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Content

Editorial

Engineering has evolved in different professional branches, contributing creatively and innovatively to developing new technologies. However, despite the efforts of engineering to motivate new developments, it is only possible with the knowledge of the sciences that give life to engineering and its contributions. In the March issue of Athenea Magazine, experimental analyses of the sciences are presented as analyses of the environmental impacts that technology faces in its trajectory.

Athenea Magazine is projected as a space to make known the engineering sciences from a global vision that allows the incorporation of science, technology, and the protection of life and nature, highlighting those aspects that can promote new research.

Ángel Lezama

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Use of artificial intelligence in cleaner production proposals

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Abstract. - This paper aims to present a critical essay on the importance of artificial intelligence for companies' future, its objective of leaving a positive ecological footprint, and rewarding the use of natural resources spent by industries. Humanity has made life easier for everyone with technological advances; for this reason, with the proper research of accurate data, a prediction can be given of the savings and other economic and social benefits companies will obtain with artificial intelligence for cleaner production.

Keywords: Cleaner production, industry 4.0, harnessing, big data, artificial intelligence.

Uso de la inteligencia artificial en propuestas de producción más limpia

Resumen: El propósito de este trabajo es presentar un ensayo crítico sobre la importancia de la inteligencia artificial para el futuro de las empresas y su objetivo de dejar una huella ecológica positiva, premiando el uso de los recursos naturales que han sido gastados por las industrias. La humanidad ha hecho la vida más fácil para todos con los avances tecnológicos; por esta razón, con la investigación adecuada de datos reales consultados, se puede dar una predicción de los ahorros y otros beneficios económicos y sociales que las empresas obtendrán con la inteligencia artificial para una producción más limpia.

Palabras clave: Producción más limpia, industria 4.0, aprovechamiento, big data, inteligencia artificial.

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I. INTRODUCTION

The environment is precious, and its care and protection must be constantly encouraged using all possible tools. All the objects found on the planet come from nature, so taking care of them is essential. For this reason, the implementation of artificial intelligence as a cleaner production proposal is applied in different sectors to improve them, the environment one of them, due to the high technology implemented to protect the other natural resources necessary for life.

Currently, natural resources are being depleted, but as time passes, tools have also been developed that are based on artificial intelligence and that, as far as possible, delay the depletion of these resources and the effects they entail. Moreover, while the development of technologies has inevitable negative consequences for the planet, the advancement of these technologies has also brought benefits.

An example of the impact that artificial intelligence has had on the environment has been smart agriculture. The implementation of automated data collection has made it possible to detect problems in crops (in early stages) and know the optimal time of planting, irrigation, and fertilization, allowing greater efficiency in controlling resources such as water, pesticides, and fertilizers. On the other hand, the use of artificial intelligence has been put into practice in respective problems to reduce air pollution with the creation of eco-driving algorithms, route optimization, and decrease urban transport traffic, as well as the establishment of intelligent traffic lights, capable of reducing the driving time by adjusting traffic flow.

Thus, it can be determined that using artificial intelligence in cleaner production proposals provides new and more innovative solutions that allow us to fight many threats, such as climate change, pollution, and the health of the planet's waters.

II. Elements that prevent the creation of proposals for cleaner production in industry 4.0.

The environmental impact generated throughout history by the industrial sector is already quite studied and known, so implementing preventive or corrective actions is increasingly practiced by different companies that accept or encourage a positive environmental culture. This brings us to industry 4.0, which radically changes how some industries operate, making them more efficient and, directly or indirectly, reducing the environmental impact.

Industry 4.0 can be seen as the combination of advanced production techniques and intelligent technologies implemented in all organizations. The processes that are part of the value creation chain are connected through a digital network. [1]. And in a certain way, some factors limit the use or implementation of industry 4.0 and are similar to those that restrict the creation of more ecological proposals within this industry.

Economy

The economic factor is a significant gap in implementing new technologies, which limits a little more to industry 4.0. Although investments can be made in technological systems, increasing investment in proposals considering the ecological impact generated has yet to be considered.

Culture

Although industry 4.0 brings benefits in terms of reducing the environmental impact of certain activities, we must also take into account the effect it has, such as the production of materials that are the physical inputs of the systems and the high energy expenditure generated by some hardware in different industries, but that is not something as visible as the emission of CO2, It is often left aside, and there is no concern about the environmental impact of this industry.

It should also be borne in mind that despite its advantages, energy consumption will always be necessary and that traditional electricity will be dependent until some alternative is found, and this may be increasingly significant since the European Commission estimates that the energy footprint caused by technology is between 5% and 9% of world consumption [2].

B. Methods that prevent better use and use of cleaner production

Bottled products

According to Eco envases (2020), it is useless to consume bottled products. However, millions consume plastic bottles produced yearly for product packaging, and not all are recycled worldwide to create new materials. On the other hand, most of these containers end up in landfill, which significantly impedes the use and use of cleaner production. In addition, the unnecessary use of oil to produce plastic containers affects the environment and the beings that inhabit it.

Pesticides

Although the damage caused to the environment and animals is known, millions of people use pesticides to cultivate gardens and eliminate insects. Today, numerous natural remedies allow to keep insects away and keep the garden or plantations cared for naturally, without harming the environment or affecting living beings. That is, they encourage the use of cleaner production.

Plastic waste

Plastic waste has become part of everyday life, the same that can be easily found on roads, on the beach, in the forest, in parks, and in water resources. This waste, over time, has created plastic islands in the oceans and seas, causing the poisoning of marine animals.

Detergents and soaps

The Environmental Working Group in the United States has developed a blacklist of cleaning products used in homes that pose the most significant risks to health and the environment. Both detergents and soaps are not recommended because they have an antibacterial chemical compound that can destroy water and have catastrophic consequences for the marine environment and human health.

Glass bottles and cans

The most common waste on planet Earth is glass jars and cans. For one, glass jars can become small animal traps, and sharp parts (such as broken glass bottles, aluminum cans, and steel cans) can cause injury to wild animals. In addition, unfortunately, there is much waste of this type that is exposed to the air, and that takes decades to decompose.

Cosmetics

Many countries struggle to eliminate microcontaminants in cosmetic products, such as toothpaste and body scrubs. These tiny particles are not biodegradable, as they are made of polyethylene or polypropylene and, through sewers, reach seas, rivers, and lakes. Because of this, the danger has increased for fish and aquatic animals that ingest the micro granules, thinking they are food.

C. Big Data is a way to generate new proposals for cleaner production

To know the viability of a project, it is essential to know the organization's current situation, which is why data plays a vital role in understanding the benefits and waste reduction.

Data is at the heart of digital transformation, and the revolution is in being able to capitalize on it, take advantage of the value it brings to understand better what is happening, and, above all, be able to predict what will happen and prescribe what should be done. This will allow the optimization and generation of business opportunities and new sources of income.

There are several ways to collect data. However, they only sometimes treat this data correctly because of the large volumes, variety of sources, and the speed with which it is generated, known as Big Data. That is why several computational solutions have been developed that allow the treatment of Big Data, such as the following techniques to work with Big Data[3].

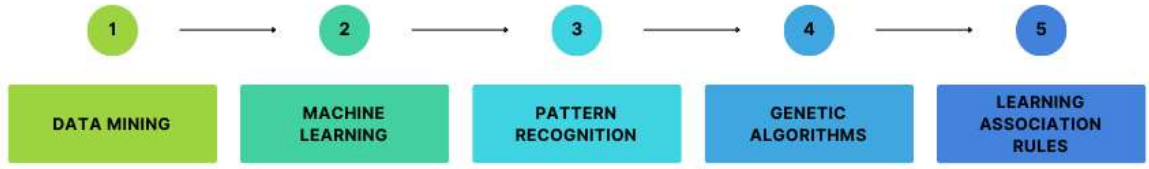

Fig. 1. Generation of new proposals through the application of Big Data

By applying these techniques, we obtain information that, when interpreted correctly, allows correct decision-making. Within a cleaner production project, costs can be reduced because the information is obtained from the workstations, which produce more waste and allows alternatives, such as the reuse of materials that allows the best use of the raw material used in the industry. [4] An example is observed in the aeronautical sector through optimizing aircraft routes. In 2019, IATA estimated 188,000 million dollars in fuel consumption in the global airline industry. Through the use of Big Data, it was possible to obtain data on the aircraft's speed and the influence of wind direction, with which they could establish the best routes with a saving of around 30 to 50 million dollars. [5] It is essential to highlight that this achievement also has an environmental impact by reducing the emission of CO2 into the environment. The application of Big Data allows us to identify the material that hurts the environment due to the use of chemicals or the amount of energy needed to transform it, opening the opportunity to look for new ways to offer a similar product to the market, optimizes the resources used in the process of adding value, which will allow the company to be more attractive to another niche market.[6]

II. Artificial intelligence and new proposals for cleaner production.

Environmental care, all the actions taken to reduce the deterioration of nature, has been affected mainly by the various companies that exist worldwide. For this reason, with the growth of technology, industries have found multiple ways to prevent pollution. One is artificial intelligence, the algorithms proposed to create machines that can perform human actions [2]. Artificial intelligence indicates an era of enterprise digital transformation. Although the investment ranges from $ 20,000 to 1,000,000 dollars, the benefits generated by this implementation are the reduction of operating costs, improved efficiency, and customer experience, which as a result, will obtain greater profitability [3]. It is estimated that by 2030, production will increase by 16% using this intelligence [4]. That is to say that in the future, companies will be obliged to make use of machinery with this type of technology and thus maintain a solid competitive level.

Companies are prone to various accidents, for example, fires. It is estimated that electrical fires cause 19% of business fires, that is, due to a lack of maintenance of cables, machinery, or electricity services. With artificial intelligence, the "B2FireDetection" tool has been created to calculate any fire risk that is about to occur with a minimum margin of error. In addition, it contains algorithms to monitor the status and behavior of infrastructures in extreme weather conditions [5]. In this way, this intelligence contributes to reducing the carbon footprint and protecting assets. In Latin America, it is estimated that as of 2018, fires in companies have increased by 8%. With AI, fires can be reduced to 90% due to their level of accuracy [6].

Food waste is a big problem for companies because it negatively impacts nature and generates significant economic losses in stores selling food and household products. For this reason, artificial intelligence has been developed that analyzes any food to determine the exact period in which the food is no longer consumable [7]. This system can be effective in the food and beverage industries because production would achieve a balance in terms of waste, increasing food availability and reducing the wear and tear of natural resources. Globally, 1300 million tons of food are wasted. However, by implementing artificial intelligence, it can be reduced by up to 80% due to its level of accuracy [8].

As we know, electricity generation is a polluting factor, and using this energy produces high amounts of greenhouse gases that cause climate change when expelled into the atmosphere. That is why one of the preventions for environmental care is to turn off devices that are not being used, which is not a habit among families. Consequently, artificial intelligence also helps us with this problem. Machines with algorithms have been created that can diagnose sleep stages by breathing users for automatic shutdown [9]. For companies, this type of machine will be advantageous since it would help reduce electricity costs and, at the same time, generate a tremendous ecological impact. This intelligence would help detect when the operator is not in place, so the machinery would not be used. By using these machines, it would be possible to reduce at least 5% of the current consumption [10]. We take the example that an Ecuadorian industrial SME has a consumption of $ 250 per month. Therefore, by reducing the abovementioned percentage, the SME would save $ 125.

Finally, the use of artificial intelligence has a significant impact on companies and their way of carrying out new business strategies that allow implementation of this machinery throughout the infrastructure so that, in this way, optimal results are achieved, and the investment is reflected in greater profitability and even provide differentiation with customers. The savings proposals of the machinery that have algorithms will save 80% in electricity, economy, and waste savings. For this reason, companies have to adapt to the new realities of being part of this new era.

III. RESULTS

For this point, it will be considered a food company that makes natural juices, so it has a farm with plantations of the fruits it needs for its production, and on the other hand, it has its factory in which the fruits are processed. Finally, the finished product, the bottled natural juice, comes out. For this cleaner production plan, everything from plantation control to processing will be considered. Then, in the first place, big data will be used to collect information from each fruit. That is, specific sensors will be implemented for each plantation to collect relevant data, such as the ripening time of the fruit and the amount of water it needs. With this information, we can use artificial intelligence to program a system in which the data collected is taken into account and automate the frequency of irrigation of the plantations. On the side of sustainability, this will minimize water consumption, allowing only the necessary amount to be used. On the side of business profit, the raw material will be in optimal condition.

Then we will consider the logistics, for this essential data will be used to predict the demand for raw materials: the number of fruits needed for production. With this, it will be possible to program and plan the planting of fruits with artificial intelligence, but it will also be possible to determine which fruits are already ready to be sent. By this, we mean that the fruits are already ripe, and the amount established by using big data is already available; With this information, you can schedule the transports and their frequency of them and minimize unnecessary transfers. On the sustainability side, there will be fewer transfers, which means less environmental pollution, and the company will have fewer logistics costs.

Finally, once the raw material is in the factory, big data will be used to recognize quality problems of the final product and within the process, and the availability of the machines will also be recognized. In this way, the use of these will be optimized. Furthermore, with artificial intelligence, the use of the devices will be programmed, so if one of them will not be used, it will remain off until its use is required. This reduces the company's energy consumption and expenditure. In conclusion, these measures will reduce the energy and water consumption of the company's productive activity by optimizing processes using big data and artificial intelligence.

CONCLUSIONS

-Although the development of technologies related to big data entails inevitable negative consequences, it cannot be denied that it has allowed the creation of new and very good solutions for the implementation of cleaner production proposals in the environment.

-Data within organizations plays an important role because it allows to know the current situation of the processes, however,if the data are not treated appropriately, the information does not contribute to decision making. For which it is recommended that organizations look for software that uses techniques, which adapt to their process and providing the visualization of management indicators that allow the continuous improvement of the organization by identifying lossesin the production process.

-The industrial future is also going towards automation and digitalization, which includes industry 4.0, in which many proposals can be made guided towards environmental care, so that both companies and governments will need to encourage proposals for cleaner production within the industry

-The industry must necessarily be supported by sustainable development, that is, it must try to maintain a balance with the components that surround it, as well as humans, as well as the environment in which it develops its activities, and although technology has been a trigger for this balance to be affected, at present, Technology can also allow industries to improve their processes with an emphasis on caring for the environment. This care is achieved through cleaner production techniques that are backed by technological tools which allow a serene coexistence between economic activity and the environment that surrounds them.

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The pendulum of the hand of statistics and engineering

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Abstract. - In the following work, you will find the research carried out to understand in a more feasible way the analysis of the simple pendulum since this study helps to understand many aspects found in everyday life, such as the operation of a clock. For this, a model was made to carry out all the necessary measures to process the data obtained. It was observed that there is a variation of the average time depending on its length, so applying statistical principles, where taking several samples, it was possible to visualize a natural phenomenon, applying an analysis based on engineering for gravity calculation, analytically and graphically.

Keywords: Gravity, statistics, physics, measurement, pendulum.

El péndulo de la mano de la estadística y la ingeniería

Resumen: En el siguiente trabajo encontrarás las investigaciones realizadas para entender de una manera más factible el análisis del péndulo simple, ya que este estudio ayuda a entender muchos aspectos que se encuentran en la vida cotidiana, como el funcionamiento de un reloj, para lo cual se realizó un modelo que permitió realizar todas las mediciones necesarias para luego procesar los datos obtenidos. Se observó que existe una variación del tiempo promedio como consecuencia de su duración, para lo cual, aplicando principios estadísticos, donde tomando varias muestras, fue posible visualizar un fenómeno natural, aplicando un análisis basado en ingeniería, para el cálculo de la gravedad, de manera analítica y gráfica.

Palabras clave: Gravedad, estática, física, medición, péndulo.

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I. INTRODUCTION

The pendulum is a severe body that can oscillate suspended from a point by a thread or rod. This has a mass, so, in turn, it generates a force that attracts it toward the gravitational center. There are several variations of the system. These can be formed from different materials. However, they are all governed by the same principle, oscillating and performing in certain circumstances, movements considered periodic or quasi-periodic [1]. In this sense, the pendulum represents the oscillatory movements of physics. The pendulum describes a circular trajectory. However, the arc it generates will have the radius of the length of the thread, being the pendulum at the most significant angle at which the weight will be thrown; this has potential energy, which will be converted into kinetic energy until reaching the equilibrium point (when it has an angle of 90° with the horizontal), When it begins to rise to the greater angle it becomes potential again.

One of the most valuable tools for analyzing the behavior of simple pendulum variables is descriptive statistics, which contributes significantly to most engineering work. Descriptive statistics is a branch used to summarize and present data clearly and concisely. In simple pendulum-based work, measurements of pendulum swing times can be summarized by descriptive statistics and presented as tables, graphs, and statistics as mean median, and standard deviation. This allows for a better understanding of the data and a more accessible interpretation of experimental results.

In this work, the behavior of gravity in the simple pendulum was analyzed with statistical applications. For this, an experimental practice of the pendulum was carried out to take the necessary data to evaluate the severity values later and make the respective calculations of errors and statistical analysis. Ten length measurements and three-time values have been considered for each case to optimize calculation procedures.

This work consists of 4 sections; in the first, the fundamentals of the subject of study have been described; in the second, the theoretical elements that support this research will be raised; in the third section, we will proceed to explain the methodological processes of the experiment. Finally, the results and conclusions are presented.

II. DEVELOPMENT

Ideally, a simple pendulum has a mass (m) suspended from a wire of length (l), inextensible and without mass [1]. The mass moves through an angle θ with the vertical axis. In our case, this angle should not exceed 15°, and the oscillation, without imparting an initial speed, is allowed to move only under the restrictions imposed by gravity and rope.

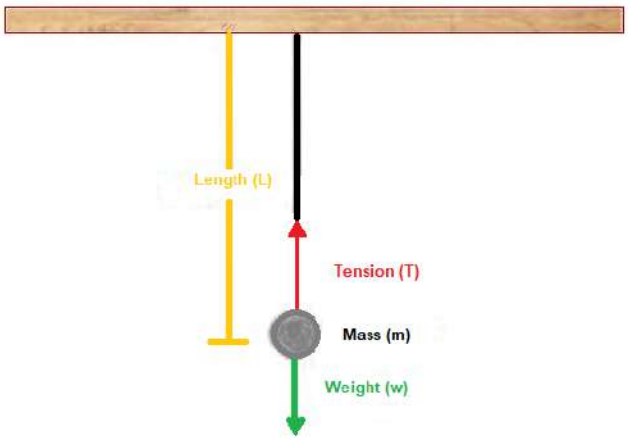

Fig. 1. Simple pendulum in balanced position.

Therefore, the particle's motion is confined within an arc of radius (θ) in the plane. The only forces acting on this mass are the weight ($\vec{w}$) and the string's tension ($\vec{T}$).

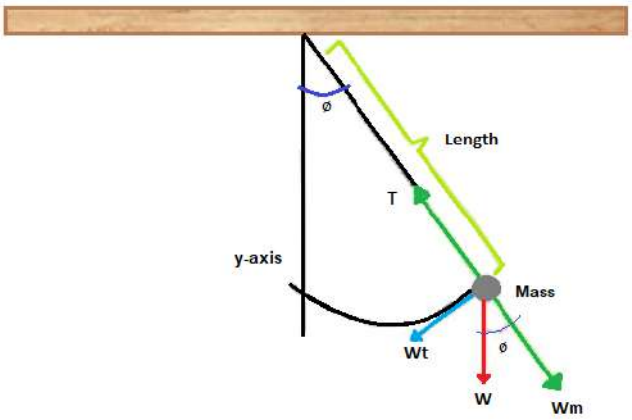

Fig. 2. Physical relationship of a simple module

Some movements are constant in physics and everyday life, such as tides, heartbeats, and clocks. Still, this last is the most thought for analyzing a simple pendulum because it is the most obvious example of periodic movement. Periodic motion is the movement of a body from one side to the other along a fixed path, returning to each position and velocity after a fixed time interval. A simple pendulum consists of an insignificant mass suspended from a string [2].

Any periodic motion can be thought of as the result of a set of simultaneous simple harmonic oscillatory movements. For this reason, simple harmonic motion is the basis for studying all periodic motion and, therefore, all periodic phenomena. The actual period and frequency are obtained in current practice, and the pendulum formula obtains the theoretical frequency.

$$T = 2\pi\sqrt{\frac{l}{g}} \quad (1)$$

where T = period (s), l = length and g = gravity m/s.

For laboratory analysis, single pendulum oscillators are idealized as natural systems with less than fifteen-degree angles. Due to their relative vibration relative to equilibrium, they generate mechanical energy dissipated in the form of kinetic energy. Based on equilibrium calculations, kinetic energy at its peak is idealized to identify its other measurements, such as amplitude, frequency, period, rapidity, and quality [3].

Gravity and oscillation are two fundamental parts of this study. However, it is known that gravity is the force that attracts objects to the earth's center. While oscillation is the movement of an object between two certain positions, these oscillations can vary depending on the length of the thread or material that holds it suspended. Due to this, it was decided that the best way to check everything described above would be to make a model that is functional, that allows and perform the analysis of the oscillation and the change that exists in it according to the length of the thread that helps to keep the dough suspended. This model aims to verify that what is in theory can be put into practice. On the other hand, you want to implement automation to it in a way that facilitates the collection of data and the necessary calculation with them.

A. Descriptive statistics in engineering

Statistics is essential to engineering, providing a solid foundation for decision-making and problem-solving. In experiment design, statistics is used to plan, design, and analyze experiments to determine relationships between variables and to optimize processes. For example, engineers use statistical techniques in chemical process engineering to optimize reaction conditions and maximize process efficiency.

In addition, in quality control, statistics are used to control and improve the quality of products and processes through statistical techniques such as process control and process capability. This allows engineers to detect and correct quality issues early, reducing costs and increasing customer satisfaction. In maintenance engineering, statistics are used to plan and schedule preventive and predictive maintenance of machinery and equipment, helping to reduce costs and increase asset availability. In short, statistics is a valuable tool for engineering as it allows engineers to collect, analyze, and use data to make informed decisions and solve problems in various fields.

The main errors to analyze in this paper are:

1. Absolute error: the difference exists between the measurements' theoretical and practical values obtained when making the measurements [1].

2. Systematic error: it varies predictably; this means you have an idea of the error that will come out [2].

3. Zero error: this error is one of the most common on a day-to-day basis; many times, it is due to a factory error; this happens when the equipment is zero; it marks a value that it should not.
4. Non-linearity error happens when the results do not generate a straight line but have a nonlinear trend [3].

5. Standard deviation: determines the variation between the data and the mean; when it is low, the data is concentrated near the mean. A high deviation indicates that the data is distributed over a broader range [4].

6. Variance: is an indicator of how uneven the data are around the mean; the higher the average, the greater the dispersion of the data and the less representative the mean [7].

III. METHODOLOGY

For the experimental data, the data collection was carried out with the prepared model and a body of 7 grams of weight at 15 degrees of inclination.

The model includes a design to build a model in a physical or a simple oscillatory pendulum. It has a wooden base to keep it stable, a wooden bar 1m 30cm high with a crossbar at the tip to hold a string with a weight attached as presented in the fig. 3.

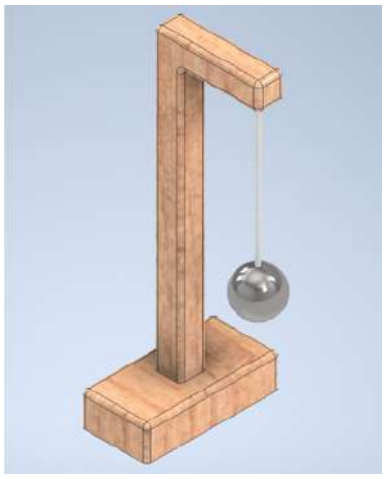

Fig. 2. Physical relationship of a simple module

After making the model as presented in the schematic diagram, a weight of 7 grams was incorporated with a diameter of 3 cm attached to a string of initial length of 10 cm, which is varied for different lengths, increasing from 5 cm to 5 cm after each measurement, in turn, to determine the time the pendulum was positioned at an angle of 15°, where the weight will be released to start with the taking of time until a complete oscillation ends, to later continue with the analysis of the average and obtain a more accurate measurement.

For the theoretical data, data were taken from a simulator at the University of Colorado, where the weight of the body was prepared as 0.10 kg; due to the minimum mass limitation of the system, the same inclination was adjusted and taken at a slow speed for greater precision of the time in which the cycle is completed.

Once the data was obtained, it was entered into an Excel table. With the experimental data collected at three different times, an average of the three values was obtained (Table 1)

Table 1. Physical relationship of a simple module

Theoretical		Experimental			
L (cm)	**T (s)**	**L (cm)**	**T_1(s)**	**T_2 (s)**	**T_3 (s)**
10	0.69	10	0.76	0.6	0.67
15	0.85	15	0.87	0.85	0.83
20	1	20	0.93	0.99	1
25	1.13	25	1.06	1.03	1.05
30	1.24	30	1.13	1.1	1.15
35	1.31	35	1.2	1.33	1.32
40	1.44	40	1.34	1.5	1.37
45	1.54	45	1.4	1.48	1.53
50	1.61	50	1.55	1.57	1.6
55	1.66	55	1.67	1.69	1.66
60	1.74	60	1.68	1.67	1.7
65	1.83	65	1.85	1.82	1.86
70	1.91	70	1.9	1.92	1.98

IV. RESULTS

Once the experiment was performed, the following results were found:

Regarding the calculation of errors, it can be seen in Table 2. That the absolute error is very little because the measures taken did not significantly differ from one to the other. Therefore, it is considered that the values are the most accurate possible.

For absolute error calculations, the formula is implemented:

$$EA = X_0 - X \quad (2)$$

The absolute error presented a range from 0.0133s to 0.0233s, representing the study. On the other hand, the zero error was 0.68s.

On the other hand, in Table 2, you can see the nonlinearity errors obtained when evaluating the values in the formulas found and the period and severity calculations; these values help to understand the system's behavior.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad (3)$$

$$y = mx + b \quad (4)$$

$$\frac{L_2 - L_1}{(T_2)^2 - (T_1)^2} = \frac{g}{4\pi^2} \quad (5)$$

$$T = 2\pi \times \sqrt{\frac{L}{g}} \quad (6)$$

The absolute error presented a range from 0.0133s to 0.0233s, representing the study. On the other hand, the zero error was 0.68s.

On the other hand, in Table 2, you can see the nonlinearity errors obtained when evaluating the values in the formulas found and the period and severity calculations; these values help to understand the system's behavior.

Table 2. Physical relationship of a simple module

Non-linearity error				
Straight	**Y (experimental)**	**Y (theoretical)**	**Difference**	**Difference between points**
ye=48x - 22.64	9.94	10.2442	0.3042	0.304492065
	18.26	18.113	-0.147	0.147
	24.18	25.49	1.31	1.310271388
	27.7	31.8834	4.1834	4.184229918
	31.54	37.2932	5.7532	5.754316179
	39.06	40.7358	1.6758	1.676012157
	44.82	47.1292	2.3092	2.309491088
yt=49.18x - 23.69	48.02	52.0472	4.0272	4.027808317
	52.98	55.4898	2.5098	2.510067825
	57.78	57.9488	0.1688	0.169325774
	58.26	61.8832	3.6232	3.623643105
	65.94	66.3094	0.3694	0.369640552
	70.26	70.2438	-0.0162	0.028405711

For calculating the lines, equations (3) to (6) were used, allowing the use of both theoretical and experimental data.

For the calculation of gravity, equations (5) and (6) have been considered, where the lengths and times of the experiment are related.

As can be seen, the gravity calculations closely resemble the theoretical value of 9.81 m/s^2.

For the comparison of the theoretical and practical values, figure 4 was made. The theoretical and experimental data show a practically identical similarity between both.

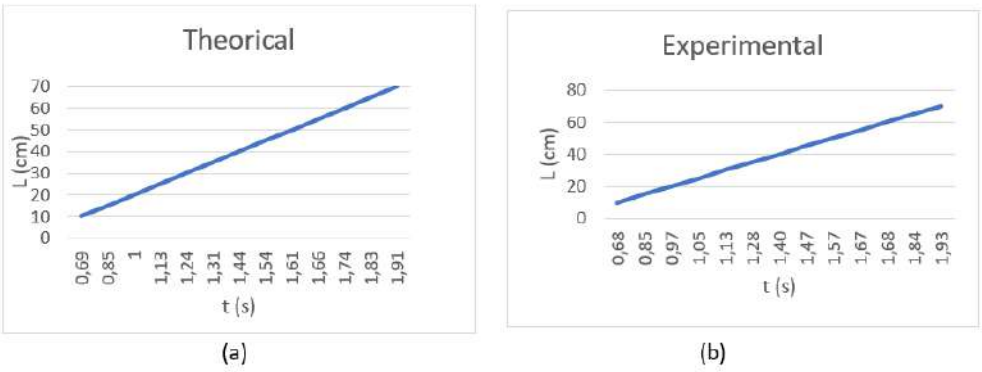

Fig. 4. Length as a function of time, (a) theoretical valúes, (b) experimental values.

It was observed that analytical gravity has a value very close to the theoretical value of gravity, while gravity analyzed graphically presents an average error of 0.00011667 to the theoretical value of gravity; this reflects that the experiment was performed consistently and fairly accurately. However, it would be prudent to repeat the tests with a more consistent mass, a thread with less resistance, and a more accurate stopwatch to reduce error values and improve the quality of the process performed m/s^2.

CONCLUSIONS

Throughout the research and the implementation of the theory, it was understood that in many opportunities, the theoretical result is very similar to the practical one. However, it must be taken into account that these values may differ if, when taking the measurements, the forecast of having precision in them needs to be taken.

Statistics is a great tool that facilitates calculations and allows you to predict the results obtained throughout the studies.

On the other hand, it is confirmed that statistics and engineering can shake hands when conducting studies. Statistics is a great ally when doing research because it helps predict results and know if the results being obtained are adequate.

The practical formulations in the understanding of concepts of physics and statistics are beneficial for teaching and learning in engineering careers since they allow interaction with the theoretical context and deepen the concepts achieving more significant learning.

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Smart models for cleaner production in Industry 4.0: A Scoping Review

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Abstract. - A scoping review is presented to know the new artificial intelligence trends in developing environmental proposals for industry 4.0. A review of 13 academic papers published in high-impact journals was carried out to evaluate the environmental proposals of expert researchers for the digitized industry. The main results show that there is a high tendency to research in the area of environmental process management, waste management, and treatments. In the material analyzed, there are no contributions from engineering developments or software developments for creating new and better materials that contribute to the environment and cleaner production plans.

Keywords: Smart models, cleaner production, industry 4.0, artificial intelligence, environmental developments.

Modelos inteligentes para una producción más limpia en la Industria 4.0: una revisión de alcance

Resumen: Se presenta una revisión del alcance para conocer las nuevas tendencias en inteligencia artificial en el desarrollo de propuestas ambientales para la industria 4.0. Se realizó una revisión de 13 documentos académicos publicados en revistas de alto impacto, para evaluar las propuestas ambientales de investigadores expertos para la industria digitalizada. Los principales resultados muestran que existe una alta tendencia hacia la investigación en torno a la gestión de procesos ambientales, gestión de residuos y tratamientos. Se observó que en el material analizado no hay aportes de desarrollos de ingeniería o desarrollos de software para la creación de nuevos y mejores materiales que contribuyan al medio ambiente y planes de producción más limpios.

Palabras clave: Modelos inteligentes, producción más limpia, industria 4.0, inteligencia artificial, desarrollos ambientales.

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I. Introdución

Cleaner production is a form of industrial production that reduces the use of non-renewable resources and waste and the emission of harmful materials such as greenhouse gases and chemicals. This is achieved by adopting clean technologies, improving existing production processes, introducing new, cleaner, and more efficient production processes, and eliminating hazardous materials or processes [1]. It can help significantly reduce production costs, improve product quality, increase productivity, reduce energy consumption and operating costs, improve occupational safety and worker health, and reduce air and water pollution. These benefits can be particularly important for local businesses and small and medium-sized enterprises (SMEs) that may need more resources to invest in cleaner technologies [2].

Cleaner production is becoming a priority for many companies as it helps them improve their reputation and comply with environmental regulations. This, in turn, allows them to take advantage of new business opportunities, such as producing products with green labels, which attract consumers interested in environmental protection. It also contributes to sustainable economic growth once improved productivity and reduced production costs [3]. This, in turn, generates employment, increases competitiveness, and improves the quality of life of the population.

In short, cleaner production is a form of industrial production based on continuous improvement and reduction of pollution, energy efficiency, and the use of resources to achieve sustainable industrial production. Several countries are promoting cleaner production through initiatives such as the Kyoto Protocol, the Stockholm Convention, and the United Nations Environment Programme [3], [4]. These initiatives set goals and standards to reduce pollution and improve the energy efficiency of industrial production to achieve sustainable development. In short, cleaner production is an essential tool for sustainability and sustainable economic development. This technique helps companies improve their reputation, reduce production costs, increase productivity, and contribute to sustainable development. In addition, governments also promote cleaner production to achieve sustainable development globally.

This paper will describe the elements that characterize the cleaner production process in digitized industries and the participation of artificial intelligence in the formulation of new sustainable proposals. In this sense, this work aims to show the contributions of artificial intelligence in cleaner production processes in the new business and industrial vision. Therefore, it consists of four main sections, the introduction, where the essential elements of the study problem have been described. A second section, where the theoretical aspects that support this research will be described, then the methodology and the results obtained are reflected to expose the conclusions finally.

II. Industry 4.0 and its participation in environmental improvements

Industry 4.0 focuses on increasing efficiency and productivity using digital and connected technologies to improve production processes. This is achieved by connecting production systems, automating processes, and collecting and analyzing data [4]. This also allows production to be more flexible and production changes faster. In addition, Industry 4.0 also cares about the environment. This is achieved by reducing production costs, which reduces the energy and resources needed to produce a product. It is also achieved through using renewable energy to power production systems. This helps reduce carbon emissions and other greenhouse gases, minimizing environmental impact [5], [4].

Thus, Industry 4.0 is concerned with efficiency, productivity, and the environment. This makes it an ideal solution for companies looking for more sustainable production. In addition, this technology also helps to improve product quality, which contributes to higher customer satisfaction.

This, in turn, improves the image of the company and its financial results. In summary, Industry 4.0 is a solution that brings benefits both in terms of productivity and sustainability. This makes it an ideal solution for any company looking to improve production [6], [7].

In addition, this technology also helps to improve the quality of the product, which contributes to greater customer satisfaction and improves the image of the company and its financial results. For these reasons, Industry 4.0 is an ideal solution for any company looking to improve its production. In conclusion, Industry 4.0 offers an ideal solution for companies looking to improve their products and care about the environment [6], [8]. This technology offers benefits in terms of productivity and sustainability, as well as contributing to improving product quality, customer satisfaction, and the company's financial results. For this reason, Industry 4.0 is an ideal solution for all those companies that want to improve their products responsibly.

A. Industry 4.0 and cleaner production

Industry 4.0 is a new industrial revolution that combines information and communication technologies (ICT) and automation to improve productivity, efficiency, and quality [9]. This is achieved by optimizing production processes, reducing errors, improving customer service, and reducing costs. This industrial revolution also allows the production of higher-quality products with fewer resources. Cleaner production is a concept related to Industry 4.0. It is a systemic approach to industrial production that improves productivity and efficiency by reducing waste, risks, and environmental costs [5], [10]. This involves a design approach focusing on reducing pollution and energy use, improving production processes, and using more efficient materials to reduce environmental impact. This contributes to the sustainability of industrial production [11].

Finally, Industry 4.0 and cleaner production are directly related. Industry 4.0 enables greater efficiency and productivity by automating production processes, while cleaner production focuses on reducing waste, risks, and environmental costs [12]. This contributes to the sustainability of industrial production. These concepts promote industrial innovation and produce higher-quality products with fewer resources [13]. This helps to improve the competitiveness of companies, reduce costs and improve the efficiency of production processes.

B. Artificial intelligence in the industry

Artificial intelligence is projected to play an essential role in cleaner production through process automation and resource optimization. For example, AI is expected to help reduce energy consumption and carbon emissions by optimizing energy efficiency in factories and implementing green technologies [14]. AI is also expected to help improve waste management and material recovery. In addition, AI is expected to assist the industry in decision-making and sustainable planning.

Artificial intelligence [15] plays an essential role in generating eco-sustainable materials, as it can help identify new ways to produce materials with less environmental impact. Some examples of how AI is used in the generation of eco-sustainable materials include:

Material design: AI can help design new materials with specific properties, such as higher strength or lower environmental impact [16].

Production processes: AI can help optimize production processes to reduce energy consumption and waste [2].

Recycling: AI can help improve material recycling by automated material identification and optimization of separation processes [15].

AI is expected to create a circular economy where waste is turned into valuable resources through advanced technologies [17].

A circular economy process with AI could include the following stages:

Waste collection and sorting: AI could use machine learning and image processing technologies to automatically sort waste and separate it by type. This could help reduce the time and costs associated with manual sorting [14].

Optimization of recycling processes: AI could use algorithms to optimize recycling processes and maximize the recovery of valuable materials [18]. For example, you could use machine learning techniques to predict the best method for each type of waste and adjust the processing parameters accordingly.

Material design: AI could use machine learning techniques to design new materials from recycled waste [11]. This could help reduce dependence on natural resources and create new sustainable products and solutions.
Demand prediction: AI could use machine learning techniques to predict future demand for products and materials, helping the industry plan production and resource use more efficiently.

Monitoring and evaluation: AI could use data analysis techniques to monitor and evaluate the performance of circular economy processes and determine areas for continuous improvement.

Overall, the use of AI in the circular economy could help improve efficiency and sustainability at all stages of the product lifecycle, from production to recycling and the design of new materials [15], [17], [14], [19].

III. Methodology

In this work, a non-in-depth literature review was carried out to know what contributions artificial intelligence offers to the best environment within industry 4.0 to initiate new research. Scientific articles from primary sources were evaluated, showing interest in formulating new proposals that help the best climate in the digital sector. Figure 1 presents the characteristics of the references made, taking into account the sources and the contributions they offer.

The research carried out is simplified, with the fundamental purpose of evaluating the conceptual knowledge, theories, or characteristic elements of artificial intelligence as a tool for the generation of sustainable environmental proposals in industry 4.0. To this end, the methodology proposed by Kirtchenham and Okoli, and Schabram on desk review, which in practice is similar to the PRISMA [11] (Preferred Reporting Items for Systematic reviews and Meta-Anayses) review model, was considered. The proposed method consists of three phases: planning, development, and reporting of the systematic review, which are carried out following eight steps for its execution: determine the purpose of the evaluation; define the protocol and training; Perform literature search; screening for inclusion; quality assessment; data extraction; study synthesis and review writing.

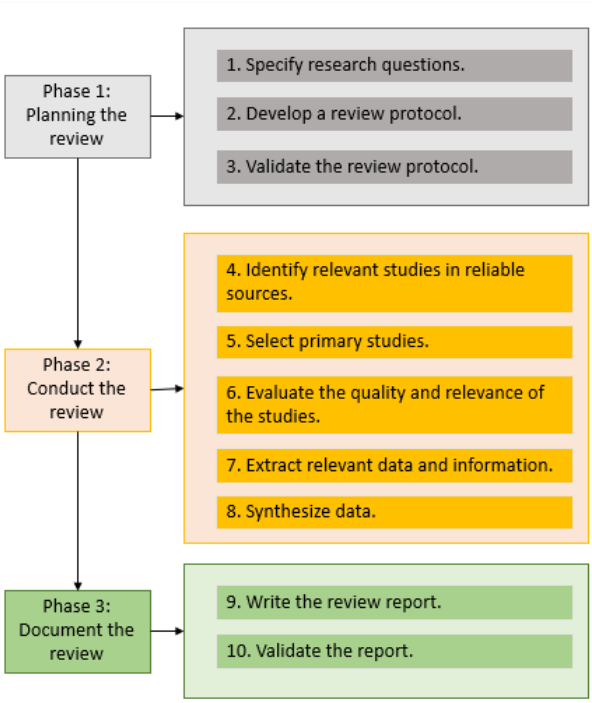

Fig. 1. Methodology proposed by Kirtchenham and Okoli and Schabram [11]

Phase 1: In this phase, the research questions have been defined, considering the relevance and timeliness of the topic of study, in this sense the questions posed are:

Q1: How does artificial intelligence participate in cleaner production processes in Industry 4? 0?
Q2: How do smart models look in environmental proposals for Industry 4. 0?
Q3: What variables have been considered in the new proposals for intelligent models for clean production?

The search process consists of conducting research of scientific documents that allow finding studies related to the subject of study, specifically in the environmental area for industry 4.0 and the contributions of artificial intelligence in this regard. In addition, the search is limited to the most recent years, from 2020 to 2023, as it is a current topic, it is intended to analyze the new proposals for intelligent models for cleaner production in the digitized industry. The Scopus database and the publications of the Elsevier publishing house that were open access were used.

A first search chain was defined based on the title and central field of the subject studied, with these elements the search chain is redefined considering the titles found, the keywords, the referenced studies, to finally achieve the following search chains:

- Smart AND modelsAND for AND cleaner AND production AND inAND industry 4.0 (6 documents).
- Artificial AND intelligence AND inAND environmental AND proposals (153 documents).
- Smart AND models AND environment (190 documents).

In Table 1, the first results found in different Scopus journals are sampled, only in the year 2023.

Table 1. Length as a function of time, (a) theoretical valúes, (b) experimental values.

Revista	Artículos
Mathematics	1
Journal of Cleaner Production	5
Sustainability	1
The 5th International Workshop on Environment and Geoscience	1
Procedia Computer Science	1
International Journal of Organizational Analysis	1
International Journal of Environmental Research and Public Health	1
Machines	1
Science of the Total Environment	1
Proceedings - 25th ACM/IEEE International Conference on Model Driven Engineering Languages and Systems, MODELS 2022	1

The manuscripts analyzed were classified according to the year of publication, in addition to the journal where it was published, the corresponding database, the number of citations, the methodology used, where experimental research, industrial case studies, and bibliographic reviews had priority.

The primary research was obtained through a chain of queries from the research questions. To know the findings of the articles and the quality of the topics, four criteria were applied: population, intervention, comparison, and outcome (PICO). In this sense, the population refers to published studies. The intervention is related to artificial intelligence and cleaner production in the new proposals of industry 4.0. The comparison refers to carefully selected studies with artificial intelligence in environmental proposals and the type of research. The result includes published studies on artificial intelligence in new environmental developments and its participation in Industry 4.0; based on PICO, five new questions were asked to ensure the quality of the extracted articles, as shown in Table 2.

Table 2. Evaluation of the quality of the documents analyzed.

Quality Control (QA)	Quality Assessment Questions	Answer
QA1	Does the paper describe the contributions of artificial intelligence to the new industry 4.0 environmental proposal?	(+1) Yes/ (+0) No
QA2	Does the document specify the characteristics of artificial intelligence developments in environmental proposals?	(+1) Yes/ (+0) No
QA3	Does the paper present any discussion of the findings surrounding artificial intelligence in environmental developments in industrial 4.0?	(+1) Yes/ (+0) No
QA4	Are the limitations present in the current environmental proposals of Industry 4.0 considered?	(+1) Yes/ (+0) No
QA5	Are future projections made for new industry 4.0 environmental proposals?	(+1) Yes/ (+0) No

The inclusion and exclusion criteria aim to find significant primary documents to answer the research questions posed. The agreement between the evaluators was resolved by applying Cohen's Kappa coefficient = 0.5 with a percentage of agreement of 87.1%, which implies a moderate agreement among the evaluators.

The inclusion criteria were that the preliminary research is associated with publications in journals on the contributions of artificial intelligence in the new environmental proposals for industry 4.0, that the year of publication is recent, between 2019 and 2022, that the document is presented in a high-impact journal, preferably in English. While the exclusion criteria were the preliminary study is limited, literature review articles and similar articles from different sources.

IV. Results

The documents analyzed to show that artificial intelligence offers an essential contribution to the generation of new environmental proposals for industry 4.0. In this sense, the review showed that many investigations are being carried out around the opportunities offered by artificial intelligence in environmental applications. It was mainly found that the proposals are framed in process and quality management, noting that many challenges for new materials and engineering developments have yet to be substantially defined, just as no proposals for software developments with artificial intelligence that contribute to new research.

The research is only an outline to open future work since the development of new materials that could be designed using artificial intelligence will have to be considered. Some examples might include:

Bioplastics: AI could help design bioplastics from organic waste, such as agricultural or food waste. These bioplastics could be used in various applications, such as packaging and single-use products. That the study of the following materials can also be included within the category of bioplastics:

Polyathide polyester (PLA): This bioplastic is produced from organic substrates such as sugar cane or beets and is one of the most common bioplastics. It is biodegradable and used in various applications, including packaging and single-use products.

Aliphatic polyester (PBAT): This bioplastic is produced from a mixture of polylactic acid and aliphatic polyester polyesters. It is biodegradable and is mainly used in packaging applications.

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Polyactidic acid (PHA) polyester: This bioplastic is biodegradable from microorganisms metabolizing carbohydrates. It is used in various applications, including packaging, single-use products, and toys.

Cellulose polyester (Cellulose): This bioplastic is biodegradable from wood pulp or plant cellulose. It is used in stationery and packaging applications.

Starch-based: This bioplastic is biodegradable from cereal or tuber starch. It is used in various applications, including packaging, single-use products, and toys.

Composite materials: AI could help design new composite materials from recycled and natural waste. These materials could have improved properties, such as increased strength and lower environmental impact.

Building materials: AI could help design new building materials from recycled waste, such as glass, plastic, and metal. These materials could be used in various applications, such as ceilings and flooring.

Hybrid materials: AI could help design new hybrid materials that combine the properties of different existing materials, improving their characteristics and performance.

Superconducting materials: AI could help design new superconducting materials with improved characteristics, such as increased energy efficiency and transmission capacity.

Overall, using AI to design new materials could help create more sustainable and efficient solutions, reducing environmental impact and increasing the efficiency of production processes.

The answers to the research questions resolved from the analysis to the studies collected in the literature review are presented below. Q1 How does artificial intelligence participate in cleaner production processes in Industry 4. 0? The documents analyzed show that the most significant participation is being presented in the management of processes and products, improvements in waste treatment, and process management that optimize productivity. Q2: How do intelligent models look in environmental proposals for Industry 4. 0? The documents analyzed show that intelligent models have a long way to go, and their development and participation in Industry 4.0 as an alternative for cleaner production is still incipient. Q3: What variables have been considered in the new proposals for intelligent models for clean production? The review showed that the main variables analyzed are occupational health and safety and the human-machine relationship for production improvement.

A high percentage of the works analyzed (64%) shows that process management for improvements in production, occupational safety, and health within environmental contexts are the most studied aspects concerning cleaner production in industry 4.0. It is essential to continue with extensive studies on artificial intelligence and its contribution to environmental improvements. Hence it is also necessary to include engineering developments that directly influence products and services for cleaner production.

Conclusions

The review is fundamental and needs to include an in-depth analysis of the selected articles. However, it allowed the yielding of relevant results that characterize the contributions of cleaner production in industry 4.0.

The analyzed documents reveal a more significant trend of studies that focus on managing environmental processes, waste treatment, and production management using intelligent tools rather than developing engineering proposals that affect the composition of materials and promote other treatment alternatives.

The limitations of this work lie in the fact that only contributions in English and open access were analyzed, ruling out possible contributions from other countries, which could include the development of intelligent software that offers new materials and waste reduction models.

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Artificial intelligence and participation in environmental protection, industry, and society

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Abstract. - Cleaner production is considered one of the essential means for manufacturing companies to achieve sustainable production and improve their competitive advantage. However, implementing the cleaner production strategy faces obstacles, such as the need for comprehensive data and valuable insights that can be used to provide better support in making optimization decisions in product lifecycle management and throughout the cleaner production process. Fortunately, with the extensive use of intelligent sensing devices in cleaner production, a large amount of real-time, multi-source lifecycle big data can now be collected. This paper presents results obtained in terms of proposals for cleaner production in areas such as the use of materials, the use of artificial intelligence, and obstacles to its use within the social and industrial world.

Keywords: Environmental protection, development proposals, life cycle.

Inteligencia artificial y su participación en la protección del medio ambiente, la industria y la sociedad

Resumen: La producción más limpia se considera uno de los medios más importantes para que las empresas manufactureras logren una producción sostenible y mejoren su ventaja competitiva sostenible. Sin embargo, la implementación de la estrategia de producción más limpia enfrenta obstáculos, como la falta de datos completos y conocimientos valiosos que puedan utilizarse para proporcionar un mejor apoyo en la toma de decisiones de optimización en la gestión del ciclo de vida del producto y durante todo el proceso de producción más limpia. Afortunadamente, con el uso extensivo de dispositivos de detección inteligentes en una producción más limpia, ahora se puede recopilar una gran cantidad de big data en tiempo real y de múltiples fuentes de ciclo de vida. Este artículo presenta los resultados obtenidos en términos de propuestas para una producción más limpia en áreas como el uso de materiales, el uso de inteligencia artificial y los obstáculos para su uso dentro de un mundo social e industrial.

Palabras clave: Protección del medio ambiente, propuestas de desarrollo, ciclo de vida.

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I. Introduction

In the production process, there is a large amount of waste and emissions due to the continuous transformations that the raw material has, which implies a waste of the resources used and inefficiency during the processes [1]. As a result, socioeconomic problems translate into the costs of production, treatment, and final disposal of waste. In the same way, they directly affect people's quality of life and the environment surrounding them. Generally [1], companies control the amount of waste once generated after production processes, so they do so through technologies and tools that require a high sum of investment. Cleaner production strategies focus on integrating preventive solutions for managing natural resources and reducing global pollution. Environmental management applies Cleaner Production techniques focused on processes, products, and services that require transforming inputs to give added value to customers. Its main objective is to optimize these resources by modifying, eliminating, or replacing raw materials [2]. The deterioration and exploitation of the environment are the problems that a realtering climatic conditions.

Environmental management is an issue that involves not only Cleaner Production strategies but also goes hand in hand with Industry 4.0 because the development of new green technologies allows the reduction of inputs in high quantities such as gasoline, but in the same way, these bring negative consequences to the environment in which people are surrounded [3]. The responsibility for sustainable development lies with all people to improve the quality of life and environmental conditions.

II. Development

Ecuador is a country in which a large amount of products resulting from the raw material cocoa is produced and exported, this since the country is present one of the highest quality seeds which allows to generate chocolates with the highest level. Thus, in figures, Ecuador has 12% of the land area cultivated by cocoa and approximately an income of $ 800,000 after the export of beans in the region [4].

Within the industrial sector, measures or programs have been promoted that contribute tothe proper management of resources, increase efficiency and strategies that reduce the impact or risks for both people and the environment. In this way, around the world companies opt for cleaner production projects because it allows them to be much more sustainable over time. This is how in the country, the Saquifrancia farm, which is located in the province of Pastaza is responsible for the cultivation of cane and cocoa; however, they have begun applying this type of projects especially in the process of obtaining cocoa, for this they had five phases:

- Stage 1: Corresponded to the definition of the objectives and goals of PML about the environmental policy of Saquifrancia. In addition, the company's current state was known, roles and responsibilities were delegated, obstacles to implementation were identified, concepts and good practices were defined and environmental regulations were considered.
- Stage 2: A technical-environmental-economic diagnosis is generated before the process considering the raw materials used and relevant information about the activities.
- Stage 3: A technical-economic-environmental evaluation considers materials, monetary units, and inefficiency costs, such as prioritization in terms of action.
- Stage 4: Cleaner production alternatives from waste and/or scrap of raw material, water, energy, products, facilities, methods, and personnel.
- Stage 5: Implementing alternatives within the company through an action plan must be controlled and evaluated periodically, considering the indicators generated in Stage 1.

With this analysis carried out in the company, inadequate water consumption and high levels of waste were generated. Primarily, the PML alternatives focused on improving the processes in which resources such as water and electricity were implemented or used and work was done to generate correct waste management. In addition, the feasibility analysis found that it is a viable process since the return on investment turned out to be approximately one year [5].

III. Methodology

The methodology developed was documentary since different sources of published information were reviewed to know the impacts of cleaner production in industrial scenarios and the participation of society in this regard. In addition, artificial intelligence's new development to face the new times' environmental challenges was evaluated.

III. Results

A.Elements that prevent the creation of cleaner production proposals in Industry 4.0

Although industry 4.0 seeks to reduce the amount of waste and emissions created by old or few automated objects, it must be taken into account that when manufacturing these new tools, many of them require the exploitation of mines to obtain organic minerals that allow improving the properties of automation, Without realizing that they are altering the ecosystem in an impactful way, due to the amount of natural space they require to obtain these minerals.

The industrial 4.0 market is so changing and exponentially way is growing. Therefore, old objects become obsolete, which makes people throw them, generating more pollution. This is because the market will always look for more efficient products that can have better characteristics in terms of connectivity. The internet has eye-catching features and new functions. Generally, by selling their new products, telephone companies make the old phones or lower versions no longer have the same compatibility with new updates. Therefore, in a certain way, they force their customers to acquire their new products more efficiently and innovative.

When discussing creating renewable energies, you can observe a certain number of problems, which will be described below; when using solar energy for large industries, they need to realize that solar panels affect biodiversity. This is because migratory birds that pass through these places can get burned by the vital emanation of heat. As for the use of wind energy, in the same way when using large mills, this affects animal biodiversity and generates hearing problems for people near these places.

B.Materials that prevent better use and use of cleaner production

Around the world, different industries generate or require materials that, despite being treated and/or handled in various ways, their consequences on the environment continue to be greater; according to the United Nations, the metals considered to have the most significant impact on the environment are gold, mercury, rhodium, or uranium. Those materials that mainly result from mining extraction and exploitation, especially the post-mining process, are the most complicated and extended after the operations carried out in a mining field [6].

At present, it is identified that there is an increase in demand for some metals since they are used for the design and creation of new technologies related to renewable energies; These materials can be indium, platinum, indium, or selenium. However; also other products with a high environmental impact can be plastics, iron, or steel [7].

Among other materials are those that pollute the atmosphere, evidenced through GHG emissions by the chemicals used for extraction processes such as transporting and/or crushing alluvial material. These turn out to be harmful during the implementation process of a cleaner production project because it seeks to reduce costs and environmental impact and that the processes are more efficient; however, these materials must be appropriately treated if it is not done, it can generate changes in the natural environment which in turn can affect directly in the creation of new processes to try to eliminate them, which prevents prevention strategies from being generated and corrective actions from being chosen [8].

In such a way, it can be mentioned that especially those materials related to extractive industries such as mining and oil are those that generate the most significant impact on the environment and, although environmental care measures or projects that seek sustainability sought, can be complicated since the actions taken for this type of materials as for the action of the environment and its care after this type of Process are only measures that turn out to be minimizing and more not of prevention and protection of the environment as of people.

a. Big Data to generate new proposals for cleaner production

Food waste is a major global problem. Several companies have been created to address it in recent years since it is a crucial sustainability problem since 1,300 million tons are generated worldwide yearly. The Food and Agriculture Organization of the United Nations estimated the total cost to society in 2014 at 2.6 trillion dollars. Many small businesses aim to address this problem by acting at different points in the supply chain, from suppliers to consumers, and at different levels of the food waste hierarchy, from prevention to energy recovery, redistribution, reuse, and recycling.

Big data analysis, using large and complex data sets manipulated by sophisticated computer programs, is increasingly used by companies in various sectors. Therefore, this proposal has analyzed case studies to provide a framework for understanding different food waste reduction business models and how they could benefit from using Big Data [9].

b. Artificial intelligence favors new proposals for cleaner production

Artificial intelligence is a tool that has become a trend today as it reduces costs and improves productivity, but that is not all due to its accuracy and the integration of information that this tool entails. Its results are a cleaner production since greater precision and efficiency represent a lower percentage of waste generated within the processes in addition to having enough flexibility of use and reliability of the Data obtained, making possible a better implementation of continuous improvement projects.

Evolution is inevitable in both people and companies and it is a fact that the digitization of data and processes, that is, the use of the software, is fundamental, and automation is a step forward for companies since it represents greater efficiency in their processes. It should be considered that the data collection took an extended period. There was a percentage of error: data with enough variability. However, using artificial intelligence not only can automate parts of the process of organizations, but it is possible to collect a large amount of data, such as the time it takes such activity. There is a large percentage of reliability in addition to contributing to decision-making.

Artificial intelligence is based on two areas, the software, which contains the programming of the activity to be carried out, and the programming of sensors and actuators, among other parts, necessary for the robot or artificial intelligence to function correctly according to its role and activities. On the other hand, there is the hardware that includes the sensors, the actuators, and the components that will work based on what is requested by programming in the software. Artificial intelligence creates new opportunities for flexible and efficient production, even for complex and increasingly customized products manufactured in small quantities.

In addition, the artificial intelligence market is increasingly demanded by different organizations due to its benefits. Although it represents a significant investment for companies, the results and advantages at a competitive level make it viable and profitable to implement. By 2035, intelligent and digitally networked systems and process chains could represent an additional growth of around 420 billion euros, only in Western Europe. According to a study by PwC, AI can contribute up to US$15.7 trillion to the global economy by 2030.

c. Idea based on artificial intelligence and Big Data for a cleaner production plan in the industry

Big Data, being a large-scale data analysis tool, represents an opportunity to democratize access to information on environmental issues, helping in the processes of measuring scenarios and baselines for both public and private decision-making.

Artificial Intelligence can also be used to significantly improve different weather forecasts worldwide. This technology allows data to be analyzed in real-time and with a minimum margin of error about meteorological catastrophes. Thus, by using various mathematical models, it is possible to offer different solutions to prevent this type of disaster, creating early warnings and adequately coordinating the management of emergencies.

Artificial intelligence, together with Big Data, allows us to create solutions to society's environmental problems. Thanks to all the technological resources that exist in the world can be used to generate environmental impact and thereby transform industries, for this these systems must guarantee to improve the quality of life relating to the environment, so it is intended to use this technology as a means of monitoring controlling risk areas to predict situations in the future and design action plans with positive results. These technologies are necessary to avoid causing environmental damage because they can automate various activities, including improving weather forecasts [10].

Conclusions

Artificial Intelligence and Big Data tools are part of the new instruments that are part of a new generation and can be decisive in developing any modern project. They are considered necessary for valuing large projects of excellent caliber worldwide. Its use in an ecological project of cleaner production can help the environment in many ways. One of them is performing several simulations of different environmental problems and, thus, together with Big Data calculating the necessary variables to know the effectiveness of the decision taken or the environmental proposal you want to execute.

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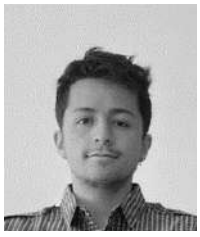

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$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

$$(1+x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} + \cdots$$

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