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Journal Industrial Engineering

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The works must be unpublished and refer to topics of Production systems design, product quality management, operations research, computer simulation, supply chains, quality certification, hydrometeorology and other topics related to Engineering and Technology.

Content Presentation

As the first article, we present, *Reactive power compensation considering a maintenance management model in an industrial plant*, by CETINA-ABREU, Rubén Joaquín, MADRIGAL-MARTINEZ, Manuel, TORRES-GARCÍA, Vicente and CORONA-SÁNCHEZ, Manuel, with adscription in the Universidad Tecnológica de Campeche, Instituto Tecnológico de Morelia and Universidad Nacional Autónoma de México, as second article we present, *Application of CAD, CAM, CAE, in prototype design and manufacturing of electric car lift* by RIVAS-RODRÍGUEZ, Amando, with adscription in the Tecnológico de Estudios Superiores de Cuautitlán Izcalli, as third article we present, *Energy saving in air conditioning systems, by using thermal insulators in an academic classroom,* by CASADOS-SÁNCHEZ, Álvaro, CASADOS-LÓPEZ, Edzel Jair, ANZELMETTI-ZARAGOZA, Juan Carlos and MARQUINA-CHÁVEZ, Alejandro, with adscription in the Universidad Veracruzana, as fourth article we present, *Biometric technological security for data and information protection*, by DOMÍNGUEZ-HERNÁNDEZ. Juan Pablo, CRUZ-GÓMEZ, Marco Antonio, TEUTLI-LEON, Margarita and POSADA-SANCHEZ, Ana Elena, with adscription in the Benemérita Universidad Autónoma de Puebla.

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Article
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Reactive power compensation considering a maintenance management model in an industrial plant

Compensación de potencia reactiva considerando un modelo de gestión de mantenimiento en una planta industrial

CETINA-ABREU, Rubén Joaquín†*, MADRIGAL-MARTINEZ, Manuel, TORRES-GARCÍA, Vicente and CORONA-SÁNCHEZ, Manuel

Universidad Tecnológica de Campeche, Mexico.
Instituto Tecnológico de Morelia, Mexico.
Universidad Nacional Autónoma de México, Mexico.

ID 1st Author: *Rubén Joaquín, Cetina-Abreu* / **ORC ID:** 0000-0003-3941-8706, **CVU CONACYT ID:** 322913

ID 1st Co-author: *Manuel, Madrigal-Martínez* / **ORC ID:** 0000-0003-1733-7673, **CVU CONACYT ID:** 25383

ID 2nd Co-author: *Vicente, Torres-García* / **ORC ID:** 0000-0002-7540-5331, **CVU CONACYT ID:** 217253

ID 3rd Co-author: *Manuel, Corona-Sánchez* / **ORC ID:** 0000-0002-0530-6493, **CVU CONACYT ID:** 590550

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Abstract

Nowadays, the development of electrical systems implies addressing issues of profitability in their processes, where decision-making aimed at energy efficiency without considering possible impacts on certain risks that can present high unprofitable costs for a plant. Integration of energy efficiency, maintenance and asset management is important for organizations. This work shows a case study where a reactive power compensation problem is presented, through the analysis from a maintenance management model aligned with an asset management. The application of different technical indicators of maintenance, reliability and economic management related to electrical parameters such as they are; active power, reactive power, apparent power, power factor (FP), peak demand current, energy losses and voltage drop, considering impacts of reliability, maintenance, energy consumption costs and penalties, showing a new way of address energy efficiency issues aligned with maintenance and asset management.

Energy efficiency, Maintenance, Asset management

Resumen

Actualmente, el desarrollo de sistemas eléctricos implica abordar tópicos de rentabilidad en sus procesos, donde la toma de decisiones orientadas a la eficiencia energética sin considerar posibles impactos sobre ciertos riesgos puede presentar altos costos no rentables para una planta. La integración de gestiones de eficiencia energética, de mantenimiento y de activos es importante para las organizaciones. Este trabajo muestra un caso de estudio donde se presenta un problema de compensación de potencia reactiva, mediante el análisis desde un modelo de gestión de mantenimiento alineado a una gestión de activos, se muestra la aplicación de diferentes indicadores técnicos de mantenimiento, confiabilidad y gestión económica relacionados con parámetros eléctricos como lo son; potencia activa, potencia reactiva, potencia aparente, factor de potencia (FP), corriente de la demanda máxima, pérdidas de energía y caída de tensión, considerando impactos de confiabilidad, mantenimiento, costos de consumo de energía y penalizaciones, mostrando una nueva forma de abordar problemas de eficiencia energética alineados con el mantenimiento y gestión de activos.

Eficiencia energética, Mantenimiento, Gestión de activos

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* Author Correspondence (Email: rubencetinaabreu@hotmail.com).
† Researcher contributing as first author.

Introduction

The changes that are occurring in the electrical grids demand management strategies that allow an optimization of critical assets at the generation, distribution, transmission, and sub-transmission levels, resulting in better profitability, risk control, operational reliability, energy saving and efficiency [1,2,3].

Electric energy efficiency is an important topic area where strategies have been implemented where many times it fails to consolidate, because it has been focused mainly on effectiveness (short-term actions) and not on efficiency (medium and long-term actions) and evaluation, having an emphasis many times on billing costs without considering the impacts that can occur in the maintenance, reliability and profitability of a plant [4,5]. On the other hand, it is very common to observe the need to have an asset management model that considers aspects of energy saving and efficiency, maintenance, reliability and profitability in industrial plants in an aligned way, otherwise undesirable situations may arise. In Fig. 1. it can be seen that there must be a hierarchical level, where the Asset Management is the most important level to consider in an industrial plant.

This work shows a way to address problems related to low effectiveness in reactive power compensation, presenting a new way of considering this type of problem and proposing justified solutions through the use of technical-economic indicators that provide benefits and consider aspects such as they are; energy saving and efficiency, maintenance, reliability and profitability.

In a such sense, section II begins by showing an 8-phases maintenance management model applied to electrical systems, briefly explaining each phase of the model, where phases 1,2,3 and 7 show the analysis of the impacts of a low power factor, which involve savings in billing costs, energy efficiency, maintenance and reliability aligned with asset management.

Section III mentions the concept of asset management, some international standards and shows some of the current problems that electrical systems are adressed.

Section IV shows the conventional methodology for calculating reactive power capacity, showing some calculations of electrical parameters. Section V shows the technical indicators of maintenance, reliability and economic. Section VI shows a case study of a reactive power compensation problem, where considering the calculated electrical parameters and applying the reliability, maintenance and economic indicators, different options can be evaluated.

II Maintenance management model used in electrical systems

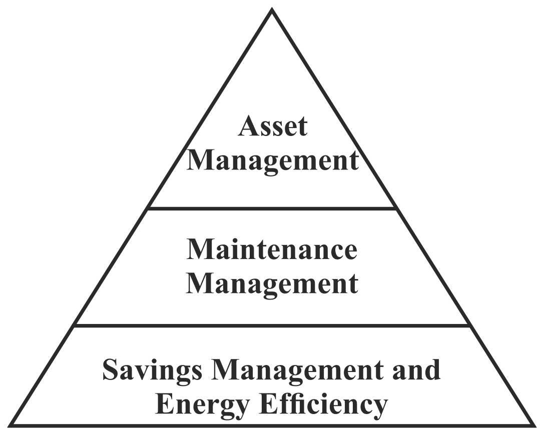

Figure 1 Considerations in energy efficiency management

A consolidated maintenance management model in electrical systems involves the use of tools and methodologies that allow adding value. In Fig. 2, a maintenance management model composed of eight phases is presented [6, 7]. The first three building blocks corresponding to condition maintenance effectiveness, the fourth and fifth ensure maintenance efficiency, blocks six and seven are focused to maintenance and assets life cycle cost assessment, finally block number eight ensures continuous maintenance management improvement. The description of each of the phases is as follows:

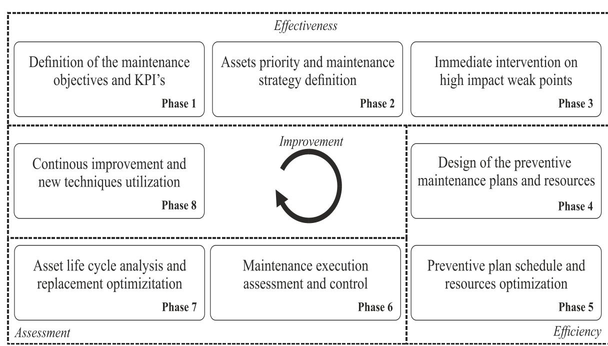

Figure 2 Maintenance Management Model aligned to asset management in electrical systems
Source: [5,6]

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Phase 1 shows the objectives set for improvements in a plant, within this stage technical, operational and financial indicators can be found through an information matrix called a balanced scorecard. Phase 2 is related to establishing a criticality in critical systems / equipment / components (such as transformers, tripping of protections that involve a financial loss, etc.). Phase 3 is related to the analysis of significant recurring problems in a plant, where many times due to ignorance of how to deal with them, it is decided to adapt to the problem (such as operating a plant at 70% or otherwise the protections are triggered or adapt to payments for penalties for low power factor and harmonic distortion). Phases 4 and 5 refer to optimizing maintenance plans to avoid the loss of the function of critical assets that could impact the plant (which must be done so that any critical asset continues its function in the operational context). In phase 6, probability distributions are applied considered in the operation of the assets based on basic indicators of maintenance and reliability. Phase 7 refers to the evaluation of assets by projecting all costs throughout the life cycle, considering the impacts in the area of reliability and maintainability of the assets. Phase 8 refers to the use and implementation of new tools that develops improvements in a plant. For the previous model to be profitable in an organization, it must be aligned with asset management as shown in Fig. 1.

III Asset management in electrical systems

Asset management can be defined as the set of activities and practices, systematic and coordinated, that an organization uses to ensure that its assets deliver results and objectives in a consistent, optimal and sustainable manner, managing risk [8]. This definition of asset management represents significantly greater scope considering that energy efficiency and maintenance must be aligned with it.

Currently, electrical systems presents problems, with vulnerabilities and the risk of economic losses due to aging assets, demand growth, limited access to capital for new assets, consequently operating costs are increasing, therefore availability and experience is limited, there is greater pressure from regulators and there is a broad focus on technical management (effectiveness) but management (efficiency) and evaluation must be improved.

Nowadays, some standards have begun to emerge, such as the ISO 55000/01/02 series of guides, which mention recommendations for managing assets throughout the life cycle [10,11,12], where it is recommended to be able to integrate the use of technical indicators with financial indicators.

IV Conventional technical methodology for reactive power compensation solutions

An electrical energy saving and efficiency strategy in a plant is to improve reactive power compensation [13, 14, 15], where the unwanted effects of not compensating reactive power is the increase in the apparent power delivered by transformers and increases in currents in feeders causing a degradation of the operational useful life of the electrical system equipment and high costs of penalties in the energy billing issued by the utility. A technical approach to solve this problem is by measuring electrical parameters such as: active power, reactive power, apparent power, power factor (*PF*), peak demand current, energy losses and voltage drop, and then calculating the required reactive power capacity.

4.1 Calculation of currents

The maximum demand current of the system can be calculated as shown:

$$I_L = \frac{P}{\sqrt{3}(V_{LL})(PF)} \tag{1}$$

Where V_{LL} is the line voltage, P is the maximum demand three-phase power and PF is the measured average power factor. This current of maximum demand, in the billing period, can be given by a measurement directly.

On the other hand, the short circuit current at the point of common coupling (PCC) of the load is:

$$I_{CC} = \frac{S_{CC}}{\sqrt{3}(V_{LL})} \tag{2}$$

Where S_{cc} is the three-phase short-circuit capacity at the load connection point expressed in kVA and is given by the utility.

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4.2 Calculation of power factor (PF)

The power factor can be calculated by:

$$PF = \frac{P}{S} \quad (3)$$

Where P and S are the active and apparent three-phase power, respectively, of a load center, generally given in kW and kVA. A conventional way to calculate PF is by using:

$$PF = \frac{kWh}{\sqrt{kWh^2 + kVArh^2}} \quad (4)$$

Depending on the measuring instruments, every 5, 10 or 15 minutes during a billing period, or by using the energy consumed in the billing period.

Considering a constant energy demand, the power factor is reduced as the apparent power increases, this due to the increase in reactive power kVAr demanded by the load. By the other hand, reducing the consumption of reactive power delivered by the main transformer will considerably improve the power factor.

4.3 Reactive power compensation using a capacitor bank

To improve the PF, capacitor banks are the most economical solution, whether they can be fixed, automatic connection / disconnection or through a stationary VAr compensator (SVC), depending on the reactive power requirements of a plant. The most conventional is through the use of fixed capacitor banks, where the reactive power calculation (Q in kVAr) to correct the PF is calculated as follows:

$$Q = P(tan\theta_1 - tan\theta_2) \quad (5)$$

Where:

$$\theta_1 = cos^{-1}(PF_1) \quad (6)$$

$$\theta_2 = cos^{-1}(PF_2) \quad (7)$$

Sub-index 1 indicates the actual PF in the system and sub-index 2 indicates the desired PF of the system.

4.4 Penalty and bonus for PF

To calculate an annual penalty for low power factor (APLPF), the equation used by the electricity company in México for high-consumption users is considered. This penalty is applied for power factors less than 0.90, and is given by [3]:

$$\boldsymbol{APLPF = Bill\left(\frac{3}{5}\right)\left(\frac{0.9}{FP} - 1\right)(12)} \quad (8)$$

Similarly, the APLPF can be converted into a bonus. The calculation for the annual bonus of the power factor (ABPF) is given by:

$$\mathrm{ABPF} = -\mathrm{Bill}\left(\frac{1}{4}\right)\left(1 - \frac{0.9}{\mathrm{FP}}\right)(12) \quad (9)$$

It is mentioned that the billing showed in this section comes from the sum of a fixed charge for the operation of the basic service provider, the cost of energy consumption and a cost of 2% of use in low voltage (LV).

V Reliability, maintenance and economic management indicators

The objective of management indicators in maintenance is diverse, however in this work some easily applicable indicators that can be related to economic indicators and an adequate profitability through an annual cost projection are shown. Developing maintenance management in a plant, consists of reducing the probability of the presence of faults (reliability), quickly and efficiently recovering the operability of the systems (maintainability) once the interruption of the function has occurred, minimizing the impact due to the consequences of fault events (unavailability costs). Efficient maintenance management seeks to: improve operational continuity (availability), maximize profitability through assets (economic gains) and minimize risks to safety, environment and operations to tolerable levels (consequences of fault events) throughout the useful life cycle [3, 16, 17, 18, 19].

5.1 Technical indicators of reliability and maintenance

The average time of operation (MTTF) is an indicator that shows the operational reliability through an average of the operating times of a component, machine or system.

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$$\mathrm{MTTF} = \frac{\sum_{i=1}^{i=n} \mathrm{TTF}_i}{n} \quad (10)$$

Where TTF is the operating time until failure or scheduled is replacement and n is the total number of faults or scheduled replacements in the evaluated period. By means of this indicator, the frequency of failures ff is given by the equation that is inversely proportional:

$$\mathrm{ff} = \frac{1}{\mathrm{MTTF}} \quad (11)$$

This indicator is used in the case of study exclusively in the transformer and in the proposed capacitor banks.

The average repair time MDTTR shows the maintainability of a component, machine or system, as shown:

$$\mathrm{MDTTR} = \frac{\sum_{i=1}^{n} \mathrm{DTTR}_i}{n} \quad (12)$$

Where the DTTR is the down time to repair.

Time out of service (TOS) is an indicator that shows the impacts of time to repair (MDTTR) and time out of control (TOC):

$$\mathrm{TOS} = \mathrm{TOC} + \mathrm{MDTTR} \quad (13)$$

For each TOSi, the time out of control (logistics, unforeseen events, etc.) plus the average repair times are considered, as shown:

$$\mathrm{TOS}_i = \mathrm{TOC}_i + \mathrm{MDTTR}_i \quad (14)$$

Another indicator used is the operational availability (Ao), which can be of various types, for this study the generic operational availability (Ao) of the system for a given period will be considered.

$$\mathrm{Ao} = \left(\frac{\mathrm{MTTF}}{\mathrm{MTTF+MDTTR}}\right) 100\% \quad (15)$$

5.2 Cost of unavailability in reliability (CUR)

It is an economic cost indicator that links the technical indicators ff (fault / year) and TOS (hr / fault) showing the impacts of reliability and maintainability in an annualized monetary value [3,20]. Consider the penalties costs PC (direct costs, penalty, quality, safety, etc) as shown:

$$\mathrm{CUR} = (\mathrm{ff})(\mathrm{TOS})(\mathrm{PC}) \quad (16)$$

5.3 Annualized Total Risk (ATR) for the life cycle

It is an economic indicator that projects annual costs and serves to make a cost comparison of components / equipment / system and is given by:

$$\mathrm{ATR} = \mathrm{AC} + \mathrm{OC} + \mathrm{MMC} + \mathrm{PMC} + \mathrm{CUR} \quad (17)$$

Where AC are the acquisition costs, OC are the operating costs, they include the costs for energy, supplies and raw materials, MMC are the major maintenance costs, PMC are the preventive maintenance costs and the CUR are the costs of unavailability in reliability.

5.4 EBITDA (Earning Before Interest Taxes Depreciation Amortization)

It is a financial indicator that shows the profitability before interest, taxes and depreciation [19,20]. One way to calculate it is given by:

$$\mathrm{EBITDA} = \mathrm{NI} - \mathrm{AMC} - \mathrm{OC} - \mathrm{AE} - \mathrm{SE} + \mathrm{DA} \quad (18)$$

Where NI is the net income (product sold), calculated as:

$$\mathrm{NI} = (\mathrm{PI})\,(\mathrm{Ao}) \quad (19)$$

Where PI is the potencial income ($) and Ao is the operational availability (%).

AMC are anual maintence costs, where preventive, major and corrective maintenance are considered (CUR).

$$\mathrm{AMC} = \mathrm{PMC} + \mathrm{MMC} + \mathrm{CUR} \quad (20)$$

OC are the operating costs. For the present study, only energy consumption expenses are considered, involving the costs of penalties and bonuses for PF.

AE is administrative expenses, SE is selling expenses and DA is depreciation / amortization.

VI Case study. Optimized reactive power compensation

The study presented corresponds to an electrical system of an industrial plant in steady state, there is a 500 kVA transformer, operating at PF of 0.7 (-), which feeds a load of 360 kW. The load is fed by a feeder of 2 conductors per phase 600 KCM size with a length of 100 m, operating 20 hours a day [15]. The Fig. 3 shows the diagram of the current system and the proposed system with its capacitor bank with the aim to guarantee a power factor of 0.95 and avoid any penalties.

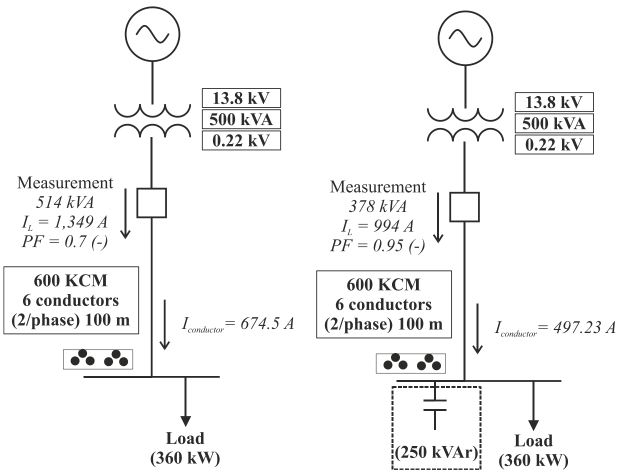

Figure 3 Current system and technically proposed system

For the system in Fig. 3, there is an Ordinary Medium Voltage Large Demand rate (OMVLD). Table I shows the values in the monthly billing, before of compensation this table shows a penalty for low power factor that corresponds to the system without reactive compensation.

Concept	Amount	Charge
kWh	210,000	
kVArh	214,254	
PF	0.7	$118,349.8
kW max	360	
$/kWh	$2.85	$598,588.2
$/kW 2% LV	$85.00	$30,600
$/kW Charge	$170.00	$61,200
TOTAL		**$808,738.75**

Table 1 Initial system billing

If it is calculated the capacitor bank for a PF of 0.95 applying (5) we have:

$$Q = 360(\tan(45°) - \tan(15°)) = 250 \text{ kVAr}$$

By means of this technical solution, it is observed in Fig. 3 that the transformer is not overloaded, likewise the current per phase I_L in the feeders is reduced and consequently the currents of the conductors $I_{conductors}$, this is due to the insertion of the capacitor bank with a capacity of 250 kVAr. The 600 KCM size conductor has a resistance of 0.0753 Ω / km, therefore the resistance for a distance of 100 m is:

$$R = 0.1(0.0753) = 0.00753\ \Omega$$

Where the losses considering the current in the conductor for the uncompensated system is:

$$P = 674.5^2(0.00753) = 3.425 \text{ kW}$$

And for the system with compensation:

$$P = 497.23^2(0.00753) = 1.861 \text{ kW}$$

It can be observed the low reduction of losses, for the compensated system the billing values are shown in Table 2, it is observed a bonus for power factor.

Concept	Amount	Charge
kWh	204,389	
kVArh	69,034	
PF	0.95	-$8,437.28
kW max	360	
$/kWh	$2.85	$582,454.5
$/kW 2% LV	$85.00	$30,600
$/kW Charge	$170.00	$61,200
TOTAL		**$665,871.07**

Table 2 System billing with compensation

Comparing Tables I and II, is shown a clear reduction in the monthly cost. On the other hand, there is a reduction in monthly energy consumption due to losses in the cables of:

$$P_{saving} = (3.425 \text{ kW} - 1.861 \text{ kW})(6 \text{ conductors})$$

$$(20 \text{ hr/day})(30 \text{ day}) = 5{,}630.4 \text{ kWh}$$

Which represents a saving of $ 16,046.64 considering the cost per kWh of $ 2.85.

For the return on investment of the capacitor bank, a cost of $ 250,000.00 is considered, then the simple return on investment is given by:

$$ROI = \frac{\$_{solution}}{\$_{Annual\ saving}} \quad (21)$$

Where the return on investment is approximately in two months:

$$ROI = \frac{\$250{,}000.00}{(\$808{,}738.75 - \$665{,}871.07)} = 1.74 \text{ months}$$

It is worth mentioning that this technical solution proposal through the ROI indicator does not consider the impacts of reliability and maintenance.

Using the model shown in Fig. 2 and through the first three phases, it is possible to analyze a recurring problem that corresponds to a low PF.

Phase 1 corresponds to the objectives set by management, which are set out in a balanced scorecard, where technical and economic indicators are considered, as shown in Table 3. Phase 2 corresponds to determining the equipment and systems that are critical in a plant, in a such sense in Table IV it can be observed the technical problems that impact management objectives.

Strategic objetives	Measures (KPI's)	Goals	Action	Perspective
Improve profitability considering the maintenance, reliability and efficiency and saving of electrical energy in the plant	Power Factor (*PF*), Electric Power Billing Costs in impacts on reliability and maintenance (*CUR*), Annualized Total Risk Indicator (*ATR*) *EBITDA* financial indicator	Increase profitability Improve maintenance, Improve reliability Improve energy savings and efficiency Decrease in operating costs (electrical energy)	Ensure adequate data acquisition (Billing costs, Evaluation of Cost-Risk-Benefit solutions) Simulations with software to avoid unwanted events (resonances) Development of new internal policies (acquisition, reengineering)	Financial Customers Internal processes Learning and growth

Table 3 Balanced scorecard, showing technical and financial indicators

Technical-operational problems		Costs to mitigate
Low PF of 0.70	Impacts on	Costs of penalties in energy billing and non-compliance with regulations
Transformer with overload (103%)	Impacts on	Corrective maintenance costs and penalties
Feeders with improper currents	Impacts on	Corrective maintenance costs and penalties

Table 4 Unwanted situations associated with a deficiency in reactive power compensation

Phase 3 corresponds to the analysis of vulnerabilities, which corresponds to unwanted events present in critical equipment / systems. The unwanted event of a low PF is a recurring problem that impacts management objectives, which corresponds to an analysis of the technical solution (250 kVAr capacitor bank).

Key Performance Indicators	Transformer
MTTFTranf (years)	20
ffTranf (Failure/year)	0.05
MDTTRTranf (hour/failure)	72
TOSTranf (hour/failure)	72
PCTranf ($/hour)	5,000.00
MCTranf ($/year)	24,000.00
ACTranf ($)	750,000.

Table 5 Technical maintenance and reliability data of capacitor banks

Considering the impacts of reliability, maintainability and profitability, the equations shown above are applied using data collected in the plant. Table V shows the transformer data, where the cost per penalty corresponds to lost in production due to total interruption.

Annualized Major and Preventive Maintenance Costs are in $CM_{Tranf.}$ For this case, it is mentioned that only a single transformer fault mode is analyzed in the three conditions.

Key Performance Indicators	Capacitor Bank Type 1	Capacitor Bank Type 2
MTTFCap (years)	4	1
ffCap (Failure/year)	0.25	1
MDTTRCap (hour/failure)	24	24
TOSCap (hour/failure))	24	24
PCCap ($/hour)	164.37	164.37
MCCap ($/year)	3,000.00	3,000.00
ACCap ($)	250,000	150,000

Table 6 Maintenance and reliability technical data of transformers

Table VI shows the data of the two types of capacitor banks proposed from different utilities, where the technical characteristics of each of them are observed. It is mentioned that the PC_{Cap} penalty costs are calculated based on the billing when there is a penalty for low FP, considering the capacitor bank in fault, either type 1 or type 2. The difference in the types of capacitor banks is according to the technical characteristics of maintenance, reliability and investment costs shown in Table 6.

Annualized major and preventive maintenance costs are in CM_{Cap}. For this case it is mentioned that only a single fault mode of the capacitor bank is analyzed.

With the above data, indicators are calculated that allow selecting the most appropriate proposal as shown in Table VII.

PF	0.7	0.95	0.95
Total CUR ($/year)	36,000.00	37,972.50	43,889.99
ATR ($/year)	9,802,364.95	8,155,425.31	8,248,842.80
TMC ($/year)	60,000.00	64,972.50	70,889.99
OC ($/year)	9,704,864.95	7,990,452.82	7,990,452.82
Ao	0.9992	0.9991	0.9990
PI ($/year)	10,000,000.00	10,000,000.00	10,000,000.00
NI ($/year)	9,991,787.57	9,990,875.91	9,989,573.83
AE($/year)	20,000.00	20,000.00	20,000.00
SE($/year)	30,000.00	30,000.00	30,000.00
DA($/year)	300,000.00	300,000.00	300,000.00
EBITDA($/año)	476,922.62	2,2185,450.60	2,178,231.03

Table 7 Scenario evaluation using technical and financial indicators

In the study of the CUR indicator for each scenario, in the initial condition it is only applied to the transformer and in the subsequent conditions it is applied to the transformer and capacitor bank, showing that the initial condition is the most favorable, however this indicator is limited only to consider corrective maintenance costs, reliability and penalties. The best practice of application of this indicator should be to compare similar systems, in the study is observed that the system with the type 1 capacitor bank is more convenient than the system with the type 2 capacitor bank.

In the study of the ATR indicator for each scenario, the investment costs of each component of the system are considered. The operating costs involve the annual energy billing with a penalty and bonus for PF. For the costs of preventive maintenance (PMC), major maintenance (MMC) and corrective maintenance (CUR) there is an annualized value of $ 60,000.00 for the initial condition, of $ 64,962.50 for condition with the capacitor bank type 1 and of $ 70,889.99 for the condition with capacitor bank type 2. In this analysis it is observed that although the investment costs are higher for the condition with the capacitor bank type 1, the lowest costs projected annually are obtained, being the most favorable condition.

For the interpretation of the EBITDA indicator, which is a financial indicator of profitability, emphasis is placed on the variables NI, TMC and OC, where in the NI indicator the impact produced by availability Ao is observed, which in turn is linked to the indicators MTTF and MDTTR. The TMC variable shows how the CUR indicator that links the ff, TOS and PC influences. Finally, in the OC, it is observed how reactive compensation influences the billing of electricity consumption, with penalties or bonuses. The PI and the costs of AE, SE and DA are considered fixed costs. In this analysis, the most favorable condition is the system with the capacitor bank type 1, having the highest annual projected monetary value.

VII Conclusions

The problem of improving the power factor in an industrial plant is very common, mainly in installations with several industrial loads, where selecting a technical solution for reactive power compensation problems requires considering additional factors such as maintenance, reliability and financial indicators. In this work, indicators allow to justify criteria that improve the profitability of a plant considering aspects of reliability, maintenance, energy saving and financial. Through a maintenance management model that considers energy savings and efficiency aligned with asset management, it is possible to analyze recurring problems through the proposed phases 1, 2, 3 and 7, that considering the most appropriate condition for the plant.

VIII Acknowledgment

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Article
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Application of CAD, CAM, CAE, in prototype design and manufacturing of electric car lift

Aplicación de CAD, CAM, CAE, en diseño y manufactura de prototipo, de elevador eléctrico para autos

RIVAS-RODRÍGUEZ, Amando†*

Tecnológico de Estudios Superiores de Cuautitlán Izcalli, Mexico.

ID 1st Author: *Amando, Rivas-Rodríguez* / **ORC ID:** 0000-0002-8543-0426, **CVU CONACYT ID:** 336139

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Abstract

Industry 4.0 is currently supported by additive technologies that are increasingly accessible, which allow us to use them in different applications within the industry, such as designing devices, mechanisms or machinery in less time and cost, within the technologies. Additive, there is 3D printing, simulation software (CAD, CAM, CAE) that allows us to visualize and simulate the operation before manufacturing it, avoiding errors and costs. The use of additive technologies in the design of an electrical device for a car scissor lift, commonly known as a "scissor jack", will be demonstrated.BFirst step, the components that already exist such as the standard scissor lift are drawn, to be able to manipulate it in design software, later we will design the elements, such as motor fastening and other components. Second, perform a finite analysis of the components, to analyze that the parts and materials with which they were designed will withstand the stress to which they will be subjected, so that if necessary, corrects the model before making the prototype. Third, assemble and simulate its operation in software, verifying any anomaly in the simulation to correct before manufacturing. Fourth, carry out field tests, for their validation

Design, Innovation, Cost

Resumen

Actualmente la industria 4.0, se apoya con tecnologías aditivas que son cada vez más accesibles, lo que nos permiten su uso en las diferentes aplicaciones dentro de la industria, como es diseñar dispositivos, mecanismos o maquinaria en menor tiempo y costo, dentro de las tecnologías aditivas, está la impresión 3D, software de simulación (CAD, CAM, CAE) que nos permiten visualizar y simular el funcionamiento antes de fabricarlo, evitando errores y costos. Se demostrará el uso de las tecnologías aditivas en el diseño de un dispositivo eléctrico para elevador tipo tijera de auto, conocidos comúnmente como “gato de tijera”. Primero paso se dibuja los componentes que ya existen como el elevador de tijera estándar, para poderlo manipular en software de diseño, posteriormente diseñaremos los elementos, como son sujeción del motor y demás componentes. Segundo, realizar un análisis finito de los componentes, para analizar que las piezas y materiales con las que fueron diseñadas soportarán el esfuerzo a la que serán sometidos, para que en caso necesario corregir el modelo antes de realizar el prototipo. Tercero, ensamblar y simular su funcionamiento en software, verificando alguna anomalía en la simulación para corregir antes de manufacturar. Cuarto, realizar las pruebas de campo, para su validación.

Diseño, Innovación, Costo

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† Researcher contributing as first author.

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Introduction

The industry is becoming more competitive and demanding, they have to apply technological tools to be more efficient and more competitive, one area of application is that of design. When designing we must avoid manufacturing it and that they do not work because it has too many errors and this causes us costs, with the tools we anticipate and minimize errors, cost and time. Giving a competitive advantage to the company for its faster response in the design of a product or in proposing solutions, therefore it is necessary to know and handle technologies to be more efficient, some tools that can support, for the design of new products and equipment. I present an example of the application of tools in the design of "electrical device for scissor lift for automobiles" that most of us know to come in standard equipment of most vehicles. Using 3D printer and materials like PLA.

Objetive

Demonstrate the application of technology in the design and manufacture of a prototype of an electric device for a car scissor lift (scissor jack), using additive technologies, CAD software, CAE, and 3D printer.

Methodology

It began with the drawing of a standard equipment scissor jack, scaled 1:1.

Using design software, each component was designed for subsequent assembly.

Subsequently, a finite analysis of the components was carried out to analyze that the parts and materials with which they were designed, if they are adequate, simulate the effort to which the components will be subjected, and if necessary, correct the model before making the prototype. Once the analysis has been validated, they will be assembled, simulates their operation in software, verifying any anomaly in the simulation, such as interferences or an erroneous assembly, to correct before manufacturing, already validating the simulation we will continue to carry out field tests, for their validation, and go ahead or, if applicable, return to the design and correct depending on the field test results.

Component drawing

We start with the drawing of a scissor lift that generally comes as standard equipment in compact cars and the motor with a 12volt reducer that we will use, in the scissor lift, shown below.

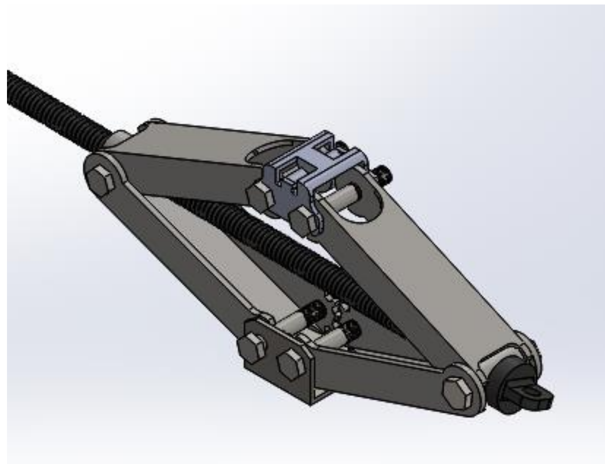

Figure 1 Drawing of a conventional scissor lift, design software

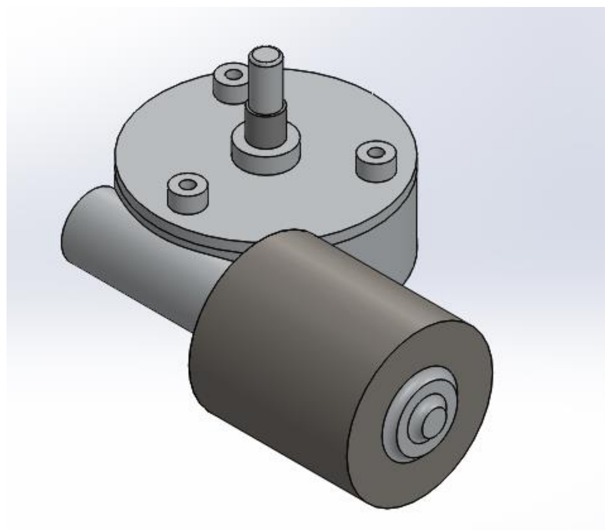

Figure 2 12 Volt motor, design software

The next step was to design the fastening elements to join the motor to the scissor lift, such as: a motor support base, to fasten the 12-volt motor to one side. And in turn will join the scissor lift, PLA material was assigned, for subsequent 3D printing.

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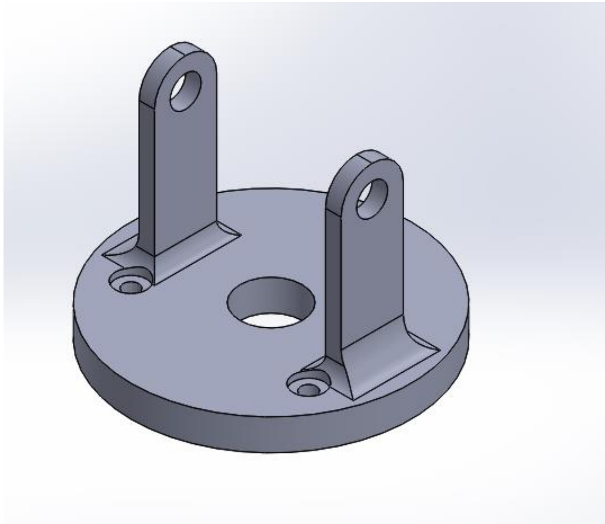

Figure 3 Design of motor support in LA, design software

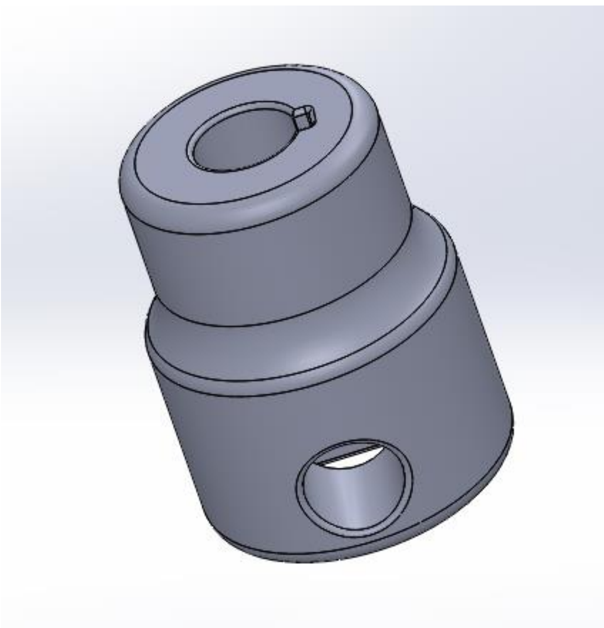

Figure 4 Coupling design, design software

Coupling design to give movement of the scissor lift motor, at one end it has a hole and at the other end it has a slot with a through hole, also in PLA material.

Control design, the button was acquired, but the housing had to be designed, leaving the assembly as shown in figure 5, with an outlet and inlet for the power cables at the bottom a cover-to-cover contaminants and dust.

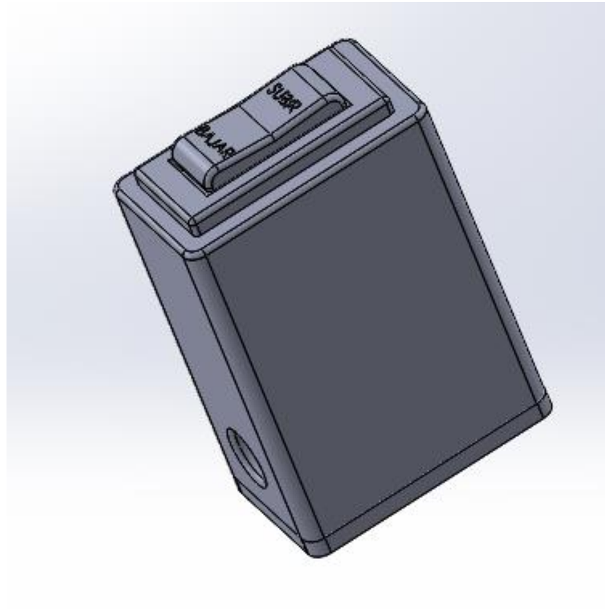

Figure 5 Control design, design software

Having the designed components, the finite analysis is carried out, a force of 150 nm was applied. For torsion, we started with the base of the motor support and the results were as follows.

Finite element analysis

Having the components designed, we proceed to the finite analysis applying a force of 150 nm. For torsion, we started with the base of the motor support and the results were as follows.

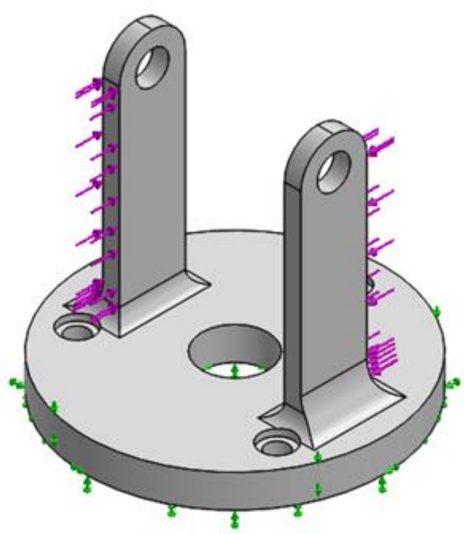

Figure 6 Finite analysis support model, finite analysis software

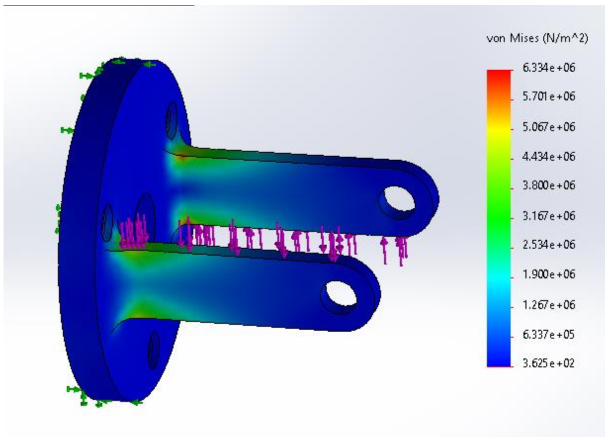

Figure 7 Results VonMises Tensions, finite analysis software

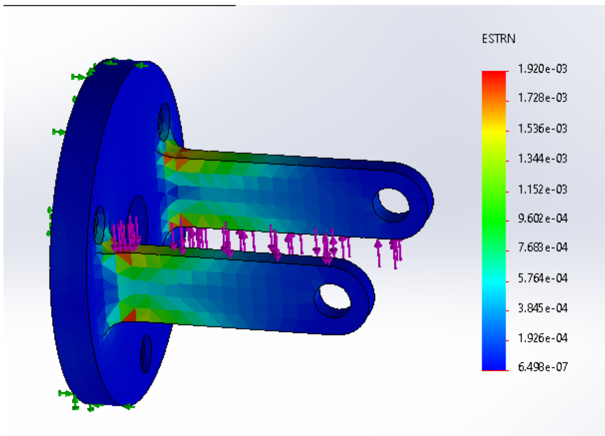

Figure 8 Results Unit deformations, finite analysis software

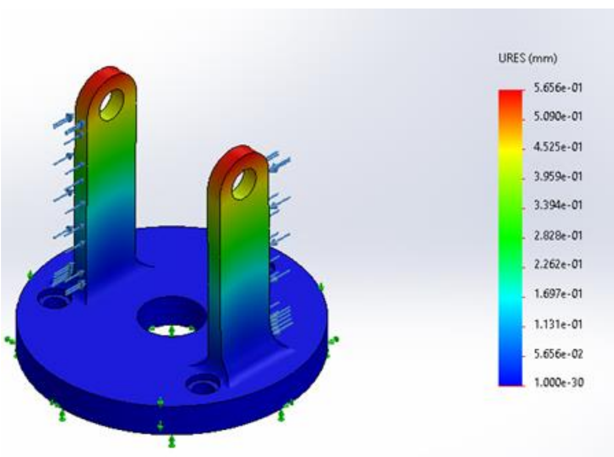

Figure 9 Results of displacement analysis, finite analysis software

As can be seen in the images, the results are satisfactory, red is when it is close to the limits, which is minimal, this gives us certainty in the design.

Subsequently, we subjected the coupling to analysis, also in PLA material, to a torque of 150 nm. and the results were as follows.

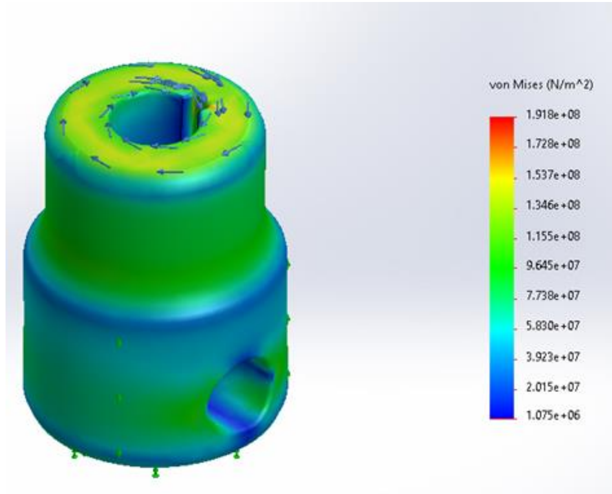

Figure 10 Results VonMises Tensions, finite analysis software

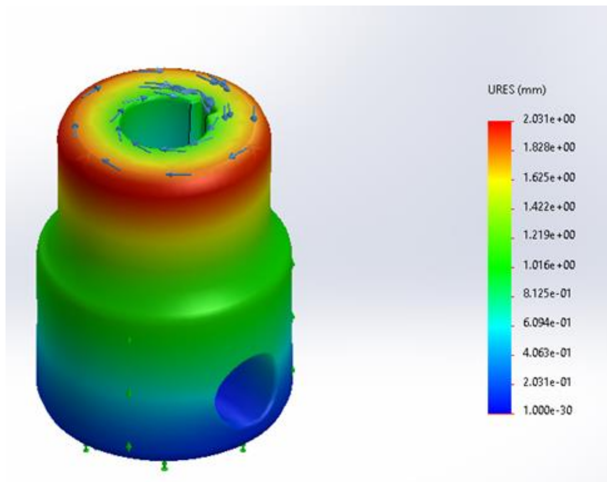

Figure 11 Results Torsion analysis –displacement, finite analysis software

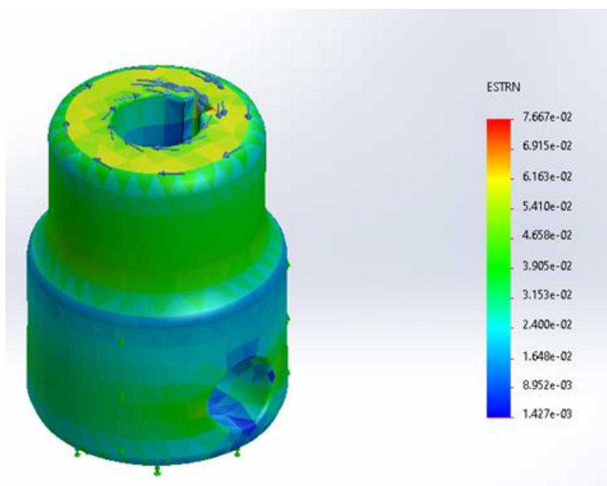

Figure 12 Results Strain analysis, finite analysis software

It can be seen that the analysis results were satisfactory, the switch housing, it was considered unnecessary to submit it to stress analysis. So we proceed to the assembly and simulation of movement.

Assembly and motion simulation

It was assembled in a simulator with the components, such as, scissor lift, motor, motor support, coupling, switch and hardware, movement was applied.

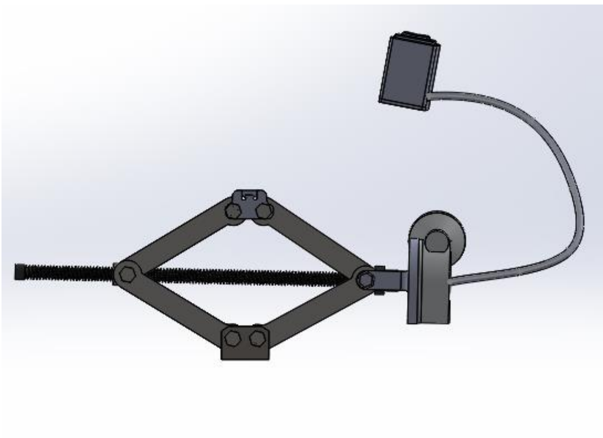

Figure 13 Assembled set, design software

Assembled with all fastening accessories and movement simulation was performed.

The stress analysis simulation being satisfactory, the components were manufactured, in the case of coupling, motor support and switch housing, using a 3D printer, they were printed in PLA material.

3D printing PLA (polylactic acid) material

A 3D printer was used, with a printing area of 250 x 250 x 300 mm. For the manufacture of elements such as motor support, switch housing and coupling, the material was used PLA, first the 3D printing is configured in the CURA software, then it is printed, printing time 7 hours for the 3 pieces.

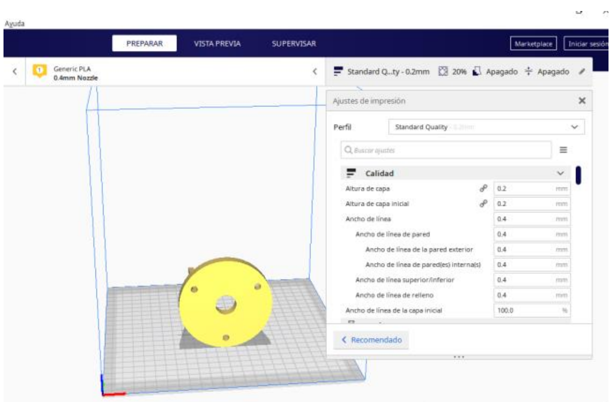

Figure 14 3D Printing software screen, CURA software.

Once configured it is printed, the images are displayed.

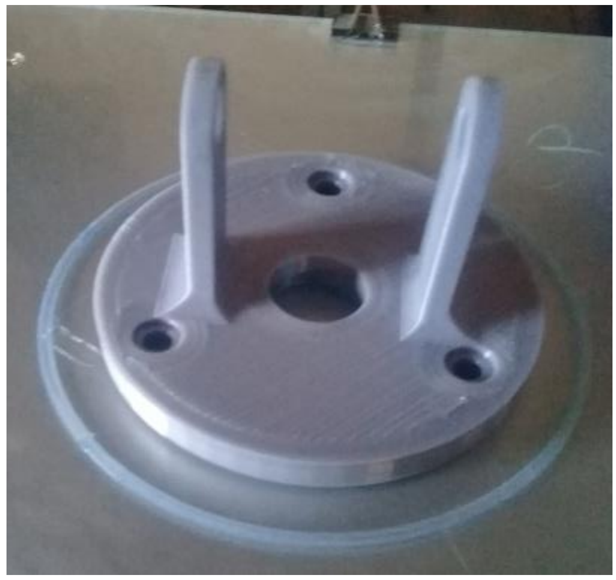

Figure 15 3D Printing in PLA. Motor mount
Source: Own source.

Figure 16 3D Printing in PLA. Cople
Source: Own source

Figure 17 3D Printing in PLA. Switch housing
Source: own

Prototype assembly and test run

Figure 18 Manufactured and assembled set
Source: Own

Prototype with all the attachments, already assembled and connected, there were no setbacks in terms of component design.

Figure 19 Empty test
Source: Own

Idle test, its operation will be verified and in case of having an error correct it, to be functional, the next step is to perform a field test, with load, of a compact car.

Results

The desired ones were obtained, in terms of design (CAD) and components; Several adjustments were made in dimensions and shape, adjusting the elements of the elevator and the motor, to later validate it with the software, the load and torsional stresses (CAE), the motor and coupling support elements were analyzed, giving certainty From the design, in the assembly simulation, it was verified that there were no interferences or collisions of the different components, before their manufacture and assembly, minimal details were presented, which were corrected for their manufacture with 3D printing in PLA (CAM) which is One of the additive technologies, with this technology, manufacturing costs and times were saved, 118 grams of material was used, the approximate cost of the PLA material was $ 90.00 Mexican pesos with 7 hours - printing machine.

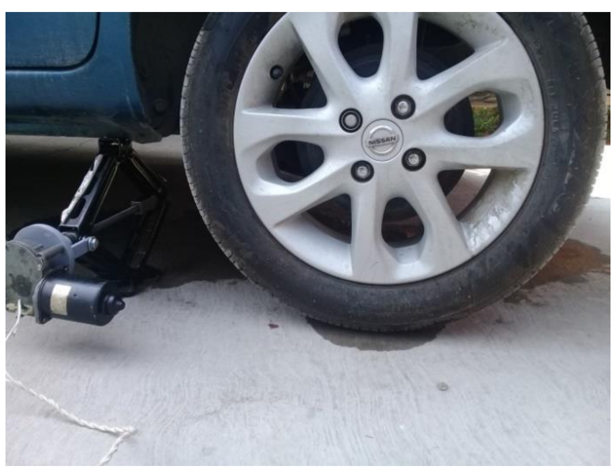

Figure 20 Load test
Source: Own

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Conclusion

CAD, CAM, and CAE technologies have great application in the manufacture of prototypes. As demonstrated in the manufacture of "electric car lift", they are increasingly essential in industries that are constantly innovating their products, to use software specialized from the design, simulation and obtaining a virtual assembly give us a broader and more real vision of the behavior that the new product and components will physically have, increasing the reliability of carrying out the prototypes to a successful conclusion.

At the beginning there were doubts about the resistance of the PLA material, however, when using the technology in the simulations that indicated that the material was resistant, it was carried out with the components and materials applied in the simulations, working as demonstrated, saving costs and Time is essential to increase the competitiveness of companies, especially SMEs, as it makes them more competitive.

With these technological tools, a new design or product can be evaluated, right up to manufacturing, giving greater certainty of the behavior, obtaining as a result competitiveness between companies, with faster response time in an increasingly dynamic market, Industry 4.0 is present.

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Energy saving in air conditioning systems, by using thermal insulators in an academic classroom

Ahorro de energía en sistemas de aire acondicionado, mediante el uso de aislantes térmicos en un aula académica

CASADOS-SÁNCHEZ, Álvaro†*, CASADOS-LÓPEZ, Edzel Jair, ANZELMETTI-ZARAGOZA, Juan Carlos and MARQUINA-CHÁVEZ, Alejandro

Universidad Veracruzana, School of Mechanical and Electrical Engineering, Campus Poza Rica - Tuxpan, Veracruz, Mexico.

ID 1st Author: *Álvaro, Casados-Sánchez* / **ORC ID:** 0000-0002-3122-4571

ID 1st Co-author: *Edzel Jair, Casados-López* / **ORC ID:** 0000-0002-0601-9242

ID 2nd Co-author: *Juan Carlos, Anzelmetti-Zaragoza* / **ORC ID:** 0000-0001-5721-3486

ID 3rd Co-author: *Alejandro, Marquina-Chávez* / **ORC ID:** 0000-0001-7988-1477, **CVU CONACYT ID:** 894120

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Abstract

This article proposes a methodology of calculating the cooling load in an academic classroom at The Universidad Veracruzana located at Poza Rica, in the state of Veracruz, Mexico., using the ASHRAE CLTD / SCL / CLF method. The method of calculating the cooling load CLTD / SLC / CLF consists in applying the cooling load as accurately as possible so, in consequence the air-conditioning equipment will not oversize. By using thermal insulation, a decrease in energy consumption is achieved and thus contributes to sustainable development. Next, we will proceed to calculate the cooling load as follows, applying the proposed methodology in two cases: In the first case, it will be in a classroom with an air-conditioning unit without thermal insulation, first with 30 students and then with only 3 students in the classroom. In the second case we used the same method in a classroom with an air-conditioning unit but this time with thermal insulation, and we proceed to compare the results first with 30 students and then with only 3 students in the classroom. What we discovered when reviewing the results of these two cases is that based on energy consumption measurements, the saving is much greater using an air-conditioning unit with thermal insulation than an air-conditioning unit that is not thermally insulated

Energy saving, Thermal insulators, Academic classroom

Resumen

En este artículo se propone una metodología para el cálculo de la carga de enfriamiento, en una edificación objeto de estudio, utilizando el método CLTD/SCL/CLF de la ASHRAE. La edificación en la que se utiliza el método mencionado es un aula académica de la Universidad Veracruzana situada en Poza Rica, estado de Veracruz, en México. El método de cálculo de la carga de enfriamiento CLTD/SLC/CLF se aplica con la finalidad de obtener la carga de enfriamiento lo más exacto posible y de esa manera evitar el sobredimensionamiento en los equipos de aire acondicionado, y al utilizar el aislante térmico, lograr una disminución en el consumo energético y de esa manera contribuir al desarrollo sustentable. A continuación, se procede a calcular la carga de enfriamiento aplicando la metodología propuesta a dos casos: el aula académica sin aislante térmico, y con aislante térmico para 30 alumnos y para 3 alumnos. Se comparan los resultados para los dos casos de prueba en el aula académica, objeto de este estudio. Se realizan mediciones de consumo energético para realizar la comparación del consumo real energético respecto al calculado utilizando el método. Por último, se cuantifica el ahorro energético.

Ahorro de energía, Aislantes térmicos, Aula académica

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

Introduction

Air conditioning has been one of man's most recent and valued services in his quest for a more comfortable existence. The primary purpose of an air conditioning system, whether heating or cooling, is to maintain suitable conditions, either to provide thermal comfort to the occupants of a building or conditions that are required for certain products and processes within industry. Central heating systems were developed in the 19th century while the development of cooling systems with comfort applications came in the 20th century. Since then, progress in this direction has achieved great advances with significant developments in various areas of science and technology.

The pioneering load calculation methods paid little attention to operating costs and the related aspect of environmental sustainability resulting in the calculation of oversized equipment. However, the increasing price of energy, construction materials and complex building structures, as well as the increasing concern for natural resources and the environment have required a continuous refinement of load calculation methods. Load calculation methods are nowadays directed more towards the dimensioning of appropriately sized minimum systems which result in economical systems with good energy performance and thus more in line with the philosophy of a sustainable environment.

On the other hand, the optimum degree of thermal protection depends on economic and technical criteria. Furthermore, it is determined by considerations of the cooling and heating demands of the building and the feasibility of the investment required to achieve the desired degree of thermal protection of the building. As all these parameters vary with respect to climatic conditions, fluctuating cost factors and the actual way in which buildings are designed and constructed, the determination of optimal thermal protection is always subject to discussion.

Improving the thermal protection of the building envelope could not only lead to a reduction of thermal losses during the winter period, but also lead to a reduction of the cooling load in the summer, a problem that has gained significant importance in the last decade.

Finally, the use of low-energy lighting systems, together with the application of shading devices, constitute new actions that can contribute to the reduction of energy consumption for air conditioning, despite the fact that they are not directly related to the thermal protection of buildings.

Therefore, an appropriate method for the calculation of the cooling load in a building together with the choice of an appropriate thermal insulation constitutes an effective way to properly size an air conditioning system in order to provide comfortable conditions while minimising energy consumption.

Therefore, the objective of this work is to propose a methodology for the calculation of the cooling load in a building under study, in this case an academic classroom of the Universidad Veracruzana located in the city of Poza Rica, state of Veracruz, in Mexico, in order to reduce the energy consumption of an air conditioning system by reducing its capacity.

Construction characteristics of the academic classroom

Figure 1 Academic classroom at FIME, Poza Rica
Source*: UV FIME – Poza Rica*

Figure 2 Lateral view of the academic classroom at FIME, Poza Rica
Source*: UV FIME – Poza Rica*

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Figure 3 Meters provided by CFE for measuring energy consumption
Source: UV FIME - Poza Rica

The construction where the methodology of this work is applied, is an academic classroom located in the city of Poza Rica de Hidalgo, Edo Veracruz in Mexico, and its main characteristics are: Cement tile floor, Reinforced concrete slab, and both have an area of 53 m^2, East wall of apparent brick on the outside and cement plastered inside with an area of 12.65 m^2, Clear single glazed window with an area of 4. 8 m2 for the west wall is the same composition of materials as the east wall, including the entrance door, which is made of galvanised sheet metal with an area for the wall of 11 m^2, window 4 m^2 and for the door 1.7 m^2, south and north wall is made of brick and cement plaster on both sides with an area of 24.85 m^2, for each one.

The architectural plans of the academic classroom are shown below:

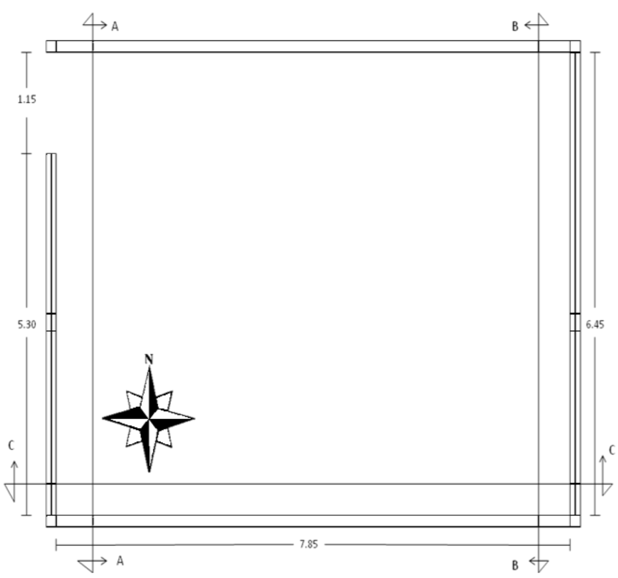

Figure 4 Floor plan of the academic classroom (in metres)
Source: Own elaboration

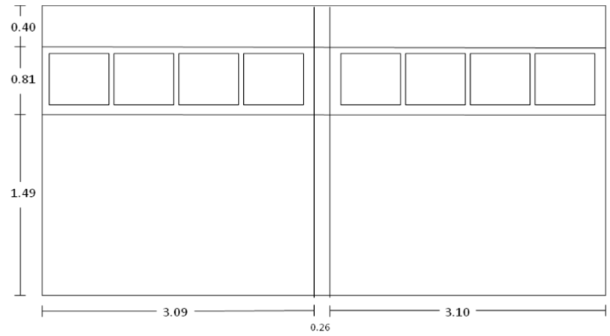

Figure 5 A-A section of the academic classroom (in metres)
Source: Own elaboration

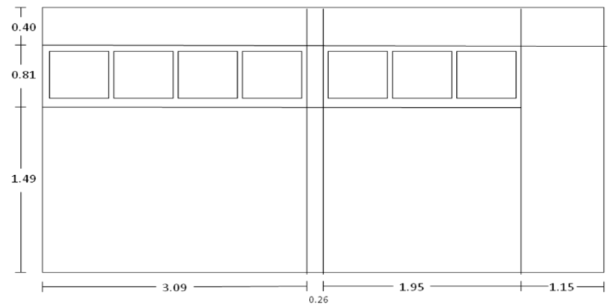

Figure 6 B-B section of the academic classroom (in metres)
Source: Own elaboration

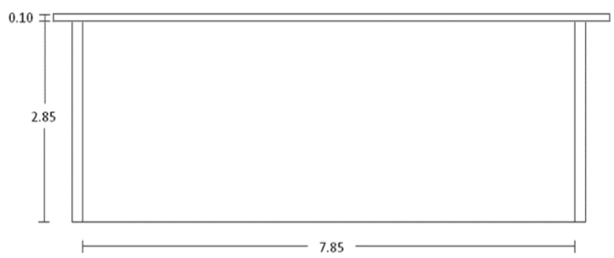

Figure 7 Cut C-C (metres)
Source: Own elaboration

The methodology was applied for two case studies using the academic classroom.

1. Without thermal insulation, single glazed window, which is how they are currently built.

2. With thermal insulation, 1" thick extruded polystyrene for walls and ceilings.

The first case represents the type of academic classrooms built by the University of Veracruz, the second case corresponds to the objective to be achieved by reducing energy consumption by up to 48.3 %.

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Calculation of the Global Heat Transfer Coefficient

The calculation of this coefficient is carried out considering each of the materials of which the walls and ceilings are composed.

The insulation used is extruded polystyrene 0.0254 metres thick with a thermal conductivity of 0.043 Watts - m °K. The values of the resulting overall heat transfer coefficient for each structural element and for the area to be air-conditioned are presented in table 1. These are derived from the materials and architectural plans that were used in the design and construction of the building, which are the case studies of this work.

Table 1 shows that the behaviour of the overall heat transfer coefficients depends on each case.

In the cases where there is no thermal insulation, the coefficients are high. In the case where thermal insulation is applied, a reduction in the values of the coefficients is shown.

Structural elements	Without thermal insulation	With thermal insulation
Brick wall with sand-cement filling on one face	2.874	0.8068
Brick wall with cement-sand filled on both faces	2.7864	0.80
Reinforced concrete slab	4.246	0.8873
Reinforced concrete castle	0.3281	
Cement floor	1.950	
Sheet metal door	5.624	0.9449

Table 1 Overall heat transfer coefficients of building elements (Watts /m^2 °K)
Source: Own elaboration

Determination of cooling demand

The cooling demand calculations were based on the ASHRAE CLTD/SCL/CLF method. The following conditions were considered: Latitude 20 °N, for July 21, indoor temperature 25 °C, outdoor temperature 37 °C, daily percentage temperature 32 °C, daily temperature range 12 °C, outdoor convective heat transfer coefficient 22.68 W/m^2-°K, indoor heat transfer coefficients 7.48 W/m^2-°K.

The corrected CLTD values were obtained according to the following equation:

$$CLTD_{Corr} = (CLTD + LM)\,K + (25.5 - T_i) + (T_{OAV} - 29.4\ °C) \quad (1)$$

Where:

LM: Correction factor for latitude and month

K: Colour adjustment factor

Ti and TOAV: Design values

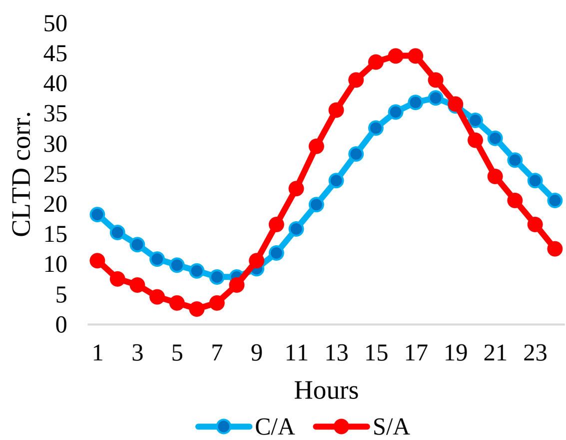
Ti: Indoor temperature

TOAV: Daily percentage of temperature

Figures 1 and 2 show the tables of the corrected CLTD values for the slab and the west wall.

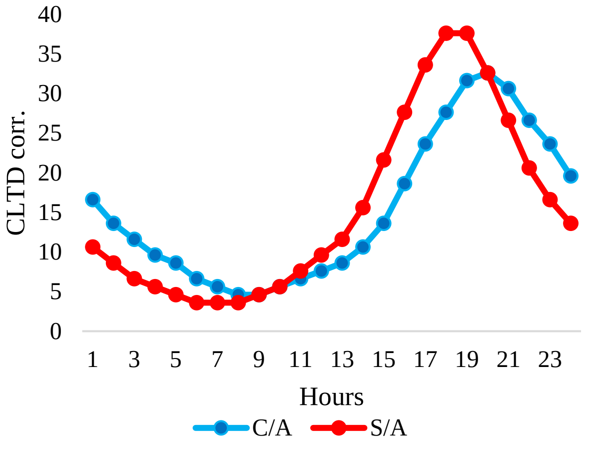
Figures 3 and 4 show the tables of the cooling demands for the peak load hours, which in this case is considered to be from 15 to 19 hrs. Without thermal insulation, the cooling demand is higher, and in the other case, when thermal insulation is installed, the cooling load decreases.

HORAS	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
S/A	10.6	7.6	6.6	4.6	3.6	2.6	3.6	6.6
C/A	18.3	15.3	13.3	10.9	9.9	8.9	7.9	7.9
HORAS	**9:00**	**10:00**	**11:00**	**12:00**	**13:00**	**14:00**	**15:00**	**16:00**
S/A	10.6	16.6	22.6	29.6	35.6	40.6	43.6	44.6
C/A	9.3	11.9	15.9	19.9	23.9	28.3	32.6	35.3
HORAS	**17:00**	**18:00**	**19:00**	**20:00**	**21:00**	**22:00**	**23:00**	**24:00**
S/A	44.6	40.6	36.3	30.6	24.6	20.6	16.6	12.6
C/A	36.9	37.6	36.3	33.9	30.9	27.3	23.9	20.6



Graphic 1 Corrected CLTD values for uninsulated and insulated slabs, for 24 hrs
Source: ASHRAE Handbook of Fundamentals 1997

HORAS	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
S/A	10.6	8.6	6.6	5.6	4.6	3.6	3.6	3.6
C/A	16.6	13.6	11.6	9.6	8.6	6.6	5.6	4.6
HORAS	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
S/A	4.6	5.6	7.6	9.6	11.6	15.6	21.6	27.6
C/A	4.6	5.6	6.6	7.6	8.6	10.6	13.6	18.6
HORAS	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
S/A	33.6	37.6	37.6	32.6	26.6	20.6	16.6	13.6
C/A	23.6	27.6	31.6	32.6	26.6	20.6	16.6	13.6



Graphic 2 Corrected CLTD values for West walls, without insulation and with insulation, for 24 hrs
Source: ASHRAE Handbook of Fundamentals 1997

Figures 3 and 4 show the cooling demands of the academic classroom for 30 students and for 3 students.

It is shown that without thermal insulation the cooling demand is higher and for the case where thermal insulation is installed the cooling load decreases.

The calculation of the cooling load is obtained with the following equation:

$$Q = A\ U\ (\text{CLTD corrected}) \quad (2)$$

Where:

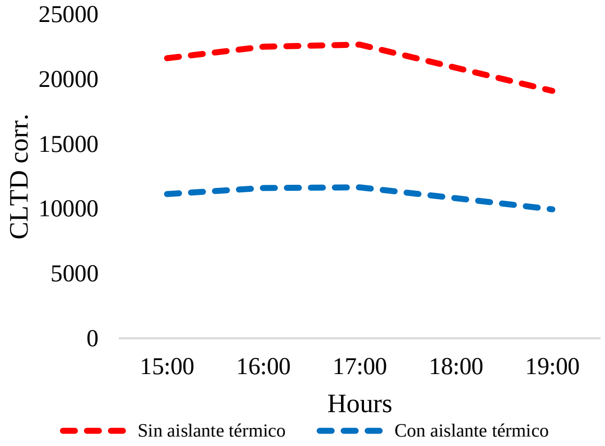
Q: Heat in Watts

A: Area in square metres

U: Overall heat transfer coefficient in W/m^2-°K.

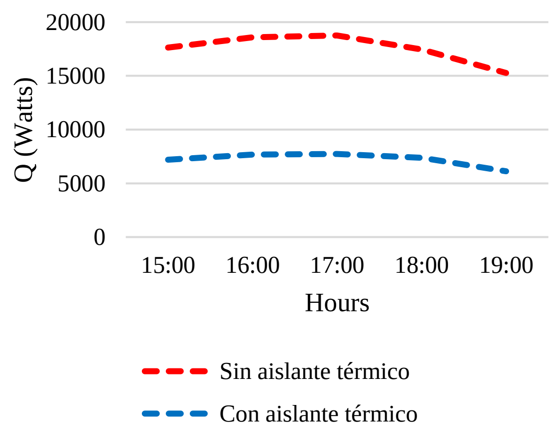
The cooling load will be calculated only for the hours of highest cooling load, which are from 15:00 to 19:00 hrs.

HORA	15:00	16:00	17:00	18:00	19:00	TOTAL
Sin aislante térmico	21639	22534	22683	20898	19110	106864
Con aislante térmico	11143	11612	11658	10820	9963	55196



Graphic 3 Cooling demand in the academic classroom considering 30 students (Watts)
Source: ASHRAE Handbook of Fundamentals 1997

HORA	15:00	16:00	17:00	18:00	19:00	TOTAL
Sin aislante térmico	17640	18583	18757	17467	15270	87717
Con aislante térmico	7194	7661	7732	7389	6123	36099



Graphic 4 Cooling demand in academic classroom considering 3 students (Watts)
Source: ASHRAE Handbook of Fundamentals 1997

Table 2 below shows a comparison of the decrease in cooling demand of the academic classroom with and without thermal insulation, for 30 students and 3 students in Watts.

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Hours →	15:00	16:00	17:00	18:00	19:00	Total
30 students						
Without thermal insulation	2163	2253	2268	2089	1911	106864
With thermal insulation	1114	1161	1165	1082	9963	55196
3 students						
Without thermal insulation	1764	1858	1875	1746	1527	87717
With thermal insulation	7194	7661	7732	7389	6123	36099

Table 2 Comparative cooling demand in the academic classroom considering 30 students and 3 students, with and without insulation. (Watts)
Source: Own elaboration

The decrease in cooling demand of the academic classroom with insulation and those without insulation is presented in table 3, for both cases as a percentage.

Hours →	15:00	16:00	17:00	18:00	19:00	Average
Academic classroom with 30 students	48.5	48.5	48.6	48.2	47.9	48.3
Academic classroom with 3 students	59.2	58.8	58.8	57.7	59.9	58.8

Table 3 Reduction of cooling demand, compared to uninsulated construction (%)
Source: Own elaboration

In table 3, a clearer picture of the comparison of the cooling demand for the case without thermal insulation and for the case where insulation is applied is shown. The values shown are in percentages.

Determination of cooling energy consumption

For the determination of the energy consumption in the academic classroom for cooling, 120 V, 60 Hz, 2 F, 3 H wattmeters and 16 thermometers with a scale from -20 to 50 °C were used.

1. The indoor temperature was considered to be 25°C dry bulb and 50% relative humidity in both cases.

2. The academic classroom under study was occupied by 30 students and subsequently by 3 students.

3. The temperature and humidity conditions were taken from the climatological station belonging to the Faculty of Environmental Engineering of the Universidad Veracruzana in Poza Rica de Hgo.

Measurements were carried out for 28 days in each of the months of June and July 2018.

Cooling energy consumption (Results)

The cooling energy consumption calculations consisted of determining the total heat gains through the building structure, as well as the solar gain, sensible internal gain, due to occupants, lighting, ventilation and air infiltration. As a result, the energy requirements for the academic classroom during cooling were obtained.

The operating coefficient of the air conditioning equipment was considered to be 2.5. Table 4 shows the cooling energy in thermal Kw-hr and electrical Kw-hr calculated for the classroom without insulation and with thermal insulation, considering 30 students.

Hours →		15:00	16:00	17:00	18:00	19:00	Total
Without thermal insulation	Kw - hr Thermal	21.64	22.53	22.68	20.90	19.11	106.8
	Kw - hr Thermal	8.66	9.01	9.07	8.36	7.64	42.74
With thermal insulation	Kw - hr Thermal	11.14	11.61	11.66	10.82	9.96	55.19
	Kw - hr Thermal	4.46	4.64	4.66	4.33	3.98	22.07

Table 4 Cooling energy (Kw - hr Thermal) and (Kw - hr electrical) for the classroom without insulation and with insulation, considering 30 pupils
Source: ASHRAE Handbook of Fundamentals 1997

Table 5 shows the cooling energy in thermal Kw-hr and electrical Kw-hr calculated for the classroom without insulation and with thermal insulation, considering 3 students.

Hours →		15:00	16:00	17:00	18:00	19:00	Total
Without thermal insulation	Kw - hr Thermal	21.64	22.53	22.68	20.90	15.27	87.72
	Kw - hr Thermal	8.66	9.01	9.07	8.36	6.11	35.09
With thermal insulation	Kw - hr Thermal	7.19	7.66	18.76	17.47	6.12	36.09
	Kw - hr Thermal	2.88	3.06	3.09	2.96	2.45	14.44

Table 5 Cooling energy (Kw - hr Thermal) and (Kw - hr electrical) for the classroom without insulation and with insulation, considering 3 pupils
Source: ASHRAE Handbook of Fundamentals 1997

Table 6 shows the cooling energy in thermal Kw-hr and electrical Kw-hr measured, for the classroom without insulation and with thermal insulation, considering 30 students.

Hours →		15:00	16:00	17:00	18:00	19:00	Total
Without thermal insulation	Kw - hr Thermal	21.64	22.53	22.68	20.90	19.11	106.8
	Kw - hr Electrical measured	9.12	9.49	9.55	8.80	8.04	45.00
With thermal insulation	Kw - hr Thermal	11.14	11.61	11.66	10.82	9.96	55.19
	Kw - hr Electrical measure.	4.64	4.84	4.86	4.51	4.15	23.00

Table 6 Cooling energy (Kw - hr thermal) and (Kw - hr electrical) measured for the classroom without insulation and with insulation, considering 3 students
Source: ASHRAE Handbook of Fundamentals 1997

Table 7 shows the cooling energy in thermal Kw-hr and electrical Kw-hr measured, for the classroom without insulation and with thermal insulation, considering 3 students.

Hours →		15:00	16:00	17:00	18:00	19:00	Total
Without thermal insulation	Kw - hr Thermal	21.64	22.53	22.68	20.90	15.27	87.72
	Kw - hr Electrical measured	7.45	7.83	7.91	7.37	6.44	37.00
With thermal insulation	Kw - hr Thermal	7.19	7.66	18.76	17.47	6.12	36.09
	Kw - hr Electrical measured	2.99	3.18	3.21	3.07	2.55	15.00

Table 7 Cooling energy (Kw - hr thermal) and (Kw - hr electrical) measured, for the classroom without insulation and with insulation, considering 3 students
Source: ASHRAE Handbook of Fundamentals 1997

As can be seen in tables 6 and 7, there is a considerable saving of electrical energy when thermal insulation is used in the walls and slab in the academic classroom. It can also be seen that there is a difference when 30 or 3 students are considered in the academic classroom.

The decrease of the calculated cooling demand of the academic classroom with insulation and those without insulation is presented in table 8, for the two cases in percentage.

Hours →	15:00	16:00	17:00	18:00	19:00	Average
Academic classroom with 30 students	49.12	48.99	49.10	48.75	48.38	48.86
Academic classroom with 3 students	59.86	59.38	59.42	58.34	60.40	59.48

Table 8 Measured electrical energy reduction, for the academic classroom without insulation and with insulation in (%)
Source: ASHRAE Handbook of Fundamentals 1997

As can be seen in table 8, there is a considerable saving of electrical energy when thermal insulation is used in the walls and slab of the academic classroom. It can also be seen that there is a difference when 30 or 3 students are considered in the classroom.

Annexes

- ASHRAE (1979, 1992). "Cooling and Heating Load Calculation Manual.

- ASHRAE (1967, 1972, 1972, 1985, 1989). "ASHRAE Handbook of Fundamentals". Atlanta, American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

- Thermal properties, and Code numbers of the coatings used in the description of walls and ceilings.

paredes y techos (apendices 10)

Numero de código	Descripción	L	k	p	Cp	R	Masa
		Espesor y propiedades técnicas					
A0	Resistencia de la superficie exterior	0	0	0	0	0.059	0
A1	25 mm de estuco	25	0.692	1858	0.84	0.037	47.34
A2	100 de ladrillo	100	1.333	2002	0.92	0.076	203.5
A3	Acero forrado	2	44.998	7689	0.42	0	11.71
A4	12 mm de escoria	13	0.19	1121	1.67	0.067	10.74
A5	Resistencia de la superficie exterior	0	0	0	0	0.059	0
A6	Final	13	0.415	1249	1.09	0.031	16.1
A7	100 de ladrillo	100	1.33	2002	0.92	0.076	203.5
B1	Resistencia del espacio de aire	0	0	0	0	0.16	0
B2	25 mm de aislamiento	25	0.043	32	0.84	0.587	0.98
B3	50 mm de aislamiento	51	0.043	32	0.84	1.173	1.46
B4	75 mm de aislamiento	76	0.043	32	0.84	1.76	2.44
B5	25 mm de aislamiento	25	0.043	91	0.84	0.587	2.44
B6	50 mm de aislamiento	51	0.043	91	0.84	1.173	4.88
B7	25 mm de madera	25	0.121	593	2.51	0.207	15.13
B8	65 mm de madera	63	0.121	593	2.51	0.524	37.58
B9	100 mm de madera	100	0.121	593	2.51	0.837	60.02
B10	50 mm de madera	51	0.121	593	2.51	0.42	30.26
B11	75 mm de madera	76	0.121	593	2.51	0.628	45.38
B12	75 mm de aislamiento	76	0.043	91	0.84	1.76	6.83
B13	100 mm de aislamiento	100	0.043	91	0.84	2.347	9.27
B14	125 mm de aislamiento	125	0.043	91	0.84	2.933	11.71
B15	150 mm de aislamiento	150	0.043	91	0.84	3.52	14.15
B16	4 mm de aislamiento	4	0.043	91	0.84	0.088	0.49
B17	8 mm de aislamiento	8	0.043	91	0.84	0.176	0.49
B18	12 mm de aislamiento	12	0.043	91	0.84	0.264	0.98
B19	15 mm de aislamiento	15	0.043	91	0.84	0.352	1.46
B20	20 mm de aislamiento	20	0.043	91	0.84	0.44	1.95
B21	35 mm de aislamiento	35	0.043	91	0.84	0.792	2.93
B22	42 mm de aislamiento	42	0.043	91	0.84	0.968	3.9
B23	60 mm de aislamiento	62	0.043	91	0.84	1.408	5.86
B24	70 mm de aislamiento	70	0.043	91	0.84	1.584	6.34
B25	85 mm de aislamiento	85	0.043	91	0.84	1.936	7.81
B26	92 mm de aislamiento	92	0.043	91	0.84	2.112	8.3
B27	115 mm de aislamiento	115	0.043	91	0.84	2.64	10.74
C1	100 mm de placa de arcilla	100	0.571	1121	0.84	0.178	113.7
C2	100 mm de block de concreto de baja densidad	100	0.381	609	0.84	0.266	61.98
C3	100 mm de block de concreto de alta densidad	100	0.813	977	0.84	0.125	99.06
C4	100 de ladrillo común	100	0.727	1922	0.84	0.14	195.2
C5	100 mm de concreto de alta densidad	100	0.731	2243	0.84	0.059	227.9
C6	200 mm de placa de arcilla	200	0.571	1121	0.84	0.352	227.9
C7	200 mm de block de concreto de baja densidad	200	0.571	609	0.84	0.352	123.46
C8	200 mm de block de concreto de alta densidad	200	1.038	977	0.84	0.196	198.62
C9	200 mm de ladrillo común	200	0.727	1922	0.84	0.279	390.4
C10	200 mm de concreto de alta densidad	200	0.731	2243	0.84	0.117	455.79
C11	300 mm de concreto de alta densidad	300	0.731	2243	0.84	0.176	683.2
C12	50 mm de concreto de alta densidad	50	0.731	2243	0.84	0.029	113.7
C13	150 mm de concreto de alta densidad	150	0.731	2243	0.84	0.088	341.6
C14	100 mm de concreto de baja densidad	100	0.173	641	0.84	0.587	64.9
C15	150 mm de concreto de baja densidad	150	0.173	641	0.84	0.88	97.6
C16	200 mm de concreto de baja densidad	200	0.173	641	0.84	1.173	130.3
C17	200 mm de block de concreto de baja densidad	200	0.138	288	0.84	1.467	58.56
C18	200 mm de block de concreto de alta densidad	200	0.588	849	0.84	0.345	172.75
C19	300 mm de block de concreto de baja densidad	300	0.138	304	0.84	2.2	92.72
C20	300 mm de block de concreto de alta densidad	300	0.675	897	0.84	0.451	273.28
E0	Resistencia de la superficie interior	0	0	0	0	0.121	0
E1	20 mm de yeso o yesiforo	20	0.727	1602	0.84	0.026	30.74
E2	12 mm de escoria o piedras	12	1.436	881	1.67	0.009	11.22
E3	10 mm de fieltro o membrana	10	0.19	1121	1.67	0.05	10.74
E4	Espacio de aire en el techo	0	0	0	0	0.176	0
E5	Mosaico acústico	19	0.061	481	0.84	0.314	9.27

L = Espesor, mm
k = Conductividad térmica, W/(m°K)
p = Densidad, kg/m³
Cp = Calor especifico, kJ/(kg°K)
R = Resistencia térmica, (m²°K)/W
Masa = Masa x unidad área, kg/m²

- Roof group numbers.

Techo sin cielo

Materiales del techo[a]		Masa interior						Masa integral						Masa exterior					
		Números del rango del valor R[b]						Números del rango del valor R[b]						Números del rango del valor R[b]					
No	Códigos	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	B7							1	2	2	4	4							
2	B8							4	5	9	10	18							
3	B9							19	21	27	27	28							
4	C5	6	7	7	10	10		3						6	7	7	10	11	
5	C12	2	2	4	4	5		2						2	3	4	5	5	
6	C13	7	12	13	13	20		5						7	12	13	13	20	
7	C14		4	5	9	9		2	2						4	5	9	9	
8	C15		5	10	18	18	18		4						5	10	10	18	18
9	C16		9	19	20	27	27		9						9	18	20	27	27
10	A3							1	1	1	2	2							
11	Ático							1	2	2	2	4							
Sistemas de azotea																			
12	C12-C12							4	5	9	9	9		5	5	7	9	9	
13	C12-C5							6	11	12	18	18		7	12	12	12	20	
14	C12-C13							11	20	20	21	27		12	13	21	21	21	
15	C5-C12							5	10	10	17	17		5	10	11	11	18	
16	C5-C5							10	20	20	26	26		10	13	21	21	21	
17	C5-C13							20	27	28	28	35		20	22	22	22	28	
18	C13-C12							10	18	20	20	26		10	13	20	29	21	
19	C13-C5							18	27	27	28	35		20	22	22	28	28	
20	C13-C13							21	29	30	36	36		21	29	30	31	36	

Techo con cielo

Materiales del techo[a]		Masa interior						Masa integral						Masa exterior					
		Números del rango del valor R[b]						Números del rango del valor R[b]						Números del rango del valor R[b]					
No	Códigos	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	B7								4	5	9	10	10						
2	B8								9	20	21	22	28						
3	B9								20	28	30	37	38						
4	C5	8	15	18	18	23		6						7	7	7	10	10	
5	C12	5	8	13	13	14		3						3	3	4	5		
6	C13		18	24	25	25		11	11						12	13	13	20	
7	C14		4	10	11	18	20		4						4	5	9	9	17
8	C15		10	18	21	21	28		9						9	10	18	19	26
9	C16			20	28	29	36			18						18	26	27	27
10	A3							1	1	2	2	4							
11	Ático																		
Sistemas de azotea																			
12	C12-C12							6	13	22	22	22		5	5	7	9	9	
13	C12-C5							10	21	23	24	31			12	12	18	20	
14	C12-C13							13	23	24	33	33			13	21	21	21	
15	C5-C12							10	20	22	28	29			10	12	18	18	
16	C5-C5							13	23	32	32	33			20	21	21	21	
17	C5-C13							21	32	34	40				22	22	28	28	
18	C13-C12							12	28	30	31	37			13	20	20	21	
19	C13-C5							21	31	39	40	40			22	22	28	28	
20	C13-C13								39	41	41	42	42		29	30	31	36	37

[a]Los espacios en blanco denotan un techo que no es posible con las combinaciones de los parámetros elegidos.
Los números 12 a 20 son sistemas de azoteas. El primer material es una capa exterior, el segundo material es una capa interior. Los números de los materiales masivos son: 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19 y 20.
Los números de los materiales no masivos son: 1, 2, 3, 10 y 11.

Rangos del valor R en m²°K/W

No	Rango	No	Rango	No	Rango
1	0 a 0.88	3	1.76 a 2.64	5	3.52 a 4.40
2	0.88 a 1.76	4	2.64 a 3.52	6	4.40 a 5.28

- Different cooling load temperatures for the month of July for the calculation of the cooling load of flat roofs at 20° north latitude.

Techos	Hora																							
No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	-1	-2	-3	-3	-3	0	7	16	25	33	41	46	49	49	46	41	33	24	14	8	5	3	1
2	1	0	-1	-2	-3	-3	-2	2	9	18	27	34	41	46	48	47	44	39	31	22	14	8	5	3
3	7	4	3	1	0	-1	0	3	7	13	19	26	32	37	40	41	41	37	33	27	21	17	13	9
4	9	6	4	2	1	-1	-2	-2	0	4	9	16	23	30	36	41	43	43	41	37	31	25	19	13
5	12	9	7	4	3	2	1	1	3	7	12	17	23	28	33	37	38	38	36	33	28	23	19	15
8	16	13	12	9	8	7	6	6	7	9	12	16	19	23	27	29	31	32	31	29	27	24	21	18
9	18	14	12	9	7	5	3	2	2	4	7	11	15	20	25	29	33	35	36	35	32	29	25	21
10	21	18	15	13	11	8	7	6	5	6	7	9	13	17	21	24	28	31	32	32	31	29	26	23
13	19	17	16	14	12	11	10	9	9	9	11	13	16	18	21	23	26	27	27	27	26	24	22	21
14	19	18	17	15	14	13	12	11	11	11	12	13	16	18	20	22	23	24	25	25	24	23	22	21

Nota: 1. Aplicación directa de datos
Superficie obscura
Temperatura interior de 25.5 °C
Temperatura máxima exterior de 35 °C con temperatura promedio de 29.5 °C y rango diario de 11.6 °C
Radiación solar tipica de un día claro el día 21 del mes
Resistencia de la película de la superficie exterior de 0.059 m^2K/W
Con o sin techo suspendido y sistemas de cámaras de retorno de aire
Resistencia de la superficie interior de 0.121 m^2K/W

Nota: 2. Ajuste de la tabla de datos
Diseño de temperaturas: Corr: CLTD = CLTD + (25.5 - t_r) + (tm - 29.4)
Donde:
t_r = temperatura interior y te = temperatura exterior promedio
tm = temperatura exterior máxima - (rango diario)/2
Ningún ajuste recomendado para el color
Ningún ajuste recomendado para la ventilación del aire del espacio sobre el techo

Conclusions

By applying the methodology developed for the calculation of the cooling load, derived from the CLTD/SCL/CLF method, the exact dimensioning of the required air conditioning equipment is achieved, avoiding over-dimensioning, which implies sustainable energy savings.

Additionally, the use of thermal insulation combined with the aforementioned method will allow energy savings of 48.86 % when the classroom is occupied by 30 students and 59.48 % when it is occupied by 3 students, which represents a considerable saving in energy consumption, thus justifying the use of these materials in building construction from the energy point of view.

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Biometric technological security for data and information protection

Seguridad tecnológica biométrica para obtener datos y protección de la información

DOMÍNGUEZ-HERNÁNDEZ. Juan Pablo†*, CRUZ-GÓMEZ, Marco Antonio, TEUTLI-LEON, Margarita and POSADA-SANCHEZ, Ana Elena

Benemérita Universidad Autónoma de Puebla, Faculty of Engineering, Tribology and Transportation Group, Academic Body 189 Disaster Prevention, College of Mechanics and Electrics, Blvd. Valsequillo corner San Claudio Ave. Ciudad Universitaria. Col. San Manuel. CP.72570, Puebla Mexico.

ID 1st Author: *Juan Pablo, Domínguez-Hernández* / **ORC ID**: 0000-0001-5569-3869, **Researcher ID Thomson**: RID-14265 **CVU CONACYT ID**: 1104893

ID 1st Co-author: *Marco Antonio, Cruz-Gómez* / **ORC ID**: 0000-0003-1091-8133, **Researcher ID Thomson**: S-3098-2018, **CVU CONACYT ID**: 349626

ID 2nd Co-author: *Margarita, Teutli-León* / **ORC ID**: 0000-0002-8799-8891**, Researcher ID Thomson:** AAL-8481-2021, **CVU CONACYT ID:** 120326

ID 3rd Co-author: *Ana Elena Posada-Sánchez* / **ORC ID**: 0000-0001-6328-2576**, Researcher ID Thomson:** S-8705-2018, **CVU CONACYT ID:** 543011

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Abstract

Technological systems based on biometrics are an effective and efficient method for human recognition, data collection, and information protection. The objective of the research is to analyze the security and privacy offered by these systems, which include signature recognition, facial recognition, iris pattern and fingerprint recognition. The mixed analysis methodology will help in implementing protection, showing the strengths and weaknesses of these systems. By differentiating itself as the best at present for data protection, by collecting important information of each human being, through elements that make this technology the most reliable, its description makes it clear that these systems will have a great impact, also renewable energies can be used in the infrastructure avoiding polluting agents. Emphasizing to remain as a precedent of research in information technology. Future generations will see that security is not just about passwords. Currently, the trend is to generate security through biometric traits.

Safety, Protection, Privacy

Resumen

Los sistemas tecnológicos basados en biometría son un método eficaz y eficiente para el reconocimiento del ser humano, la obtención de datos, así como protección de información. El objetivo en la investigación es realizar un análisis de seguridad y la privacidad que ofrecen estos sistemas dentro de los cuales destacan reconocimiento de firmas, facial o rostro, patrón del iris y de huellas dactilares. La metodología de análisis mixto ayudará en implementar protección, al mostrarse las virtudes y debilidades de estos sistemas. Al diferenciarse como los mejores en la actualidad para resguardo de datos, al recopilar información importante de cada ser humano, mediante elementos que hacen de esta tecnología la más confiable, su descripción permite dejar en claro que estos sistemas serán de gran impacto, asimismo pueden usarse energías renovables en la infraestructura evitando agentes contaminantes. Haciendo énfasis para quedar como antecedente de investigación en tecnología de la información. Generaciones futuras verán que no sólo la seguridad son contraseñas. En la actualidad se identifica que la tendencia es generar seguridad mediante rasgos biométricos.

Seguridad, Protección, Privacidad

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

Introduction

Biometrics consists of measuring the characteristics of the human body in order to identify an individual. For this, a characteristic endowed with strong variability from one individual to another must be chosen. The need to increase security is a priority worldwide, not only for private companies but also for governments and public institutions. Because of this, intelligent biometric protection systems have become the main security option. *Royer, J (2007).*

On today's emerging technologies, the main emphasis has been focused on properties for device innovation, especially application to new biometrics advances in security. Where they select the electronic and electrical engineering materials for the design specifications and required service conditions of the component. The first step in the selection process requires a study of the application to determine its most important characteristics. Since selection of the electronic and electrical engineering materials are a key factor for design specifications and required service conditions of the component. Once the required properties are known, the appropriate design to be installed can be selected using established network data. *Francois, J (2006).*

Fingerprinting is among the top ten emerging technologies that will change the world according to a report by Massachussets Institute of Technology *[MIT] (2006).* The French biometrics researcher and creator of the FingerPrint fingerprint sensor, says that a key does not prove that a certain person is the one who should have access to something". Biometrics fills that void, such a system verifies identity, since it is unique and unrepeatable, so there is no way to lend it out or lose it.Fingerprint recognition margin of error in the device is related to where the user's biometric data is stored, although it is being considered a minor error in this prototype. *Royer, J (2007).*

Methodology

This research has a mixed analysis approach defined on the differences between quantitative and qualitative technologies, using systematic processes, as well as recorded and estimated data.

The main idea to highlight in its performance is the security and privacy that devices for biometric recognitions offer. The quantifiable data will show the field they have covered over time, including recognition of the units that have this technology. The concepts and background that show the efficiency of a biometric system are supported by the historical files that are created when processing new credentials, files which are the basis for the development of the theory being related to providing a signature; therefore, through photograph or fingerprints it is created an identity, leaving it registered in a unique identification memory for each human being. The scope of the benefits associated to the performance generated in security systems based on the unique traits of individuals, is astounding, as each device is unique, efficient and secure, especially those for exclusive use. Within the research, the most outstanding systems were considered positively, because they are very useful, in terms of data protection. From the data obtained by the biometrics in developments, both quantitative and qualitative, a discussion of findings is generated about the implementation, these systems work, in favor of security, privacy, but above all in data protection. The role played by biometrics for specific cases in society different accesses either to goods and/or services is simple, since each system is adapted to the needs of the utility to be used. Thanks to the existing variants, it can be affirmed that there is a solution in all areas and problems related with each biometric recognition, mainly because it is being unique and unrepeatable, also variations are implemented in the system to avoid errors and thus be more reliable

Face or facial recognition

Currently there are many source codes, that allow a facial analysis in a simple way, the same way as those implemented in social networks, or latest smartphones. The facial recognition is taking over the market, since it has a great utility the use of this technology, which should be promoted, to help public institutions housing a large presence of older adults who by their jobs or lifestyle have lost their fingerprints, putting in doubt and even denying their identity, because the system does not recognize them, however facial recognition will help in identifying the individual.

Without neglecting the great advantage that this technology will provide, it is advisable to update year after year, as people get older, because ageing it is giving rise to the limitation that personal traits do not match, but that is in very extreme cases. *Moctezuma, O. (2016), Utreras, P. (2021)*

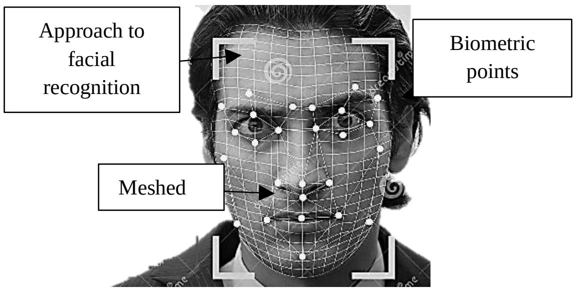

Figure 1 Generation of algorithm for facial recognition *Source:(Emmitroshin ID 179776613, dreamstime.com)*

Currently there are many source codes, already developed that allow a facial analysis in a simple way as those implemented in social networks, high-end phones, taking over the market, since it has a great utility in proposal by which the use of this technology should be promoted, to help public institutions in which they have a large presence of older adults who by their jobs or lifestyle lose their fingerprints, putting in doubt and even denying their identity, the system does not recognize them, however under facial recognition will help in identifying the individual. It is advisable to update year after year, as we get older, giving rise to the limitation that our traits do not match, but that is in very extreme cases, without neglecting the great advantage that this technology will provide. *Moctezuma, O. (2016), Utreras, P. (2021).*

Signature recognition

The handwritten biometric signature, made on tablets or smartphones can collect biometric aspects, such as stroke, pressure or speed, which together make a unique signature, unequivocally associated to only one user. This type of technology guarantees the integrity of the signed content, since it ensures that it has not been altered or changed since it was signed. It is the less problematic biometric technology, currently the most widespread in the world, among other advantages, because it is very economical being implemented. *Diaz, V. (2013), Ponce, W. (2021)*

In addition, it should be considered in modern life and current situations where this electronic signature is required. The social isolation has led directly to the use of this tool, which turned out to be very useful, avoiding crowds for public institutions, the response is immediate, also it has the same validity as going for a seal or signature, in the same way there is a contribution in sustainability since do not use paper, therefore pollution will decrease, it is clear that everything is digital, nothing is printed, you should only see detail by detail the great benefit it will make in streamlining procedures, seals, document validation even the agility gotten in terms of response. *Diaz, V. (2013), Mendoza, M. (2021).*

Iris pattern

Iris recognition belongs to the static biometrics, since it is a measurement of physical characteristics in people, it is a secure method, with a 95% reliability rate (a high one), because it accounts for about 266 unique points, while most biometric systems have about 13 to 60 different characteristics. Each eye is unique and remains stable over time and in different climatic environments. *Cortes, O. et. al. (2010).*

A description of a reference mesh is shown in figure 2 with only a few points to consider, in reality it is more extensive, but it is useful to show the approaches that are made to measure the distance, the lines that are perceived belongs to the recognition algorithm. Also, there is a circumference, which corresponds to the approximation made by the iridology camera for taking a shot of the analyzable features. *Cortes, O et. al. (2010).*

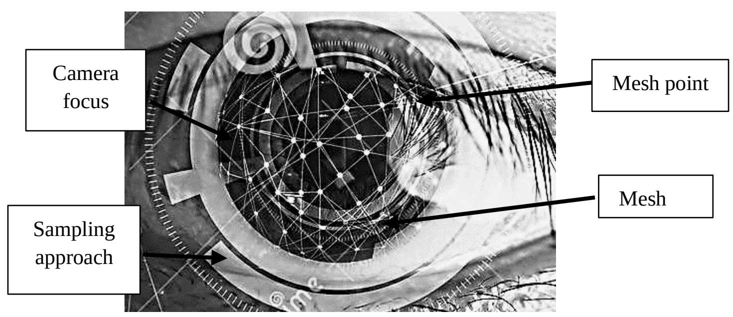

Figure 2 Meshing to obtain the iris pattern
Source:(Bodlennon ID 125922760, dreamstime.com)

Fingerprint recognition

This biometric identification method is chosen by excellence, because it is easy to acquire, use and enjoys great acceptance by users. The use of fingerprints to establish a person's identity was originated in the mid-19th century, pioneered by Sir William Herschel. Fingerprint identification is based primarily on the location and direction of terminations, ridges, bifurcations, deltas, valleys and ridges. Figure 3 shows the different lines from which data are taken for single use. *Cortes, O et. al. (2010).*

Figure 3 Fingerprint traces
Source: Cortés, O et.al. (2010)

The fingerprint is one of the most used methods to decrypt a device, it serves as an opening and closing method in any system where its installation is needed, that is why it is one of the most used in security matters. *Cortes, O. et. al. (2010).*

Structure of a biometric system

Biometric devices have three basic components. The first deals with analog or digital data acquisition by highlighting some biometric indicator on a person, such as the acquisition of fingerprint images by means of a scanner. The second handles factors like compression, processing, storage and comparison of acquired and stored data. The third component establishes an interface with applications located on the same or another system. Figure 4 shows the flow chart structure which is composed of two modules: registration and identification. *Cortés, O et.al. (2010).*

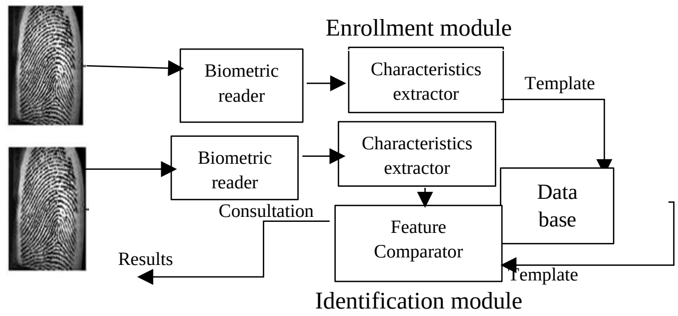

Figure 4 Data record structure
Source: Cortés, O et.al. (2010)

The biometric reader is responsible for acquiring data relative to the chosen biometric indicator and delivering a digital representation of it. The feature extractor takes the representative features of the indicator from the output to the reader. These are stored in the database. The enrollment module is in charge of acquiring and storing signals coming from the biometric reader in order to be able to match a captured signal with the one provided in subsequent entries to the system. Otherwise, the identification module is responsible for the recognition of individuals. The resulting representation is known as a query and it is sent to the feature matcher, which is responsible for matching the query against one or more templates to establish the identity of the person. *Boulgouris, N et.al. (2005).*

Institutions in Mexico using biometric technology

Both public and private institutions have done use of information provided by people, the data are considered confidential and public agencies have taken the lead for digital processing. In any service that it is used to establish personal identity such as credentials, they must comply with a series of requirements, which range from taking photos, signatures and even get fingerprints. *Díaz, V. (2013).*

Therefore, once it is created a historical file as a citizen of Mexican nationality, the personal information appears in the government system. Information includes hospitals and state headquarters, that are the only ones authorized to access the official information that is in the database, with the compromise of using it safely and reliably. There will be those who ask where they get all our information from, we only have to look back to the past, remembering when a photo, signature or fingerprints are provided, thus identifying that all records are analyzed and stored.

Table 1 shows examples of documents where the information is related to biometric data, since they are mandatory as requirements in procedures and services of public institutions. *Díaz, V. (2013), Cando, S (2021).*

Institution	Fingerprint	Iris	Facial recognition	Electronic signature
INE (Instituto Nacional Electoral)	Yes	/	Yes	Yes
Visa Processing	Yes	Yes	Yes	Yes
Passport Processing	Yes	/	Yes	Yes
Military ID	Yes	/	Yes	Yes

Table 1 Data and institutions using biometric technology
Source: Procedures and services of public institutions (2020)

Implementation of a fingerprint reader using visual studio

Example of a biometric fingerprint reader

A fingerprint reader (model No. URU2S-U) was used to implement the biometric reader. This device connects to the computer via USB port and is compatible with a wide range of Windows operating system versions. It is easy to install and has a compact and modern design that facilitates its use. Figure 5 shows the fingerprint reader implemented in the published work of *Cortes, O. et.al. (2010).*

Figure 5 Fingerprint reader U.are.U2000
Source: Windows SDK .NET, Digital Person Database

Software development

The portable board for Windows SDK .NET Edition was used for fingerprint processing. This application is a software development tool that allows programmers to integrate fingerprint biometrics into a broad set of operating system applications.

The implemented program performs the following processes and functionalities:

- Enrollment. This point captures a person's fingerprint four times. After capturing the fingerprint, it will perform its extraction on the characteristics of the digital fingerprint features; then it creates a template for the captured fingerprint, and finally it performs the storage in the template for later comparison.

- Verification. The process of comparing a captured fingerprint with a fingerprint template to determine if the two matches.

- De-enrollment of a fingerprint. It is the elimination of a fingerprint template associated with a previously enrolled fingerprint.

Figure 6 shows the form that the Visual Studio program provides the output for the processing of a fingerprint.

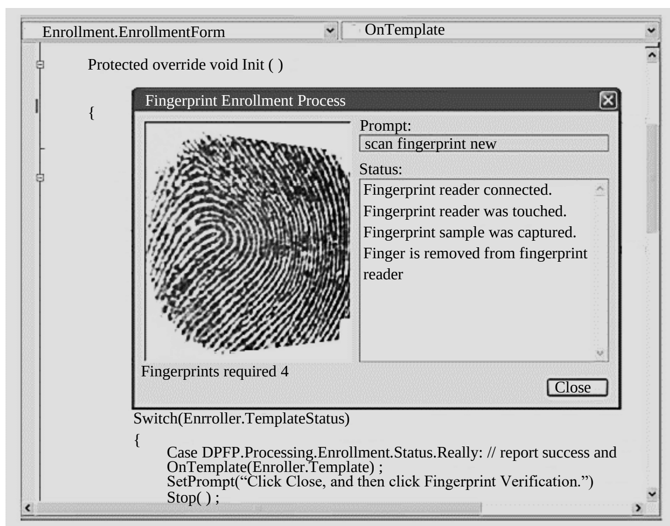

Figure 6 Fingerprint Enrollment Process
Source: Visual Studio Version 1.6 (2021)

Discussion of Results

Nowadays data acquisition is always done with previous consent of the user. Although, usually data have been provided before without having a clear idea of what providing information means, and the bewilderment have come evident when the information is made public.

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Legal concerns can be found in the Article 15 of the National Registry of Mobile Phone Users, a law whose purpose is provide a legal frame to stop crimes such as extortion, kidnapping or bank fraud; in this sense the reform contemplates fines of up to ninety thousand Mexican pesos for those who fail to register their line, and fines go higher for people who provide false data; although there is concern since legislators mention that they violate human rights, in terms of privacy invasion and obtaining personal data, incurring in an administrative offense for those who request this information.

A clear example is obtaining a digital ID card, using biometric technology. Although people have the right to an identity from birth, there are countries where they have never used an identification card, as it is the case in other countries looking to promote inclusion to exert civil, political, economic and social rights. On the other hand, in Mexico citizens have a multiplicity of documents, credentials and passwords that are required in different situations to have access for multiple services and rights, but without reliability for proving their identity. The ideal record should contain, at least: main name, surname, Unique Population Registry Code (Clave Única de Registro de Población, CURP). The right to identity is enshrined in Article 4 of the Mexican Constitution, which establishes that all Mexicans (including residents of other countries), minors and foreigners residing in the country have the right to an ID having a photograph, place of birth, signature, fingerprint, iris and voice. The right to identity is enshrined in the fourth article of the Constitution. Identity is the set of traits, attributes of the person, which characterize him/her, distinguish him/her from other individuals, and constitute him/her as a subject of rights and obligations.

The implementation of biometric technology will help to provide faster care in private and public centers, for instance, when someone suffering accidents or mishaps, they will no longer be unknown since hospitals are the front line of being able to use information to report those events.

It is also important to mention that biometrics it is a sustainable and very efficient technology, since it does not pollute the environment, as in the case of online procedures, since it avoids the use of paper, and if energy is needed, it can be obtained through solar panels or include rechargeable batteries. The companies that create these systems must use equipment that is not disposable, on the contrary, their designs must be environmentally friendly, reusable, but above all systems must be easy to use, with a plus input since it will also generate jobs, for those persons in charge of taking biometric samples.

It is of outmost importance to continue in favor of the contribution represented by biometric systems implementation, since using it is promoting innovation in technology. However, two of the most particular cases being served are banking and mobile telephony, mentioning. At present it is also useful to provide the requested information, with the confidence that no one else will be able to use the data given to these institutions. Although the scenario becomes quite strange due to fear that the encrypted information is downloaded, and then used as a way of extortion or illicit movements, it is well known that the user will have support to track any movement, verify the location where their documentation was used, since biometrics is so efficient, there will be no doubt of the progress that is reaching the population. It is clear that the law was passed quickly, although it was prepared with great wisdom, patience, but above all with the inclusion of supporting the creation of servers that provide security to the population in general. It is clear that the law was passed quickly, although it was prepared with great wisdom, patience, but above all with the inclusion of supporting the creation of servers that provide security to the population in general. It is clear that the law was passed quickly, although it was prepared with great wisdom, patience, but above all with the inclusion of supporting the creation of servers that provide security to the population in general.

As it was based on democracy, it was submitted to a vote, in which the competent authorities participated, resulting in 54 votes in favor, 49 against and 10 abstentions, which shows how close the decision was taken, leaving even more doubts as to whether the right thing is being done.

In public opinions, this method of obtaining data is considered unconstitutional and a violation of human rights, which favors a system of surveillance and harassment with an authoritarian character, unworthy of a democratic country, only countries like China, Tajikistan, Saudi Arabia, Afghanistan, Venezuela have this type of records. It is not that Mexico is proposing to be the same; what is being promoted is a modern, up-to-date country, but above all, one of the safest.

Conclusion

Biometric technology has proven to be a reliable and efficient system, therefore in matters of security, data protection and identity will be technologically something that will revolutionize the world in terms of safeguarding information, but also as an identification method, people should take a look at their cell phone, which is wrapped in a series of high-end engineering technologies. At first glance unlocking by fingerprint recognition, the owner accesses the information, thus giving a proof on how a biometric system works and is becoming more and more a fact from the engineering point of view, where the research is pointing out to reliable security factors to ensure the security in different spheres like international, cultural, social, political and geopolitical without leaving any individual vulnerable

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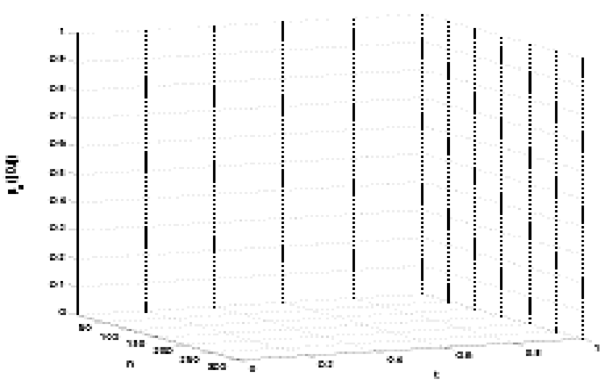

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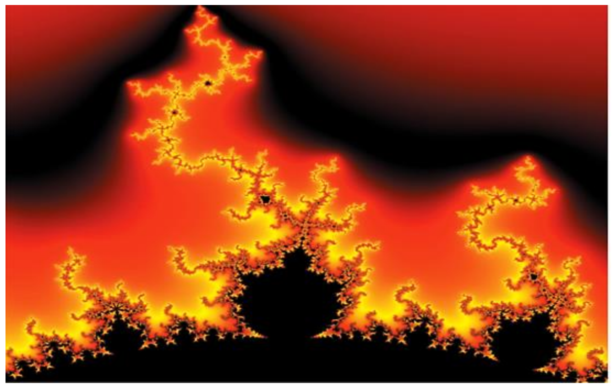

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