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Journal of Technological Engineering

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Knowledge Area

The works must be unpublished and refer to topics of sources innovation in electrical, engineering signal, amplification electrical, motor design science, materials in electrical power, plants management and distribution of electrical energies and other topics related to Engineering and Technology.

Presentation of Content

As first article we present, *Recent advances of graphene-based nanofluids for the application in solar collectors*, by ROSALES-GUZMÁN, Miguel, DÍAZ-SILVESTRE, Sergio Enrique, CANALES-PATIÑO, Eduardo Luis and IBARRA-SAMANIEGO, Lucía del Carmen, with secondment at the Universidad Tecnológica de Saltillo, as the second article we present, *Development of sanitizing system*, by PÉREZ-GALINDO, Liliana Eloisa, SANDOVAL-LUNA, Miguel Ángel, CRUZ-BARRÓN, Alonso and PÉREZ-PASCUAL Agustín, with affiliation at the Universidad Tecnológica Fidel Velázquez, as the third article we present, *Design and construction of a forced convection solar fruit dryer in the municipality of Durango*, by GARCÍA-ARÁMBULA, Cintia Germania, GARCÍA-GODINA, Luis Fernando, CARDOZA-CARRASCO, Martín David and ORTEGA-VALDEZ, Karla María, with affiliation at the Universidad Tecnológica de Durango, as last article we present, *Electronic card applied to the disseminate and collection of information on SARS-CoV-2 in marginalized areas*, by GONZÁLEZ-SILVA, Marco Antonio, with assignment at the Universidad Autónoma de la Ciudad de México.

Content

Article **Journal of Technological Engineering**
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Recent advances of graphene-based nanofluids for the application in solar collectors

Avances recientes de los nano fluidos basados en grafeno para su aplicación en colectores solares

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Abstract

The present work provides a perspective on the recent research on the application of graphene based-nanofluids in different types of solar collectors such as flat plate, evacuated tube, parabolic and linear Fresnel, among many others available. Although significant advances have been reported in this direction regarding the efficiency and short-time stability of the reported dispersions, there remain challenges that need to be addressed before the full potential of these graphene-based nanofluids can be realized. For example, there are not efficient and green routes for the mass production of nanofluids at relatively low cost. In addition, the need for detailed studies on the effect of graphene nanoparticles on the internal surfaces of solar collectors as well as its effect on the pumping systems used is mandatory. Lifetime of the different nanofluids, environmental concerns and recycling of these nanofluids is still a topic to be explored.

Graphene, Efficiency, Solar collectors

Resumen

El presente trabajo provee una perspectiva acerca de investigaciones reciente en la aplicación de nano fluidos basados en grafeno y su aplicación en diferentes colectores solares tales como los de superficie plana, tubos al vacío, parabólicos y de Fresnel, entre muchos otros. Aunque se han reportado avances significativos en esta dirección relacionados a la eficiencia y estabilidad en periodos de tiempo cortos, todavía existen desafíos que tienen que ser superados antes de que el potencial de estos nano fluidos pueda llevarse a cabo. Por ejemplo, se requieren todavía rutas eficientes y verdes para la producción a gran escala de dichos nano fluidos a costo un costo relativamente bajo. De igual manera, se requieren estudios detallados del efecto de las nanopartículas en las superficies internas de los colectores solares, así como en los sistemas de bombeo utilizados. Tiempo de vida de los nano fluidos, efecto sobre el medio ambiente y reciclado de dichos nano fluidos es todavía un tema que está por explorarse.

Grafeno, Eficiencia, Colectores solares

Citation: ROSALES-GUZMÁN, Miguel, DÍAZ-SILVESTRE, Sergio Enrique, CANALES-PATIÑO, Eduardo Luis and IBARRA-SAMANIEGO, Lucía del Carmen. Recent advances of graphene-based nanofluids for the application in solar collectors. Journal of Technological Engineering. 2022. 6-18:1-5.

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Introduction

Energy in all its variations is an essential component of our modern era. Electrical energy, for example, has completely revolutionized our society to the point where it is impossible to imagine a life without, artificial illumination, internet, and mobile phones, amongst many others.

However, the population increase around the world, has led to the necessity of increasing the production of electrical energy. In 2017 it was estimated that the consumption of electrical power in our planet was approximately 108,854 Terawatt-hour, with an astonishing estimated increase of about 28% by 2040 (Shamshirgaran et al., 2018). The concerns have been raised around the world because this demand of energy will not be satisfied by traditional sources of energy such as carbon and petroleum. This is due in part to the fact that these sources are non-renewable, and therefore limited, but also because they have been exploited irrationally. Therefore, the necessity to switch to renewable energies (eco-friendly) is mandatory, being solar energy the main alternative. Along this line, solar collectors and solar cells are the most popular technologies that are taking advantage of a renewable source of energy, the sun. Accordingly, renewable energies can be classified in six big categories:

- Sun energy
- Geothermal energy
- Wind energy
- Hydroelectric energy
- Ocean energy
- Biomass Energy

Solar collectors are one of the most common examples in which the radiation from the sun is converted directly to thermal energy for household applications. Nevertheless, the efficiency of solar collectors is still limited by the use of conventional thermal fluids such as water and ethylene glycol. The alternative is the use of nanofluids that essentially encompass a conventional thermal fluid in which nanoparticles in the order of 100 nm have been dispersed. The main characteristic of nanofluids is an enhanced thermal conductivity and improved heat transfer coefficients in comparison to their base fluids (Chen et al., 2017).

From the great variety of metallic (Au, Ag, Al, Fe, etc.) and non-metallic nanofluids (SiC, ZnO, TiC, C-based) (Nagarajan et al., 2014), probably the ones based on graphene are promising candidates to replace conventional thermal fluids because they are easier to be produced and with relatively low cost.

For this reason, the present review highlights the recent advances in the production of graphene- based nanofluids as applied to solar collectors, current challenges and future perspectives.

Nanofluids

A nanofluid can be defined as a two-phase system in which a continuous fluid matrix contains nanometer-sized particles in the form of a stable colloidal suspension. There are essentially two routes in which a nanofluid can be obtained according to the schematic representation in Figure 1.

a) One-step process: The thermal fluid and nanoparticles are produced simultaneously, for example by ultrasonic energy and appropriate stabilizers.

b) Two-step process: nanoparticles are first produced and then dispersed in the corresponding nanofluid.

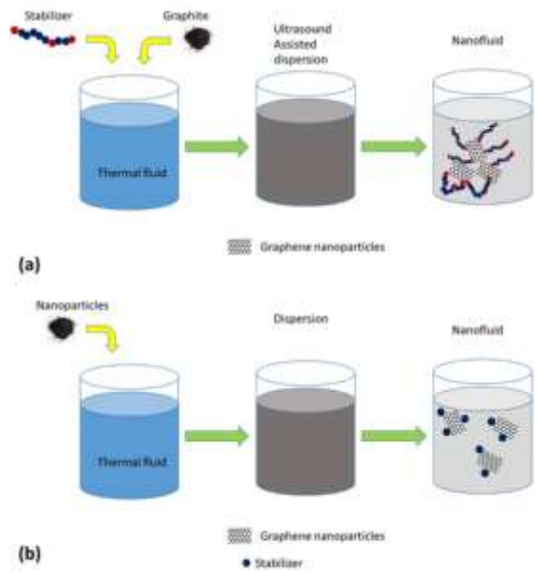

Figure 1 Schematic representation of the production of nanofluids by (a) one-step process and (b) two-step process

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Types of solar collectors

A solar collector can be defined as a device in which the energy from solar radiation is transferred to a liquid or nanofluid. There are principally two types of solar collectors: Non-concentrating and concentrating (Mahian et al., 2021). With respect to the first one, the following examples can be given:

- Flat plate solar collector.
- Evacuated solar collector.
- Direct absorption solar collector.

Regarding the second one, the following examples can be mentioned:

- Parabolic solar concentrator.
- Fresnel solar collector.
- Solar dish collector.

Some of these solar concentrators can be visualized in Figure 2.

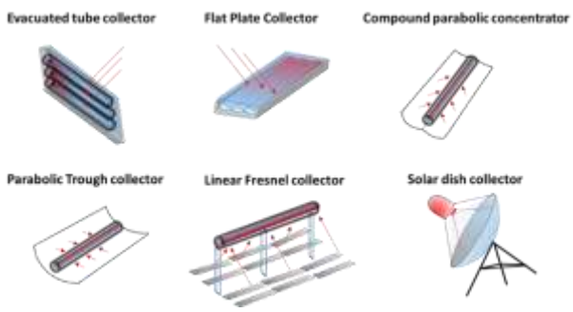

Figure 2 Different types of solar collectors

Recent applications of graphene-based nanofluids in solar collectors

The efficiency of solar collectors is affected by various parameters such as concentration of nanoparticles, flow rate and intensity of radiation in w/m^2. For example, Verma and coworkers concluded that the efficiency of a flat plate solar collector (FPSC) is enhanced by 21.46% at a graphene volume concentration of 0.75 and mass flow rate of 21.46 % in the case of water/graphene nanofluid. Another advantage of using nanofluids is the reduction in area of solar collector. For this same work, a 14.66% reduction in area was obtained at the same particle volume concentration and mass flow rate (Verma et al., 2017).

Later Bioucas and collaborators studied the performance of nanofluids based on graphene and water/ethylene glycol (70:30 % w/w) mixtures at particle concentrations of 0.05, 0.08, 0.10 wt.%. The three different nanofluids were first tested in a controlled environment using a lamp of 1000 W. It was observed that the best performance is obtained at 0.1 wt.% graphene concentration. Later this nanofluid was tested in real conditions resulting in an enhancement of 5.90% in comparison to the base fluid (Bioucas et al., 2018). On the other hand, graphene nanofluids have been studied as potential candidates for applications that involve direct absorption solar collectors (DASC). For example, Shende and collaborators reported an enhance of 18.5% in the thermal conductivity of reduced graphene oxide/deionized water and 17.8% in the case of reduced graphene oxide/ethylene glycol nanofluids(Shende & Ramaprabhu, 2017).

Likewise, the thermal conductivity of water/reduced graphene oxide nanofluids was reported and variations from 9.63% to 33.6% were found in comparison to variations of 7.74% to 26.25% for water/graphene oxide nanofluids when temperature is increased from 30 °C to °80 C (Chen et al., 2017). Both types of nanofluids showed stability after two months. A similar work was carried out and reported, nonetheless, emphasis was given to the stability and antifreeze property of different nanofluids; graphene oxide-water/ethylene glycol and graphene oxide-water with different degrees of reduction using UV-irradiation (Wang et al., 2017). In this research work, dispersions were stabilized with polyvinylpyrrolidone. The zeta potential of the nanofluids based on water/ethylene glycol mixtures at 0.06% mass fraction of graphene oxide was detected to increase with temperature which indicates good stability at relatively high temperatures.

These nanofluids can be used at temperatures as low as -47 °C. In the same work, graphene/oil nanofluids at 0.02, 0.05, 0.1, 0.2, 0.5, 1.0 mg/ml particle concentrations were studied and an increase in the relative thermal conductivity between 4% and 25% was reported. In addition, apparent reduction in the kinetic viscosity of the nanofluids was observed by comparing pure oil and the corresponding graphene/oil nanofluids at ambient temperature.

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The instantaneous heat collection efficiency was measured in a simulated environment and found that the maximum value appears at 30 °C but rapidly declines as the inlet temperature increases which was ascribed to heat loss through the walls of the solar collector. Finally, in a recent work, the thermal performance of a two-phase closed thermosiphon with nanofluids based on water and Al_2O_3 or carbon nanotubes (CNT) was studied and reported. Optimum operating conditions were stated for a nanofluid containing 1.5% CNT.(Carrión M., 2022)

Current limitations of graphene based nanofluids

Despite all the apparent increase in efficiency of solar concentrators with the use of graphene nanofluids, there are still some challenges that have to be overcome. For example, large production of graphene is still made from graphene oxide which is at its time produced by Hummer´s method (Olorunkosebi et al., 2021). This method uses toxic chemicals such as sodium nitrate and sulfuric acid that have large environmental concerns. Although alternatives have been proposed (Zhu et al., 2022), there is too much work to perform on this direction. Other aspect that has not been studied in detail is the effect of the nanoparticles on the wear of internal surfaces (Molina et al., 2013) of the corresponding solar collectors and/or system pumps used. Additionally, the efficiency of the reported nanofluids has not been fully tested in real conditions but in controlled laboratory environments.

Recycling of the nanofluids after its life-time is another aspect that has not been studied. There are only some examples in which this can be done (Liu et al., 2021).

Conclusions

In this work the recent advances in the graphene-based nanofluids and its applications to solar collectors is provided. Aspects as graphene synthesis and efficiency of solar collectors is reviewed. Finally a brief discussion of the current limitations on the state of the art is given.

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Development of sanitizing system

Desarrollo de un sistema higienizador

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Abstract

In accordance with the health emergency suffered at the international level, as a result of the pandemic generated by COVID-19, this research consists of the development of the design of a prototype of a technical full-body disinfection chamber to prevent the spread of COVID-19. 19, Through a research methodology carried out in the best way where it includes the implementation of a descriptive method based on the study and analysis of the existing bibliography, which is characterized by the collection of national and international background information, with the in order to generate a solid database as a guide, mainly focused on the explanation of the operating mechanisms and design methods of disinfection cabinets. At the same time, fulfilling the execution of a series of specific activities, which result in the first place the parameterization of all the elements, both mechanical and electromechanical, necessary for the chamber to be designed, as a second a modeling in Software Solidworks of the chamber of disinfection where it has the design of the electrical circuit of the chamber, design of the hydraulic system, the structure and the electromechanical accessories that the chamber must have.

Development, System, Saniting

Resumen

De acuerdo con la emergencia sanitaria sufrida a nivel internacional, producto de la pandemia generada por el COVID-19, La presente investigación consiste en el desarrollo del diseño de un prototipo de una cámara de desinfección de cuerpo completo tecnificada para prevenir el contagio del COVID-19. Por medio de una metodología de investigación realizada de la mejor manera, donde abarca la implementación de un método descriptivo fundamentado en el estudio y análisis de la bibliografía existente, la cual se caracteriza por la recopilación de información de antecedentes nacionales e internacionales, con el fin de generar una base de datos sólida como guía, principalmente centrada en la explicación de los mecanismos de funcionamiento y los métodos de diseño de cabinas de desinfección. A su vez, cumpliendo la ejecución de una serie de actividades específicas, que dan como resultado en primer lugar la parametrización de todos los elementos, tanto mecánicos como electromecánicos necesarios para la cámara a diseñar, como segundo un modelamiento en Software Solidworks de la cámara de desinfección donde este cuenta con el diseño del circuito eléctrico de la cámara, diseño del sistema hidráulico, la estructura y los accesorios electromecánicos con los que la cámara debe contar.

Desarrollo, Sistema, Higienizador

Citation: PÉREZ-GALINDO, Liliana Eloisa, SANDOVAL-LUNA, Miguel Ángel, CRUZ-BARRÓN, Alonso and PÉREZ-PASCUAL Agustín. Development of sanitizing system. Journal of Technological Engineering. 2022. 6-18:6-11.

† Researcher contributing as first author.

Introduction

This article presents the development and study of a prototype of a sanitising system, which aims to contribute to the reduction of body contamination of viruses and bacteria, mainly the virus called SARS CoV 2 commonly known as COVID-19, which began in December 2019 in the city of Wuhan, China and subsequently the outbreak and contagions identified worldwide led us to two years of pandemic in which a new lifestyle was generated performing all activities both school, work and daily life from home. However, not everyone and not all activities could be carried out in this way, there were exceptions that required staff to attend and move from one point to another, putting themselves and those around them at risk.

Having safe spaces in which there is a sanitised environment is the key to recovering and maintaining the lifestyle that existed before the pandemic, just as the population learned to wash their hands in the correct way, it became natural to see people using masks and masks to protect themselves from the virus, disinfectants were used more frequently in work areas or those areas where people spent more time, in the same way we seek to offer a practical and adaptable solution to everyday life.

An equipment capable of generating a cloud of sanitiser which is not harmful to the user and provides 99% disinfection, so that each and every person who passes through the area in which this equipment is located will be less risk of contagion for each and every one of those who are in that area.

Problem

Countries worldwide are affected by a pandemic, known as SARS-Cov 2 (COVID 19), whose ravages are evident in that health systems are overwhelmed by the high demand for care of patients infected by this virus, likewise the education system was affected by this virus resulting in 2 years of quarantine in which school activities were conducted virtually, however with the vaccine for the virus is expected to resume activities in a manner close to that which had before suffering the pandemic.

On-site activities on university premises can only continue if students, teachers and administrative staff take the necessary precautions and care inside and outside the premises. However, outside the facilities, the care that we find is minimal and inside the facilities may not cover the flow in and out of the entire student community.

Hypothesis

The development of a sanitising system that can be placed in the doors of offices and rooms that are able to spread a sanitiser in a safe and economical way, decreasing with this action the level of viruses and bacteria that could contain each person that crosses this frame.

Objective

To develop a sanitising system to be placed in the entrance doors to offices and/or classrooms of building K of the Universidad Tecnológica Fidel Velázquez to minimise the viral load in the people who enter the building.

Theoretical framework

The creation and implementation of this system requires the analysis of different factors such as the number of people who pass through the facilities on a daily basis, the capacity of the container necessary to maintain a constant flow of liquid. The pressure necessary to avoid humidity in those who pass through the system, therefore, it is necessary to take into consideration the following aspects.

Fluid pressure is the force per unit area exerted by a fluid on the element (pipe) that contains it.

Vaporisation occurs because molecules are continuously projected across the surface of the liquid, due to their thermal energy or vibration.

Frictional energy loss, The viscosity of fluids generates shear stresses when they are in motion.

Friction losses in injection systems and hoses, Similar to the case of friction in pipes, losses in injection systems or fire protection hoses are directly proportional to the length.

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Principle of operation of hydraulic pumps, Hydraulic control valves are operated by two important component parts and by a basic principle of physics. The hydraulic actuator (diaphragm or piston) and the plug are two elements that are in contact with both upstream and downstream pressures, generating forces on them.

Methodology to be developed

Through the research, the bibliographic review of different sources is established with the aim of knowing the types of disinfection booths currently implemented to mitigate the global pandemic of COVID-19 that has affected 185 countries with a total and has seriously damaged the economy. The booths allow a degree of control to be maintained over entry to certain areas, which is why the cleaning and disinfection of people is so important for the prevention, control and eradication of the virus. This is an ideal system for: Public institutions, Medical centres, Event venues, Business and commercial centres, Markets and supermarkets.

Phases of the research

Phase 1. Bibliographic review

Phase 2. Characterise the necessary technical parameters that a disinfection chamber should have, taking into account the type of local population.

- Activity 1. Determine the structural measures required for the chamber.
- Activity 2. Determine the necessary hydraulic equipment used in these facilities.
- Activity 3. Determine materials to be used for the structure of the equipment.
- Activity 4. Determine accessories required for the equipment.

Phase 3. Develop the modelling of the disinfection chamber, its structure and the electromechanical accessories it should have.

- Activity 1. Make the mechanical model of the chamber structure.
- Activity 2. Design the electrical circuit of the chamber.
- Activity 3. Design the hydraulic system of the disinfection chamber.
- Activity 4. Assemble all the cabin systems.

Design the necessary documentation for the start-up of the disinfection chamber.

- Activity 1. Draw up the required drawings of the structure.
- Activity 2. Draw up operating manuals and technical sheets for the equipment.

Elaborate an economic proposal for the equipment

For the development of this objective, it is necessary to establish the parameters observed in the investigations of disinfection processes, taking into account the norms and standards implemented. From different investigations it is intended to know the course of the study, the factors that were taken into account and the results that were achieved, whether advantages or disadvantages. And through this information, the requirements that are needed to carry out the execution of the present project are made. The following is a description of the investigation of booths in different cities of the country.

The process that was carried out was primarily to design and make the booths in software in order to define what electronic devices they were going to use (sensors or buttons) but they decided to make them automatic so that people do not need to come into contact with the booth, they only need to enter, inject the product and leave. After the design, they looked for the materials to manufacture them and started the construction process.

The cabins are made of aluminium structures. The walls are made of PVC bank. They have an automation system and a proximity sensor so that when the person enters, they just put their hand close to the sensor, about 3-4 cm away, and automatically receive the spray or nebulisation of the product, which is a mixture of alcohol (70%), hydrogen peroxide (5%) and drinking water (25%).

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The booths have three atomisers or nebulisers in order to cover the whole body of the person, from head to toe. The injection time is 6 to 8 seconds. They also indicate a number of advantages and disadvantages characterised by:

Advantages

- It is designed so that the person does not come out completely wet.
- Does not stain.
- No risk of causing allergies.
- Disadvantages.
- People do not come out 100% disinfected.

The mechanism of operation of the sanitising arch is by means of a micro-spraying system that prevents viruses and bacteria.

To start with the equipment it will be necessary to take the measurements of the area where the equipment will be placed, taking into account the height, the width of the entrance frame, in this way there will be no problems if the equipment is not custom-made.

Once the information is available, we can start with the prototype of the equipment, in which the main functioning elements will be the hoses, nebulisers, sensors, etc., which will be in charge of spreading the liquid in an easy and non-invasive way.

The solution is constituted as follows:

- Alcohol 70%.
- Oxygenated water 5%.
- Potable water 25%.

Construction process.

Fabrication of the structure.

Implementation of the piping.

Lifting of the PVC structure.

Implementation of sensory equipment.

Connection of the electrical system.

Assembly of the automated system.

Connecting the elements such as hoses and nebulisers in such a way that the necessary pressure of the equipment is maintained in order to obtain the liquid to be sprayed as a gas on the people passing through this area.

Establish a connection between the spraying equipment and the electronic board that will be connected to the ultrasonic sensor which will send the signal to start the spraying process.

Once the connections of the equipment have been made, it will be necessary to implement the power supply for the operation of the equipment. Once the operation of the equipment has been verified, it is possible to move on to the installation and testing of the equipment.

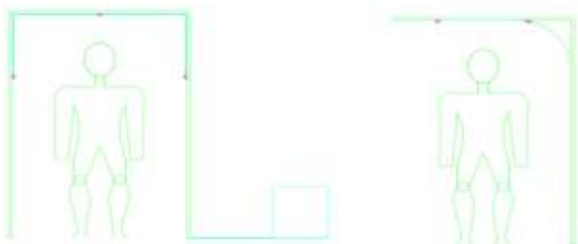


Figure 1 Door frame

Establish an average number of people who will pass through the sanitising frame per day, thus obtaining the amount of sanitising liquid needed for the equipment per day.

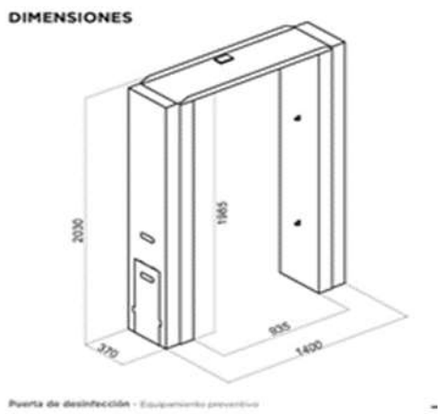


Figure 2 Door frame design

Results

Structural models of the disinfection chamber will be elaborated taking into account the material to be used and a simulation of the structure to define maximum stresses. Also, using other tools, the electrical and hydraulic drawings of the equipment will be drawn up.

Proposed model

The model was tested according to the characteristics and the environment in which the installation was to be carried out. The results were as follows:

The sanitising system does not have enough space to include its storage tank.

The distance between the sprinklers and the proximity sensor is too short, so the liquid would interfere and even damage the sensor.

In the case of not including a storage tank for each system, a piping system should be installed on the premises.

The infrastructure is not in place to make the piped connections, a person would be needed to maintain each and every one of the installed systems.

The system would have to be refilled and monitored at certain times to prevent the system from running out of liquid.

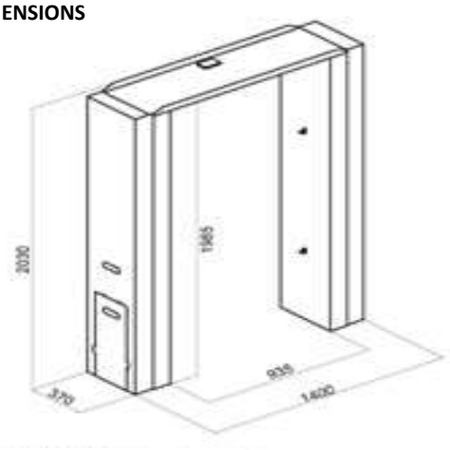
The cost of this system would be too high with current technology.

Alternative

Cabin disinfection system.

No additional piping would need to be installed in the facility, the sensor is protected and performing its function, the storage tank can be of larger capacity and one can be installed per building, which would reduce the investment cost. Maintenance can be carried out by one person. It fulfils the function of disinfecting everyone who passes through it.

DIMENSIONS



DISINFECTION DOOR

BILL OF MATERIALS FORAUTOMATIC SPRINKLER						
TOTAL	MATERIAL					COST
						.
1	BOMM MICRO DIAPHRAGM PUMP 12V 3A 60W					
3	SPRINKLERS AND NOZZLE					KIT 1700 MX
	SUPPORT (STRUCTURE WHERE THE HOSES AND SPRAYERS WIL BE)					
1	HOSE d=4mm, 5m.					
1	FILTER PP COTTON					
1	ULTRASONIC SENSOR					60 MX
1	CONTROL BOARD WITH TIMER					78MX
1	CABLE					
					APPROX	1838MX

Table 1 List of materials

Funding

The development of this prototype was self-funded. A breakdown of costs is shown below.

Conclusions

This prevention system complements the sanitary measures recommended by the health authorities and helps to mitigate the risk of infection of diseases caused by viruses and bacteria. The design of the optimal cabin was based on the revision of transcendental points such as the position and ignition of the sprinklers, the decontamination process at the entrance of the cabin and the adequate selection of materials for its basic structure. In this way, the health of teachers, students or any other person entering the facilities can be monitored, prevented and controlled.

In accordance with the research carried out, the characterisation of the necessary technical parameters that a disinfection chamber must have, taking into account the type of local population, is concluded. The results obtained allow the evaluation of a series of investigations which were a guide for the authors in relation to the types of materials used, nominal measurements, among other factors.

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Secondly, the disinfection chamber, its structure and electromechanical accessories were modelled using software. The design was distributed by means of geometrical drawings which show the nominal measurements of the structure.

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Design and construction of a forced convection solar fruit dryer in the municipality of Durango

Diseño y construcción de un secador solar de fruta por convección forzada en el municipio de Durango

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Abstract

The main aim is the design and build of a Convection Forced Solar Dryer used to dry Spicy Pineapple. The prototype was designed using Inkscape 1.1.2 software with 60cm*44cm*44cm dimensions, having a Drying chamber of 5 trays, two air-circulation serpentine heaters on top and back of the drying chamber and two solar modules of 6v each to power some fans to force convection. The main material used was MDF laser cutted for assembly, then black paint was applied due to the absorption capability and finally water sealer for humidity protection. Finally tests were carried on in State of Durango with Mean Solar Radiation of 5.7 kWh/m^2*day been 6.5 the Peak Sun Hour on may, concluding on three days' time needed for drying 3 kilograms of Spicy Pineapple, average initial temperature of 28°C and 55°C max, humidity reduced from 55% to 24% inside the system.

Solar dryer, Relative humidity, Solar radiation

Resumen

En la presente investigación se tuvo como objetivo el diseño y construcción de un secador solar de convección forzada para conservar piña enchilada. Se diseñó en el software Inkscape 1.1.2 con las dimensiones de 60cm*44cm*44cm, consta de una cámara de secado con cinco charolas, dos cámaras de circulación de aire anexas una en la parte superior y otra en la anterior cuyo sistema es similar a un serpentín de condensación y dos paneles solares de 6v lo cuales alimentan a los ventiladores en el proceso. El principal material utilizado para la construcción fue MDF utilizando una cortadora laser para su posterior ensamblado, se utilizó pintura color negro por su capacidad de absorción y sellador para protegerlo de la humedad. Al terminó del ensamblado se evaluó su funcionamiento en el Estado de Durango teniendo una radiación Promedio de 5.7 kWh/m^2*día y siendo el mes de mayo la radiación solar promedio de 6.5 HPS terminando con un tiempo de secado para la piña en 3 días para 3 kilogramos, con una temperatura promedio inicial de 28°C y una temperatura máxima promedio de 55°C, así mismo los valores de humedad relativa dentro del sistema variaron desde 55% a 24%.

Secador solar, Humedad Relativa, Radiación Solar

Citation: GARCÍA-ARÁMBULA, Cintia Germania, GARCÍA-GODINA, Luis Fernando, CARDOZA-CARRASCO, Martín David and ORTEGA-VALDEZ, Karla María. Design and construction of a forced convection solar fruit dryer in the municipality of Durango. Journal of Technological Engineering. 2022. 6-18:12-17.

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† Researcher contributing as first author.

Introduction

Food preservation is necessary for the daily life of human beings, as well as for the development of the population, with the increase in the cost of electricity, it is therefore necessary to take up alternative sources of energy for food preservation, one of the most widely used techniques is the drying of food using solar energy (Maupoey, 2001), either directly or indirectly (Lingayat, Chandramohan, Raju, & Meda, 2020); indirect exposure drying is preferred for the controllability of food quality, as it is possible to control the process by measuring the Water Activity (Aw) ensuring the quality of the final product (Badui Dergal, 2006).

Another advantage of the use of solar dryers is the prevention of the generation of Greenhouse Gases (GHG) in food preservation, and by reducing the mass and volume of the food by eliminating the water content, it is possible to reduce the cost of storage. The State of Durango is located at a latitude of 24.0277, longitude of -104.653 24° and 1′ 40″ North, 104° 39′ 11″ West presents an average radiation potential of 5.7 kWh/m²/day, thus providing optimal conditions for development and implementation of photovoltaic and photothermal solar energy systems. based on this it was decided to develop a solar dehydrator for residential use, using low cost and high availability materials such as MDF for mass marketing. The climatic conditions of the average temperature and relative humidity in the study area according to (CONAGUA, 2022) were identified as 24.7 and 25.8 respectively, whose values were considered for the sizing of the solar dryer.

Inkscape 1.1.2 design software was used to create and edit lines, graphics and design images. The system was then laser cut, assembled, painted and sealed. The drying time was approximately 3 days, during which time temperature and humidity measurements were taken inside the system in order to evaluate its performance. It is recommended to carry out thermodynamic analyses of the system, as well as tests to determine the quality of the product in accordance with NOM-044-FITO-1995 (DOF - Diario Oficial de la Federación, 1999).

Development

Characterisation of the study area

This project was carried out for residential use in the municipality of Durango, so the following climatic conditions were considered for the month of May 20202, according to CONAGUA 2022.

Climatological variable	Value
Precipitation	0
Relative humidity	27.3%
Solar radiation	670 w/m^2
Wind speed	4.08 k/h
Temperature	14-24°C

Table 1 Climatic conditions
Source: (CONAGUA, 2022)

Forced convection solar dryer design

Inkscape 1.1.2 software was used for the design of the system, its dimensions were 60cm*44cm*44cm. The stages of the design and construction of the solar dryer are shown below:

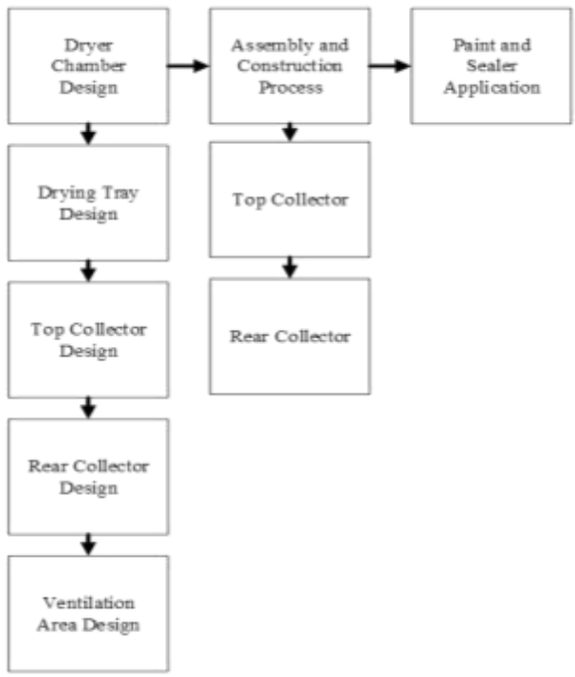

Figure 1 Flow diagram of the design and construction of the solar dryer
Source: Own elaboration

We started with the drying chamber in which we considered 5 previously sealed trays for fruit drying, with a capacity of 600 g of fruit each.

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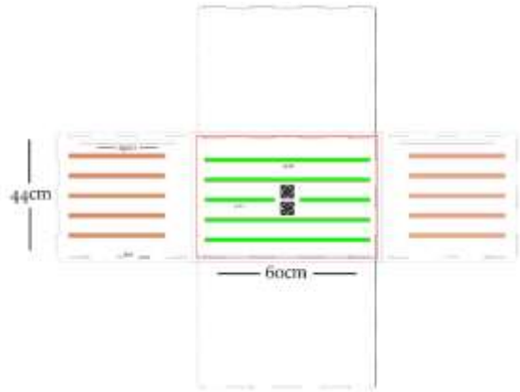

Figure 2 Design of drying Chamber in Inkscape
Source: Own elaboration

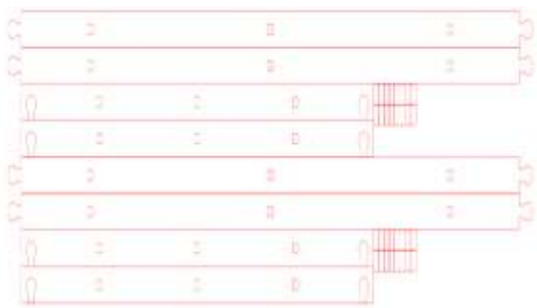

Figure 3 Design of drying trays Pieces in Inkscape
Source: Own elaboration

For the Upper Collector a condensing coil system was considered inside which the air was heated by the sun rays and therefore its air velocity increased and went directly into the drying chamber.

In Figure 4 the black arrow indicates the cut for assembly of the parts having a serpentine type assembly, the green arrow indicates the air circulation inlet, the blue arrow indicates a reduction in the circulation area for an increase in the air flow velocity.

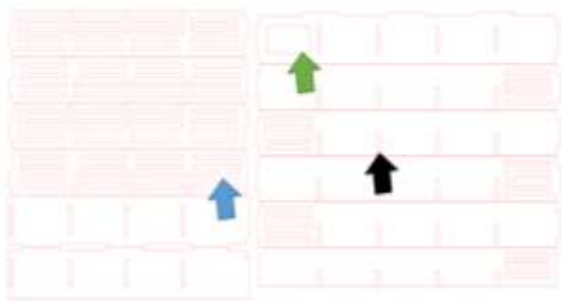

Figure 4 Design of Upper Collector parts in Inkscape
Source: Own elaboration

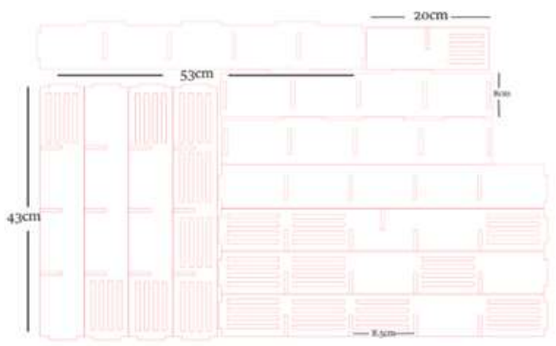

Figure 5 Inkscape rear manifold part design
Source: Own elaboration

The rear collector measures 53cm*43cm*8cm with circulation spaces of 5cm, these dimensions allow to support the glass which is the final layer of this chamber. For the forced convection, there are two 40mm x 40mm fans for the circulation of hot air, and thus have an adequate flow for drying, these will be powered by a 6v solar panel, with a capacity of 330mA, sufficient to achieve the operation of both fans.

Assembly, painting and sealing of the system

The parts were manufactured on the CO2 laser CNC using parameters of 10mm/s speed and 30% laser power. The parts were assembled, having first the sides, and the placement of the trays, as well as the top and bottom of the drying chamber, as shown in the following images:

Figure 6 Drying chamber assembly
Source: Own elaboration

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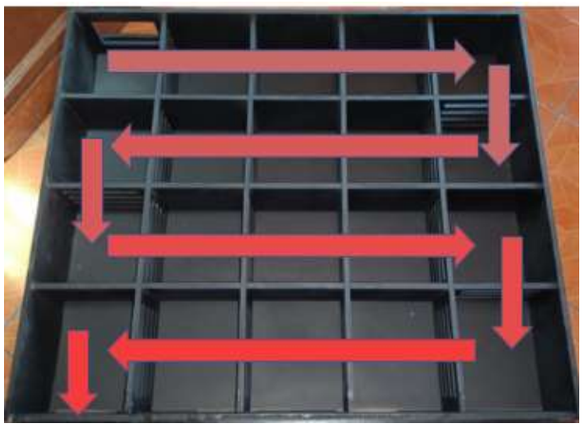


Figure 7 Airflow in the upper collector
Source: Own elaboration

Figure 8 Air Flow in the rear collector
Source: Own elaboration

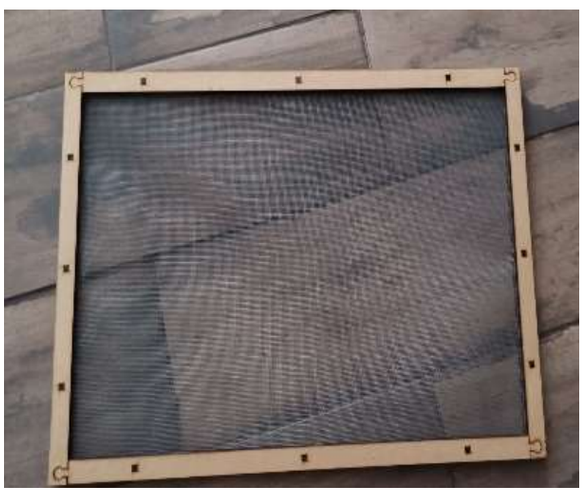
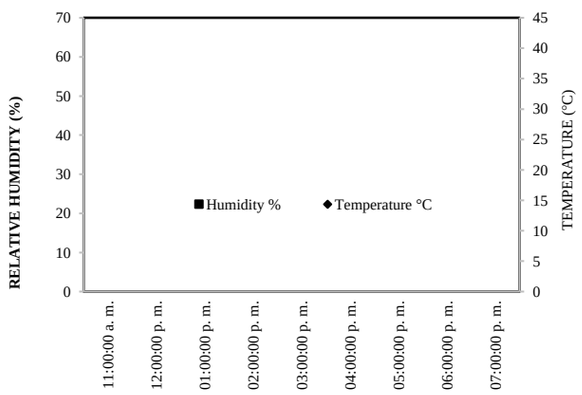


Figure 9 Drying tray assembly
Source: Own elaboration

Figure 10 Final finish of the solar dryer
Source: Own elaboration

Drying of honey pineapple under ambient conditions

Approximately 3kg of piñamiel were placed to dry at ambient conditions corresponding to the month of May. The temperature and humidity inside the system were measured and the following values were obtained:



Graphic 1 Dehydration test - day one
Source: Own elaboration

Measurements were taken from 11:000 am to 18:00 h, as shown in graph x, the highest temperature in the system was recorded at 16:00 h with a temperature of 43°C and a relative humidity of approximately 38%.

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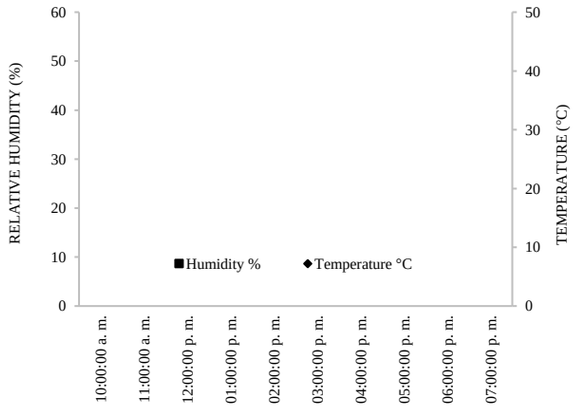
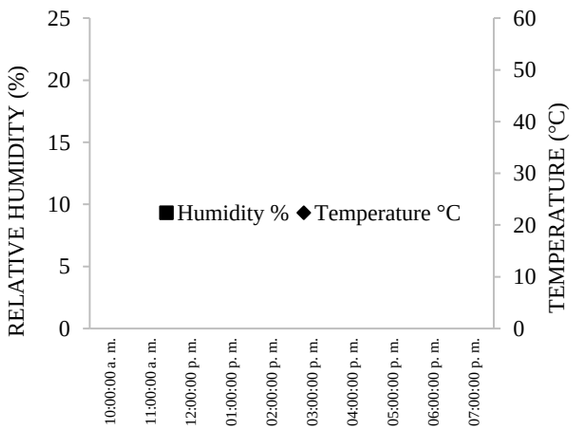


Graphic 2 Dehydration test - day two
Source: Own elaboration

As can be seen, the initial temperature was 28°C, and relative humidity was 54%. One hour later, after the fans had been turned on by the solar cells, and the humidity in the drying chamber had levelled off, the temperature increased to 39°C and the humidity dropped to 39%, For the next hour at midday the temperature increased to 44°C and the humidity decreased to 36%, in comparison to the previous day a decrease in humidity can be observed, serving as a reference that the pineapple is following the dehydration process, the highest temperature on this day was at 5: 00 p. m., also coinciding with the lowest humidity, achieving a temperature of 45°C with a humidity of 19%, ending at 7:00 p.m. with a humidity of 25%, having a humidity 50% lower compared to the previous day and its temperature was 31.5°C.



Graphic 3 Dehydration test - day three
Source: Own elaboration

As can be seen in this graph, the humidity started with 23%, and a temperature of 30°C, this at 10:00 am. After two hours it can be seen that the humidity dropped sharply, having 15% humidity and 52°C temperature, equalling at that time the humidity of the environment, the following two hours, this humidity rose due to a decrease in the temperature of the dehydrated, this thanks to the fact that the day was not completely sunny, the temperature was 49°C and a humidity of 17%, to finish the dehydration process at 5:00 p.m. with a constant humidity: 00 p.m. with a constant humidity of 15% and a temperature of 52°C, it is observed that in the temperature decrease there was no increase in humidity, which indicates the completion of the process.

Cost estimation of the system

The following table shows the costs for the production and assembly of the solar dryer.

Description	Unit cost (MXN)	Quantity	Total cost (MXN)
Sealer	130.00	1	130.00
Paint Can	50.00	3	150.00
MDF 5.5mm	320.00	1	320.00
Laser	20.00	7	140.00
Solar panel 6v	110.00	1	110.00
Fan 40mm	80.00	1	80.00
Glass plate 3mm	110.00	2	220.00
Mesh	5.00	5	25.00
Power	150.00	1	150.00
Labour	250.00	1	250.00
		Total:	1575.00

Table 2 Unit and total costs
Source: Own elaboration

Conclusions

The efficacy of the design was proven, as well as presenting lower manufacturing costs than those found on the market, resulting in a technically and economically viable solution, as solar dryers with similar capacities were found available to the public for more than 3 times the cost of the prototype presented in this document.

The objective of the next stage of the project is to obtain the drying curve characteristic of the process, in addition to the thermodynamic analysis of the system. As for the product, a quality analysis is planned.

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Electronic card applied to the disseminate and collection of information on SARS-CoV-2 in marginalized areas

Tarjeta electrónica aplicada a la difusión y recolección de información sobre SARS-CoV-2 en zonas marginadas

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Abstract

According to the World Health Organization, misinformation is a threat to public health. In the case of the SARS-CoV-2 virus, not knowing and rejecting the use of vaccines makes people vulnerable and puts control at risk deaths from contagion in the communities. The information media that have been used to publicize the use of vaccines and other recommendations are mostly digital and radio communication such as Internet sites, mobile applications, radio, and television, which do not have enough coverage in many communities. The development of this project is aimed at showing a portable hardware prototype that allows the disseminating information on the use of vaccines and recommendations to reduce the effects of the SARS-CoV-2 virus in marginalized communities. For this, the design of an electronic card capable of reproducing audio in a chosen language or dialect is presented. The purpose of the audio is to include sectors of the population with communication problems such as illiteracy that could exist in these areas. In addition, the card allows you to save certain geographic data of the places where it is distributed and the possible contagions in it for later analysis.

Prototype, Disseminating, Geographic

Resumen

De acuerdo con la Organización Mundial de la Salud, la desinformación es una amenaza para la salud pública. En el caso del virus SARS-CoV-2, no conocer y rechazar el uso de vacunas hace vulnerables a las personas y pone en riesgo el control de muertes por contagio en las comunidades. Los medios de información que se han utilizado para divulgar el uso de vacunas y otras recomendaciones son en su mayoría digitales y de radiocomunicación como sitios en Internet, aplicaciones móviles, radio y televisión, los cuales no tienen suficiente cobertura en varias comunidades. El desarrollo de este proyecto va orientado a presentar un prototipo de hardware portátil que permita la difusión de información sobre el uso de vacunas y recomendaciones para mitigar los efectos del virus SARS-CoV-2 en comunidades marginadas. Para ello se presenta el diseño de una tarjeta electrónica capaz de reproducir audio en algún lenguaje o dialecto elegido. El audio tiene la finalidad de incluir a sectores de la población con problemas de comunicación como el analfabetismo que pudieran existir en estas zonas. Además, la tarjeta permite guardar ciertos datos geográficos de los lugares donde se distribuye y los posibles contagios existentes en ella para su análisis posterior.

Prototipo, Difundiendo, Geográfico

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Introduction

According to figures from the World Health Organization (World Health Organization, 2022), on its website on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), known as covid-19, 519,105,112 cases of infection have been reported worldwide, with Mexico in 21st place with 5,745,652 registered cases. These figures correspond to the month of May 2022.

This virus, which is transmitted between people, has mutated naturally, producing new variants, some of them more contagious (Islam, 2022). In various regions of the world, strategies have been implemented to reduce its spread, such as patient isolation, home quarantine, hygiene, closure of public places, vaccination of the population and dissemination of information through different media such as radio, television, Internet, mobile applications, among others. However, there have also been outbreaks, i.e., an increase in the number of cases of infection and deaths. This is why it is important to maintain some of these measures, such as vaccination and the dissemination of timely information to the population.

In this context, the United Nations (UN) has published that this pandemic has disproportionately affected the population, with indigenous peoples being the most vulnerable due to widespread discrimination. In the information published by this organisation, it is mentioned that governments in each country have had a mixed response, that is, while some implement exclusive programmes dedicated to dealing with the virus in marginalised areas, others do so in a limited or non-existent manner (United Nations, Human Rights, 2020).

Recent studies show that socio-economically vulnerable communities and individuals are at higher risk of COVID-19 infection and death (Watchler et al 2020). This inequality is related to, among other things, poor access to and lack of knowledge about information.

In Mexico, the National Institute of Indigenous Peoples (INPI) has carried out prevention and communication actions towards these communities to address covid-19. These actions include:

a) Distributing food packages in substitution of what is offered in indigenous children's homes and canteens.

b) Liaison with the Inter-Institutional Technical Group (GTI) to obtain information on public health, which in turn is transmitted to the communities. It is not specified how this information is disseminated.

c) Informative actions in social networks and based on indigenous languages on prevention measures to be followed. Use is made of Internet portals.

d) Dissemination of information through cultural radio stations (SRCI).

e) Production of cultural, educational and health materials. The published information does not specify how this material is delivered to the communities.

Although these actions are a great step towards the containment and mitigation of the effects of covid-19 in indigenous areas, it is considered that it is necessary to monitor the results obtained. Some of these actions may even have a short reach, that is, the information is not reaching the whole community, but only certain areas or groups.

The lack of communication technology, which is very common in these regions, limits the coverage of territories far away from the central areas, where the information is disseminated in the first instance. Furthermore, the inclusion of groups with learning and communication deficiencies, such as illiteracy, has not been considered.

The incorporation of new strategies to inform certain sectors of the population and the constant monitoring of all geographical areas is of utmost importance if the spread of the disease is to be controlled and the number of serious cases of infection reduced. An alternative is the use of media that are easy to transport and distribute in hard-to-reach areas where there is little or no communication technology.

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Hypothesis

The design and development of a prototype of a printed and electronic information medium (e-card/e-brochure) will help to disseminate information about covid-19 in hard-to-reach geographical areas and inform groups of people with reading difficulties. In addition, it will be possible to collect information on cases of infection and vaccinated persons in a certain region.

Objective

To design an electronic booklet capable of reproducing audio and storing geographic data that is linked to information variables about covid-19 in a population. The circuit, which forms the electronic part of the prototype, should be hidden inside a paper leaflet for easy transportation.

To define the structure of the circuit and its operation, this work was based on a prototyping methodology with a quantitative approach. For the hardware part, a development platform with an Arduino microcontroller was used, where the various components were integrated to test their operation and interconnection.

The structure of this work is organised as follows. In section 2, methodology, the techniques used in this project are mentioned. Section 3, development, details the structure, implementation and functional testing of the proposed board. Section 4 presents the tests and conclusions of this work. Section 5, references, shows the documentation consulted.

Methodology

Because of its evolutionary approach, the prototyping methodology has been used in many of the hardware developments where integrated circuits are used (Poure et al 2000), allowing short-term improvements to be planned and adapted to the needs detected.

In this project, a descriptive prototyping methodology was used. As such, there is no client to specify the functional requirements, but these are defined through the descriptive analysis method and adapted to the needs defined in the context of indigenous communities.

Requirements gathering and refinement:

Needs: Disseminate information quickly and concisely in hard-to-reach communities on the use of vaccines and recommendations against covid-19. Adapt information to existing language diversity and reading comprehension problems. Store geographic data on where information is disseminated. From the areas covered, store information on possible covid-19 cases and people with or without a vaccination schedule.

Functional requirements:

Prototype to allow audio message to be recorded and played back in different languages or dialects. Allow basic iteration for a user to save binary responses about covid-19. Saving geographic coordinates is desired. Avoid, to some extent, redundancy of saved data.

Non-functional requirements:

Maximum hardware dimensions of 20 x 15 cm, for easy transportation and incorporation into printed material (brochure). It does not require the use of the Internet or manipulation with a smart device.

For a better use of the card, it is considered the premise that only one of them can pass from hand to hand between users and be placed in different places for consultation.

Rapid design:

Prototype based on electronic cards, playing audio with some switch. The audio will be a message about the use of vaccines and recommendations against covid-19 in different indigenous languages. Use of a controller circuit capable of receiving binary responses from users by pressing two buttons that are included, the responses expected to be received from users have to do with whether or not there are covid-19 cases at home and whether or not the person is vaccinated. This binary data will be stored in an internal EEPROM memory of the circuit and will be related to geographical coordinates that are obtained periodically through a GPS sensor. By means of an algorithm running on the circuit, a spatial distribution of covid-19 cases and vaccinated persons in a given area can be generated.

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Development

According to the rapid prototype design, the block diagram of the electronic circuit is shown in figure 1.

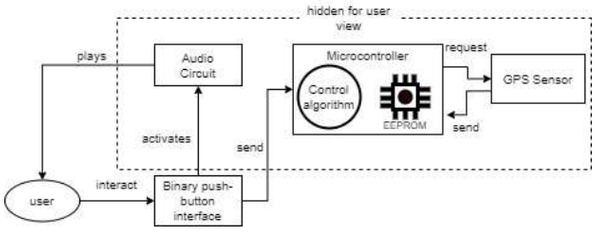

Figure 1 Block diagram of the electronic circuit of the portable multimedia prototype

The components of the above diagram are discussed below.

A. Audio Circuit. The purpose of this element is to store information in audio format for broadcasting. According to Have and Stougaard 2020, the incorporation of audio in reading materials allows information to be adapted to various needs. In this case, illiteracy, use of different languages or dialects in marginalised communities would be needs to be covered.

For this project, the Ashata FLR100A-B V.1.6 circuit was used. This circuit is capable of recording audio for up to 120 seconds. By means of a push button the user can play back the previously recorded audio.

B. Binary push-button interface. Another objective of this project is to obtain information about covid-19 from the community where the electronic cards are distributed. For this purpose, two push buttons, which are visible to the user and connected to the microcontroller, were used. By means of the information printed on the card or the playback of the recorded audio, the following questions are asked:

- Are there currently COVID-19 positive cases in your household?

- Are there any unvaccinated COVID-19-positive adults in your household?

By means of the buttons, the user enters his answers and these are stored in binary format in the microcontroller according to the status of the button:

Pressed = 1 (affirmative answer).
Not pressed = 0 (negative response).

By joining both binary responses, the following four combinations can be obtained: 00, 01,10,11. Where the first bit in each combination is the answer to question (a) and the second bit is the answer to question (b). This defines the following coding of table 1.

	Question (a)	(b)	Decimal coding (dc)
Response values	0	0	0
	0	1	1
	1	0	2
	1	1	3

Table 1 Coding of responses on COVID-19

Push-button data generation has been used in various automation and variable sensing projects, where fast interaction and easy adaptation to prototypes is required (Knapen and Holmgren, 2020).

The pushbuttons used in this project are of the simple open-circuit switch type.

C. GPS sensor. A global positioning system known as GPS (Global Positioning System) can obtain geographical coordinates of any object on earth. For some applications such as tourism, route finding and navigation, the accuracy of these systems is sufficient for their operation, ranging from 3 to 6 metres (Castro et al., 2020).

For this project, the GPS module model GY-GPS6MV2 was used, which has a ceramic antenna and a baud rate of 9600.

D. Microcontroller. When in an electronic system it is desired to control the operation of a given task, the most common solution is to use microcontrollers. Currently, these are integrated circuits that execute instructions stored in their memory and once programmed only serve to perform the planned task (Palacios et al., 2014).

There are development boards with microcontrollers on the market that are the basis for embedded systems solutions, the internet of things, automation, etc. Among the development boards most commonly used in the design of these prototypes is the Arduino from Atmel (Badamasi, 2014).

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For this project, an Arduino nano ATmega328 board equipped with a 1 KB EEPROM was used.

It is in this EEPROM memory where the data obtained from the GPS module is stored. Through the TinyGPS library, compatible with all Arduino architectures, it is possible to decode the signal sent from the GPS and display the latitude and longitude values in decimal coordinates. The format of the possible values obtained for these two variables is shown below:

$$\text{Latitude}_{\text{tyni}} \,/\, \text{Longitude}_{\text{tiny}} = \text{sign} + num_{integer} + num_{fractional} \quad (1)$$

Where:

- $\text{Latitude}_{\text{tiny}}$ / $\text{Longitude}_{\text{tiny}}$: These are the numeric values of the latitude and longitude variables, respectively, returned by the TinyGPS library.
- sign: positive or negative sign of the returned number.
- $\text{num}_{\text{integer}}$: integer part of the returned number.
- $\text{num}_{\text{fractional}}$: the fractional 6-digit number returned.

Since the values of these variables are stored in binary format, then the following maximum and minimum conditions must be taken into account for their storage:

The possible integer values you can take from the variable $\text{Latitude}_{\text{tiny}}$ are [-90,90].

The possible integer values you can take from the variable $\text{Longitude}_{\text{tiny}}$ are [-180,180].

To eliminate rounding errors due to fractional conversions between decimal and binary systems when storing the values, and taking into account conditions (i) and (ii), it is proposed to use a long type variable in Arduino to store the coordinates returned by the GPS.

Since a long type of variable can only store integers, a conversion will have to be made to eliminate the fractional part of $\text{Latitude}_{\text{tyni}}$ and $\text{Longitude}_{\text{tiny}}$ but without reducing the precision of the numerical value obtained. For this purpose, the following formula is used:

$$\text{Latitude}_{\text{integer}} = \text{Latitude}_{\text{tiny}} * 1000000$$
$$\text{Longitude}_{\text{integer}} = \text{Longitude}_{\text{tiny}} * 1000000 \quad (2)$$

Where:

$\text{Latitude}_{\text{integer}}$ and $\text{Longitude}_{\text{integer}}$ are the GPS coordinate values of a point whose decimal point was shifted 6 positions to the right.

In Arduino, long is a variable that can store signed numbers between -2, 147, 483, 648 and 2, 147, 483, 64, and requires 32 bits of space. Thus, each stored location point will occupy a space of 8 bytes in the EEMPROM.

Linking COVID-19 responses with GPS coordinates.

According to the explanation of the components Binary push-button interface and Microcontroller, the electronic board obtains COVID-19 data from a community and GPS coordinates.

To make the relation between both data the following formula is used where one of the values obtained in (2) is used

$$\text{Latitude}_{\text{final}} = (\text{Latitude}_{integer} * 10) + dc \quad (3)$$

Where:

$\text{Latitude}_{\text{final}}$: value linking COVID-19 responses to latitude data of an area.

dc: coding value defined in table 1.

This way the data is stored as shown in figure 2.

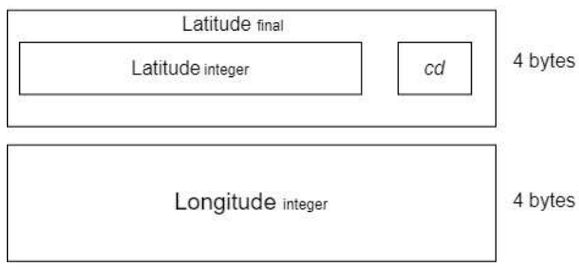

Figure 2 Storage format of GPS coordinates and COVID-19 responses in EEPROM

To illustrate this process, the following example is described:

It is assumed that a user's answers to questions (a) and (b) had a dc value of 2, according to table 1.

The data obtained from the GPS in format (1) were:

$Latitude_{tiny}$: 19.426991
$Longitude_{tiny}$: -99.167646

Applying (2) we obtain:

$Latitude_{tiny}$: 19,426,991

$Longitude_{integer}$: -99,167,646

Applying (3) to $Latitude_{integer}$ gives:

$Latitude_{Final}$ = (19,426,991)*10+2 = 194,269,912

As can be seen in this example, in the result of $Latitude_{final}$ the least significant figure indicates the value of cd which seems to have been concatenated to the value of $Latitud_{entire}$. This composite and encoded value, obtained from (3), is the one that is stored in the EEPROM memory. When retrieved, the reverse process is done to obtain the cd and $Latitude_{tiny}$ data for further analysis. For the case of $Longitude_{tiny}$, it does not carry any linked response and is stored in memory as obtained from formula (2).

Control algorithm. This element is the code executed by the microcontroller to coordinate the tasks of the circuit, including data storage.

According to Figure 2, 8 bytes are required to store the geographic coordinates of a point (latitude and longitude) and the responses at that location from a user on covid-19 data in cd-encoding. If it is known that the microcontroller has a memory of 1024 bytes, then up to 128 different points can be stored on a single card.

On the other hand, it is desired to reduce the redundancy of stored data, i.e., not to store the data of a point and its close surroundings more than once. It is considered that, if the data of a point p1 is already stored, neighbouring points located at a distance ≤ X from p1 provide information of the same group of persons.

For this purpose, we consider implementing a function that calculates the distance between two geographic points using Haversine's formula, used in place mapping and information analysis projects (Vinayak et al., 2016), and shown below:

$$d = 2r\sin^{-1}\left[\sqrt{sen^2\left(\frac{lat2-lat1}{2}\right) + \cos(lat1)\cos(lat2)\,sen^2\left(\frac{lon2-lon1}{2}\right)}\right] \quad (4)$$

Where:

d is the distance obtained between two points

r is the radius of the earth (6371 km)

lat1, lat2 are the latitude values and lon1, lon2 are the longitude values of any two points.

In case the distance calculated by (4) between the current point and any other point stored in EEPROM is ≤ X, then that data is not stored. The value of X could vary according to the populations, in rural areas dwellings follow a less uniform dispersion pattern than in cities.

Tests and Conclusions

To test the functionality of the proposed circuit, data collection tests were conducted in a square and inhabited area of approximately 39,416 m², located in the municipality of Villa de Tezontepec in the state of Hidalgo, Mexico. Due to the dispersion of houses in this place, an X value of 10 metres was considered, mapping the area as shown in figure 3.

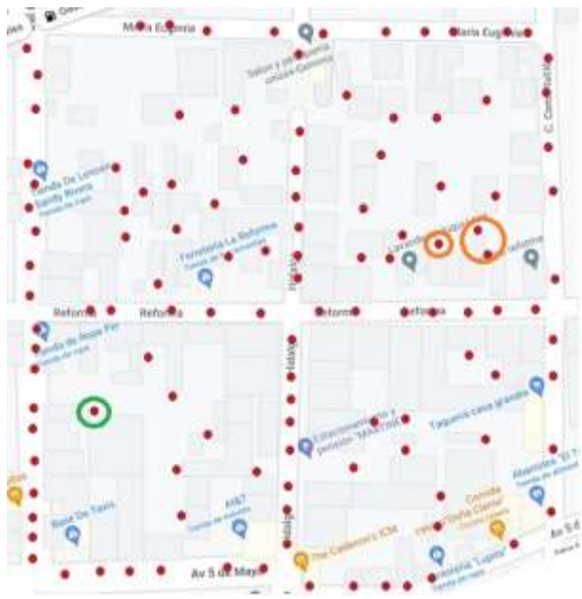

Figure 3 Measuring data collection via the portable electronic card in an urban area

Figure 3 shows the test area with the location of the data collection sites (red dots). According to the information on the map there are approximately 140 houses and/or businesses in this area, of which 121 samples were obtained, representing 86%.

The collection tests consisted of manually moving the electronic card to each house and/or business located in the area and to which access could be gained. At each location, the prototype was handed to a person who answered the questions via the button interface.

According to the sub-directorate of epidemiology of Hidalgo, in its technical report of April 2022 (Sinave, 2022), there are no active cases of covid-19 in this locality. However, during the sampling, three responses with positive cases were recorded; these points are encircled in orange in Figure 3.

These three points represent 2.4% of the total number of infected samples, which is very close to the 0% that should have been obtained according to official data from the region. It is considered that, due to the proximity of two of these points, it could be the same case; another option is a misinterpretation by the user when using the prototype, generating a false response, or real data, but not officially recorded.

With regard to the cases of adults without any vaccination schedule, only one case was recorded, which is shown in a green circle.

From the data obtained from these tests, it can be seen that there is a favourable trend in the collection of data that coincide with the real data of the population. In addition, a high percentage of the population of an area with certain characteristics can be covered with a single card.

In the next phase of this project, the aim is to carry out tests in areas where there is no control over the prototype's route or assistance to users in handling it.

It will also be sought that the dispersion of houses is greater and test the coverage that can be achieved.

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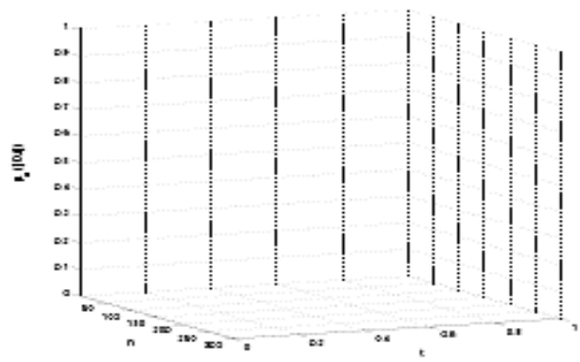

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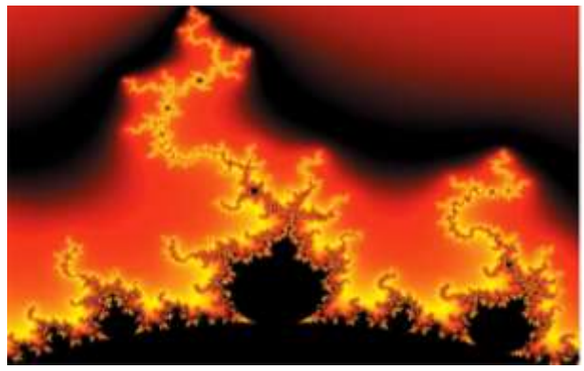

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