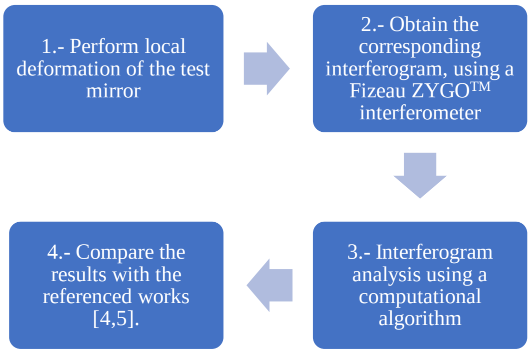
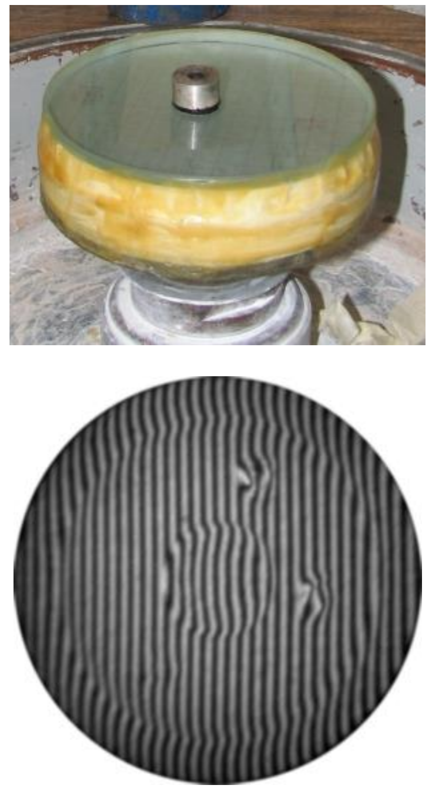


Figure 1 Proposed methodology to analyze the local deformations of an interferogram

1. **Local deformation of a mirror:** The optical test is performed on a concave spherical mirror with a radius of curvature of 60 cm and a diameter of 13 cm. The newly constructed mirror has an optical quality that meets the specifications established by the optics workshop "Alejandro S. Cornejo Rodriguez" of the National Institute of Astrophysics, Optics and Electronics (INAOE) where it was manufactured. To generate the local deformations in the test mirror, the optics workshop technician uses a mirror-polishing piece to manually generate random deformations on the surface. Figure 2a) shows the test mirror and on it, the polishing piece that makes physical contact causing considerable damage to the test surface.

2. **Obtain an interferogram of the test mirror:** In the work of (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012), they describe that with a commercial Fizeau interferometer of the ZYGOTM brand provided by INAOE, the mirror under test is analyzed and an interferogram is obtained as shown in figure 2b); where it is clearly observed that the interferogram contains localized distortion fringes, mainly in the center and the superior part. It is also observed that there are areas where the fringes are kept straight and parallel, this region is very important for this proposal, on the other hand it is known from the scientific literature; that if the mirror is free of damage or aberrations, it is expected to obtain an interferogram with straight, parallel and equally spaced fringes, otherwise distorted fringes are observed, as it is in this case that local damages were generated.



a)

b)

Figure 2 a) Deformations caused to the test mirror b) Interferogram obtained from the ZYGOTM commercial interferometer

3. **Analysis of the interferogram using a computational algorithm:** The computational algorithm is developed in Matlab and with the use of matrix arrays the pixels of the interferogram image shown in figure 2b) are identified. First, the program declares the input variables that will allow reading the interferogram image in bmp format; this is possible with the following instruction.

```
clear all
close all
clc
num1=input('Insert image:','s');
I = imread(num1);
[i,j]=size(I);
```

Second, the conditions for locating the dark fringe of the interferogram image in the vertical and horizontal direction are set to perform the reading of the image in gray level; the following code is used to make this possible.

ISSN 2444-4928

```
p=0;
for y=1:i;
   for x=1:j-1;
      if I(y,x) < I(y,x+1)
      p=p+1;
         if p==14
         K(y,x-(p-1))=250;
         p=0;
         end
      else
         K(y,x)=0;
         p=0;
      end
   end
end

p=0;
for y=1:i;
   for x=j:-1:2;
      if I(y,x) < I(y,x-1)
      p=p+1;
         if p==14
         P(y,x+(p-1))=250;
         p=0;
         end
      else
         P(y,x)=0;
         p=0;
      end
   end
end
```

Third, input variable declarations are made in the (x,y) direction that allow inserting the position from 0 to 1400 pixels and corresponds to the position of the profile to be plotted within the interferogram, using the following syntax.

```
[i,j]=size(K);
X=1:j;
Y=i/2;
x=[1,j];
y=[500,500]; % Coordinates for plotting the profile of interest
[xcx,xcy,xdatos]=improfile(K,x,y,j);
[cx,cy,datos]=improfile(I,x,y,j);
xdatosinv=250-xdatos;
datosinv=250-datos;
```

It is also possible to plot the behavior of the stripes corresponding to the profile mentioned above, also plotting the position of each dark stripe, this is achieved by performing a sweep as follows:

```
[xcx,xcy,xXdatos]=improfile(P,x,y,j);
xXdatosinv=250-xXdatos;
figure;
imshow(I)
hold on
p=plot(datosinv);
set(p,'Color','red')% Graph showing the behavior of the light and dark fringe xlabel('Pixels en X');
ylabel('Pixels en Y');
pp=plot(x,y);
set(pp,'Color','white')% Profile selected in the interferogram
ppp=plot(xXdatosinv);
set(ppp,'color','green');% Plot showing the position of the dark fringe
hold off
```

Figure 3 shows the interferogram under test, where a sinusoidal graph representing the distribution of light and dark stripes is observed. It also shows a green graph that indicates the position of each dark fringe and finally the white line that represents the profile under analysis. The number of detected fringes will depend on the area of the interferogram being selected.

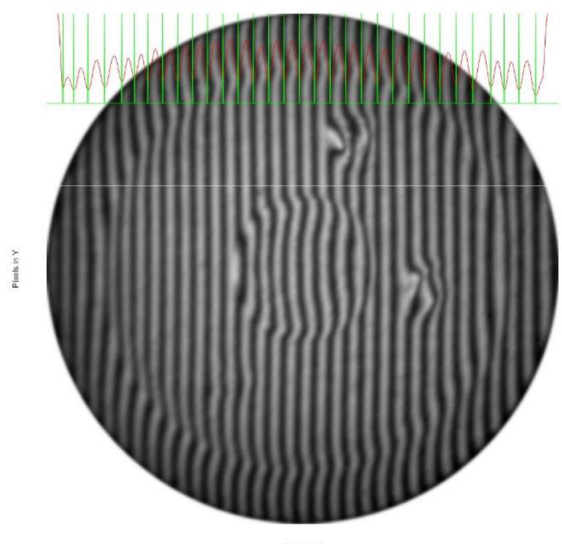


Figure 3 Interference fringes behavior corresponding to a specific interferogram profile

In this algorithm proposal it is possible to identify the position of each dark stripe, for this purpose the following code is used and its corresponding graph is shown in figure 4, where it can be seen that the separation between strips is almost constant, except at the edges where it can be visually identified that the strips are distorted.

ISSN 2444-4928

June 2021, Vol. 7 No.19 18-24

```
figure;
hold on
ppp=plot(datos);
set(ppp,'Color','red');
xlabel('Pixels');
ylabel('Gray levels');
% pp=plot(xdatosinv);
% set(pp,'Color','blue');
ppp=plot(xXdatosinv);
set(ppp,'Color','green');
axis([0 1400 0 275]);
```

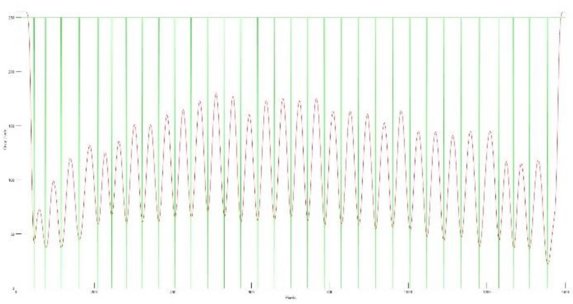


Figure 4 Location of the dark stripes in terms of pixels on the x-axis

It is important to remember that the main objective of the proposal is to measure the error of the optical surface by finding the separation between two dark fringes of the interferogram. For this purpose, several zones of the interferogram are chosen that present a quasi-constant distribution in the period of the fringes, i.e. the region where straight and parallel fringes are observed, as shown in figure 4.

In this zone, the position of the dark fringe is identified by associating it with the corresponding pixel and a sweep is made over the profile, in such a way that it is possible to know the separation between them and subsequently calculate an average value. The value obtained is considered constant and is taken as reference ***S*** or also considered as an ideal separation between two dark fringes. To know the displacement of a distorted fringe Δ***S*** the procedure is similar; a profile is drawn in such a way that it crosses a zone of the interferogram with local deformation and then the position of the fringe of interest is known, then the difference between the position of the distorted fringe and ***S*** is obtained, thus knowing the displacement of the fringe Δ***S***.

To calculate the error of the surface corresponding to the area where there are distorted fringes, we start from the fringe analysis theory, where it is known that if the interference pattern originated from the superposition of two waves as is the case in this study, then the distance between two consecutive dark or bright fringes is **λ/2**. Finally as a first approximation, the algorithm performs a quantitative analysis that allows to know the deviations of the localized fringes of the interferogram, using the equation of ((Guenther & Liebengerg, 1978), assigned an error which is given by;

$$Surface\ error = Es = \frac{\Delta S\left(\frac{\lambda}{2}\right)}{S} \qquad (1)$$

Where Δ**S** is the deviation of a fringe and **S** is the separation between two consecutive experimental fringes, **λ** is the wavelength of 633 nanometers.

Results

With the computer program developed by the authors, it is possible to know the behavior of the fringes in any profile of the interferogram, including the ability to plot an inclined profile as shown in Figure 5.

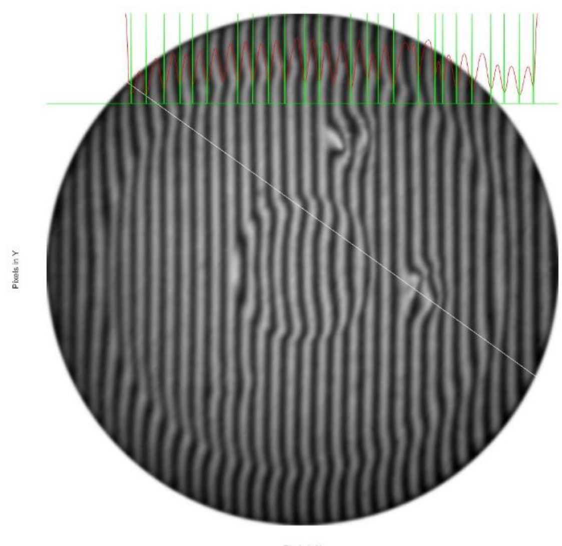


Figure 5 Behavior of the interference fringes corresponding to an inclined profile

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As an example of calculating the surface error in a local zone of the test mirror, 4 zones are selected from the interferogram identified as; A, B, C and D as shown in figure 6, where it can be observed at a glance that they contain distorted fringes, due to the fact that the test mirror contains local damage as mentioned in point 1 of the methodology.

These same zones were analyzed in the work of B. Canales, where they use a Special Light Modulator for Reflection and in the work of Benito where they use the DURANGO software that allows the analysis of interferograms.

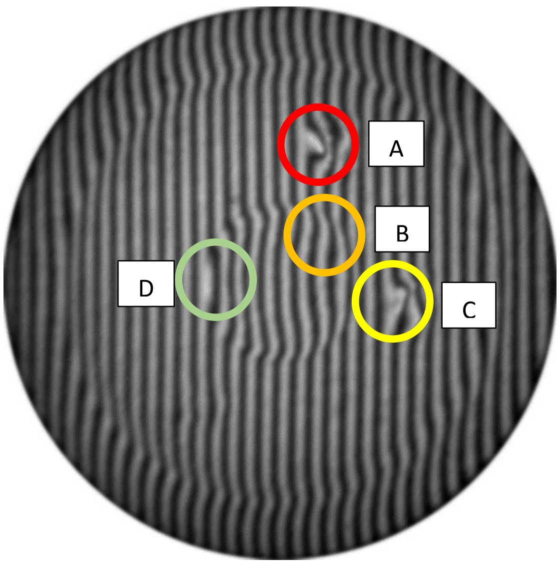

Figure 6 Behavior of interference fringes corresponding to an inclined profile

Table 1 shows the results obtained from the different proposals cited in this document, in particular in column 1 the analysis area is indicated and corresponds to the same for the three methods, column 2 shows the surface error value, using a reflective light spatial modulator as a simulator of the Chalmers screen, column 3 shows the results using the Commercial Fringe Analysis Software. Finally in column 4 the results using the method proposed here, of using a computational algorithm to measure local deformations of an interferogram and assign a surface error in terms of wavelength from equation 1, it should be clarified that the same areas of the interferogram were analyzed for comparison.

Surface error			
Zone	Using a Special Light Modulator by Reflection	Using Durango, Interferometry Software	Proposed algorithm in MATLAB
A	0.51 λ	0.49 λ	0.50 λ
B	0.30 λ	0.30 λ	0.31 λ
C	0.44 λ	0.45 λ	0.44 λ
D	0.27 λ	0.28 λ	0.28 λ

Table 1 Comparison of results in the evaluation of local zones of the interferogram

Table 2, shows the difference between the error assigned with the described proposal and the results published in the aforementioned works (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012) and (Canales Pacheco, Toto Arellano, & Austria González, Analysis of the local defects of a concave spherical surface using three measurement techniques, 2018), where it can be observed that there is a variation of 0.1 λ.

Difference in surface error		
Zone	Using a Special Light Modulator by Reflection	Using Durango, Interferometry Software
A	0.1 λ	0.1 λ
B	0.1 λ	0.1 λ
C	0 λ	0.1 λ
D	0.1 λ	0 λ

Table 2 Difference in the error assigned to the local deformations of the mirror under test

Conclusions

With the development of the computational algorithm, a proposal for interferogram analysis has emerged that is considered economical because it does not require specialized laboratory equipment to measure local errors of an optical surface.

The results obtained are supported by the works presented by (Canales Pacheco, Cornejo Rodríguez, & Granados Agustin, Chalmers Interferometric Test Using a Reflective Spatial Light Modulator, 2012) and (Canales Pacheco, Toto Arellano, & Austria González, Analysis of the local defects of a concave spherical surface using three measurement techniques, 2018), which analyzed the same interferogram as mentioned in results.

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June 2021, Vol. 7 No.19 18-24

With the results shown in Table 1, it can be interpreted that the proposal presented can analyze surface errors of 0.01λ, equivalent to an optical quality of $\lambda/80$ The results obtained were similar, which allows the described proposal to be reliable.

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Comparative study of P25/BiOCl mixtures as photocatalysts in Acid Orange 7 degradation

Estudio comparativo de mezclas de fotocatalizadores (P25/BiOCl) en la degradación del Naranja ácido 7

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Abstract

Objectives. Among strategies used to improve the photocatalytic properties of titanium dioxide (TiO_2), coupled semiconductor has been widely studied. Bismuth oxychloride (BiOCl) semiconductor has been highlighted, specially, with hierarchical structures (3D), because it has been shown to have higher performance in the photodegradation of organic dyes in wastewater. Therefore, in this work the degradation efficiency of acid orange 7 (AO7) was studied using TiO_2 (P25 Degussa), synthesized BiOCl with hierarchical structure, and mixtures of them as photocatalysts. Methodology. BiOCl was synthesized by the solvothermal method. The BiOCl was characterized by different techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). In addition, the pore distribution and the surface area were determined. Photocatalytic experiments were carried out with a photocatalyst dose of 1 $g \cdot L^{-1}$, initial dye concentration of 50 $mg \cdot L^{-1}$, and UV light illumination. Contribution. The interaction of P25 Degussa with BiOCl microspheres (75/25, respectively) improved the photocatalytic degradation achieving a 50% degradation efficiency.

Titanium dioxide, Bismuth oxychloride, Photocatalysis

Resumen

Objetivos. Con la finalidad de mejorar las propiedades fotocatalíticas del dióxido de titanio (TiO_2), se han propuesto diversas estrategias, una de ellas ha sido el acoplado de TiO_2-semicondutor. Un material semiconductor que ha ganado atención en la fotocatálisis es el oxicloruro de bismuto (BiOCl), especialmente con morfología jerárquica (3D), debido al gran desempeño en la degradación de colorantes orgánicos en aguas residuales. En el presente trabajo se estudió la eficiencia de degradación del colorante naranja ácido 7 (AO7) usando los fotocatalizadores: TiO_2 (P25 Degussa), BiOCl sintetizado de estructura jerárquica, y mezclas de ellos. Metodología. El BiOCl fue sintetizado mediante una ruta solvotermal. Este material se caracterizó mediante diferentes técnicas: difracción de rayos X (XRD), microscopia electrónica de barrido (SEM), y se determinó la distribución de poro y área superficial. Las pruebas fotocatalíticas se llevaron a cabo con1 $g \cdot L^{-1}$ de fotocatalizador, una concentración inicial de 50 $mg \cdot L^{-1}$ del AO7 y empleando luz ultravioleta (UV). Contribución. La interacción de las microesferas del BiOCl con el P25 Degussa mostró una mayor eficiencia de degradación del naranja ácido 7, en una relación de peso de P25/BiOCl de 75/25.

Dióxido de titanio, Oxicloruro de bismuto, Fotocatálisis

Citation: MENDEZ-ALVARADO, Lorena, RIVERA-FLORES, Miguel A., SANDOVAL, Miguel A. and FUENTES, Rosalba. Comparative study of P25/BiOCl mixtures as photocatalysts in Acid Orange 7 degradation. Journal of Scientific and Technical Applications. 2021. 7-19:25-28.

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June 21, Vol.7 No.19 25-28

Introduction

Rapid industrial development has brought with it an increase in the release of chemical pollutants into the environment. These pollutants are often highly harmful to the environment and difficult to degrade by conventional treatments.

Among these chemical pollutants are the organic dyes. There are a large variety and high production of organic dyes, around 280,000 tons per year worldwide, of which from 2 to 20% are directly discharged into wastewater causing an environmental damage.

Several techniques have been used to treat wastewaters. Photocatalysis (PC) is one of them and it has been considered as a good and effective alternative for water remediation. PC is based on the photoactivation of semiconductor materials (photocatalyst) by irradiation of suitable energy to generate electrons and holes, and highly oxidant species like hydroxyl radical (•OH), responsible of degradation of organic dyes (1).

Titanium dioxide (TiO_2) is the most studied photocatalyst due to its biocompatibility, low cost, and high chemical stability. However, TiO_2 has showed some drawbacks. For example, it can only be photoactivated under UV-light irradiation considering its large band gap (~3.2eV) and high charge recombination rate. Thus, several strategies have been employed to improve the photocatalytic activity of TiO_2 (2,3).

In recent years, bismuth-based photocatalysts, particularly the bismuth oxychloride (BiOCl) with hierarchical structures (3D), have demonstrated to be more effective in the photodegradation of organic dyes in wastewater compared to the commercial TiO_2 (4–6).

For this reason, in this work the photocatalytic activity of mixtures of TiO_2-P25/ BiOCl hierarchical structure (3D) was studied to degrade acid orange 7 (AO7) dye under UV light.

Methodology

Synthesis

Solvothermal method was used to synthesize BiOCl [7]. This procedure consisted in 5 mmol of $Bi(NO_3)_3{\cdot}5H_2O$ which was dissolved in 30 mL of methanol.

Then, 5 mmol of KCl and 5 mmol of citric acid were added to the solution maintaining a constant stirring for 3 h. The mixture was transferred to Teflon-lined stainless autoclave. The solvothermal reaction was maintained at 150°C for 12 h. After, it cooled down to room temperature. Finally, the product was washed with distillate water and ethanol and dried at 60°C for 12 h.

Characterization

Scanning electron microscopy (SEM), X-ray diffraction (XRD), and N_2 adsorption-desorption were used as characterization techniques for synthesized BiOCl. The surface area (BET, Brunauer-Emmett-Teller method) and porosity of BiOCl were determined by from nitrogen adsorption-desorption isotherms data, which were obtained at 77K (Micromeritics TriStar II Plus equipment). The diffraction patterns were obtained by Rigaku MiniFlex® powder diffractometer with Cu Kα radiation, $\lambda = 1.54$ Å at 40 kV tube voltages and 100 mA tube current. The XRD data were collected in a 2θ range from 10 to 70 °C with a speed of 5 °C per minute. The morphology of BiOCl was analysed by the field emission Scanning Electron Microscopy (FE-SEM; ZEISS, Sigma HD VP), equipped with an angle selective backscatter (AsB) detector. The following experimental conditions were used: voltage 10 kV, aperture size: 30 μm and magnification 10 kX.

Experimental

P25/BiOCl mixtures were prepared with different weight relation of each semiconductor: 0/100, 25/75, 50/50, 75/25 and 100/0.

For each photocatalytic experiment, 0.1 g of pure and mixture of photocatalyst (pure or in mixture) was dispersed into 100 mL of AO7 (50 $mg{\cdot}L^{-1}$) dye. The solution (photocatalyst and dye) was stirred in darkness for 30 min to establish adsorption-desorption equilibrium between photocatalyst and dye.

Oxygen supply to the solution was carried out using an air pump and UV lamps (4 W) were used for system illumination. The change of dye concentration over time was followed by UV-vis spectroscopy (wavelength of 483 nm).

Results

Characterization of BiOCl

N_2 adsorption-desorption isotherm was obtained for synthesized BiOCl. The presence of micro- and meso-pores was observed. Moreover, a value of 41.4 $m^2 \cdot g^{-1}$ specific surface area was determined.

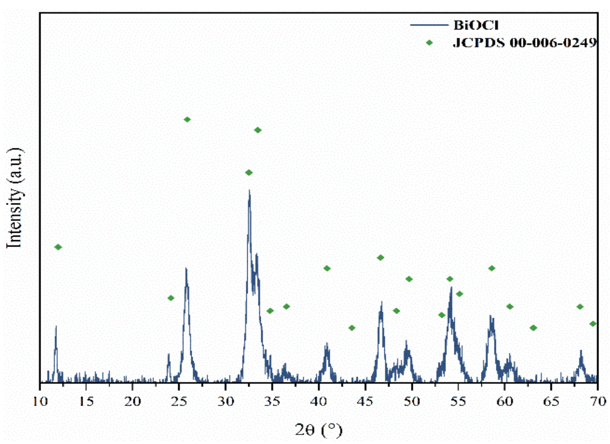

Figure 1 X-ray diffraction pattern of the BiOCl synthesized

Figure 1 shows X-ray pattern of BiOCl, which all peaks coincide with the tetragonal phase of BiOCl (JCPDS 00-006-0249 with crystallographic parameters of a=b=3.8910 Å and c=7.369 Å). It is important to highlight that the solvothermal synthesis method promoted the growth of the (110) plane. The Scherrer equation through X'pert Highscore Plus (2.2a) software was used for calculated the crystal's size of 19.1 nm.

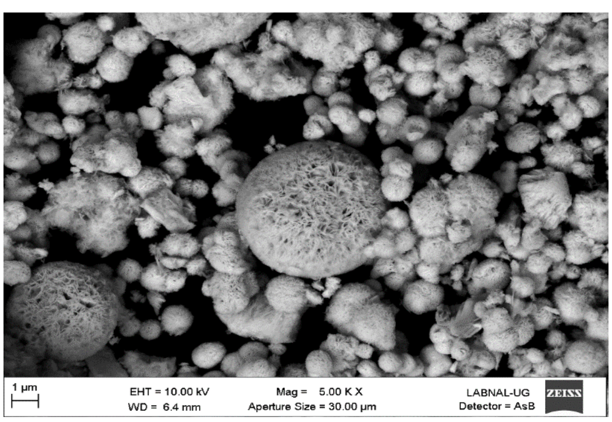

Figure 2 SEM image of hierarchical microspherical-like structure BiOCl

SEM image of the synthesized BiOCl is displayed in Figure 2. It can be observed that BiOCl has hierarchical structures (3D) that were made up of irregular nanosheets, interconnected with each other. SEM image shows that there are particles in the sample with different morphologies, from microspherical to irregular shapes, both constructed from the assembly of nanosheets. This result suggests that the BiOCl microspherical structures may provide reaction sites where the photodegradation of AO7 is carried out.

Evaluation of photocatalytic degradation of AO7 dye

Preliminary to photodegradation experiments, the photolysis of AO7 dye under UV light illumination was examined. Only 2.5% of initial dye concentration decreased. Photodegradation of AO7 dye was evaluated using TiO_2-P25 and synthesized BiOCl photocatalysts. The photodegradation efficiency is shown in Figure 3. The micro-spherical structure of BiOCl offered a higher photodegradation efficiency than P25.

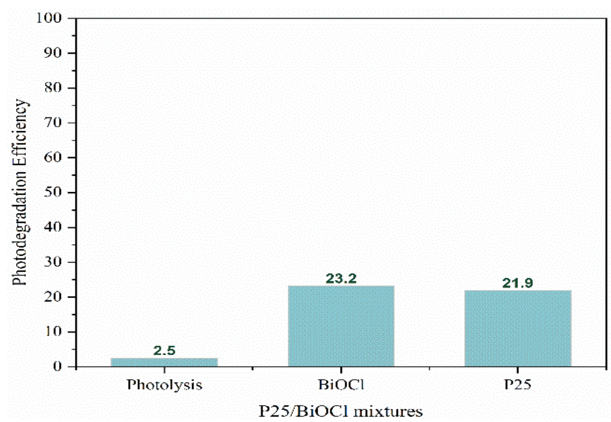

Figure 3 Photodegradation efficiency of AO7 dye (50 $mg \cdot L^{-1}$) using P25 and BiOCl as photocatalysts

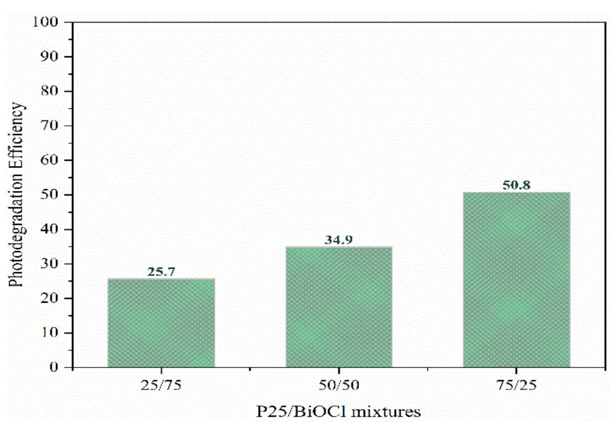

Figure 4 Photocatalytic activity of P25/BiOCl mixtures in degradation of AO7 dye (50 $mg \cdot L^{-1}$)

Figure 4 shows the photodegradation efficiency of AO7 (50 mg·L^{-1}) under UV light using the P25/BiOCl mixtures. The maximum degradation achieved for AO7 dye was using 75/25 weight relation of photocatalysts P25/BiOCl, respectively. It is important to note that load of BiOCl synthesized played an important role, diminishing synthetized BiOCl concentration an increase in the photodegradation efficiency of AO7 dye under UV light illumination was observed.

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Conclusions

In summary, the obtention of BiOCl was successful by solvothermal method, obtained a hierarchical structure like-microspheres with a particle size of 1 - 4 µm and surface area of 41.4 $m^2 \cdot g^{-1}$.

The photocatalytic degradation of AO7 dye was improved using coupled semiconductors (P25/BiOCl). A maximum degradation efficiency (50.8%) was obtained at a weight relation of 75/25. This result suggests, that at low weight loading of microspheres BiOCl promoted the separation of photogenerated charge (electron-holes) and reaction sites, for photodegradation to take place.

This enhancement in the photodegradation of AO7 dye with the photocatalysts mixtures (P25/BiOCl) under UV light, allows to propose the photoactivity evaluation of this mixtures under visible light illumination. Additionally, photocatalysts mixtures can be tested in the degradation of other organic pollutants, such as: drugs and pesticides.

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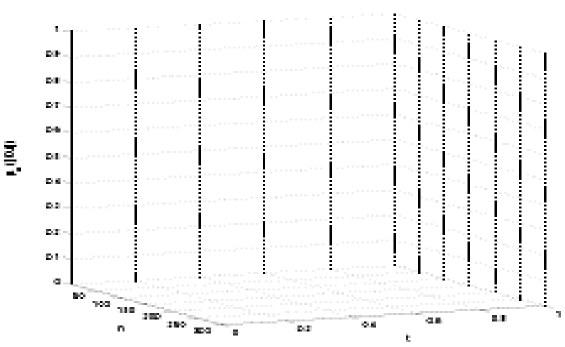

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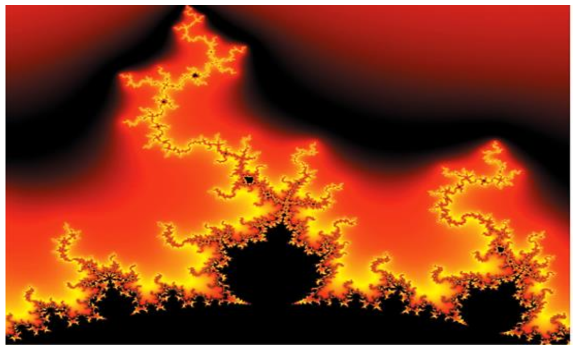

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