Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Eléctrica

Tesis

Design and Construction of a Dynamic Equipment for Diagnosis of Electronic Ignition Devices of Internal Combustion Engines

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Design and Construction of a Dynamic Equipment for Diagnosis of Electronic Ignition Devices of Internal Combustion Engines

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***Abstract*—The purpose of this study was to design and build a dynamic equipment for the diagnosis of electronic spark ignition devices in internal combustion engines. To achieve this, a module was developed specifically designed to carry out tests and diagnose the operational status of the electronic ignition system in vehicles of various brands. Likewise, a study was carried out to select appropriate materials for the construction of the equipment, including a detailed analysis of each component of the power transmission. Studies were carried out both on the structural part to guarantee the integrity of the user and on the power transmission of the dynamic engine and the electronic ignition components. These studies allowed the identification and diagnosis of possible failures in said components.**

Keywords—electronic ignition, high voltage, electronic module, electric spark

I. INTRODUCTION

Electronically controlled ignition systems used in vehicles have been meticulously designed to integrate advanced electronic control technology. Its main purpose is to react more effectively to various external conditions compared to conventional mechanical systems. This approach brings significant benefits, such as reduced gas emissions, lower fuel consumption, increased ignition voltage and optimization of space in the engine compartment, among other aspects.

Despite the increasing design demands placed on ignition coils today, the fundamental function of spark ignition engines remains the same: to achieve precise ignition of the air-fuel mixture at the right time, with the optimal ignition time in terms of energy, to ensure complete combustion. With the aim of reducing fuel consumption, reducing gas emissions and improving efficiency, engine technologies continue to evolve constantly. In parallel, automotive electronic component manufacturers continue to develop electronic ignition systems to adapt to these advances [1].

The various modes of operation and the demands on the ignition systems used in vehicles with gasoline engines that make up the country's extensive vehicle fleet make preventive and corrective maintenance of the auxiliary components of the internal combustion engine essential to guarantee its optimal functioning. This is necessary to keep the elements that are part of the ignition system in good condition.

The problem addressed in this research is the lack of equipment that allows effectively demonstrating the operation of the ignition coils and modules of modern electronic systems to students and personnel in the automotive area, including mechanics and technicians. The versatility of operation and standard design of this equipment make it suitable for a wide range of vehicle brands and models, representing a minimal investment compared to similar equipment available on the market.

As a result, it has been decided to develop a proposed solution for this problem for academic purposes. The creation of this machine has a positive impact on automotive workshops, as it allows them to more efficiently diagnose the electronic components of ignition systems, such as modules and coils. This, in turn, ensures that the ignition coils and electronic modules are in optimal condition, reinforcing their warranty, prestige and technical reputation [2].

It has been identified that one of the most challenging diagnoses today is determining why a vehicle will not start, which often leads to the investment of time in performing various tests on components that are not part of the ignition system. For this reason, the creation of a team that addresses this problem effectively is proposed.

One of the significant technical advantages of this equipment is its ability to perform electrical tests on vehicle modules and coils, adapting to the needs of our vehicle fleet, which includes vehicles of American, Japanese and Korean origin [3]. In the country, there are no companies dedicated to the design and manufacturing of training equipment specifically oriented to the automotive field and with the characteristics mentioned above. Therefore, to acquire this type of equipment, it is necessary to turn to foreign companies or other options, which generally offer a variety of products and equipment designed to train on individual systems, which can limit the ability to integrate and flexibility in training. [3].

II. Materials and Methods/Methodology

The essential components of the ignition system regardless of the type, the essential components are: Crankshaft Position Sensor, Camshaft Position Sensor, ignition module, ignition coils, wiring, spark plugs, ECM (Electronic Control Module), signals from various sensors.

A. *Method*

This is an inductive-deductive approach research, since its object of study is the design of diagnostic equipment for electrical and electronic components of the ignition system of internal combustion engines. This research is carried out under controlled operating conditions and has a practical utility approach, since its main objective is to improve the accuracy and safety of diagnoses performed by technicians in automotive workshops.

For a comprehensive analysis of the proposed machine, the production of the electronic ignition was considered, which allowed the input and output signals to be detailed, as illustrated in Figure 1.

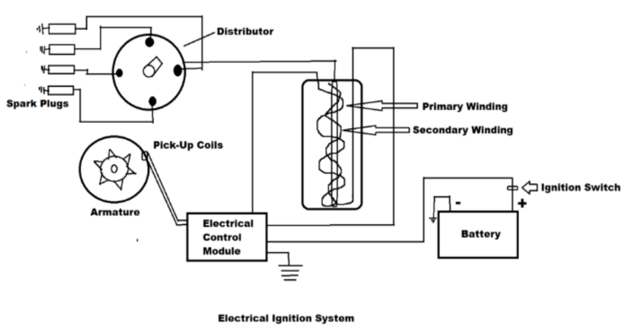

Fig. 1. Electronic ignition system.

B. *Methodology*

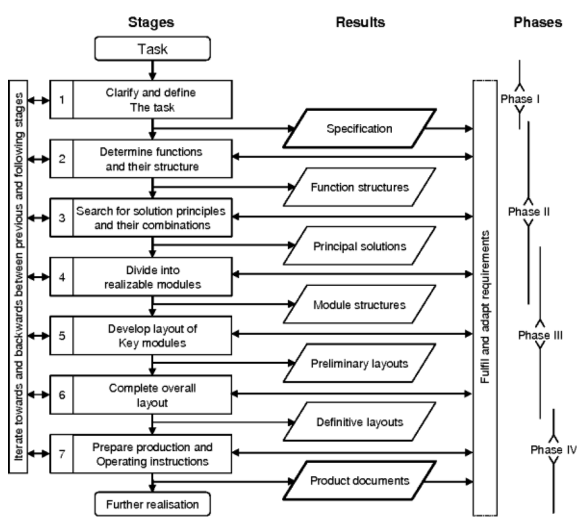

Fig. 2. Generalized process of the VDI 2221 Standard [4].

The design approach is mainly applied to streamline the creative activities of the designer and accelerate to the desired limits. This methodology has been developed and tested extensively and they all have something in common, but you can understand the variations depending on the purpose of the application. However, this is intended to standardize the structural design method as well as the languages and definitions of VDI Recommendation 2221 titled "How to Develop and Implement Engineering Products and Systems." Figure 2.

The model developed in this process is a general approach and we believe it is highly adaptable to the design of dynamic diagnostic equipment. In this way, users can learn with or without experience.

The quality of the design results is the result of the knowledge and experience that the designer has acquired in his activities in all cases [4].

TABLE I. List of Demands

Characteristics	**Condition**
Principal function	Transmit mechanical power
Geometry	The dynamic equipment must adapt to the specifications (portable), allowing the support and clamping processes. The geometries of the power transmission elements are already defined, so this design has to adapt to these specifications.
Kinematics	The revolutions should be from 500 to 3000 rpm
Kinetics	The dynamic equipment will have to support the workloads so that it does not suffer any deformation that would prevent its correct functioning.
Forces	The dynamic equipment must have good stability and rigidity such that it does not prevent the tests from being carried out without vibrations. It must also withstand the forces so that deformations do not occur that impair its correct functioning.
Manufacturing	The materials used for the parts of the dynamic equipment must be available in the Peruvian market
Mounting	The dynamic equipment will be simple to assemble, facilitating maintenance.
Maintenance	Maintenance should be easy, economical and infrequent. Equipment components must be easy to replace (manufacturing).
Security	The dynamic equipment must comply with the safety standards established for this type of assembly.
Cost	Manufacturing costs should be as minimal as possible.

Source: self made

To design the structure of the ignition module, certain calculations will be needed.

TABLE II. Parameters to Determine the Static System Structure and Analysis

Parameters	Equation	Reports
Bank structure calculation	$w = Wd/L$	$801.15 \frac{N}{m}$
Maximum effort calculation	$\sigma\, max = \frac{Mmax}{Sxx}$	148.4 Mpa
Security factor	$n = Sy/\sigma\, max$	1.44
Limiting factor	$Se = Ka * Kb * S\acute{e}$	27.55 $Kpsi$

Having already developed the calculations, all the measurements of the structure are drawn, the SolidWorks program was used to develop the operating simulation, as well as the plans presented to be able to observe the operation of the machine in detail.

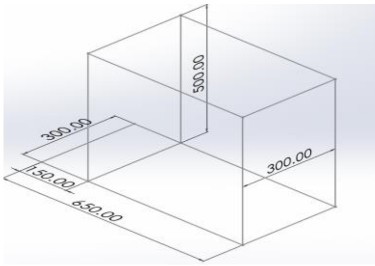

Fig. 3. 3D structure.

III. Results

A. Structure Design

Analysis with vertical loads:

Image 4 the figure shows the maximum stress that will be supported when applying a distributed vertical load, which is 148.4 Mpa .

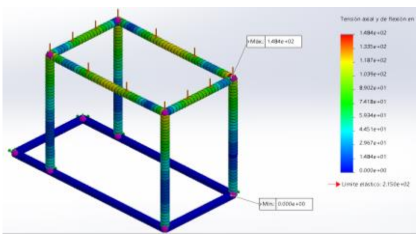

Fig. 4. Analysis of static loads – Stresses.

B. Shear Strength

The red diagram is the most critical and therefore the type of profile is chosen. Figure 5 shows the result of the shear stress.

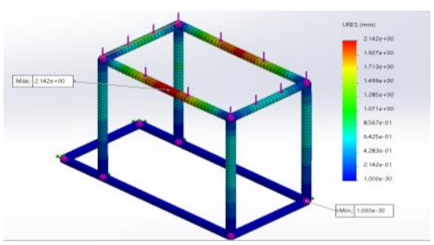

Fig. 5. Shear strength.

C. Safety Factor

The minimum safety factor is 1.44, which indicates that the structure is well designed and can support the weight. In this calculation, the Von Misess theory is applied.

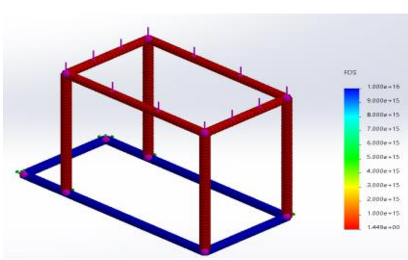

Fig. 6. Security factor.

D. Hall Ignition System

The electrical design of the panel begins with the power source, which is the battery. From there, it goes through a power switch responsible for regulating the power to the circuit. The power is then directed to the pulse generation module, which receives a signal from a pulse generator located in the engine distributor. This module generates pulses that are sent to the ignition coil, thus generating a high voltage that is transmitted to the spark plugs through high voltage wires.

In Figure 7, the ignition system of the Hall van is composed of a static part including a Hall integrated circuit and a permanent magnet with conductive parts. The moving part of the generator is made up of a shutter drum that has a series of screens, one for each cylinder of the engine. When one of the shutter drum screens is placed between the magnetic parts, it interrupts the magnetic field, preventing it from reaching the integrated circuit. When the shutter drum screen is removed from the space between the magnetic parts, the integrated circuit detects the magnetic field again, thus activating the ignition. The width of the displays determines the duration of coil activation.

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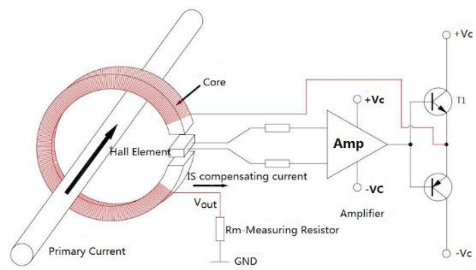

Fig. 7. Hall system electrical circuit.

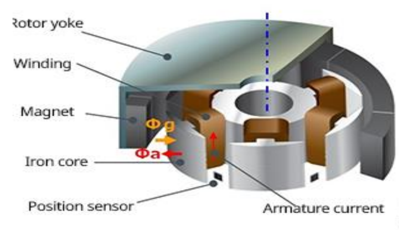

Fig. 8. Elements of a Hall sensor.

E. Spark System Circuit

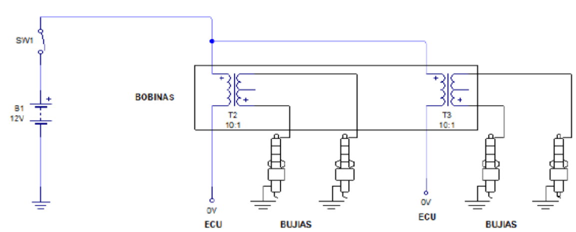

Fig. 9. Electrical circuit of the spark system.

F. Spark System Element Diagram

In an internal combustion engine, the electronic ignition system is used to start the combustion of air and fuel.

Fundamentally, this system generates a spark that acts as a heat source to initiate ignition. It works internally in the engine, specifically in the spark plug, where a spark is generated to start the combustion process

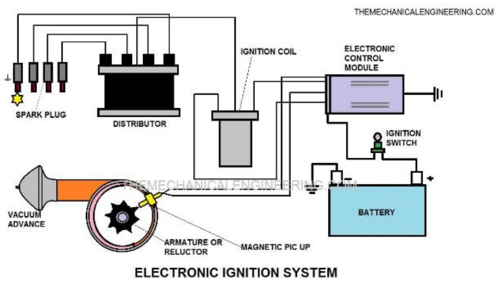

Fig. 10. Spark Electrical Circuit Element Diagram.

G. *Test Bench Assembly Features*

The equipment has been designed to operate analogously to the ignition system of a car. It supplies a 12V voltage to the ignition coils and modules, performing simulations of accelerations and temperatures similar to those experienced by a vehicle, although the latter are limited to a small section. An analysis of the coil is carried out to evaluate its behavior at various operational stages.

When supplies and signals reach the ECM (Engine Control Module), the computer activates and deactivates the ignition module, thus allowing testing of the modules and coils. To address the diversity of electrical terminals of the modules, a standard harness has been designed that allows the installation of different module connectors and coils, adapting to the specific harnesses of the modules to be evaluated.

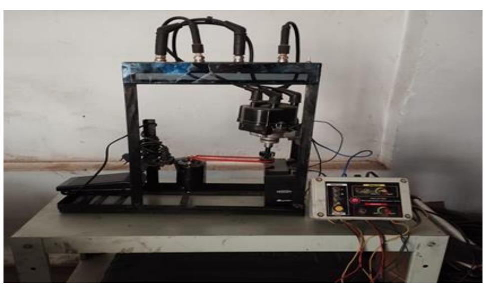

Fig. 11. Dynamic equipment test bench.

Fig. 12. Generation of the electric spark in the testing bench.

IV. Conclusions

This dynamic system, created to diagnose electronic ignition devices in internal combustion engines, stands out for its effectiveness. It uses innovative technologies and is characterized by its ease of use, addressing the challenge of avoiding excessive investment of time in diagnostics that do not lead to effective solutions for vehicles.

The aforementioned situation underlines the relevance of those who work in the automotive industry and lack the appropriate tools and equipment to carry out an accurate diagnosis of electronic ignition systems in internal combustion engines, seeking to update their knowledge and skills.

All the systems assembled in the dynamic equipment have been correctly adjusted, and the materials used in this ignition simulator are easily accessible and require a reduced investment.

The dynamic diagnostic equipment makes it possible to perform functional tests, identify faults and measure the switching states of the ignition system coils. This allows you to determine if any component is failing.

The design of the equipment is aimed at carrying out tests in three states of electronic ignition: for lost spark, Hall and DIS COP. This enables a more efficient and versatile use of the system.

The equipment designed for the diagnosis of electronic ignition components has received an excellent response from the student population that visits our workshops. Therefore, our commitment is to continue innovating in equipment that can compete with the technology present in the current vehicle fleet.

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