Experimental Analysis of Fluke 345 Measurement Instrument Laboratory: Unloaded and Loaded Engines Case Studies

João Pedro Ferraz Mourão Maya Barbosa[1], Wesley Mota dos Reis[1] and Jadiel Caparrós da Silva[1]

[1] *Federal University of Tocantins, Electrical Engineering Department, Tocantins, Brazil*

Reception date of the manuscript: 16/08/2023
Acceptance date of the manuscript: 02/10/2023
Publication date: 16/10/2023

Abstract—This scientific initiative project was carried out using the resources available in the laboratories of the Federal University of Tocantins (UFT), focusing on the Fluke 345 measuring equipment. The experiment presented in this paper involved two different approaches: one with an unloaded engine and another with a load consisting of a DC generator, both powered by a 60-volt supply. The Fluke 345 measures the voltage RMS, current RMS, and power factors and plots them along with the harmonic analyzes. The experiment showed that no harmonics were detected at no load, while harmonics occurred under load. The data collected validates the theoretical concepts through practical application. This study provides valuable insights for power engineering, especially regarding the performance of the devices under different conditions.

Keywords—Electric energy, Power Quality, Fluke 345, Validation, Theoretical Conceptions, Experimental Data.

I. INTRODUCTION

The aim of this paper is to study and analyze the device Fluke 345 [1] which was used to measure magnitudes related to electrical energy in three-phase engines. The results demonstrate the coherence of the recorded measurements both when the engine is unloaded and during operational loaded, underscoring the capacity of this apparatus to facilitate a thorough statistical assessment of the gathered data. This insight holds significant implications, as it enriches the comprehension of the interplay between engine attributes and the quantified electrical parameters by the Fluke 345 equipment. Furthermore, users have the flexibility to tailor the input configuration of the device, broadening its utility in scientific investigations focused on the evaluation and resolution of electrical power-related issues [2, 3]. The results also establish a robust foundation for advancing sophisticated measurement and analytical methodologies applicable to three-phase engines, thereby enhancing the progression of research in this domain. Consequently, this paper furnishes substantial and authenticated content through empirical investigations and theoretical frameworks rooted in the scientific approach.

The significance of researching methods for quantifying electrical energy within three-phase engines is widely acknowledged within the scientific community [4]. Prior investigations have contributed a plethora of invaluable insights to the entire subject domain. In a study conducted by [5], which presents 3Ph-oZm, an affordable open-hardware device for precise monitoring in smart grids. It measures energy and power quality in three-phase networks, handles voltage, current, frequency, power, and energy. 3Ph-oZm processes harmonics, logs power quality disturbances using custom software, surpassing commercial devices in versatility and data processing. Validated through lab testing and real-world applications like photovoltaic power plants, it also supports engine health monitoring, energy savings, and microgrid estimation.

Given the intricate nature of three-phase engines and the nuanced interactions between their operational attributes and electrical parameters [6], the selection of a robust measurement methodology is paramount. The utilization of the Fluke 345 device in this study offers distinct advantages. Its advanced technology ensures precise and reliable measurements, even under varying load conditions, guaranteeing the accuracy of recorded data. The device's adaptability in configuring input parameters facilitates tailoring measurements to specific engine setups, a crucial feature when dealing with the diverse array of three-phase engines configurations. Moreover, the Fluke 345's capability to capture both instantaneous and average values enables a comprehensive understanding of dynamic changes occurring during engines operation [1]. By harnessing these capabilities, the methodology provides a comprehensive framework for obtaining meticulous and insightful data, establishing a solid foundation for the subsequent analysis and interpretation of the intricate interplay between engine

Contact data: João Pedro Ferraz Mourão Maya Barbosa, jpfmmb@gmail.com

behavior and electrical parameters.

Next, Section II (Methodology and Tools) describes the approach of the study, Section III presents the Results, and Section IV contains the Conclusions.

II. Methodology and Tools

The principal objective of this work is to meticulously investigate, as expounded in this manuscript, the analysis of the Fluke 345 equipment [1], as illustrated in Fig. 1. To accomplish this, the experimentation encompassed the utilization of the WEG induction engine unloaded and loaded, powered by a DC generator operating under unloaded conditions. The outcomes of the investigation distinctly demonstrate that the utilization of the Fluke 345 yields enhanced effectiveness for deployment within modern industrial and laboratory environments.

Fig. 1: Fluke 345 [1].

The analysis revolves around some theses that form the central point of the discussion. Complementary theoretical sources are also integrated to provide a comprehensive understanding of the conceptual path. For full technical details on the Fluke 345 meter [1] and the used Engine [4], refer to their respective manuals, which are a comprehensive source of accurate information on this scientific endeavor.

III. Results

a. Initial considerations

The data presented in this section were obtained through measurements conducted in the Federal University of Tocantins machine laboratory. To gain a comprehensive understanding, two distinct experimental approaches were employed. The first approach involved testing the engine under unloaded conditions, while the second approach involved adding a load in the form of an unloaded direct current generator. Also, the experiment was conducted with a voltage of 60 Volts.

The Fluke 345 equipment [1] is capable of measuring various parameters, including RMS voltage, RMS current, and the different powers within the power triangle (active, reactive, and apparent power). Additionally, the instrument displays voltage, current, and harmonic graphs on its screen.

b. Comparison of the engine at Unloaded and Unloaded load

This section shows the engine's comparative results in unloaded and load, which Fig. 2, measurements of data from an unloaded engine are depicted, with the frequency indicating a value different from 60 Hz, and at the Fig. 3, the values of the aforementioned quantities are illustrated for the engine with the attached load. This indicates that all values increased as a consequence of the load increment. The equipment displays voltage waveforms, as shown in Figs. 4 and 5. In addition, the Fluke equipment has an internal memory that can store data, providing software that allows users to access the information stored within.

Fig. 2: Measured values for the engine unloaded.

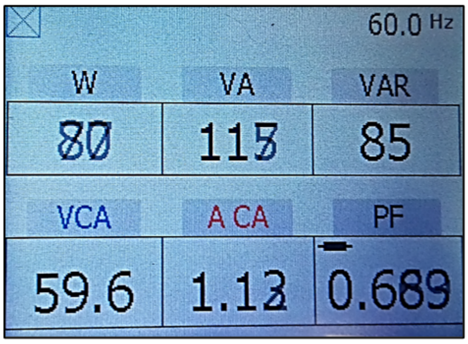

Fig. 3: Measured values for the engine with load.

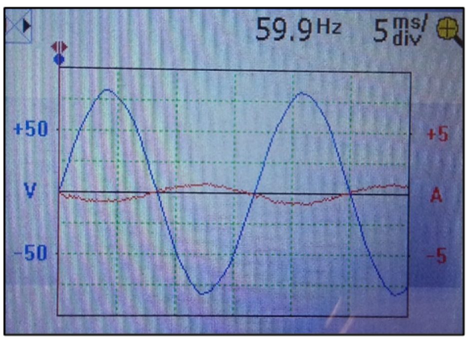

Fig. 4: Voltage and current waveform for the engine without load.

The values acquired with this equipment in the experiment conducted with the unloaded engine did not exhibit harmonics, as shown in Fig. 6, and Fig. 7 presents values related to harmonics for the loaded engine.

 ISSN: 2675-3588

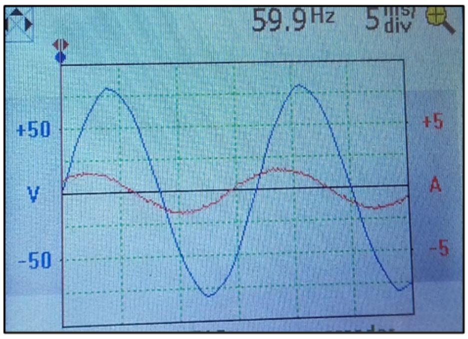

Fig. 5: Voltage and current waveform for the engine with load.

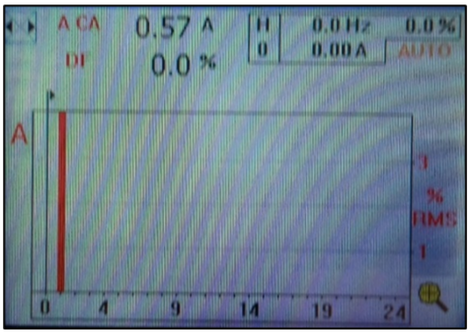

Fig. 6: Harmonics in the engine without load.

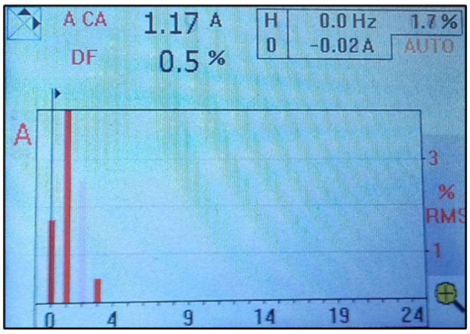

Fig. 7: Harmonics in the engine with load.

c. Final Considerations

A comprehensive comparison of the experimentally obtained data can be found in Table 1, which meticulously lists the measured values for both the unloaded and loaded engines. These values cover a spectrum of important parameters, including: RMS Voltage (V), RMS Current (A), Active Power (W), Reactive Power (VA), Apparent Power (VAr), Power Factor Harmonics (%).

The tabulated data enables a systematic evaluation of the equipment's performance in different conditions, facilitating insights into their interactions. To better visualize the values recorded by the Fluke 345 measurements, Fig. 8 shows a graphical representation in the form of a bar chart.

This graph shows the variations in the measured parameters - RMS voltage, RMS current, active power, reactive power, apparent power, power factor, and harmonics - between the unloaded and loaded engine configurations. The bar graph provides an intuitive display and helps identify power differences in different operating conditions.

TABLE 1: COMPARATIVE ANALYSIS OF MEASURED PARAMETERS.

Measured Parameters	Engine Empty	Engine With Load
RMS Voltage (V)	60.7	59.6
RMS Current (A)	0.6	1.12
Active Power (W)	36	77
Reactive Power (VA)	37	117
Apparent Power (VAr)	8	85
Power Factor	0.972	0.89
Harmonics (%)	0	0.5

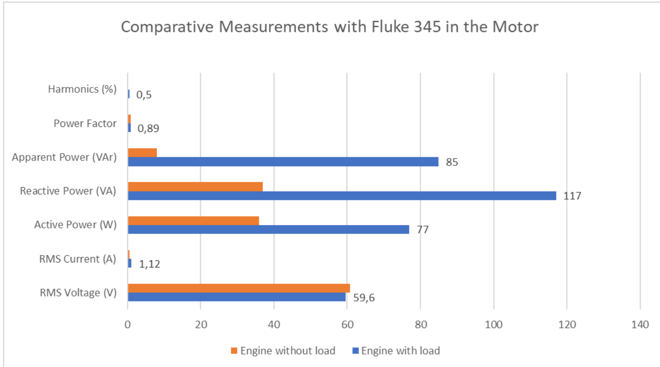

Fig. 8: Performance evaluation via bar chart.

IV. CONCLUSIONS

In this investigation, the Fluke 345 meter proved to be a key instrument for comprehensively evaluating the electrical parameters of engines. The results shed light on the nuanced behavior of engines in different operating contexts, highlighted by the instrument's robust data storage and analysis capabilities. These results provide a solid foundation for further development of measurement methods in the field of engines systems.

The importance of the precise measurement of electrical parameters enabled by the Fluke 345 is consistent with the broader drive to improve energy efficiency, cost effectiveness and environmental protection. By providing researchers with a versatile tool, this study promotes the development of engine control strategies and improves the understanding of engine characteristics and electrical variables.

Fluke 345 reaffirms the central role of accurate measurement instruments in scientific research and in promoting efficient energy practices in industry, commerce, and homes. The findings from this study will lead to transformative advances in engine technology and contribute to sustainable energy practices.

V. ACKNOWLEDGMENT

The authors would like to thank the Federal University of Tocantins, in particular, the Electronic Laboratory.

REFERENCES

[1] F. Corporation, *FLUKE 345 - Power Quality Clamp Meter*, Fluke Corporation, Everett, WA, USA.

[2] M. L. Verissimo, "Estudo teórico e prático de equipamentos de medição de energia elétrica e de um motor de indução trifásico," 2019.

[3] W. M. Reis and J. C. Silva, "Estudo de equipamentos medidores de grandezas relacionadas a energia elétricas em um motor trifásico," 2017.

[4] W. S.A, *Especificação do Motor Elétrico*, WEG S.A, Jaraguá do Sul, SC, Brasil.

[5] E. Viciana, F. M. Arrabal-Campos, A. Alcayde, R. Baños, and F. G. Montoya, "All-in-one three-phase smart meter and power quality analyzer with extended iot capabilities," *Measurement*, vol. 206, p. 112309, 2023.

[6] J. Mamede Filho, *Instalações elétricas industriais*. Rio de Janeiro: LTC, 2017.

 ISSN: 2675-3588