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The works must be unpublished and refer to topics of optical astronomy, optical characterization, optical encoder, experimental research, planetary magnetic fields, ultraviolet radiation, lasers, algorithms and optical waves and other topics related to Physical Sciences Mathematics and Earth sciences.

Presentation of the content

In the first article we present, *Analysis of speckle patterns in electronic devices for the monitoring of current changes*, by LÓPEZ-ÁLVAREZ, Yadira Fabiola, JARA-RUÍZ, Ricardo, RODRÍGUEZ-FRANCO, Martín Eduardo, and DELGADO-GUERRERO, Sergio Humberto, with adscription in the Universidad Tecnológica del Norte de Aguascalientes and the Universidad de Guadalajara, Lagos de Moreno, in the last article we present, *Study of the mechanical properties of magnetic composites supported on a PU matrix*, by MARTINEZ-MORENO, Miguel, FUENTES-RAMÍREZ, Rosalba, CONTRERAS-LOPEZ, David and GALINDO-GONZALEZ, Rosario, with adscription in the Universidad de Guanajuato, in the last article we present, *The emotions of upper secondary level students in a virtual learning environment*, by FLORES-GONZÁLEZ, Efigenia, with adscription in the Benemérita Universidad Autónoma de Puebla, in the last article we present, *Creating a backscatter multispectral mosaic with the R2Sonic 2024 Echosounder*, by AGUILAR-RAMIREZ, Ana María, GONZALEZ-JUAREZ, Aníbal, MOLINA-NAVARRO, Antonio and UTRERA-ZARATE, Alberto, with adscription in the Instituto Oceanográfico del Golfo y Mar Caribe.

Content

Analysis of speckle patterns in electronic devices for the monitoring of current changes

Análisis de patrones de speckle en dispositivos electrónicos para el monitoreo de cambios de corriente

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Abstract

Derived from new advances technological focused on the development of highly functional electronic devices; the manufacturers are obliged to the implementation of techniques to monitor their behavior. These techniques can be destructive or non-destructive, taking the analyzed device to the maximum working range. In this investigation report we show of the results obtained in the study of the speckle patterns of a positive voltage regulator, we used the probability density function and the correlation coefficients, as a statistical analysis of first and second order. The analysis was realized in each terminal of the electronic device, with changes in the input current. The result obtained suggest that the first and second order statistical analysis are good tool in a not destructive measurement and that its results can be relationship with the supply current. These changes are present a behavior ascending as the device operates in the junction temperature range; presenting itself as a mechanism for transmission and convection of heat, using the random distribution of speckle pattern, taking to optical measurement as an technique alternative in the study of electronic devices.

Speckle pattern, Probability density function, Correlation coefficients

Resumen

Derivado de los nuevos avances tecnológicos enfocados en el desarrollo de dispositivos electrónicos altamente funcionales, los fabricantes se ven obligados a la implementación de técnicas para el monitoreo del funcionamiento de cada dispositivo electrónico, estas técnicas pueden ser destructivas o no destructivas, llevando al máximo rango de trabajo al dispositivo analizado. En este trabajo se reportan los resultados obtenidos en el estudio de los patrones de moteado *(speckle)* de un regulador de tensión positiva, mediante el análisis del comportamiento de la función de la densidad de probabilidad y de los coeficientes de correlación. Los resultados obtenidos sugieren que el comportamiento de la función de densidad de probabilidad de los patrones de *speckle* y los coeficientes de correlación de cada terminal del regulador de voltaje muestran una relación directa con los valores de la corriente de alimentación, estos cambios infieren en un comportamiento ascendente, a medida que el dispositivo opera en el rango de temperatura de unión se presenta como un mecanismo de radiación y convección de calor, estos cambios térmicos son representados por una distribución al azar en los patrones de speckle y poniendo a la metrología óptica como una alternativa para determinar el funcionamiento del dispositivo electrónico de estudio.

Patrón de speckle, Función de densidad de probabilidad, Regulador de tensión

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Introduction

Recent studies have allowed the development of new and improved electronic devices that perform various tasks (Park, 2012), such is the case of the positive voltage regulator; Among its applications, the regulation of fixed voltages can be mentioned, they are also used as external components to obtain adjustable voltages and currents and as a power pass-through element, among others (Rashid, 2006). However, the passage of current through electronic devices can generate heat between their terminals and in the device itself, affecting its performance or causing structural damage (López, 2018).

Various works on the measurement of operation, temperature and structural changes of electronic devices have been developed, using both destructive and non-destructive tests (López, 2018), (Ashrafi, 2019) and (Avenas, 2012), considering that in an electronic system connected to a power source, most of its components generate heat. Ahmed et.al, in a study carried out to determine the effects of overheating in electronic devices determined that these are the product of the physical and chemical properties of the device, highlighting the study in silicon wafers where the concentration of electrons directly affect the phonons, preventing heat dissipation, however, surface fractures occur in the device due to fatigue of the semiconductor material, they also mention causes such as welding of the components, among others (Ahmed, 2017).

The main purpose of voltage regulators is to maintain inputs and outputs with stable parameters under variable input and load conditions (Schuler, 1986), being one of the most used IC integrated circuits (Rashid, 2006), they provide output currents of Around the milliampers, they have a protection circuit, its main purpose being to limit the current, it is inactive when the device works under normal operating conditions and it is activated when it is working at the limit (Cirovic, 1991).

Several are the parameters that are considered for the analysis of the operation of the ICs, among which the maximum dissipation power, quiescent current, voltage drops, among others can be highlighted. However, changes in these parameters can influence the operation of ICs, according to the datasheets (Whitaker, 2005).

For these reasons, the study of the structural behavior of electronic devices, through the use of optical metrology, in addition to providing information on the operation of the device, encourages the implementation of non-destructive techniques. The purpose of this work is to study the structural changes in electronic devices in operation, subjected to current changes, without bringing the structure of the analyzed device to a breaking point.

1. Power in electronic devices

The power dissipated by the electronic device is released in the form of heat, considered one of the most important factors in the loss of stability of the systems (Avenas, 2012), (Boylestad, 2003), it is represented by the equation (1).

$$\boldsymbol{P_d = f_s \int_0^{1/f_s} v(t) I(t) dt} \quad (1)$$

Where f_s represents the frequency, $1/f_s$ is a cycle period of the signal, v (t) and I (t), are the voltage and the current. If it is instantaneous power, equation (1) will be given as the product of voltage and current, equation (2).

$$\boldsymbol{P_d = v * I} \quad (2)$$

Since the dissipation power influences the temperature and thermal resistance of the device, the following relationship can be made (Donate, 2010), (Whitaker, 2005):

$$T_j = T_A + P_d \theta_{JA} \quad (3)$$

Where T_j is the junction temperature in degrees Centigrade (° C), T_A represents the ambient temperature in the vicinity of the device housing, P_D the power dissipated by the device in Watts (W) and θ_{JA} represents the thermal resistance bonding to the environment, this can also be determined by adding the thermal resistances that comprise the different parts of the device, equation (4).

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA} \quad (4)$$

Where θ_{JC} is the thermal resistance of the junction to the case, θ_{CS} is the thermal resistance of the case to the heatsink and, θ_{SA} the thermal resistance of the case to the environment, each of these parameters are described in the datasheet, with units of degrees centigrade / watts (° C / W) (Whitaker, 2005).

Therefore, from equation (3), the power dissipated can be represented as a function of the difference in the junction T_j, the environment T_A and the thermal resistance of the junction to the environment, where the latter depends on the resistances between the junction and the casing, the heatsink and the environment, as indicated in equation (4).

$$P_D = \frac{T_j - T_A}{\theta_{JA}} \quad (5)$$

Where θ_{JA} is the thermal resistance, for values of conduction mechanisms this is considered constant and is described in terms of the length, area of the section and thermal conductivity, however, for cases of radiation and convection it will depend on the thermal changes and will be validated only for small changes according to equation (4). In terms of thermal resistance, equation (5) can be rewritten as:

$$P_D = \frac{T_j - T_A}{\theta_{JA}} = v * I \quad (6)$$

The analysis of the current behavior in the device is shown in equation (7).

$$I = \frac{T_j - T_A}{\theta_{JA} * v} \quad (7)$$

According to the above, it is feasible to perform an analysis of the behavior of the IC through current changes represented as a thermal mechanism, as shown by equation (7).

2. Origin of the speckle pattern

From the different destructive techniques that take each analyzed device to the maximum working range, the need arises to estimate the operating variables that interfere with its behavior, using non-destructive analyzes, in which optical metrology can stand out (López, 2018). There are several techniques that involve a beam of light as a measurement system, however, the analysis of the structural characteristics of the elements can be studied using DSP (Digital Speckle Patter), this technique consists of the measurement of full optical field and It is used to determine the deformations of the object that is illuminated by a laser beam by means of the mottling movements (speckle);

The results obtained can be seen as two images with a slight change in the study points (x, y); uses the correlation between these two images to find the average displacement of the study surface, see Figure 1 (Stetson, 2011, Sirohi, 1993).

Optical metrology techniques base their measurement on a laser light system with temporal and spatial coherence characteristics, this is made to impinge on an optically rough surface, presenting a random intensity distribution, giving rise to the phenomenon called speckle (Rastogi, 2001); said phenomenon is a representation of bright and dark points formed by the random distribution of said coherent light, the intensity of a speckle field at a point in space P is determined by the coherent sum of the contributions of the complex amplitudes, considering that the study surface is rough compared to the wavelength. At the microscopic level, a surface will show a random distribution of the amplitude contributions of the phase differences at an observation point P. As a consequence of this, the coherent sum of each of the dark and bright amplitudes will depend on how many phases come to pass through point P (Rastogi, 2001).

In general, the statistical properties of the speckle pattern depend on the coherence of the incident light and the surface of the medium (Rastogi, 2001), (Dainty, 1975), (Dainty, 1977). If each wave has coherence characteristics and can be represented in turn by a phasor, then it is possible to represent the resulting field as the sum of the phasor. The real and imaginary components of said resulting phasor can be expressed according to equations (8), (9), within the interval (-π, π), where N represents the number of phasor, A is the resulting phasor of amplitude, the phase $\emptyset_k$ and a_k represents the nth phasor (Rastogi, 2001), (Dainty, 1977):

$$\mathrm{R} = \mathrm{Re}\{A\} = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} |a_k| cos\emptyset_k \quad (8)$$

$$\mathrm{I} = \mathrm{Im}\{A\} = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} |a_k| sen\emptyset_k \quad (9)$$

These speckle patterns take coherence as a constant of intensity (Dainty, 1977); In some measurements it is very common to see only calculations of the intensity of the optical wave field, through a transformation of the random variable equation (Rastogi, 2001), (Dainty, 1975), (Dainty, 1977).

Where the probability density function of the intensity I and the phase of a developed speckle is given by equations (10) and (11), (Nolte, 2012).

$$P_I(I) = \frac{I}{\langle I \rangle} exp\left(-\frac{I}{\langle I \rangle}\right) \quad (10)$$

$$P_\emptyset(I) = \frac{I}{2\pi} \quad \emptyset \in [0,2\pi] \quad (11)$$

For the case of the analysis of the speckle pattern, the second order statistic implies the autocorrelation function of the intensity distribution and the power spectral density, defining the first as:

$$R_1 = (x_1, y_1, ; x_2, y_2,) = \langle I(x_1, y_1) I(x_2, y_2)\rangle = \langle |A(x_1, y_1)|^2 |A(x_2, y_2)|^2\rangle \quad (12)$$

Where A represents the complex field, the width of this function is known as the central lobe and gives an approximation to the measurement of the average diameter of the speckle size, if the surface presents roughness compared to the wavelength, the field is a variable complex circular at each point of (x, y) and the intensity autocorrelation function will then be represented as:

$$\mathrm{R}_1 = (\mathrm{x}_1, \mathrm{y}_1, ; \mathrm{x}_2, \mathrm{y}_2) = \langle \mathrm{I}(\mathrm{x}_1, \mathrm{y}_1) \mathrm{I}(\mathrm{x}_2, \mathrm{y}_2)\rangle + |\mathrm{J}_\mathrm{A} \mathrm{x}_1, \mathrm{y}_1, ; \mathrm{x}_2, \mathrm{y}_2|^2 \quad (13)$$

Where:

$$J_A(x_1, y_1, ; x_2, y_2) = \langle A(x_1, y_1) A^*(x_2, y_2)\rangle \quad (14)$$

According to Goldfisher, it is feasible to perform a second-order statistical analysis of the speckle patterns based on their autocorrelation function, their Fourier transform and the spectral power density (Henao, 1997), (Somkuwar, 2017), (Sharma, 2006). Both the probability density and the autocorrelation function are cataloged as the principle of the correlation techniques of the speckle patterns, for the case of the processing of the images resulting from the speckle pattern, two states of deformation of the study surface are considered.

3. Development

For the test circuit, a positive voltage regulator (LM7805) was used, type of TO-200 encapsulation, a power source with 8 input volts, the current was controlled from 50 to 500 milliampers (mA), a resistance was placed load of 100Ω at the output of the electronic device, R_ (th-jc) were considered, as the thermal resistance of junction to the case 3 ° C / W, R_ (th-ja) thermal resistance to the environment 50 ° C / W (Bakshi, 2009). Equation (2) was used, taking v as a voltage difference between the supply of the test circuit and the output voltage of the device, I is considered as the input current that is controlled and a stable ambient temperature of 25 ° C.

To obtain the speckle patterns, a 632.8 nm He-Ne laser light source was used, a CCD camera to obtain the patterns and a computer for data processing, Figure 1 (Sirohi, 1993).

The deformation of the system was induced by current changes and the behavior of each terminal of the device was analyzed: input (Input (1)), ground (ground (2)) and output (output (3)), before and after the current changes.

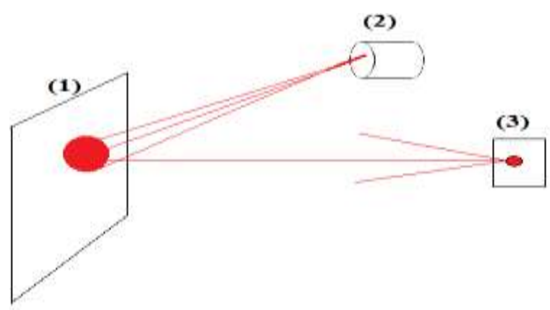

Figure 1 Optical system to obtain speckle patterns (1) Object, (2) Laser, (3) Observation plane, (Sirohi, 1993)

The normalized probability density function and the behavior of the correlation coefficients with different input current values were calculated.

The probability density function of the speckle patterns of each terminal of the device with different current values and a comparison between the correlation coefficients with changes in junction temperature was obtained..

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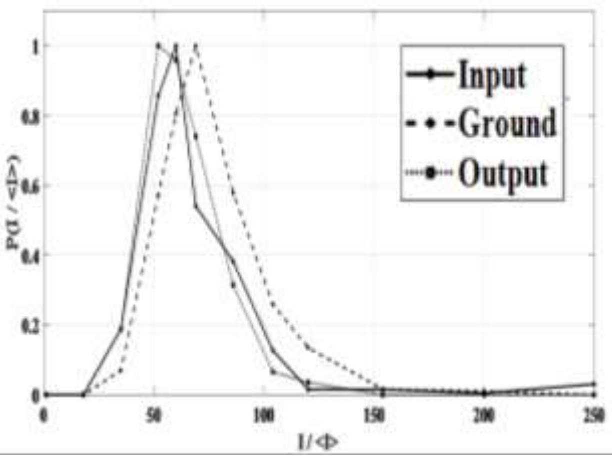
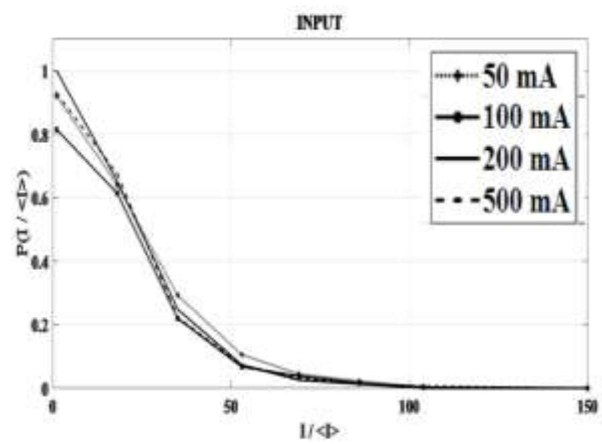
4. Results

Since the main purpose of this work is the analysis of the operation of electronic devices for control and monitoring of technical specifications, as well as lengthening their life time, the statistical behavior of the speckle patterns of each of the terminals of the electronic device, input, output and ground.



Graph 1 Probability density function of the speckle patterns obtained from the device without device power supply terminals (Input, Output and Ground)
Source: Own Elaboration

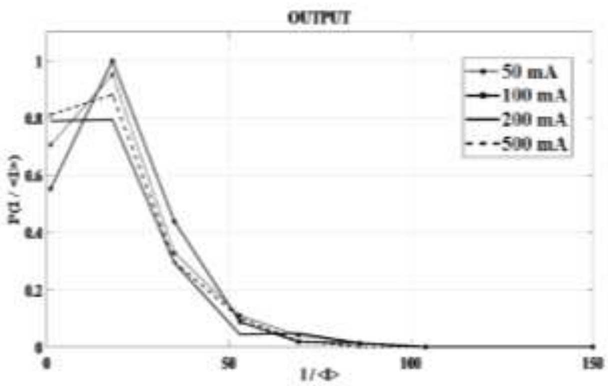


Graph 2 Probability density function of speckle patterns: Device input terminal
Source: Own Elaboration

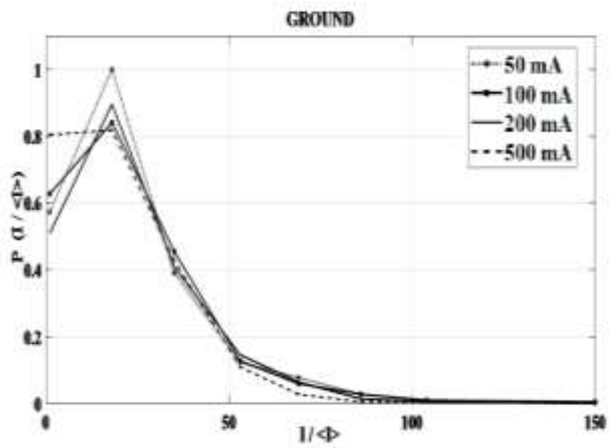
Graph 1 shows the behavior of the probability density function originating from the speckle pattern resulting from irradiating the device with coherent light, these results are taken as a reference for the analysis of the speckle patterns, it can be seen that for the terminals of the device, the negative exponential shape is preserved, as the supply current of the device increases, the maximum points of the density function show a non-linear behavior, suggesting that this resulting speckle pattern corresponds to a low-contrast speckle pattern. 3, 4 and 5.

mA	*W*	*°C*	T_j	R_1
50	0.15	7.5	32.5	0.20205
100	0.30	15	40	0.20635
200	0.60	30	50	0.21555
500	1.5	75	100	0.25085

Table 1 Thermal and electrical characteristics and correlation coefficients of the electronic device
Source: Own Elaboration

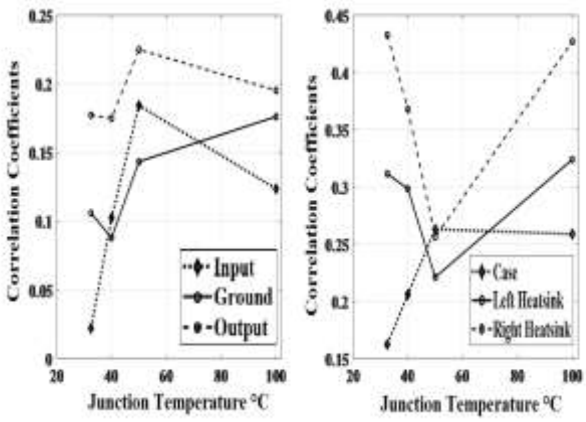


Graph 3 Probability density function of speckle patterns: Device output terminal
Source: Own Elaboration



Graph 4 Probability density function of speckle patterns: Device ground terminal
Source: Own Elaboration

For this study, the behavior of the average of the correlation coefficients resulting from the increase in the current is also analyzed, presenting in a similar way and in an ascending way, as shown in Table 1. The averages of the correlation coefficients were obtained from Considering all the sections of the electronic device, it can be seen that from 50 ° C (degrees centigrade), in the temperature range of the joint in operation, the value of the average coefficient increases significantly compared to the values for lower temperature, allowing an approximation between the statistical characteristics of the speckle patterns and the thermal properties of the device and that are the product of current changes at the input of the electronic device.



Graph 5 Behavior of correlation coefficients of the device and the junction temperature
Source: Own Elaboration

Graph 5 shows the behavior of the correlation coefficients obtained by means of second order statistics, also, a change in their behavior is observed around 50 ° C of junction temperature of the device, these changes are present in all parts of the device analyzed, which suggests that the DSP technique can monitor and correlate changes in the junction-ambient temperature of the device, registering as similar points in behavior.

Also, second order statistics were applied to the case and heatsink of the device, left and right side (left heatsink and rigth heatsink), Graph 5; It can be seen that the correlation coefficient located at 50 ° C of the junction temperature for the case of the case and the right side of the heatsink (near the output terminal) are very similar with a difference of 0.00663 arbitrary units (ua), relating the behavior of the probability density function for this section of the dissipator since it presents greater broadening than its counterpart.

On the other hand, the value of the coefficients for the case of each terminal, it can be seen that these do not exceed the value of 0.25 (u.a.), turning out to be very similar to that presented by the housing and the right section of the device.

5. Conclusion

The theoretical probability density function that illustrates the statistical behavior of speckle patterns can be demonstrated experimentally.

The changes of this function were obtained for current values between the working range of a voltage regulating device, allowing to determine the behavior of the electronic device by approximating its thermal characteristics with the statistical properties of the speckle pattern that originates in the surface of the same and assuming that these speckle patterns will show changes according to thermal resistance. DSP is taken as a monitoring technique in the change of internal and external thermal value that affect the operation of the device as well as anticipating future structural damage.

It was possible to demonstrate that by means of optical techniques it is feasible to determine the range in which the current supply enables the thermal point of the junction resistance considered stable, by means of a change in the behavior of the correlation coefficients. Also, the average behavior of the coefficients for each power change in the test circuit is disclosed, concluding that these present an upward behavior, similar to the increase in the input current.

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Study of the mechanical properties of magnetic composites supported on a PU matrix

Estudio de las propiedades mecánicas de compositos magnéticos soportados en una matriz de PU

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Abstract

Magnetic nanoparticles have been used to confer better properties to materials, particularly to polymers. Due the properties of the polymer, such as flexibility and lightness, combined, white nanoparticles provide other properties such as microhardness, corrosion resistance, among others. In this study, three types of nanoparticles were elaborated: magnetite, cobalt ferrite and nickel ferrite, through the coprecipitation method used in the elaboration of skin-like polyurethane (PU) -based composites. Specimens were made at different nanoparticle weights (0.1%, 0.3%, 0.5% and 1.0%). Likewise, the hardness was measured by means of a phase II Model PHT-2500 portable digital hardness tester and the tension tests were carried out on an Autograph Shimadzu universal machine. The stress results were plotted using the Jupyter Notebook for interpretation. Finding some improvements in the materials manufactured using the different ferrites already mentioned.

Magnetic nanoparticles, Magnetic polymers, Mechanical properties

Resumen

Se han utilizado nanopartículas magnéticas para conferir mejores propiedades a los materiales, especialmente a los de tipo polimérico. Esto es de gran interés debido a que se combinan las propiedades del polímero, como la flexibilidad y ligereza, mientras que las nanopartículas aportan otras propiedades como lo son la microdureza, resistencia a la corrosión, entre otras. En el presente trabajo se elaboraron tres tipos de nanopartículas: magnetita, ferrita de cobalto y ferrita de níquel, mediante el método de coprecipitación utilizándose en la elaboración de compositos a base de poliuretano (PU) tipo piel. Se elaboraron probetas a diferentes pesos en nanopartículas (0.1%, 0.3%, 0.5% y 1.0%). Asimismo, se midió la dureza por medio de un probador de dureza digital portátil marca phase II Model PHT-2500 y los ensayos de tensión se realizaron en una máquina universal Autograph Shimadzu. Los resultados de tensión se graficaron utilizando Jupyter Notebook para su interpretación. Encontrando algunas mejoras en los materiales fabricados utilizando las distintas ferritas ya mencionadas.

Nanopartículas magnéticas, Polímeros magnéticos, Propiedades mecánicas

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Introduction

In composites, polymers are among the most used materials as matrix, and polyurethane (PU) has been of great interest due to its wide field of applications. As reinforcement, ferrites have been used for the elaboration of magnetic composites, due to the magnetic properties they present, together with the excellent chemical stability, thermal stability and mechanical hardness, the characteristics of lightness, easy processing, etc., are combined [IV, VI, VIII-X].

Another advantage that exists in the use of ferrites are their low manufacturing cost, and therefore various studies have been carried out on their synthesis and characterization, as well as the resulting properties [III]. On the other hand, polyurethane has been widely used for being a strong and versatile material, besides having properties of a good thermal insulator, low weight, versatility, durability, low cost, and comfort [VII].

That is why the interest in the use of ferrite nanoparticles in polymeric matrices, because together with the improvement of mechanical and chemical properties, it also occurs in electrical conduction and resistance to corrosion of materials [V]. Therefore, magnetic composites are candidates for use as coatings. Finally, it is important to mention that these materials have the property of absorbing microwave frequencies, being applied in the use of coatings and paints [I, II]

Methodology

By the coprecipitation method, three types of ferrites were synthesized, magnetite, cobalt ferrite and nickel ferrite. For them, 0.5 M $FeCl_2$, $CoCl_2$ and $NiCl_2$ solutions, 1 M $FeCl_3$ and 2 M NaOH as precipitating agent were used. The $FeCl_2$, $CoCl_2$ and $NiCl_2$ solutions were mixed with the $FeCl_3$ solution for the elaboration of each ferrite and heated to 80 ° C. Subsequently, 1.2 mL of polyethylene glycol (PEG) were added. The NaOH solution was heated with magnetic stirring to 80 ° C, to destabilize the solution, then the mixture of chloride salts was added dropwise to the NaOH solution. The addition was completed, stirring was maintained for 30 minutes, it was precipitated, and the nanoparticles were washed with distilled water and ethanol. They were left to dry for 24 hours at 70 °C.

For the elaboration of the composites, skin-like polyurethane was used, considering the stoichiometric amounts of polyol and isocyanate. The nanoparticles were added to the polyol with a weight a ratio of 0.1, 0.3, 0.5 and 1.0 % with respect to the mass of the polyurethane. They were mechanically stirred for 5 minutes, the isocyanate was added and stirring was continued for 15 seconds to initiate the reaction. The polyurethane was poured into silicone rubber molds according to the ASTM E 8-79 standard to obtain the composites. All samples were obtained in triplicate.

With the help of an Autograph Shimadzu universal machine, the tension tests were carried out, obtaining the data in Trapezium software and with the help of Jupyter Notebook, the corresponding graphs were generated for their interpretation. A portable digital hardness tester, brand phase II Model PHT-2500 was used for hardness determination.

The interior of the composites was analyzed with the help of an Amszoom microscope, to qualitatively observe how homogeneously the nanoparticles were dispersed within the polymeric matrix.

Results

In Figures 1, 2 and 3 we can see the micrographs of the magnetite, cobalt ferrite and nickel ferrite respectively, observing that the magnetite has a particle average size of 30 nm and present spherical shapes, the cobalt ferrite has average size of 20 nm and with hemispherical particles, in addition to presenting an agglomeration and, finally, the nickel ferrite has average size between 40 nm, with a spherical shape and agglomerations.

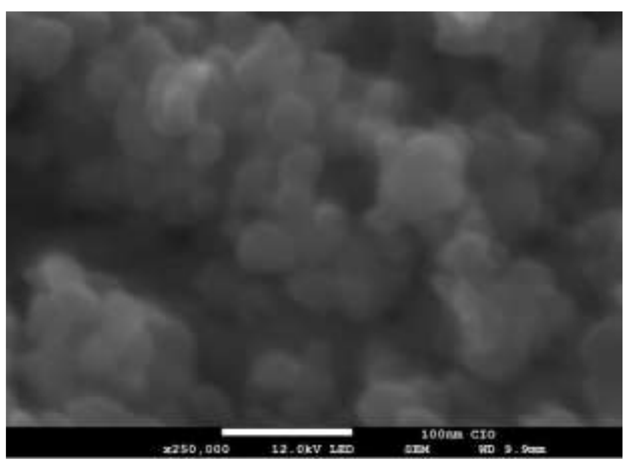

Figure 1 Magnetite micrograph
Source: Own Work [JEOL SU 3500 SEM Hitachi]

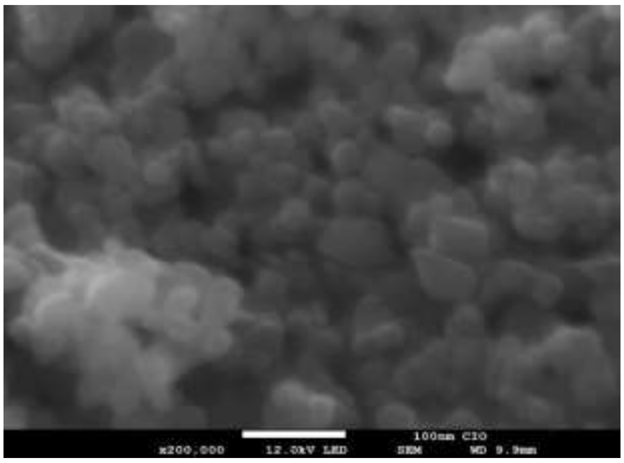

Figure 2 Cobalt ferrite micrograph
Source: Own Work [JEOL SU 3500 SEM Hitachi]

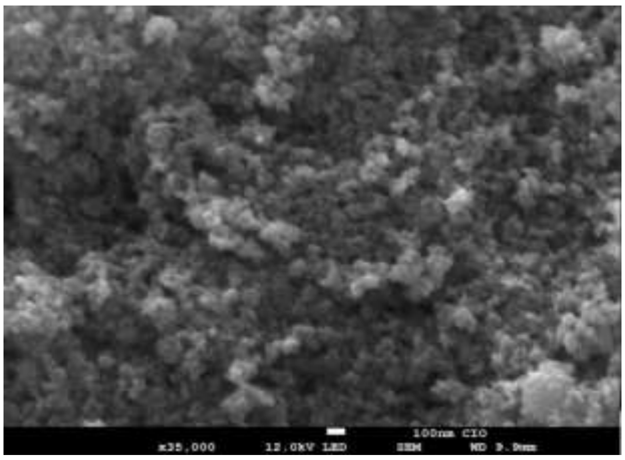

Figure 3 Nickel ferrite micrograph.
Source: Own Work [JEOL SU 3500 SEM Hitachi]

Figure 4 shows the polyurethane specimen obtained without the addition of nanoparticles, while Figure 5, 6 and 7 show the polyurethane composites with different percentages of magnetite, cobalt ferrite, and nickel ferrite respectively.

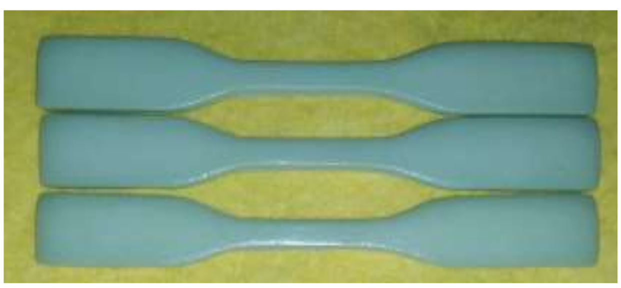

Figure 4 Polyurethane with 0% NPS
Source: own work.

Figure 5 Magnetite composites. Top left (0.1%), top right (0.3%), bottom left (0.5%) and bottom right (1.0%).
Source: Own Work.

Figure 6 Cobalt ferrite composites Top left (0.1%), top right (0.3%), bottom left (0.5%) and bottom right (1.0%).
Source: Own Work

Figure 7 Nickel ferrite composites. Top left (0.5%), top right (0.1%), bottom left (1.0%) and bottom right (0.3%)
Source: Own Work

The color change that the composites acquire when adding the nanoparticles (NPS) in their different concentrations to the polymer matrix is appreciated. It should be noted that, by increasing the concentration of nanoparticles in the composite, they begin to agglomerate as can be seen in the Figures 8, 9 y 10

Also, it is important to note that depending on the composite, there is a different behavior, such is the case of magnetite composites, where there was a good distribution below 0.5% w/w, while at 1.0% w/w, the nanoparticles began to agglomerate. With cobalt ferrite, agglomeration occurred from 0.1% w / w, which increased when adding more nanoparticles.

Finally, in nickel ferrite composites at low percentages there is no agglomeration, but from 0.5% w / w agglomeration of the nanoparticles start. These agglomerations can be observed with the naked eye on the surface of the composites, but it is more visible when the interior is analyzed under the microscope as can be seen in the (see Figures 8, 9 y 10).

Figure 8 PU-magnetite interior (0.3% w / w)
Source: own work [Amszoom Microscope]

Figure 9 PU-Cobalt Ferrite interior (0.3% w / w)
Source: own work [Amszoom Microscope]

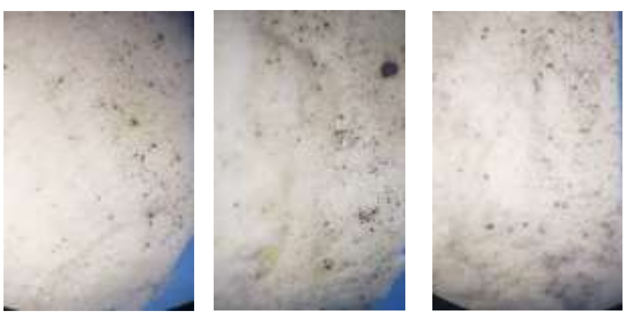

Figure 10 PU-cobalt ferrite exterior (0.3%, 0.5% and 1.0% w / w)
Source: own work [Amszoom Microscope]

The data obtained from the stress tests were obtained from the Trapezium software, load data (kN) and elongation length, with these data the stress (MPa) and deformation (%) were obtained, the corresponding graphs are presented in the Figures 11, 12 y 13.

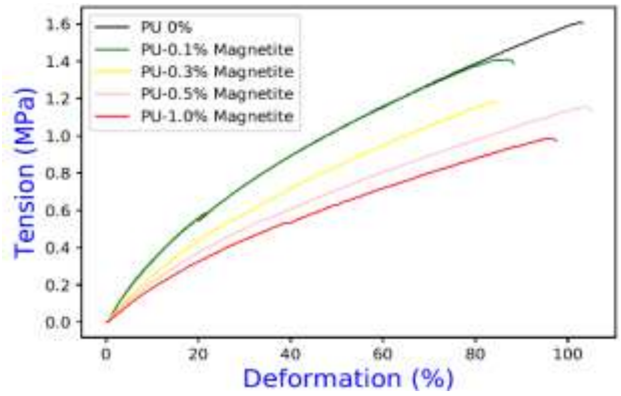

Figure 11 PU-Magnetite tension test
Source: own work [Jupyter Notebook].

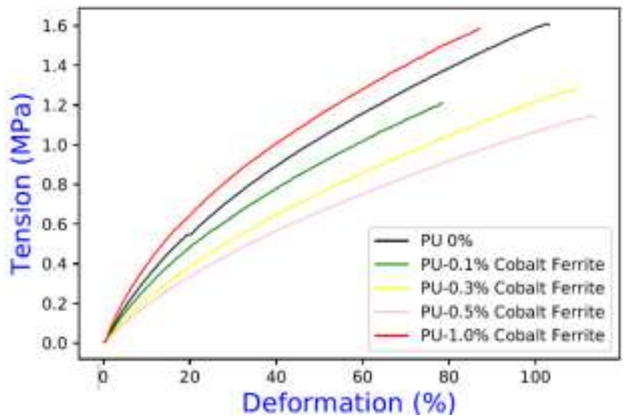

Figure 12 PU-Cobalt Ferrite tension test.
Source: own work [Jupyter Notebook]

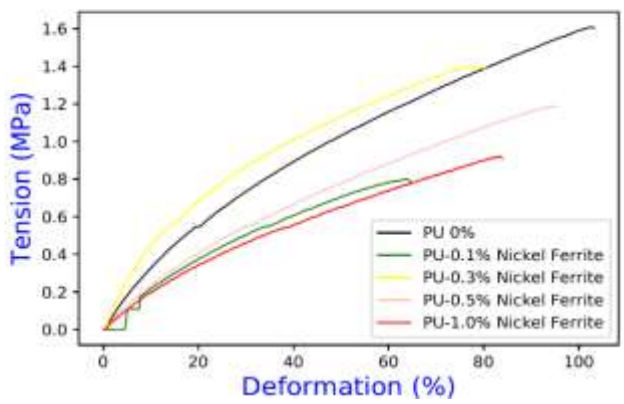

Figure 13 PU-Nickel Ferrite tension test
Source: own work [Jupyter Notebook]

We can see that when comparing the tensile strength of composites with magnetite, the material without nanoparticles is the one with the highest resistance, although the composite at 0.1% w/w presents a similar behavior, as nanoparticles are added, the resistance to tension, this is due to the fact that when adding nanoparticles, there are less crosslinks between the polymer chains, resulting in lighter materials with greater porosity, causing a decrease in the number of links between PU main chains and, therefore, decreases the tension.

When cobalt ferrite is added to matrix, the results are not improved to 0.1, 0.3 and 0.5% w/w since the resistance is decreased, although the ductility increases, since these materials reach greater deformations before fracture. It is interesting that at 1.0% w/w the tensile strength grows even above the composite without nanoparticles. The tension decreases due to what has already been explained about the crossovers, logically adding 1.0% w/w of cobalt ferrite should further decrease the tensile strength. This may be since at a certain moment said property no longer depends on the polymeric material and its chains, but rather on the reinforcement and its intrinsic properties, occupying the gaps that are available in the matrix.

On the other hand, when analyzing the composites with nickel ferrite, it is observed that at 0.1% w/w the resistance is very low and when adding 0.3% w/w the effort increases considerably since it presents a zone of notorious stiffness, the composites with 0.5 and 1.0% w/w show a decrease in effort for what has already been explained. The composition at 0.3% presented a good distribution of nanoparticles, hence it has presented better results.

It must be considered that these results depend on the homogenization of the nanoparticles in the matrix. We determined that the material with the best tensile strength is the 1.0% cobalt ferrite composite, which could be due to the nanoparticle size and distribution in the sample. To obtain better results, composites could be made using some method to better homogenize the nanoparticles, since mechanical agitation is not the best option. The presence of nanoparticles as reinforcement provides the composite with an increase in hardness with respect to the polymer, since the lower hardness occurs when the material does not have nanoparticles and as they increase, the hardness increases. Tables 1, 2 and 3 show the results obtained from the hardness tests for the polyurethane composites with magnetite, cobalt ferrite, and nickel ferrite, respectively.

Ferrite percentage (%)	Average hardness (HB)
0.0	182
0.1	200
0.3	197
0.5	207
1.0	217

Table 1 Hardness measured for the PU-Magnetite composite
Source: Own Work [Word]

In the PU-Magnetite composites it is observed that when adding nanoparticles, the hardness increases, when it reaches 1.0% w/w the highest hardness is reached, and we could observe that at 0.3% w/w the hardness decreases with respect to 0.1% w/w, which could be due to the presence of the NPS in the polymeric matrix but also to the intermolecular forces that are generated such as those of Van Der Waals or dipole moments.

Ferrite percentage (%)	Average hardness (HB)
0.0	182
0.1	202
0.3	210
0.5	210
1.0	193

Table 2 Hardness measured for the PU-Cobalt Ferrite composite
Source: own work [Word]

The PU-Cobalt Ferrite composites show that there is also a considerable increase in hardness when increasing the number of nanoparticles, although from 0.5% w/w no improvement, since the same results are obtained as at 0.3% w/w even at 1.0% w/w there is a decrease in hardness.

The explanation as already mentioned, of intermolecular forces that occur inside the matrix together with the lower presence of nanoparticles at that point could explain the decrease in hardness.

Ferrite percentage (%)	Average hardness (HB)
0.0	182
0.1	199
0.3	210
0.5	215
1.0	195

Table 3 Hardness measured for the PU-Nickel Ferrite composite
Source: own work [Word]

Finally, composites with Nickel Ferrite also show an increase as the number of nanoparticles increases. Similarly, the hardness increases up to 0.5% and when the number of nanoparticles is doubled, the hardness decreases considerably.

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Conclusions

It is possible to obtain a synergy between the properties of the polyurethane and the ferrite nanoparticles, obtaining improvements in the mechanical properties, being more evident in the hardness of the materials than in the resistance to tension, where due to the porosity and agglomerations of the nanoparticles the best results were not obtained.

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The emotions of upper secondary level students in a virtual learning environment

Las emociones de los estudiantes del Nivel Medio Superior en un entorno virtual de aprendizaje

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Abstract

In recent years and derived from the pandemic that is experienced today, online education has been advancing by leaps and bounds. It has demanded that educational actors face and adapt to a series of changes that have been generated by the implementation of digital environments in the teaching-learning process. It is in this scenario where the objective is to identify the students' emotions from High school with respect to their learning in a virtual environment. They experience a series of emotions that according to Lin, Su, Chao, Hsieh and Tsa, (2016) can generate the ideal environment to develop more successful learning processes through positive emotions. To achieve this objective, a quantitative investigation was developed, and a questionnaire with a Likert scale was designed and applied to a sample from the Enrique Cabrera Barroso Regional High School. This instrument revealed the emotions they experience in a virtual learning environment during their learning process and their interaction among the actors. Considering the results, we find that students experience a series of internal emotions that are decisive for adapting to a virtual environment.

Emotions, Virtual learning environment, Virtual learning

Resumen

En los últimos años y derivado de la pandemia que se vive hoy en día, la educación en línea ha ido avanzando a pasos agigantados, esto ha demandado que los actores educativos se enfrenten y adapten a una serie de cambios que se han generado por la implementación de los entornos digitales en el proceso de enseñanza aprendizaje. Es en este escenario donde se tiene como objetivo identificar las emociones de los estudiantes del Nivel Medio Superior (MES), con respecto a su aprendizaje en un entorno virtual. Pues experimentan una serie de emociones que de acuerdo con Lin, Su, Chao, Hsieh y Tsa, (2016) pueden generar el ambiente idóneo para desarrollar procesos de aprendizaje más exitosos con las emociones positivas. Para alcanzar dicho objetivo, se desarrolló una investigación de corte cuantitativa, se diseñó y aplicó un cuestionario con escala tipo Likert a una población muestra de la Preparatoria Regional Enrique Cabrera Barroso. Dicho instrumento reveló las emociones que experimentan ante un entorno de aprendizaje virtual, durante su aprendizaje y su interacción entre los actores. Dentro de los hallazgos encontramos que los estudiantes experimentan una serie de emociones internas que son determinantes para adaptarse a un entorno virtual.

Emociones, Entorno virtual de aprendizaje, Aprendizaje virtual

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Introduction

Online education has grown in importance in recent years. One of the many reasons is because it promotes an education without borders, with access to anyone who wishes to appropriate the knowledge and especially for those who, due to different situations, cannot join a face-to-face education.

However, nowadays virtual learning environments have become present in a necessary and immediate way, derived from the pandemic that is being lived, to such a degree that the introduction of technology in education has transformed the face-to-face educational system and has directly impacted on the way of life of each of us who make up the educational community.

This has led all educational actors to modify or potentiate attitudes and ways of working to face the new digital scenario and adapt to innovative techno-pedagogical designs that promote meaningful learning. It is necessary to mention that according to Hernández, Fernández and Pulido (2018), said adaptation process demands the development of attitudes such as internal motivation, commitment, disposition, assertiveness and efficiency, mainly in the communication process; attitudes that are evidenced in the learning processes of students. According to the aforementioned authors, the student's willingness to start or finish an online education program will be determined by various factors, one of which is her attitudes or emotions.

For the present work and taking into account different authors (Alabdullaziz, Muhammad, Alyahya & Gall, nd), attitudes are composed of affective, cognitive and behavioral elements that are manifested in emotions, determining elements to specify a perception of the context in the that the subject develops, and affect the like or dislike towards an action, task or object.

According to Bertea (2009), positive emotions in a virtual learning environment increase the chances that the student will accept the new teaching system, since they promote a good attitude to learn, which leads to active participation, avoiding resistance to the appropriation of knowledge (Lee & Li, 2016).

Based on the above, the objective of this research is to identify the emotions of students in a virtual learning environment from the exploration of the reactions they experience in their teaching-learning process and their interaction with educational actors.

Theoretical framework

The key concepts to understand the phenomenon of study are described below.

The role of emotions in the virtual learning process.

For Rebollo, García, Barragán, Buzón and Vega (2008) emotions are actions learned and carried out at significant moments or opportune occasions, which are represented in the form of adaptation to the environment in which the individual develops.

According to studies by Oye, A. Iahad, Madar and Ab. Rahim, (2012), there is a relationship between emotions and academic performance of students who are in a virtual learning environment. Thus, an emotion can trigger multiple attitudes, whether positive or negative, which will be expressed through perceptions, influencing performance. For example:

- Alter attention and willingness to learn
- Generate positive or negative behavior patterns that favor or inhibit the learning process
- Show willingness to incorporate new knowledge
- Facilitate the appropriation of knowledge or,
- Activate relevant associative networks in memory that facilitate the learning process.

On the other hand, Saabah (2013) affirms that emotions are closely related to learning in a virtual environment, identifying a positive relationship between skills for incorporating technology and the attitude towards learning in a virtual environment.

According to Quinn (2006), there is evidence that learning improves by minimizing negative emotions and enhancing or maximizing positive ones.

Virtual learning environment

The incorporation of information and communication technologies have evolved and have been inserted in education, generating gaps around the modalities of the teaching-learning process such as: face-to-face, mixed or virtual mediated by technological tools. However, in the last two scenarios, the teacher must necessarily use communication media to interact synchronously or asynchronously with their students as well as technological tools for the development of digital resources (Rodríguez, 2020).

Now, what is a virtual learning environment? Suarez (2002) conceives it as the application of a techno-pedagogical design with an educational intention, which regulates and transforms the interaction between educational actors, promoting forms of external action for learning and the modification of their learning strategies.

It is important to mention that initially these virtual learning environments emerged as a support tool for distance education, however today, they are used as a complement to face-to-face training.

According to Cruz Benzan et al (2011), a virtual learning environment has the following characteristics:

1. Offer technological support to teachers and students to guarantee an effective teaching-learning process

2. Provide a variety of ad doc tools to the teaching model

3. Generate and allow a space for fluid and active communication between the actors in the process

4. Provide a space for students to contribute as designers and content producers.

In this order of ideas, a virtual learning environment aims to become a space that facilitates the diversification of distance, face-to-face and mixed teaching modalities.

The present work is contextualized in a virtual environment. In this modality, it is considered pertinent to generate virtual learning communities that contribute to the development of emotions, where there is:

– Willingness on the part of educational actors to share and guarantee the appropriation of knowledge through the achievement of shared objectives.
– Active interaction between all actors, which promote an ideal and motivating learning environment
– Collaborative learning, which accounts for products that demonstrate learning based on established indicators
– Provide a socially constructed meaning that is conducive to learning for life.

In this regard, Mothibi (2015) affirms that the adequate implementation of information and communication technologies in a virtual learning environment are a triggering and effective tool to potentiate the development of students' skills.

Virtual learning

One of the characteristics of virtual learning is the physical absence of the teacher and the student, so the monitoring of the didactic materials for teaching and the performance criteria of the students do not require synchronous communication by the teacher-student or student-student.
Boneu (2007), considers that there are 3 axes in virtual learning:

1. Interaction. Communication process between teacher-student, or student-student in order to build learning where emotions are observed by the actors, which influence the appropriation of knowledge.

2. Collaboration. Joint tasks mediated by technology that contribute to the development of competencies

3. Production. Evidence that reflects technology-mediated learning.

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According to Barberá, Badia and Mominó (2001, p. 164), interaction is the “set of interconnected reactions between educational actors, in which cognitive activity is developed based on the elements that determine the nature of the virtual context”.

This is how in any educational process, interaction is a necessary element since it allows strengthening interpersonal relationships between educational actors and as a consequence decreases the affective distance from communication, which can generate positive emotions in the student (Alcalá, 2009).

Another characteristic of virtual learning is the design of didactic materials with which the student will interact, because the tasks are based on the principle of autonomous work. These materials should guide and motivate the student in the development and self-regulation of their own learning.

Methodology

In order to identify the emotions of students at the Upper Secondary level (NMS) in a virtual learning environment, a quantitative cross-sectional study was developed since the information was collected in a single moment (Hernández, Fernández & Baptista (2014) through a questionnaire with a Likert-type scale.

Sample

4 groups from the 4th semester of the Enrique Cabrera Barroso Regional High School participated, whose ages range between 16 and 17 years. Derived from the pandemic that is experienced today, they receive their classes in a 100% virtual mode.

The sample consisted of 103 students, selected under a non-probabilistic convenience sampling (Casal and Matéu, 2003).

Instrument

The Likert-type scale questionnaire is made up of three sections that inquire about emotions in different phases such as the interaction process, the learning process and the virtual modality.

The first distinguishes the emotions present in students in a virtual learning environment.

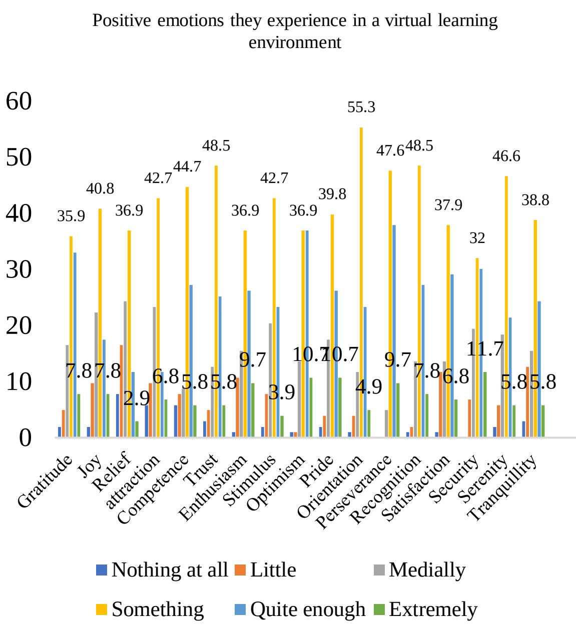
The second focuses on the learning process, a context in which emotions are presented during the construction and deconstruction of knowledge for online training.

The third aims to identify the emotions of the students during the interaction process when communicating between student-student and student-teacher.

Results

Emotions present in students in a virtual learning environment

The instrument applied for the identification of emotions experienced by students when faced with a virtual learning environment, yielded the following results.



Graphic 1 Positive emotions that students experienced in a virtual learning environment.
Source: Own Elaboration

In Graphic 1, the emotions of well-being that the students have experienced (a lot) are represented, among which security with 11.7%, followed by optimism 10.7%, pride 10.7% and enthusiasm and perseverance with 9.7%.

This agrees with the investigations of Rebollar (2008) who affirms that the presence of positive emotions such as perseverance and enthusiasm are very significant in the experience of students in the virtual environment, since the learning process demands their practice for the management of one's own knowledge, the use of resources and skills for the use of technological tools.

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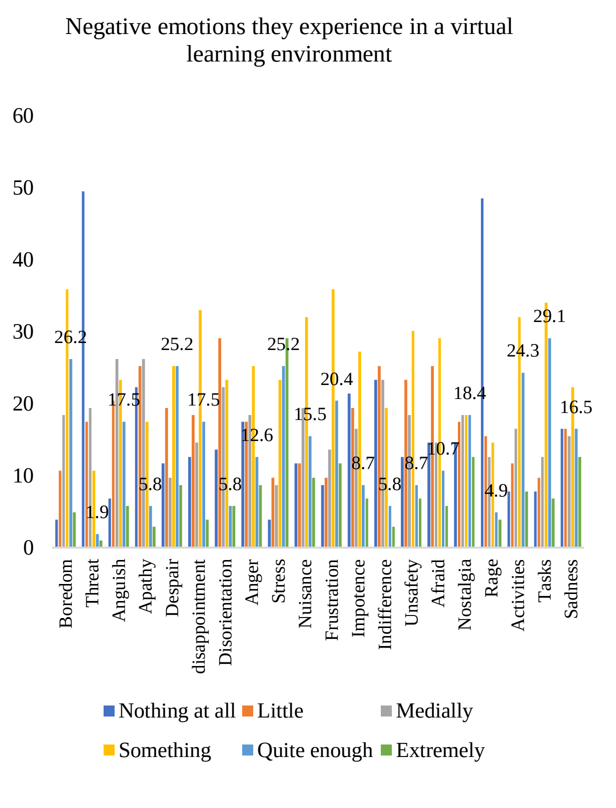
The emotions that they have experienced in "Nothing" are: relief with 16.5%, tranquility 12.6%, satisfaction 11.7%, and joy and attraction 9.7%, respectively. This shows that for some students it has been difficult to adapt to the virtual learning environment, so according to Cruz Benzan et al (2011) it is important to provide spaces to talk in a synchronous or asynchronous way about the difficulties they experience in the process and the achievement of the objectives.

The highest percentages are found in the indicator "Something" and these emotions are orientation with 55.3%, confidence and recognition 48.5%, perseverance 47.6% and serenity 46.6%.

Therefore, the strong presence of orientation, confidence, optimism and perseverance agree with the studies carried out by Barragán et al (2007) who affirm that these emotions are the reflection of the emotional competence promoted by the teacher in a virtual online environment. , based on a flexible and purposeful techno-pedagogical design (Flores-González, 2020).



Graphic 2 Negative emotions that students experience in a virtual learning environment.
Source: Own Elaboration

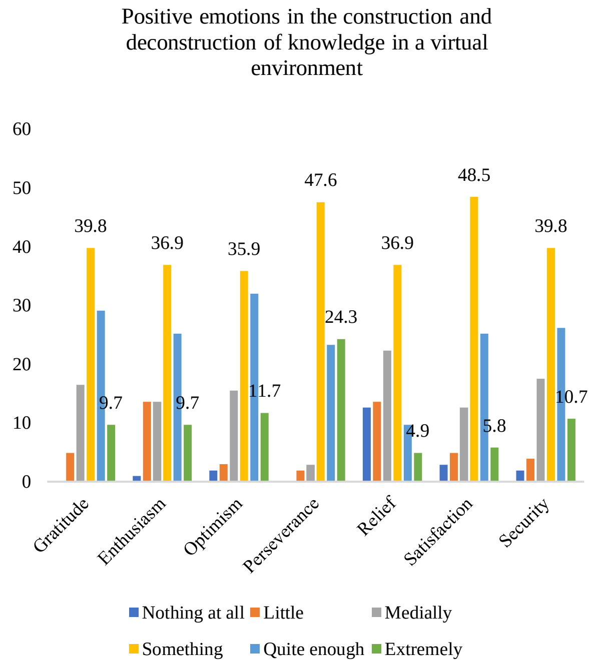
It is important to emphasize that negative emotions have manifested in a lower percentage, however, as seen in Graphic 2, students have experienced “a lot” of stress with 29.1%, nostalgia 12.6%, sadness 12.6% and frustration 11.7% . These emotions are also expressed and are closely related to the interaction between student-teacher and student-student, as will be seen later.

In contrast, 49.5% of the students have experienced “Nothing” of Threat (48.5%), anger (23.3%), indifference (22.3%), apathy and helplessness (21.4%). These results reflect the commitment of educational actors, and the purpose of the virtual space, such as regulating and transforming the interaction between educational actors promoting forms of external action for learning and modifying their learning strategies, through the application of a techno-pedagogical design (Suarez, 2002).

Of the negative emotions that they have experienced in the criterion "Something" and that in fact correspond to the highest percentages are: frustration and boredom with 35.9%, task saturation 34%, disappointment 33% and annoyance 32%. These emotions coincide with Jarvis (2006) who affirms that frustration generates a cognitive imbalance and awakens the desire to learn.

Emotions during the construction and deconstruction of knowledge in a virtual environment

In the teaching-learning process, students incorporate new knowledge to generate a more elaborate idea and it is in this deconstruction process that they experience a series of emotions.



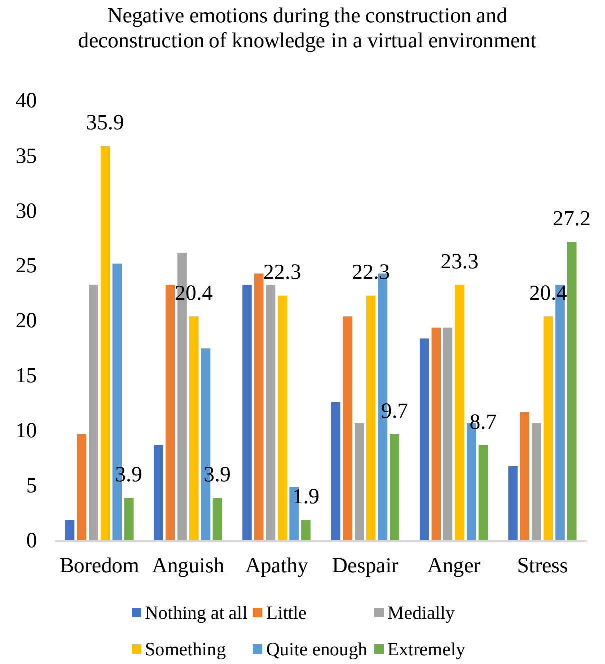
Graphic 3 Positive emotions that students experience during the construction and deconstruction of their knowledge in a virtual learning environment
Source: Own Elaboration

Graphic 3 shows the emotions that generate well-being for the student. With a higher percentage in the indicator "Something" is satisfaction (48.5%), perseverance (47.6%), security and gratitude (39.8%). On the other hand, the emotions that have not experienced (Nothing) are: relief 16.5%, tranquility 12.6%, satisfaction 11.7% and enthusiasm with 10.7%.

In this regard, Pekrum (2005) emphasizes that the relationship between reactions (evidenced by emotions of satisfaction, perseverance, security) and learning are not simple as they are regulated by cumulative factors. However, it is important to identify them, as they create a radius of opportunity to implement communication scenarios and teaching intervention.

The emotions that they experienced a lot are security (11.7%), optimism and pride (10.7%), enthusiasm and perseverance (9.7%), positive attitudes that they contribute to the students' work.

In the following lines, negative emotions are described.



Graphic 4 Negative emotions that students experienced during the construction and deconstruction of their knowledge in a virtual learning environment
Source: Own Elaboration

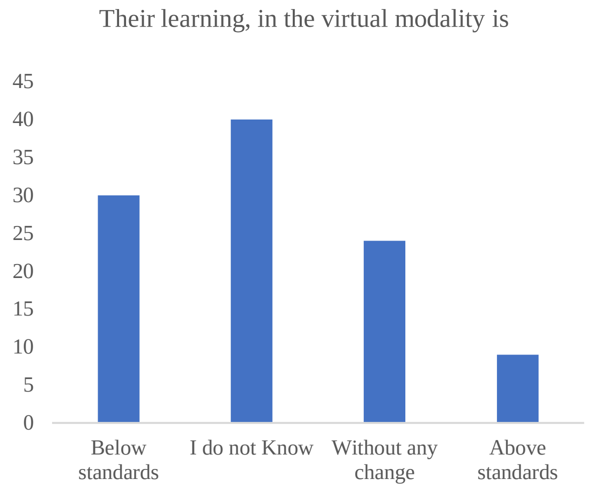
As can be seen in Graphic 4, the negative emotions that experienced a lot during the construction and deconstruction of knowledge in a virtual environment are: stress (27.2%), despair (9.7%), anger (8.7%), boredom and anguish (3.9%).

However, the emotions they did not experience are apathy (23.3%), anger (18.4%), despair (12.6%) and anguish (8.7%).

The emotions they perceived in something were boredom (35.9%), apathy, anger and despair (23.3%).

These results indicate that there is a relationship of emotions that emanate from stress, such as despair, anguish and anger. Others indicate motivation through emotions such as security, satisfaction, perseverance and optimism which contribute to learning. In this regard, Jarvis (2006) and Phelps (2006) point out that the degree of despair in relation to the construction of knowledge is essential to promote the desire to learn and keep the student alert to new information.

In order to complement the study, the students were asked how did they perceive their learning in a virtual environment?

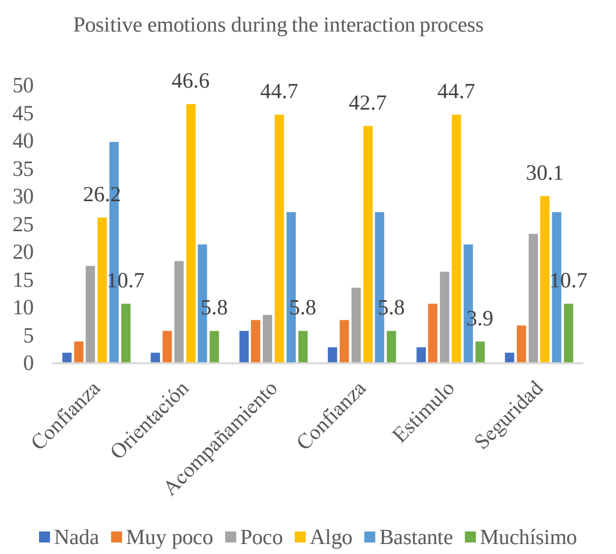


Graphic 5 Students' perception of their learning in virtual mode
Source: Own Elaboration

39% answered I do not know, while 29% consider that it is less and 23% that it is the same. Only 9% consider that it is greater as shown in the Graphic. It is imminent that the reflection-oriented interaction to make a judgment regarding the virtual learning process is associated with various positive emotions such as perseverance, satisfaction, optimism and enthusiasm.

Student emotions during the interaction process when communicating

According to Alcalá (2009), in a virtual learning environment the communication that is established through the interaction between student-teacher and student-student, is decisive for the achievement of objectives set in an educational program and depends directly on the emotions.

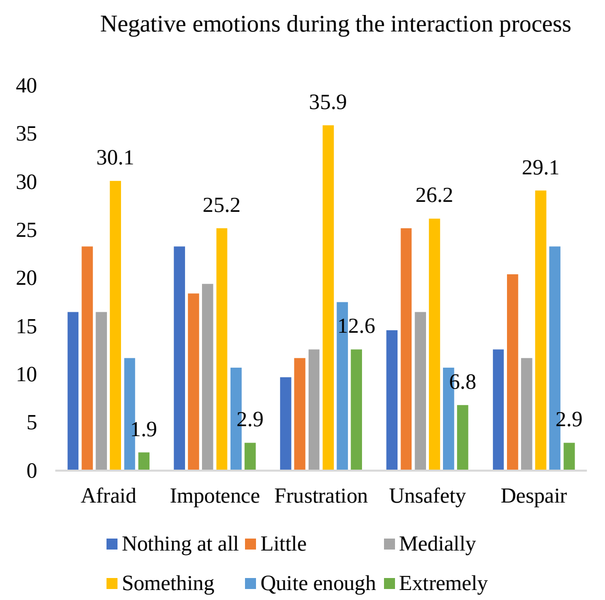


Graphic 6 Positive emotions that students experienced during the interaction process
Source: Own Elaboration

The interaction generates a series of emotions that can facilitate or inhibit the learning process. Positive emotions are captured in this Graphic. In the first instance, the students had some guidance (46.6%), support and encouragement (44.7%), and confidence (42.7%). With a lower percentage, they felt a lot of security and confidence (10.7%) as well as a stimulus for learning (3.9%)

In contrast, 5.89% of the subjects did not perceive support, trust and encouragement (2.9%). From these results we can identify good communication between the actors of the curriculum, which generates emotions such as accompaniment, encouragement and trust, which corroborates the role of a virtual environment, minimizing the gap between the student and the teacher to favor their interaction through communication (Cenich and Santos, 2005).

In addition to the above, Barberá, Badia and Mominó (2001) confirm that interaction can facilitate or inhibit the learning process in a virtual context where communication and interaction promote the development of interpersonal relationships that facilitate learning and group integration from the formulation of common objectives and learning networks (Suarez, 2004; Ortíz, 2005). On the other hand, the negative attitudes obtained in this section are closely related to the negative emotions experienced during the construction and deconstruction of knowledge in a virtual environment.



Graphic 7 Negative emotions that students experienced during the interaction process.
Source: Own Elaboration

Graphic 7 shows that 12.6% state that they have experienced a lot of frustration, 6.8% insecurity, 2.9% despair and helplessness. This corroborates what was pointed out by Antonopoulou and Gabriel (2001), Askham, (2001), who affirm that insecurity and despair can manifest themselves in the learning process as a consequence associated with the appropriation of new knowledge, the competences that it possesses to carry out a task and the experiences of discomfort they have had. Additionally, 35.9% experienced some frustration, 30.1% fear, and 29.1% despair.

In this regard, Askhan (2001); Short and Yorks (2002) consider that these emotions, together with those experienced in the virtual environment such as security, optimism, enthusiasm, are elements that affect the virtual teaching-learning process, since they facilitate learning.

The feelings they did not express were helplessness (23.3%), fear (16.5%) and insecurity (12.6%).

Conclusions

From the findings, it is inferred that the students' responses are regulated by the internal emotions they experience, because when feeling stress, it will be very difficult to express enthusiasm and perseverance to interact not only with the educational actors but also with the contents, despite the fact that the subject is interesting. However, if the emotions are self-regulating and express feelings such as security, optimism, orientation, trust and support, students will be able to put their emotional competences into practice and will be able to face the changes generated in their educational context without being carried away by attitudes that hinder your learning process.

Regarding the emotions they experience in a virtual learning environment, the students identified elements that generated emotions such as orientation, trust, security and recognition. In this sense, it is emphasized that orientation goes hand in hand with monitoring, which is carried out by the teacher in a synchronous or asynchronous way and is recognized by the student as an action that generates security and enthusiasm in their learning process.

With regard to emotions during the construction and deconstruction of knowledge in a virtual environment, it is found that positive emotions such as satisfaction, perseverance, security and optimism are representative, guaranteeing the willingness to incorporate new knowledge and achieve the purpose established in a program study. A close relationship was also identified between the negative emotions that students experience in their training through a virtual space, the deconstruction of their learning and the interaction between educational actors, since they express feelings of greater stress by reducing said interaction.

In addition, in the process of interaction mediated by communication, the fundamental elements in a virtual environment denote affective relationships such as support, trust, security, promoting a collective integration of new knowledge and learning. On the other hand, positive emotions generate empathy in a virtual learning environment, reducing negative emotions and increasing the desire to learn, creating an ideal environment for the achievement of common goals.

Finally, there are other situations that do not depend directly on the educational actors, and that trigger a series of emotions; however, the student can learn to react assertively and in a timely manner.

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Creating a backscatter multispectral mosaic with the R2Sonic 2024 Echosounder

Creación de un Mosaic multiespectral de retrodispersión con la Ecosonda R2Sonic 2024

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Abstract

The backscatter in Hydrographic surveys (LH) at the time of bathymetry is to measure the response of the acoustic pulse upon reaching the seabed, one part is reflected and another is absorbed by the type of sediment that exists on the bottom, the main objective The purpose of this work is to create a multispectral mosaic with the Broadband Multibeam Echosounder (MBES) R2Sonic 2024, in order to characterize the seabed through the use of different frequencies (170 kHz, 330 KHz and 450 kHz). Therefore, bathymetric data were obtained from the hydrographic survey carried out in the Port of Veracruz, highlighting that only one area of the seabed of said Port was analyzed, starting from the cleaning of the data with Hypack, the creation of the reference surface with the Fledermaus software and finally the backscatter data processing with the FMGeocoder Toolbox software. The processing allowed us to obtain as a final product a backscatter multispectral mosaic with acceptable parameters (due to the missing information of the 330 kHz frequency, but it was replaced by the 200 kHz one), which signify the beginning of the implementation of these mosaics in This area of research with multiple hydrographic, oceanographic and geological applications, due to the fact that currently there are not many studies on this subject in Mexico.

Mosaic, Multispectral, Backscatter

Resumen

La retrodispersión en los Levantamientos Hidrográficos (LH) al momento de realizar la batimetría es medir la respuesta del pulso acústico al llegar al fondo marino, una parte se refleja y otra es absorbida por el tipo de sedimentos que existe en el fondo, el objetivo principal del presente trabajo es crear un Mosaic multiespectral con la Ecosonda Multihaz de Banda Ancha (MBES) R2Sonic 2024, con el fin de caracterizar el fondo marino mediante el uso de diferentes frecuencias (170 kHz, 330 KHz y 450 kHz). Por lo anterior se obtuvieron datos batimétricos del levantamiento hidrográfico realizado en el puerto de Veracruz, resaltando que se analizó solo una zona del fondo marino de dicho Puerto, iniciando desde la limpieza de los datos con Hypack, la creación de la superficie de referencia con el software Fledermaus y finalmente el procesamiento de los datos de retrodispersión con el software FMGeocoder Toolbox. El procesamiento nos permitió obtener como producto final un Mosaic multiespectral de retrodispersión con parámetros aceptables (debido a que faltó información de la frecuencia de 330 kHz, pero se reemplazó por la de 200 kHz), que significan el inicio de la implementación de estos mosaicos en esta área de investigación con múltiples aplicaciones hidrográficas, oceanográficas y geológicas, debido a que actualmente no existe en México muchos estudios sobre este tema.

Mosaic, Multiespectral, Retrodispersión

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Introduction

Backscatter or Backscatter measures the intensity of the reflection of the acoustic frequency of the seabed, determined by the beam angle (R2 SONIC, 2029), the main characteristic of this backscatter multispectral mosaic is based on its possibility of supporting the In efforts to characterize the types of seabed, using different acoustic wavelengths, backscatter mosaic analysis has the following applications: assessment of the seabed, characteristics of the seabed such as hardness, monitoring of marine constructions due to changes over time , detection and verification of objects, exploration of natural resources, as well as habitat delimitation for research purposes.

All multibeam echo sounders have the kindness of determining the depth of the seabed by calculating the travel time of the pulses emitted by the transducer and received by it, the reflection of the pulse will depend on the emitted frequency, the angle of incidence and the background response. Hard bottoms reflect the signal better than soft bottoms, because soft bottoms absorb the energy received. (Ballesteros Mora & García Sala, 2010).

Derived from the problem of knowing the seabed, using information from multibeam systems, the creation of a backscatter multispectral mosaic for the analysis of the seabed was carried out with information from the multibeam echo sounder R2Sonic 2024, which has been part of the research teams of the Oceanographic Institute of the Gulf and Caribbean Sea, but the creation of the aforementioned mosaics had not yet been implemented.

To create the backscatter multispectral mosaic, it was necessary to use the mosaics of each frequency 170 kHz, 330kHz and 450 kHz, obtained with the information collected by the R2Sonic 2024 echo sounder, using the FMGeocoder Toolbox (FMGT) software, used for backscatter processing. The investigation of the creation and implementation of the backscatter multispectral mosaic was carried out in the interest of knowing more about the characterization and classification of the seabed.

In the methodology for the creation of the backscatter multispectral mosaic, a series of processes were carried out in different softwares (Hypack, fledermaus and FMGT) with the data acquired inside the port of Veracruz, during the development of the processing the collected data was analyzed, Said information allowed us to obtain as a final result a multispectral mosaic with acceptable parameters (due to the lack of information on the 330 kHz frequency, but it was replaced by that of 200 kHz).

This research has a benefit in the academic field, because it is the basis for knowing more about the aforementioned topic, it also provides institutional benefits because the backscatter multispectral mosaic means a new product that can be implemented in the direction of hydrography with information from the characteristics of the seabed.

The objective of backscattering in Hydrographic Surveys (LH) at the time of bathymetry is to measure the response of the acoustic pulse upon reaching the seabed, one part is reflected and another is absorbed by the type of bottom with which it makes contact (Carreño, 2009). So all the multibeam echo sounders, in addition to allowing us to determine the depth of the seabed, have also been able to generate various bathymetric products, such as bathymetric surfaces and the backscatter mosaic (grayscale image), in addition to the Nautical Chart (CN) that Until now it was the final product made by the Secretary of the Navy (SEMAR).

Among the equipment available to the Hydrographic Survey Brigades (BLH) at the Oceanographic Institute of the Gulf and the Caribbean Sea, there is the multibeam echo sounder R2 SONIC 2024 that, unlike the other multibeam echo sounders, not only mediates a frequency, but also They allow measurements with up to three simultaneous frequencies, which allowed us to generate a backscatter multispectral mosaic. With the backscatter mosaic generated by the returned energy snippets (fragments), it is possible to achieve an analysis for the characterization of the seabed (Craig J., Jonathan Beaudoin, Mike Brissette, & Vicki Gazzola, 2019), quoted mosaic allows to perform an analysis of the seabed, and to be the basis of various hydrography, oceanography, and research projects, among other sciences with oceanic interests.

Methodology

For the preparation of this research, a bathymetric data processing was carried out in accordance with the coverage standards of the established fund (OHI, 2008) on October 29, 30, 31, 2019, said information was acquired in the vicinity of the port of Veracruz according to the study area of Figure 1, with the R2Sonic 2024 echo sounder according to the characteristics of Table 1.

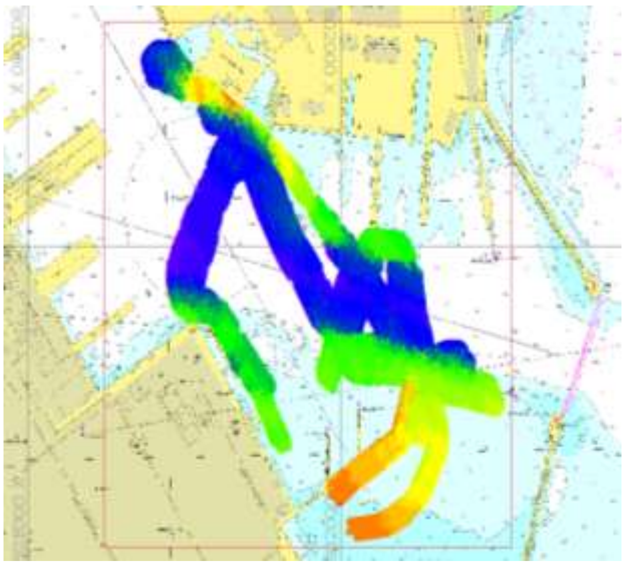

Figure 1 Study area
Source: Hypack (2020)

The multibeam echo sounder, R2Sonic 2024, has the following characteristics:

System caracteristics	Specification
Frequency	400 kHz / 200 kHz
Beam width - across sweep	0.5 ° @ 400 kHz /1.0°@200 kHz
Beam width - along the sweep	1.0 ° @ 400 kHz /2.0°@200 kHz
Number of beams	256
Sweep angle	10 ° to 160 ° (user selection)
Pulse length	15**µ** Sec- 1000 **µ** Sec
Pulse type	Continuous Waveform (CW)
Depth range	100 meters (3000 meters optional)
Operating temperature	-10 ° C to 40 ° C
Storage temperature	-30 ° C to 55 ° C

Tabla 1 R2 Sonic 2024 Echosounder Specification System
Source: R2 Sonic Operation Manual, 2024

Figure 2 Shows the R2Sonic 2021 Echosounder and modular interface and technical data modes

Figure 2 R2Sonic 2021 echo sounder and modular interface
Source: R2 Sonic 2024 Operation Manual (2019)

- Technical modes: All technical modes can be activated separately.
- Ultra High Density (UHD)
- Ultra High Resolution (UHR)
- Pipeline mode
- Prospective sonar (FLS)
- TruePixTM compressed water column
- TruePixTM Backscatter Multifrequency
- Multi-frequency TruePixTM compressed water column
- Multifrequency Bathymetry

Once the post-processing of the bathymetric data had been carried out and the bathymetric surface was generated in Figure 3 grid format, custom configurations were created for the frequencies of 170 kHz, 330 kHz and 450 kHz according to Figure 4, since these frequencies are the necessary ones. To elaborate the backscatter multispectral mosaic, due to the quality of the data collected, a processing was configured for the 200 kHz mosaic, which will be explained later.

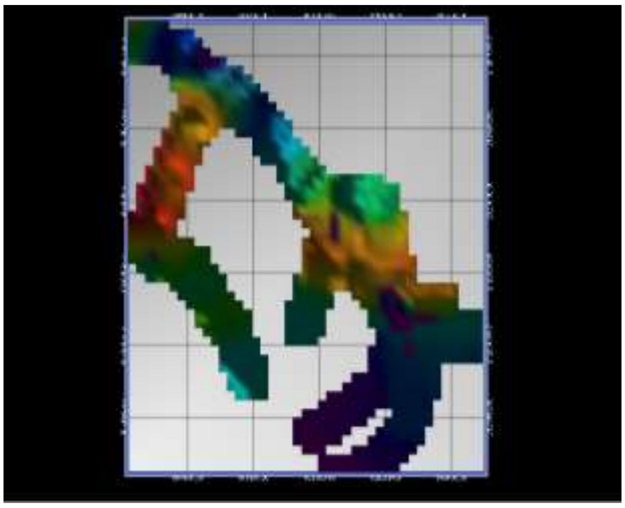

Figure 3 Grid-format bathymetric surface
Source: Fledermaus 7.0 (2020)

Figure 4 Render Settings for Tiles
Source: FGMT V.7.8.10 (2020)

In the case that the absorption has not been added for each frequency in Sonic control, it is possible to add the absorption information in the 'settings' within the processing parameters for the given frequency, as in the data collected this absorption was applied during the acquisition no value had to be applied in the FMGT tool.

Mosaic generation for each band:

If mosaics of each frequency measured simultaneously are created, it allows the possibility of identifying an acoustic response for each band according to the type of sediment. Collecting backscatter data in multi-frequency increases the uniformity and precision of the measured data.

170 kHz: The reference grid (Gridded data) must be activated, all GSF files must be selected, and in the multispectral processing parameters it is limited to a single frequency 170 kHz Figure 5.

Figure 5 Frequency limit
Source: FGMT V.7.8.10 (2020)

Afterwards, it was checked that the mosaic memory was green before starting the processing, if it was red, the mosaic size would be updated, for example 2.5 m., Then we select "Automatic Processing - Beam Time Series" a window will appear pop-up that shows the steps and progress of the backscatter mosaic processing of Figure 6.

Figure 6 170 kHz processing
Source: FGMT V.7.8.10 (2020)

The time it takes to process the mosaic is related to the number of source files, the set pixel size, the cores of the computer, and the processing power, at the end of the process the mosaic is reflected on the main screen of objects visuals, in this part the name corresponding to the mosaic frequency “170 kHz” was added.

The range of the color scale can be adjusted to improve the contrast within the mosaic, this was done on the histogram.

To generate the following mosaics, the previous mosaic was deselected, the indexed files were refreshed since the data was collected simultaneously and therefore the GSF merge file is the same base.

Finally the steps were repeated for the other frequencies, in this way we obtained the 170 kHz, 200 kHz and 450 kHz mosaics, the 330 kHz mosaic was not created due to a failure to estimate the resolution range according to Figure 7.

Figure 7 Processing Error 330 kHz
Source: FGMT V.7.8.10 (2020)

This happened because at the time of acquisition no snippets (fragments) were collected at said frequency, adding a 200 kHz mosaic that has a few snippets to be able to generate the backscatter multispectral mosaic. After processing the individual files were exported in grayscale GeoTiff format (Image).

Creating the backscatter multispectral mosaic.

Multispectral mosaic (RGB) processing uses 3 mosaics, the red channel at 170 kHz, the green channel at 330 kHz replaced by the 200 kHz, and the blue channel at 450 kHz.

Results and analysis

The representation was carried out through graphs that have an octagonal shape, where each side of the geometric Figure represents one of the components of the wind. Each of these sides is the base of a bar graph where it represents the monthly average of the frequency of the wind and the color, based on the Beaufort scale (Table 2), indicates the maximum average sustained wind that can be expected. . Likewise, in the central part it is shown if there was no wind, a situation known as periods of calm.

From the special order survey carried out on October 30, 2019, 10 navigation lines were taken, later the processing for cleaning bathymetric data and indexing was carried out and the procedure to generate the 170 kHz, 200 kHz and 450 mosaics was added. KHz, in order to create a backscatter multispectral mosaic of the study area, as shown in Figure 1.

Multibeam systems have advanced to high levels, that now we can achieve a high resolution mapping of the seabed, for that 3 different frequencies were needed to be able to appreciate how absorption reacts according to the different sediments found on the seabed, The mosaics generated for 170 KHz (Figure 8), 200 kHz (Figure 9), 450 KHz (Figure 10) and the backscatter multispectral mosaic (Figure 11) are shown first.

Mosaic 170 kHz

We can visualize that in said mosaic information was collected with the 170 KHz frequency uniformly from Figure 8, verifying the gain saturation parameters, this is one of the mosaics that are needed to generate the multispectral.

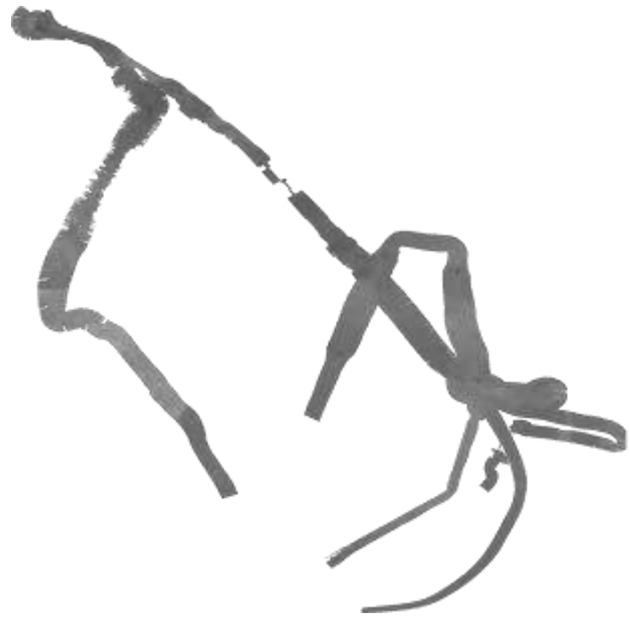

Figure 8 Mosaic 170 kHz
Source: FGMT V.7.8.10 (2020)

Mosaic 200 kHz

Figure 9 Mosaic 200 kHz
Source: FGMT V.7.8.10 (2020)

The second Mosaic was carried out using the 200 kHz frequency (Figure 9), replacing the 330 kHz frequency for which no data was collected (they were necessary to obtain better results), we can analyze that the information was not collected in a uniform, therefore the Mosaic does not cover the total area of the survey, although little information was used to generate the final Mosaic.

Mosaic 450 kHz

For the generation of the third backscatter Mosaic, the 450 kHz frequency was used (Figure 10), analyzing the Mosaic obtained we note that it only covers 70% of the total survey area, it contains more information than the 200 kHz one, but it will be necessary to generate the final Mosaic.

Figure 10 Backscatter Multispectral Mosaic
Source: FGMT V.7.8.10 (2020)

This Mosaic is used to analyze the seabed, it gives us a better perception to analyze the sediments on the bottom, it is created with the mixture of frequencies 170 kHz (red), 330 kHz (green) and 450 kHz (blue), in In this case, the 170 kHz frequency was replaced by the 200 kHz one that had some data, the methodology to create the multispectral Mosaic was achieved (Figure 11), but in subsequent studies the collection should be considered uniformly in each of them , with this a better result will be obtained.

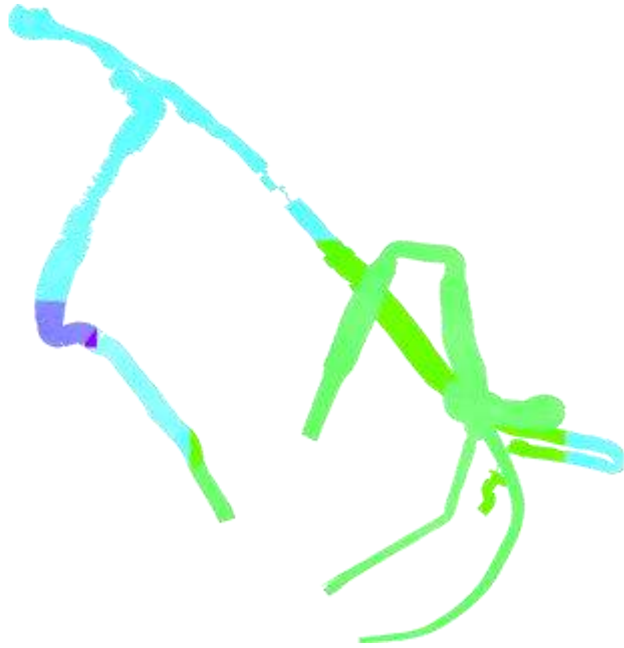

Figure 11 Backscatter Multispectral Mosaic (RGB)
Source: FGMT V.7.8.10 (2020)

170 kHz, 200 kHz and Multispectral Analysis (RGB)

We can analyze that the response of the seabed sediments changes from one frequency to another (Figure 12), but in the RGB we can notice the seabed delimited by borders (grouping of similar sediment traits), in this case the frequency was used of 200 kHz due to the absence of data of the 330 Khz frequency, in (Figure 13) an area that coincides with the other frequencies was analyzed and a better perception is appreciated in the RGB.

The result is acceptable as it forms a basis for future research in the field of backscattering for the analysis of the seabed.

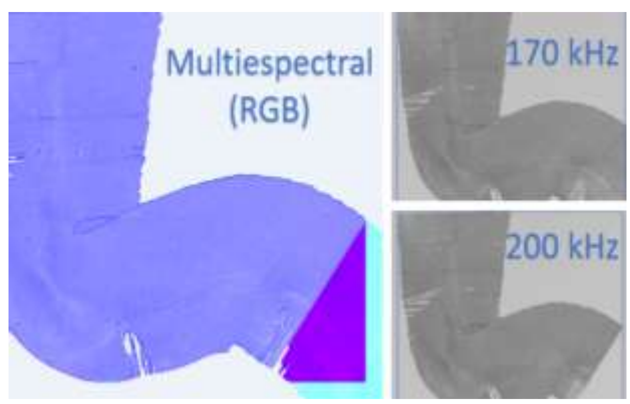

Figure 12 Boundary delimitation
Source: Microsoft 365 (2020)

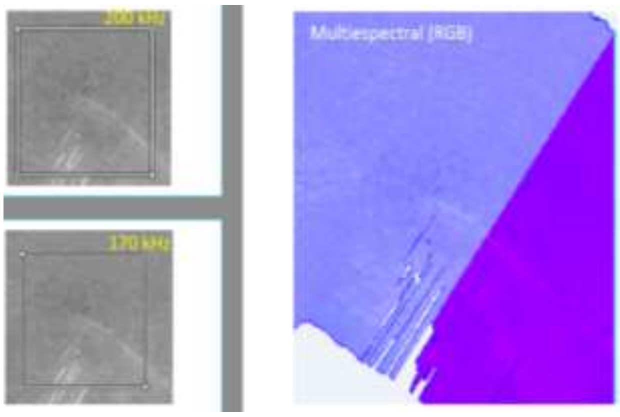

Figure 13 Analyzed Area
Source: Microsoft 365 (2020)

Mosaic Hypack Geocoder

To complement the backscatter information we add a Mosaic generated in Geocoder Hypack license software, where we can see another way of using the information of a backscatter Mosaic, in this case it is only done with a frequency and in probabilistic absorption data measured in decibels, a type of bottom sediment, called "Sandy Clay" is generalized for the study area see Figure 14.

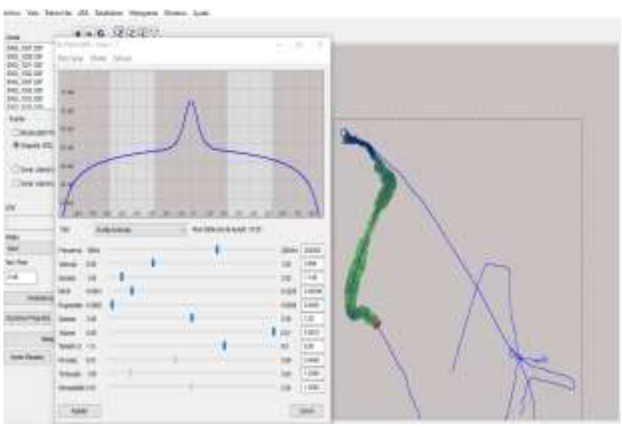

Figure 14 Mosaic Geocoder
Source: Hypack (2020)

Conclusions

In this work, the principle and characteristics of backscatter were described, focusing only on the data collected with the R2Sonic 2024 echo sounder, the most important of which is the innovation that backscatter mosaics bring with them in the analysis of the seabed.

It was understood how the R2Sonic 2024 echo sounder works in the acquisition of the bathymetric data necessary to generate the backscatter Mosaic, the most outstanding thing is that said echo sounder allows to generate a multispectral Mosaic merging the 3 spectral bands; red, green and blue (170 kHz, 330 kHz, 450 kHz), what was difficult in this case was the absence of data on the 330 kHz frequency, which is why it was replaced by the 200 kHz to generate the multispectral Mosaic.

In the aforementioned work, a backscatter multispectral Mosaic was created step by step, the most important thing was the processing in different softwares to obtain the files necessary for the creation of the multispectral Mosaic.

The creation of the backscatter multispectral Mosaic was achieved with the R2Sonic 2024 echo sounder, only a part of the seabed of the study area was analyzed, because in the acquisition it was necessary to collect data at the 330 kHz frequency, however, it is the principle to obtain information on the seabed while performing the bathymetry.

Recommendations

In the areas where special order surveys (S-44) are carried out using the R2Sonic 2024 echo sounder, activate the acquisition of truepix multifrequency data, to generate the backscatter multispectral mosaics and have a better understanding of the seabed.

The key to a good backscatter mosaic lies in good data acquisition, which is why the hydrographer must monitor the saturation levels of each frequency during this process.

Multispectral Distropersion Mosaic has the advantage of reducing the costs of traditional surveys that require multibeam data at various frequencies in addition to increasing productivity and providing other products of multispectral bathymetry for the characterization of the seabed that serve as a basis for the investigation of other areas such as oceanography and geology.

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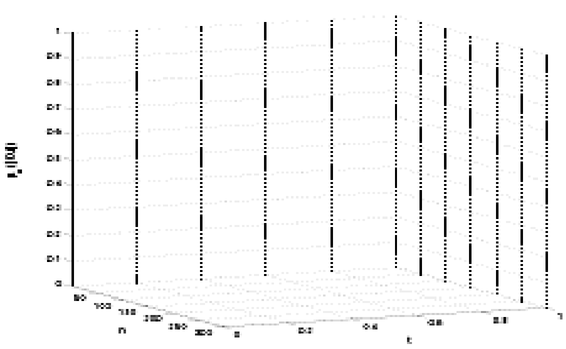

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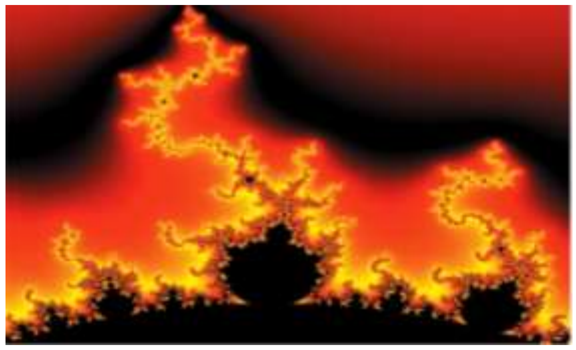

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