SOFTWARE

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Automated system for determining the operating parameters of hydraulic machines

Sistema automatizado para la determinación de los parámetros de funcionamiento de las máquinas hidráulicas

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ABSTRACT: The purpose of this paper is to develop an automated system that determines the operating parameters of rotary hydraulic machines (pumps and motors), as well as the optimal operating regimes of the hydraulic machines, the coefficient of isogonality, and the relationships between pump and motor efficiency. The software results also display curves of the total efficiency of the pump and hydraulic motor as a function of the coefficient of isogonality, ensuring rapid and accurate evaluation.
Keywords: Coefficient of Isogonality, Liquid Friction, Dry Friction, Leak.

RESUMEN: El presente trabajo tiene como objetivo desarrollar un sistema automatizado que determina los parámetros de funcionamiento de las máquinas hidráulicas rotatorias (bombas y motores), así como, los regímenes óptimos de trabajo de la máquina hidráulica, coeficiente de isogonalidad, las relaciones entre la eficiencia de la bomba y el motor. Los resultados del software muestran además las curvas de las eficiencias totales de la bomba y el motor hidráulico en función del coeficiente de isogonalidad, garantizando rapidez y precisión en la evaluación realizada.
Palabras clave: coeficiente de isogonalidad, rozamiento líquido, rozamiento seco, fugas.

INTRODUCTION

Hydraulics is one of the most versatile and flexible forms of energy transmission invented by humans (Dransfield, 1981). Hydraulic systems simply convert energy from one form to another to perform work. In heavy machinery, this translates into using the energy provided by the internal combustion engine, commonly known as diesel engines, into hydraulic power (Guasumba et al., 2021).

The hydraulic pump is a mechanical system that is part of a hydraulic system that commonly exists today (Llanes et al., 2020). The pump's movement involves regulation and control actions to increase a flow rate (Manring and Fales, 2019).

The gear pump has a positive displacement, meaning its flow rate is determined by revolutions, but this cannot be varied (Tipán et al., 2021). The fluid is transported between the gear teeth and the casing, the meshing gears fitted to the casing (Paneque, 2010). This type of pump operates at non-regulated high speeds and low pressures and is made of a cast iron or aluminum alloy casing (Merritt, 1967).

The performance of a hydraulic pump is determined by the output pressure, the flow rate at which it operates, its displacement relative to the flow rate, its driving torque, and its angular velocity.

The absence of suction and discharge valves results in the existence of spaces in hydraulic machines between the fixed and moving walls, where the main energy losses occur (Paneque et al., 2018; Yao, 2018; Merritt, 1967; Kong et al., 2022). The operating speed of a hydraulic machine is determined by the following three parameters: pressure difference or gradient, rotor rotational angular velocity, and the dynamic viscosity coefficient of the fluid (Merritt, 1967; Nekrasov, 1968a; 1968b; Paneque, 2010).

The efficiencies of rotary hydraulic machines are simply expressed by the isogonality coefficient and the leakage coefficients of fluid friction losses and dry friction losses (Pérez and Paneque, 2001).

Taking into account the above, the present work aims to develop an automated system for the theoretical determination of the operating parameters of hydraulic machines (pumps and motors).

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MATERIALS AND METHODS

Based on the theoretical research developed by Pérez et al. (2005), as well as experimental and statistical data on the operating parameters of hydraulic machines, the automated Performance Curves version 2.0 system was developed using the Excel platform of Microsoft Office Professional Plus 2021.

This automated system (Performance Curves) is used to determine the operating parameters of rotating hydraulic machines. The software was developed based on the synthesized flow diagram shown in Figure 1.

Upon entering the system, you directly access the Control Panel, which includes the selection of the machine (pumps or motors), selection of the machine status (normal or abnormal), selection of the coefficients (normal or abnormal), results (table and graph) and About: (Figure 2).

- *The machine selection window contains the following buttons*:

    Pumps or Motors: Allows you to select the type of machine being studied, using a list box that includes the hydraulic pump or motor options.

The machine status selection window contains the following:

Normal or Abnormal: Allows you to enter data on the machine's status (normal or abnormal) using a radio button.

- *The coefficient selection window includes*:

    Normal or Abnormal: Provides access to two windows, normal or abnormal, which contain information entry related to the leakage coefficient, liquid friction coefficient, and dry friction coefficient, depending on the type of pump and hydraulic motor selected.

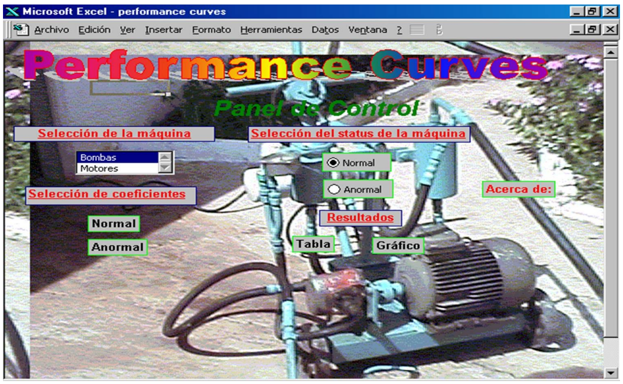

FIGURE 2. Control panel.

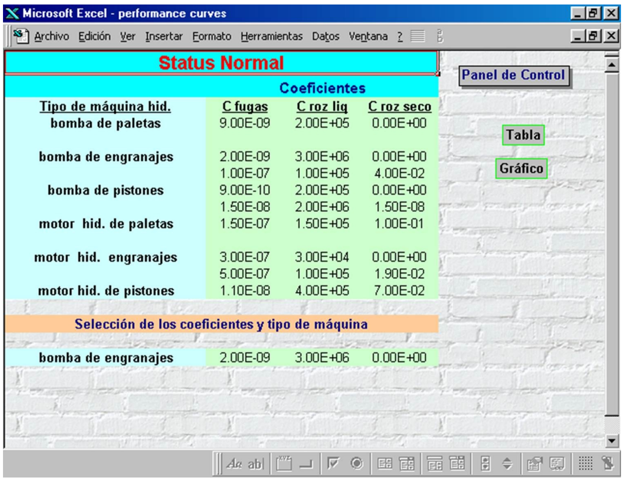

FIGURE 3. Window for calculating normal coefficients.

These windows have command buttons that facilitate returning to the Control Panel, the results table, and the efficiency graph for the selected conditions (Figures 3 and 4).

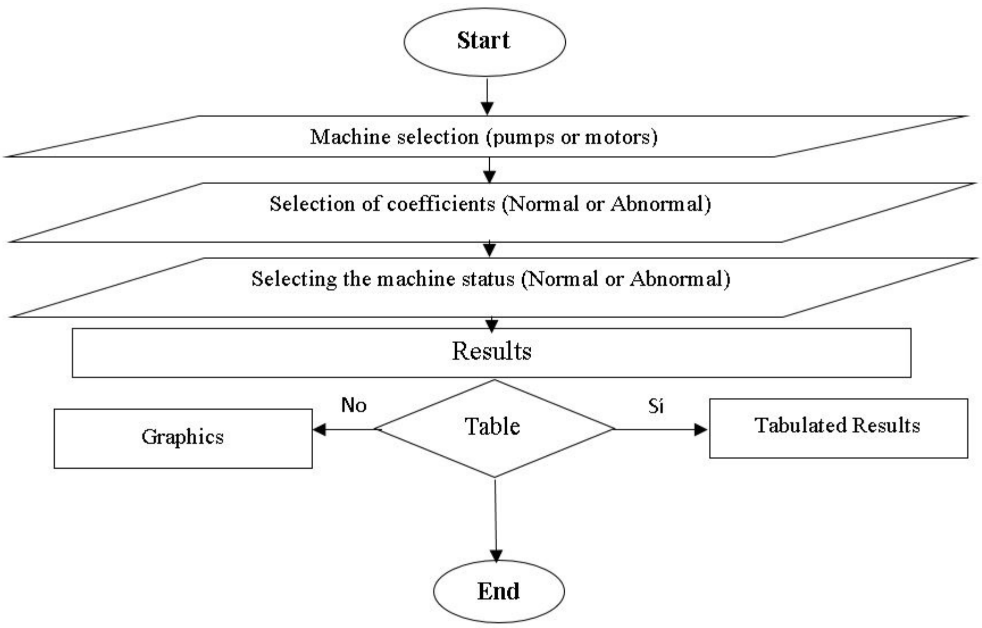

FIGURE 1. Flowchart of the automated Performance Curves system.

- *The results window contains the following buttons*:

  Table: Accesses the results window for the isogonality coefficient, volumetric efficiency, mechanical efficiency, and total efficiency for a range of pressures preset by the user. It also determines the value of the isogonality coefficient* and the maximum total efficiency of the hydraulic machine.

  This window has command buttons that allow you to return to the Control Panel and the efficiency graph for the selected conditions.

  Graph: Displays the volumetric, total, and mechanical efficiency curves as a function of the isogonality coefficient, allowing you to study their behavior for a hydraulic machine under different wear conditions, resulting from contamination and operation (Figure 5).

  This window has command buttons that allow you to return to the Control Panel and the results table.

  About: Window showing the authors' names, version, logo, and work center address, etc.

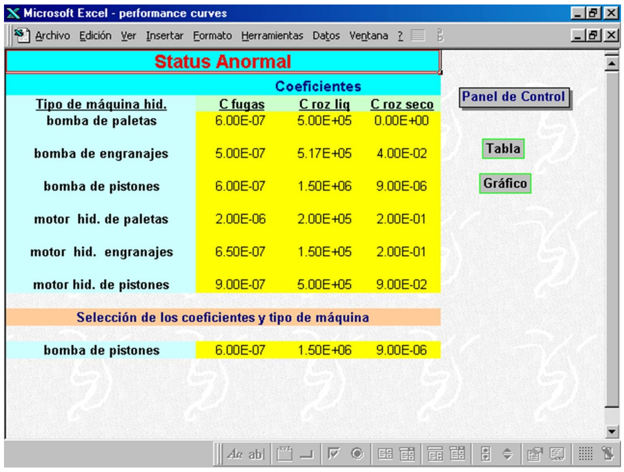

FIGURE 4. Window for calculating abnormal coefficients.

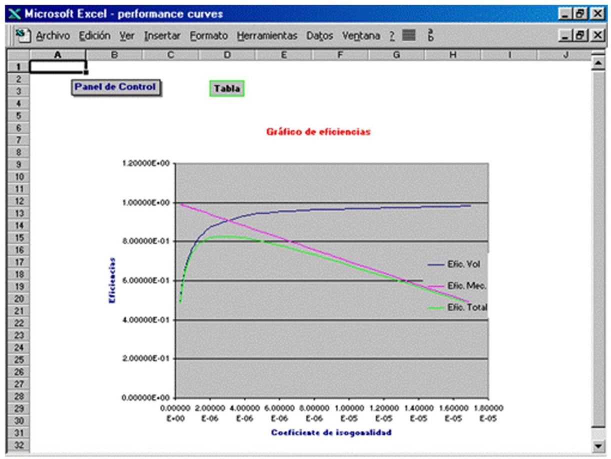

FIGURA 5. Curvas de eficiencias

CONCLUSIONS

- The automated "Performance Curves" system is easy to use, allowing access to each component via the user's link to the Main Control Panel.
- Performance Curves allows for the accurate and reliable determination of the operating parameters of hydraulic machines (pumps and motors).
- The software allows for determining the maximum total efficiency of hydraulic pumps and motors.

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