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Design and development of preventive, corrective and predictive maintenance manager software

Diseño y desarrollo de software gestor de mantenimiento preventivo, correctivo y predictivo

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Abstract

Due to the need to have adequate and affordable software for maintenance management, at the Universidad Tecnológica de Oriental, a preventive, corrective and predictive maintenance management software was designed and developed, the needs of organizations have been analyzed and considered. in terms of maintenance management, designing a conceptual architecture that integrates the maintenance modalities and ensures the modularity and scalability of the software. In addition, key functionalities were validated and early feedback from users was obtained, allowing continuous improvements in successive iterations. The software offers efficiency, productivity, economic gains, production improvements and loss reduction. Thus, the development of maintenance management software meets the needs of organizations, improves maintenance management, reduces costs and promotes a culture of continuous improvement.

Software. Management, Maintenance

Resumen

Debido a la necesidad de contar con un Software adecuado y asequible para la gestión del mantenimiento, en la Universidad Tecnológica de Oriental, se diseñó y desarrolló un software gestor de mantenimiento preventivo, correctivo y predictivo, se analizó y consideró las necesidades de las organizaciones en cuanto a la gestión de mantenimiento, diseñando una arquitectura conceptual que integra las modalidades de mantenimiento y asegura la modularidad y escalabilidad del software. Además, se validaron las funcionalidades clave y se obtuvo retroalimentación temprana de los usuarios, permitiendo mejoras continuas en iteraciones sucesivas. El software ofrece eficiencia, productividad, ganancias económicas, mejoras en la producción y reducción de siniestralidad. Asi, el desarrollo del software gestor de mantenimiento satisface las necesidades de las organizaciones, mejora la gestión del mantenimiento, reduce costos y promueve una cultura de mejora continua.

Software, Gestión, Mantenimiento

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Introduction

Effective maintenance of equipment and systems is essential to ensure optimal and reliable operation in various organizations. In this sense, the design and development of preventive, corrective and predictive maintenance management software has become a vital solution to optimize these activities. This article focuses on the creation of a software with differentiating features that addresses the problem of the high costs associated with specialized software.

One of the main obstacles to implementing specialized software solutions has been the high cost associated with them; many organizations, especially smaller ones, have been limited in their ability to acquire and use these softwares. Therefore, the development of an accessible and cost-effective maintenance management software becomes a solution to this problem, allowing a wide range of organizations to benefit from its functionalities without incurring excessive costs.

The added value of this software lies not only in its ability to integrate maintenance modalities, but also in its affordability. By developing maintenance management software that offers full functionality at a reasonable cost, access to effective maintenance management tools is democratized. This allows even organizations with limited resources to improve their efficiency and optimize their maintenance activities.

Each of the features of the maintenance management software will be clearly and precisely focused, highlighting its relevance and its contribution to overcoming the problem of high costs. The specific functionalities of the software will be described in relation to the planning and scheduling of preventive tasks, the follow-up and management of corrective work orders, and the implementation of monitoring and data analysis techniques for predictive maintenance.

General

Problem Statement: A common problem in small industry is the dependence on expensive specialized software that is beyond the economic reach of many organizations, especially those with limited resources.

This software often has high licensing and maintenance costs, which prevents its acquisition and effective use.

In addition, the lack of an efficient maintenance management tool makes it difficult to schedule preventive tasks, track work orders, and collect and analyze relevant data so many organizations rely on manual methods and fragmented systems that make it difficult to make informed decisions and optimize resources.

Justification: The development of a software that integrates the three maintenance modalities, that is accessible in terms of costs and that allows efficient planning, monitoring and analysis of maintenance activities, will make up for the lack of efficiency, the lack of comprehensive management and in addition to the economic inaccessibility of existing solutions.

General objective

To design and develop a preventive, corrective and predictive maintenance management software that integrates the three maintenance modalities in a unique and accessible platform, in order to improve the efficiency and management of maintenance in organizations.

Specific objectives

– To analyze the requirements of maintenance manager software, considering the needs of organizations in terms of maintenance management.

– Design a conceptual architecture that allows the integration of preventive, corrective and predictive maintenance modalities, ensuring modularity and scalability of the software.

– Develop functional prototypes of the software to validate key functionalities and obtain early feedback from users.

– Gradually add new functionalities in successive iterations, considering user feedback and needs identified during the development process.

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– Perform functionality, performance, security and usability testing of the software to ensure its quality.

Methodology

The methodology used in the development of the preventive, corrective and predictive maintenance manager software was based on an iterative and incremental approach, which allowed continuous adaptation as adjustments were made according to the requirements and feedback received.

The development process was divided into the following stages:

Opinion survey: In order to identify current problems in the industrial sector related to the use of specialized software, an opinion survey was conducted among companies from different sectors and industrial lines of business.

Analysis of maintenance software: Before starting the design, five softwares focused on maintenance management were compared to identify their characteristics and how they manage maintenance.

Requirements analysis: In this stage, a software requirements analysis was performed. Information was gathered on the needs of the organizations in terms of maintenance management. The key functionalities that the software should include were identified.

Conceptual design: Based on the requirements gathered, a conceptual architecture for the software was designed. The different modules and components were defined, as well as the interactions between them. Modularity and scalability were taken into account to allow future expansions and upgrades.

Software development: Functional prototypes were implemented to validate the key ideas and concepts of the software. These prototypes allowed obtaining early feedback from users and making adjustments to the design and functionality according to their needs and preferences. Appropriate technologies and programming languages were used to ensure software efficiency and usability.

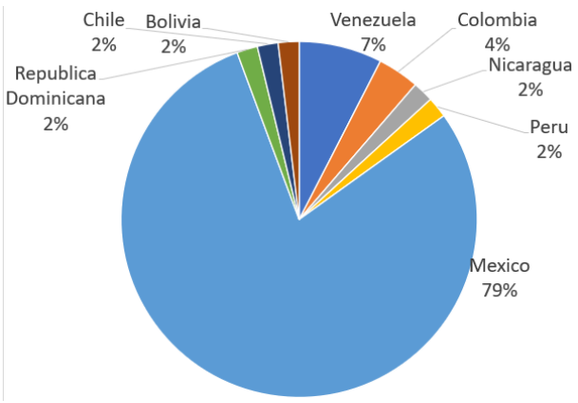
Incremental development: An incremental approach to software development was adopted. Basic functionalities were implemented and tested to ensure proper operation. In addition, new functionalities were gradually added in successive iterations.

Testing and quality control: Testing was performed at all stages of development to ensure the quality of the software. Functionality tests, performance tests, security tests and usability tests were carried out. Bugs were corrected and adjustments were made based on test results.

Results

Opinion survey:

Interviews were conducted with a total of 53 companies belonging to various industrial sectors. Of these companies, 79% are of Mexican origin, while the remaining 21% correspond to foreign companies from Venezuela, Colombia, Nicaragua, Peru, Dominican Republic, Chile and Bolivia, as shown in Graph 1.



Graphic 1 Nationality of the surveyed companies
Source: Own elaboration

During the interviews, the companies were asked about the specialized equipment they have to carry out maintenance tasks. It was found that 19% of the companies mentioned having specialized software for maintenance management, as detailed in Graph 2.

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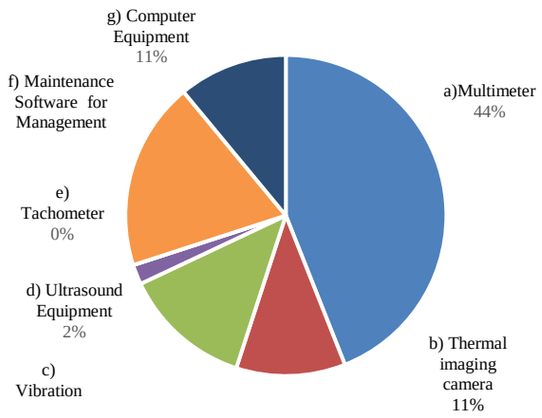

Graphic 2 Equipment used for the execution of maintenance
Source: Own elaboration

Those companies that indicated that they do not use software for maintenance management were asked the following question: Would it be desirable to implement such a software? In response, 60% said definitely yes, 25% said it would probably help in maintenance management, and only 15% said it was not necessary due to various reasons.

These indicators reveal that in most of the surveyed companies there is a desire to use maintenance management software, suggesting the need and demand for technological tools to optimize maintenance processes in the industrial environment.

Analysis of maintenance software

A comparison of some software available on the market for maintenance management was performed. In order to provide an overview and facilitate the choice of the most appropriate solution, a comparative table was prepared highlighting the characteristics of five best existing softwares. In Table 1, "the key aspects of these softwares are compared and the features and functions of each are analyzed and contrasted, providing a more complete view of the capabilities and costs associated with each solution." (Perez, 2021). [1]

SOFTWARE	FEATURES AND FUNCTIONS	PRICING MODEL
Fracttal One	Mobile Access Calibration Management Password management History tracking Inventory management. Predictive maintenance Preventive maintenance.	Free trial. Monthly payment Annual payment.
CMMS MP version 10	Documents in the MP General data Maintenance plans Spare parts used by the equipment Supplier data Images, notes and attachments Drawings and exploded parts diagrams Location: Real-time GPS location	Free trial. Monthly payment Annual payment.
IBM Maximum	Mobile Access Calibration Management Password Management Technician Management Programming History tracking	Free trial Annual fee.
Inno Maint	Mobile Access Calibration Management Technician management Programming History tracking Work order management Predictive maintenance	Free trial Annual fee.
EasyMaint	Mobile Access Calibration Management Technician management Scheduling History tracking Work order management.	Free trial One-time payment Annual fee

Table 1 Comparison of Maintenance Management Software
Source: Own elaboration

This comparative evaluation of maintenance management software was very useful to take into account both the functional aspects when designing a software solution for maintenance management

Requirements analysis

Studies were conducted to identify the key functionalities that the software should include in order to meet these needs.

It is important to highlight that, within the scope of the T.S.U. Maintenance Career, there were already some formats in physical format to carry out maintenance tasks. However, in this project a complete redesign process of these formats was carried out, seeking to optimize their structure and functionality.

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In addition, software programs must comply with a series of general parameters, including portability, accessibility, connectivity, modularity, flexibility, availability of utilities, update capacity, security and confidentiality, user management and connectivity, as well as the capacity to operate in multiple periods and exercises (Carvajal, Rios Gavira, & Montilla M., 2008). [2]

In some cases, a complete redesign of the existing formats was necessary, while in others it was only required to make modifications in their design to adapt them to the functionalities and features of the new maintenance manager software. In this section, a general description of the format redesign process is given, addressing the changes made and highlighting the benefits obtained.

With the redesign of the formats, greater efficiency in maintenance management was achieved, simplifying processes and improving data collection and analysis. This will allow organizations to optimize their maintenance activities, make informed decisions and improve task planning since managers will be able to focus their attention on selecting a system that truly meets their needs, instead of relying solely on the demonstrations presented by suppliers (Augusto Tavares, 1996) [3] [3].

A detailed description of the redesign of the formats will be presented below, highlighting the improvements and adjustments made to adapt them to the new maintenance manager software.

Check List: Check lists play a fundamental role in allowing the industrial maintenance personnel to visualize quickly and completely all the tasks to be carried out. By using checklists for the maintenance and repair of equipment, it is ensured that all necessary aspects are validated and that the equipment is functioning properly.

In this context, the format used to carry out these checklists is presented in Figure 1. However, some changes and improvements have been made to its design, as shown in Figure 2. In this figure, changes can be seen that have been incorporated to reflect the identity and specific context of the institution.

NOMBRE DEL EMPRESA: TRANPORTES DEL FUTURO

Check list:

Actividad que hace el equipo:

Área de ubicación del equipo:

Fecha de aplicación: Turno: 1 2 3 Mix

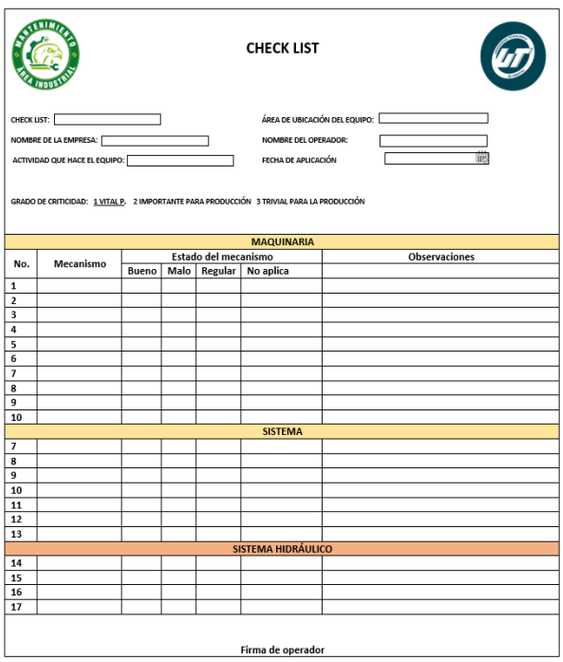
Nombre del Operador

Grado de Criticidad: 1 vital P. 2 importante para producción 3 trivial para la producción

Nun.	Mecanismo	Estado del mecanismo				Observaciones
		Bueno	Malo	Regular	No aplica	
Carrocería						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Sistema de Mecánico (Motor)						
7						
8						
9						
10						
11						
12						
13						
Sistema hidráulico						
14						
15						
16						
17						

Figure 1 Previous check list design
Source: Own elaboration

Through these changes and adjustments to the format, we seek to improve the experience of using the checklists, allowing technicians to carry out maintenance tasks more effectively and ensuring that all equipment is inspected thoroughly and systematically.



CHECK LIST

CHECK LIST:

ÁREA DE UBICACIÓN DEL EQUIPO:

NOMBRE DE LA EMPRESA:

NOMBRE DEL OPERADOR:

ACTIVIDAD QUE HACE EL EQUIPO:

FECHA DE APLICACIÓN

GRADO DE CRITICIDAD: 1 VITAL P. 2 IMPORTANTE PARA PRODUCCIÓN 3 TRIVIAL PARA LA PRODUCCIÓN

No.	Mecanismo	Estado del mecanismo				Observaciones
		Bueno	Malo	Regular	No aplica	
MAQUINARIA						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
SISTEMA						
7						
8						
9						
10						
11						
12						
13						
SISTEMA HIDRÁULICO						
14						
15						
16						
17						

Firma de operador

Figure 2 Final checklist design
Source: Own elaboration

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These changes in the format of the checklists contribute to greater visual consistency and a better representation of the institution. In addition, they facilitate quick and accurate identification of equipment and tasks to be performed, which optimizes efficiency and accuracy in maintenance management.

Activities format: The activity format is a detailed report that records all activities performed daily throughout the month. This format provides an overview of the activities performed, giving management a clear and concise picture of ongoing operations. By systematically recording and documenting activities, it facilitates monitoring, evaluation and informed decision making.

Figure 3 shows the format used for recording activities, which has been designed to include all relevant data in an organized and structured manner. This ensures the accuracy and completeness of the information collected, as well as providing the flexibility to adapt to the specific needs of each company.

Formato de actividades de mantenimiento preventivo						
Sistema mecánico						
Num.	Mecanismo	Actividad de mantenimiento preventivo	Materiales s	Herramienta	Tiempo de ejecución	Imagen
1						
2						
3						
4						
5						
Sistema Eléctrico						
Num.	Mecanismo	Actividad de mantenimiento preventivo	Materiales s	Herramienta	Tiempo de ejecución	Imagen
6						

Figure 3 Design of the Activities Format
Source: Own elaboration

Maintenance plan: The maintenance plan consists of a set of preventive tasks to be carried out in a facility in order to meet the objectives of availability and reliability, thus prolonging the useful life of the facility as much as possible (Figure 4). To achieve this, a comprehensive format has been developed to keep a detailed record of the scheduled activities in a weekly, monthly, quarterly, semi-annual and annual schedule, and includes the documentation of specific observations for each activity.

The maintenance plan format has been created from scratch, taking into account the specific needs and requirements of the facility in question. Its design facilitates the scheduling and tracking of preventive tasks over time, allowing for efficient and systematic maintenance control. The schedule included in the format covers different time periods, ensuring complete coverage and proactive maintenance management.

With this comprehensive and systematic approach to maintenance, organizations can achieve greater reliability, availability and performance of their facilities, which in turn translates into greater operational efficiency and improved bottom line results.

UNIVERSIDAD TECNOLÓGICA DE ORIENTAL
MANTENIMIENTO INDUSTRIAL

PLAN DE MANTENIMIENTO PREVENTIVO REGISTRO Y CONTROL		No.
NOMBRE:	CÓDIGO:	UBICACIÓN:

MES	SEMANA				FRECUENCIA				OBSERVACIÓN
	1°	2°	3°	4°	MENSUAL	TRIMESTRE	SEMESTRE	ANUAL	
ENERO									
FEBRERO									
MARZO									
ABRIL									
MAYO									
JUNIO									
JULIO									
AGOSTO									
SEPTIEMBRE									
OCTUBRE									
NOVIEMBRE									
DICIEMBRE									

ELABORADO POR	REVISADO POR	APROBADO POR
NOMBRE:	NOMBRE:	NOMBRE:
FECHA:	FECHA:	FECHA:

Figure 4 New Maintenance Plan Format
Source: Own elaboration

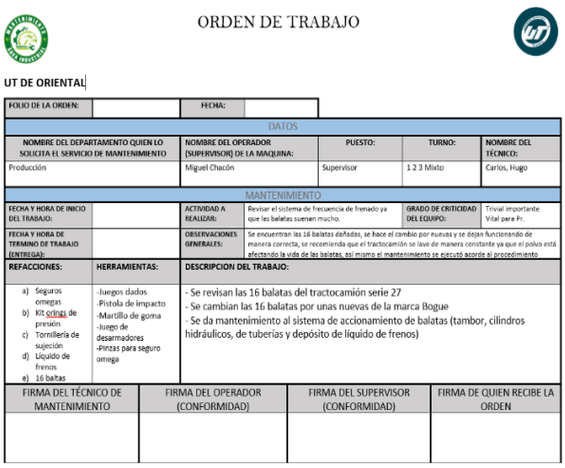
Work order: The work order plays a crucial role in the communication and execution of an intervention aimed at solving a problem detected in a machine or equipment (Figure 5).

mexicana s.a. c.v ORDEN DE TRABAJO					
				fecha	
Nombre del departamento quien lo solicita el servicio de mantenimiento	producción				Grado de Criticidad del equipo: Trivial Importante Vital Para Pr.
Nombre del Operador(supervisor) de la maquina : Miguel Chacón		Turno: 1 2 3 Mixto	Puesto: supervisor	fecha y hora de inicio de trabajo	fecha y hora de termino de trabajo (entrega)
Actividad a realizar :Revisar el sistema de frenado ya que las balatas suenan mucho. Y se accionan de manera tardía.	Descripción del trabajo Se revisan las 16 balatas del tractocamión serie 27 Se cambian las 16 balatas por unas nuevas de la marca Bogue Se da mantenimiento al sistema de accionamiento de balatas (tambor, cilindros hidráulicos, de tuberías y depósito de liquido de frenos)			Refacciones a) Seguros omega b) Kit orings de presión c) Tornilleria de sujeción d) Liquido de frenos e) 16 baltas	Herramientas Juego dados Pistola de Impacto Martillo de goma Juego de desarmadores Pinzas para seguro omega
Nombre del técnico de mantenimiento quien realizo el trabajo; Carlos, Hugo	observaciones generales: se encuentran las 16 balatas dañadas, se hace el cambio por nuevas, y se dejan funcionado de manera correcta, se recomienda que el tractocamión se lave de manera constante ya que el polvo esta afectando la vida de las balatas, así mismo el mantenimiento se ejecutó acorde al procedimiento				
firma del técnico de mantenimiento	firma del operador (conformidad)	firma del supervisor (conformidad)	firma de quien recibe la orden	folio de la orden	

Figure 5 Previous design of the work order
Source: Own elaboration

In this context, a complete redesign of the format previously used for work orders has been carried out. Although the essential fields have been maintained, significant changes have been made, such as the incorporation of new colors and the inclusion of the logos of the Universidad Tecnológica de Oriental and the Industrial Maintenance Area (Figure 6).

By completely redesigning the format, the aim is to standardize and optimize the recording of activities performed during corrective maintenance. This facilitates effective communication between those responsible for the intervention and the personnel involved, ensuring that all necessary tasks are performed in an accurate and timely manner.



ORDEN DE TRABAJO

UT DE ORIENTAL

FOLIO DE LA ORDEN:		FECHA:			
DATOS					
NOMBRE DEL DEPARTAMENTO QUIEN LO SOLICITA EL SERVICIO DE MANTENIMIENTO		NOMBRE DEL OPERADOR [SUPERVISOR] DE LA MAQUINA:	PUESTO:	TURNO:	NOMBRE DEL TÉCNICO:
Producción		Miguel Chacón	Supervisor	1 2 3 Mixto	Carlos, Hugo
MANTENIMIENTO					
FECHA Y HORA DE INICIO DEL TRABAJO:		ACTIVIDAD A REALIZAR:	Revisar el sistema de frecuencia de frenado ya que las balatas suenan mucho.	GRADO DE CRITICIDAD DEL EQUIPO:	Trivial importante Vital para Pr.
FECHA Y HORA DE TERMINO DE TRABAJO (ENTREGA):		OBSERVACIONES GENERALES:	Se encuentran las 16 balatas dañadas, se hace el cambio por nuevas y se dejan funcionando de manera correcta, se recomienda que el tractocamión se lave de manera constante ya que el polvo está afectando la vida de las balatas, así mismo el mantenimiento se ejecutó acorde al procedimiento		
REFACCIONES:	HERRAMIENTAS:	DESCRIPCION DEL TRABAJO:			
a) Seguros omegas b) Kit retén de presión c) Tornillería de sujeción d) Líquido de frenos e) 16 balas	-Juegos dados -Pistola de impacto -Martillo de goma -Juego de desarmadores -Pinzas para seguro omega	- Se revisan las 16 balatas del tractocamión serie 27 - Se cambian las 16 balatas por unas nuevas de la marca Bogue - Se da mantenimiento al sistema de accionamiento de balatas (tambor, cilindros hidráulicos, de tuberías y depósito de líquido de frenos)			
FIRMA DEL TÉCNICO DE MANTENIMIENTO	FIRMA DEL OPERADOR (CONFORMIDAD)	FIRMA DEL SUPERVISOR (CONFORMIDAD)	FIRMA DE QUIEN RECIBE LA ORDEN		

Figure 6 Final design of the Work Order
Source: Own elaboration

Conceptual design: The process of functionality of the maintenance software is shown according to the activity that the user wants to perform from the registration in case the user is not registered so that his data is saved, but if he is, he can log in without any problem and thus access any option either to access the machines or to print any of the maintenance forms. As shown in the flow chart (Figure 7).

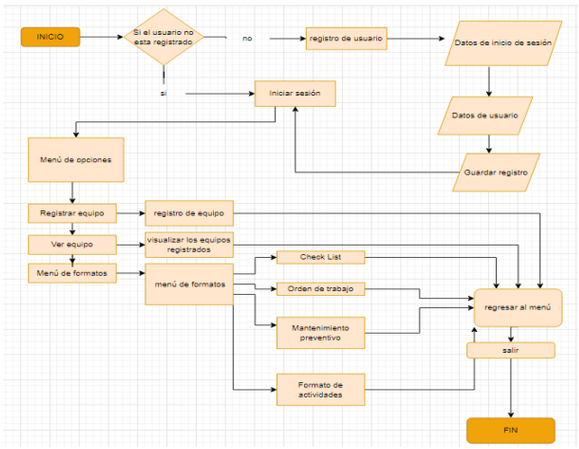


Figure 7 Flowchart of the Maintenance Management Software
Source: Own elaboration

Java

Java is an object-oriented programming language developed by Sun Microsystems in the early 1990's. "The language itself takes much of its syntax from C and C++ Programming Language, but has a simpler object model and eliminates low-level tools, which tend to induce many errors, such as direct manipulation of pointers or memory" (Gosling, 2005). To realize such software, the following programming tools are required for its elaboration. [4]

Java is a programming language used to create software compatible with a great diversity of operating systems. This language has the particularity of being compiled and interpreted at the same time; this means that it is a simplified language that automatically converts the code into machine instructions.

Traditional cascade methodology

Waterfall: it is a methodology in which the stages are organized from top to bottom, hence the name. The different functions are developed in differentiated stages and obeying a rigorous order. Before each stage, the product must be reviewed to see if it is ready to move on to the next stage. The initial requirements and specifications are not set to change, so the results cannot be seen until the project is well advanced.

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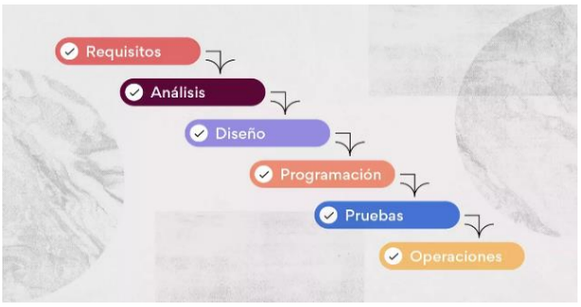

Figure 8 Stages of the cascade methodology
Source: Own elaboration

Apache NetBeans IDE

In this section we will talk about the Java work environment with the Apache NetBeans IDE, used for the design and development of this software, as well as the database management system. MySQL. [5]

NetBeans "is an IDE or integrated development environment, based on the Java language and executed in Swing" (E, 1995).

Next, a screen of the work environment is presented where the Login screen is developed as shown in the following figures. The design is made using the tools offered by NetBeans for the interface design and code for the execution of the buttons.

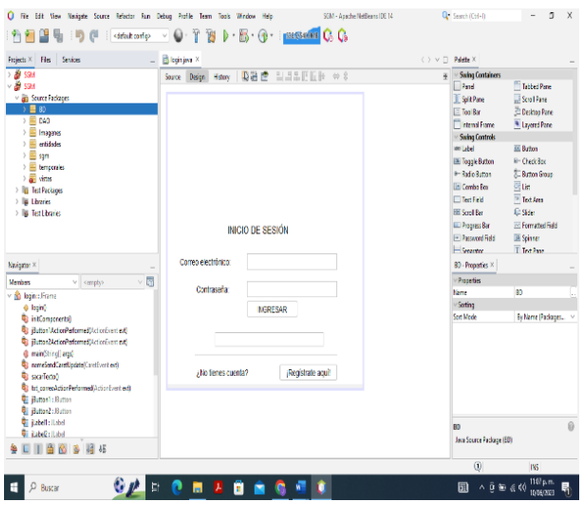

Figure 9 Design of the Login screen
Source: Own elaboration

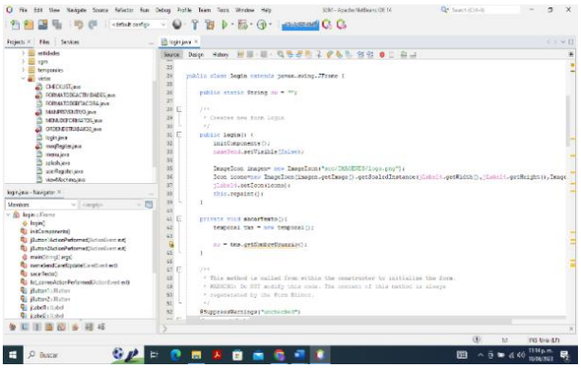

Figure 10 Login screen code
Source: Own elaboration

The following figure shows the interface design of the equipment registry, which will help to have an inventory of all the registered machinery with the following data to have a better control of these such as: Equipment name, model, serial number, description, among other data that will be necessary for the equipment information. And the source code of how each label and button to be used in this screen is programmed. See figure 11.

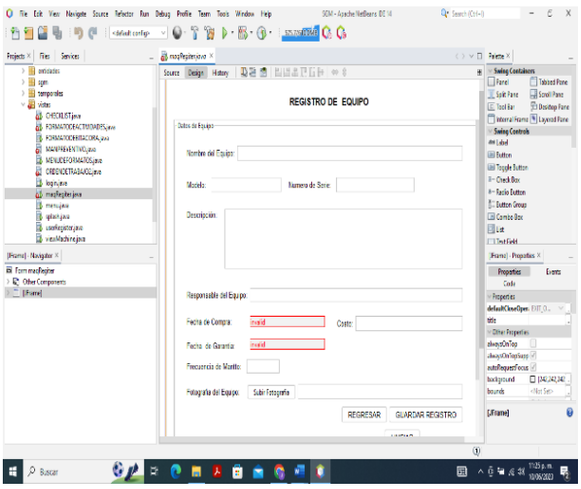

Figure 11 Machinery Register screen
Source: Own elaboration

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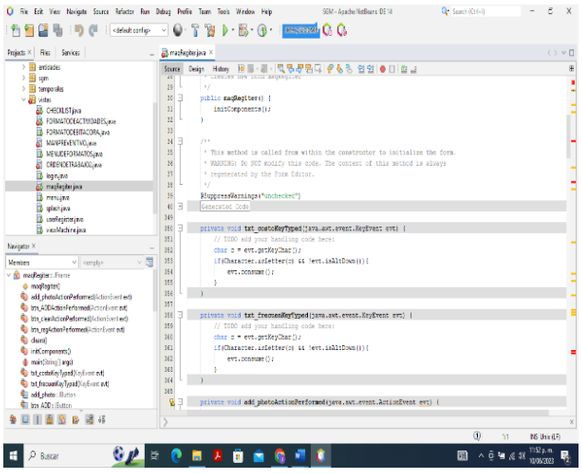

Figure 12 Source code of the Machinery Registration screen
Source: Own elaboration

DBMS

Database Management System. A Database Management System (DBMS: Data Base Management System) is a software system that allows the definition of databases; as well as the choice of the data structures necessary for the storage and search of data, either interactively or through a programming language. A relational DBMS is a data model that makes it easy for users to describe the data to be stored in the database along with a set of operations to handle the data.

Relational DBMSs are an effective tool that allows multiple users to access data at the same time. They provide efficient facilities and a set of functions with the objective of ensuring confidentiality, quality, security and integrity of the data they contain, as well as easy and efficient access to it.

XAMPP

XAMPP is an Apache distribution that includes several free software packages. The name is an acronym composed of the initials of its constituent programs: the Apache web server, the relational database management systems MySQL and MariaDB, "as well as the programming languages Perl and PHP", (COBO, 2005, p. 99). [6] The initial X is used to represent Linux, Windows and Mac OS X operating systems.

– **Apache**: the open source web server is the most widely used application globally for web content delivery. The server applications are offered as free software by the Apache Software Foundation.

– **MySQL/MariaDB**: With MySQL, XAMPP has one of the world's most popular relational database management systems. In combination with the Apache web server and the PHP language, MySQL is used to store data for web services. In the current versions of XAMPP, this database has been replaced by MariaDB, a fork of the MySQL project.

An XAMPP server can be installed quickly and easily as a local test system under Linux, Windows and Mac OS X with a single executable file. The software package contains the same components that are used in any web server, so that developers can test projects locally and conveniently transfer them to real systems. However, XAMPP is not recommended as a public server because, in the interest of user-friendliness, there are certain limitations in terms of security. The following is the Installation screen as shown in Figure 13.

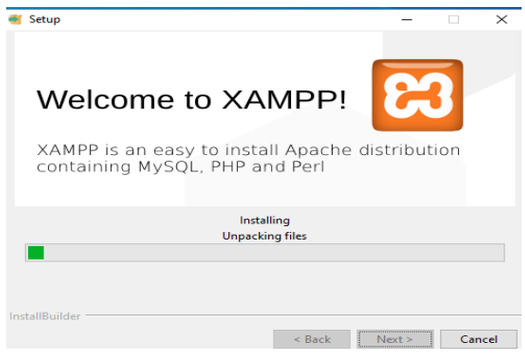

Figure 13 Xampp installation screen
Source: Own elaboration

MySQL

MySQL is an open source relational database management system (RDBMS) supported by Oracle and based on Structured Query Language (SQL). MySQL runs on virtually all platforms, including Linux, UNIX and Windows. Although it can be used in a wide range of applications, MySQL is most often associated with web applications and online publishing.

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The following figure shows the working environment of the database design and administration that will be used in the development of the maintenance software.

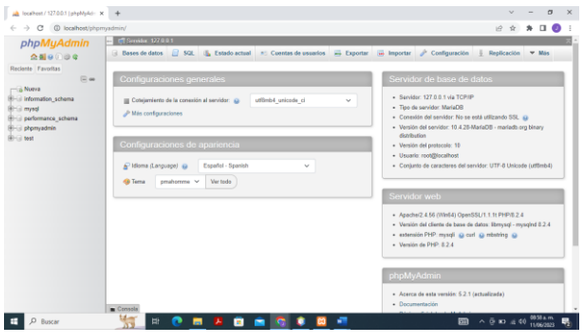

Figure 14 Work environment for the Database Design
Source: Own elaboration.

Incremental development: Following the flowchart, the user interfaces that were designed are described. Login to the platform, the user will be able to access through the e-mail with which he/she registered, in case the user is not registered he/she can do it by clicking on "Register here", once he/she has been registered he/she will be able to log in as shown in the following image (see figure 15).

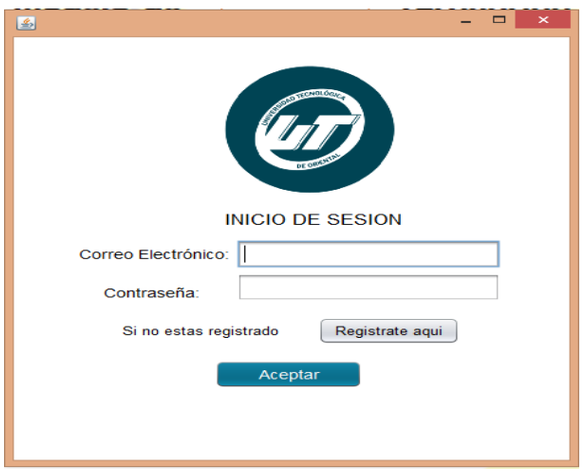

Figure 15 Login window
Source: Own elaboration

Equipment registration window in which each machine will be registered according to its characteristics so that they can be consulted later (Figure 16).

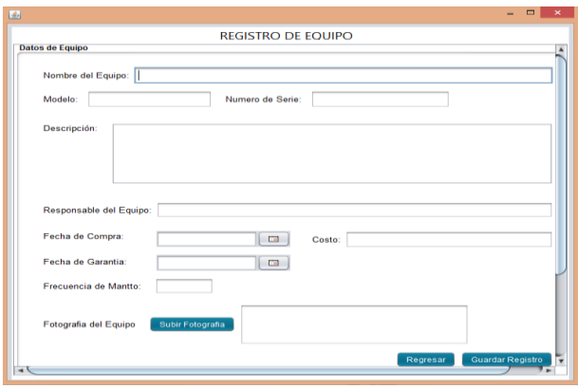

Figure 16 Equipment Registration Window
Source: Own elaboration.

The maintenance window has its respective drop-down box of No. so that the user only has to select and automatically fills the field as well as the date (Figure 17).

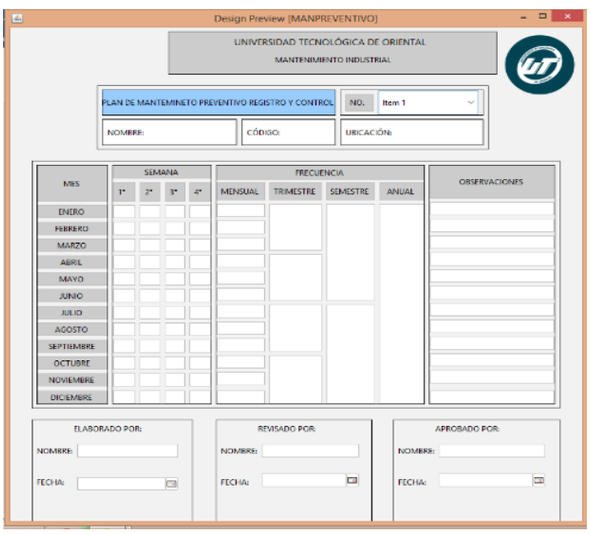

Figure 17 Result of Maintenance Plan
Source: Own elaboration.

The Check List window is filled only with drop-down lists, the only thing that the user fills by himself are the observations and data of the company and the equipment (Figure 18).

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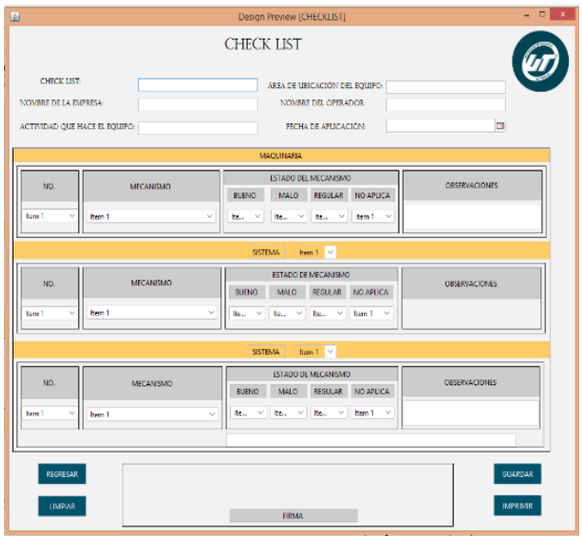

Figure 18 Result of Check List
Source: Own elaboration

The Work Order window has both drop-down lists and check boxes to fill in this format, where personnel data and maintenance data are filled in.

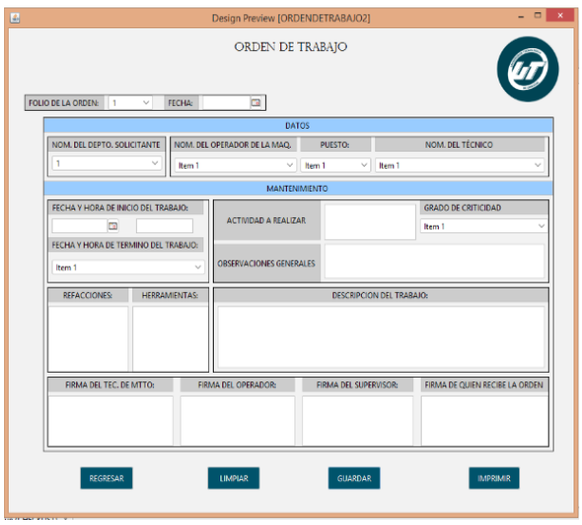

Figure 19 Result of Work Order
Source: Own elaboration

Conclusions

The development of the preventive, corrective and predictive maintenance manager software meets the objectives established in this article. The analysis of the software requirements has allowed to identify the specific needs of the organizations in terms of maintenance management, which has been fundamental for the design of a conceptual architecture that integrates in a modular and scalable way the maintenance modalities.

The implementation of functional prototypes of the software has been fundamental to validate key functionalities and obtain early feedback from users. This allowed for continuous adjustments and improvements, gradually adding new functionalities in successive iterations. In addition, extensive testing of functionality, performance, security and usability of the software has been carried out to ensure its quality and reliability.

However, a constant re-evaluation of preventive maintenance activities is necessary to avoid unnecessary costs. A continuous improvement system should be implemented and a success-oriented organizational culture should be promoted, integrating all management systems and establishing responsibilities for functions related to the work order, inventories, equipment coding, among other aspects.

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