2024 International Nuclear Atlantic Conference - INAC 2024

Escola de Guerra Naval, Rio de Janeiro, RJ, May 6 - 10, 2024

ISBN: 978-65-594-1256-3

Development of a Man-Machine Interface to Control , Monitor and Acquire Experimental Data of Thermic Fatigue

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1. Introduction

The physical phenomena related to temperature are challenging and warrant attention from researchers across various fields of knowledge specially in the nuclear area. This is because temperature significantly alters the properties of the materials we use in our daily lives. Materials, whether solid, liquid, or gaseous, are influenced by temperature, and their properties depend on this natural phenomenon.

In this context, the objective of this study was to equip and commission a machine for investigating thermal fatigue experienced by materials during industrial events with temperature variations. As a result, the primary goal of this research project is to develop a software, including a Man-Machine Interface, utilizing the programming language LabVIEW to control and automate the thermal fatigue machine at Centro de Desenvolvimento da Tecnologia Nuclear (CDTN). This involves integrating all the required sensors and actuators to facilitate the desired process.

2. Methodology

The fatigue thermal cycling process is initially based on the application of two strengths: compression and deformation on a test body composed of materials such as carbon steel and stainless steel. Furthermore, the test body must undergo a temperature variation, illustrated in Fig. 1, referred to as temperature cycles.

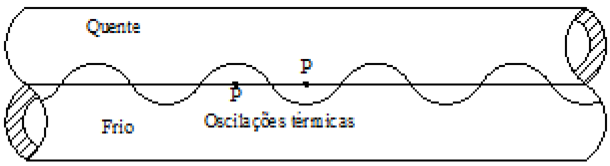

Figure 1: Thermal cycles

To meet the requirements of this rigorous rehearsal, the project development is structured into two integral components: the acquisition of temperature and deformation data, and the control of actuators. The sensors necessary for data acquisition consist of two strain gauges and one thermocouple. The actuators involved in the process include a voltage supply and a pneumatic valve.

For the acquisition of deformation data from the test body, the use of strain gauges is imperative. Consequently, two circuits of a quarter bridge were implemented to gather, store, and display the data in the software interface, as depicted in Fig. 2. The equipment utilized for data acquisition and communication with the computer was the NI DAQ 9237 from National Instruments.

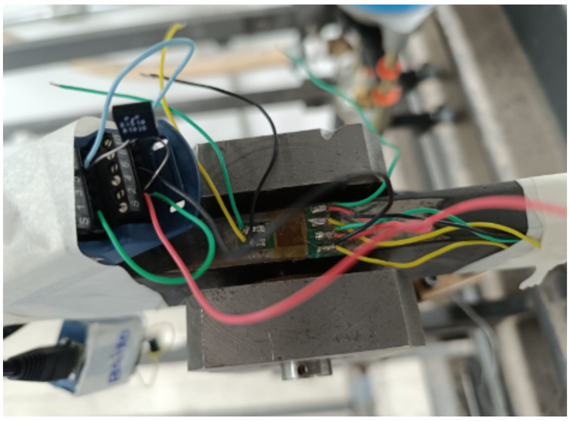

Figure 2: Built circuit to get deformation data

To collect temperature data, a thermocouple was affixed to the test body as shown in the Fig. 3. The NI USB 6218 module was employed, and the thermocouple was serially connected to the module for acquiring temperature data.

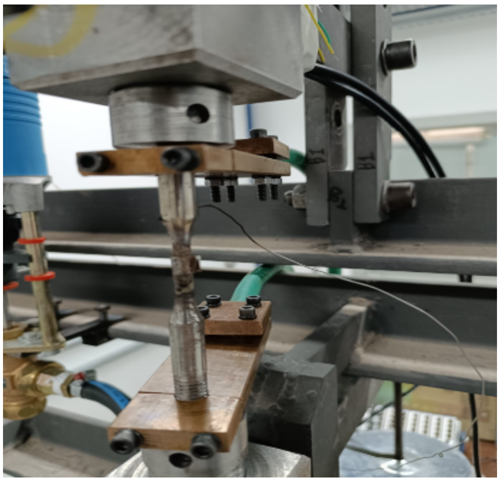

Figure 3: Thermocouple fixed to the test body

The temperature of the test body is increased using a supply voltage controlled by a signal ranging from 0 to 10 V originating from the NI USB 6218 module, as illustrated in Fig. x.

As demonstrated in Fig. 1, the temperature must fluctuate. To decrease the temperature, a valve connected to a compressor is employed. The opening of the valve is also regulated by a signal ranging from 0 to 10 V from the NI USB 6218 module.

With all communication channels and instruments seamlessly operating in unison, attention was directed towards the software components. Initially, logic to acquire data from the strain gauges and the thermocouple was developed, along with an interface allowing real-time observation of deformation over time, accompanied by options to save this data.

Regarding the actuators orchestrating the process in harmony, an On/Off controller was devised, following the logic outlined in Fig. 1. When the temperature reaches the user-set maximum threshold, the power supply is disengaged, and the valves are activated. Conversely, when the temperature reaches the user-set minimum limit, the valves are closed, and the power supply is reactivated, thus maintaining a continuous cycle.

3. Results and Discussion

The screens facilitating communication with all sensors and actuators have been meticulously developed. In Fig. 4, the primary display of the Human Interface Machine (HMI) showcases not only real-time temperature and deformation data but also provides indicators regarding the operational status of the actuators as shown in Fig.

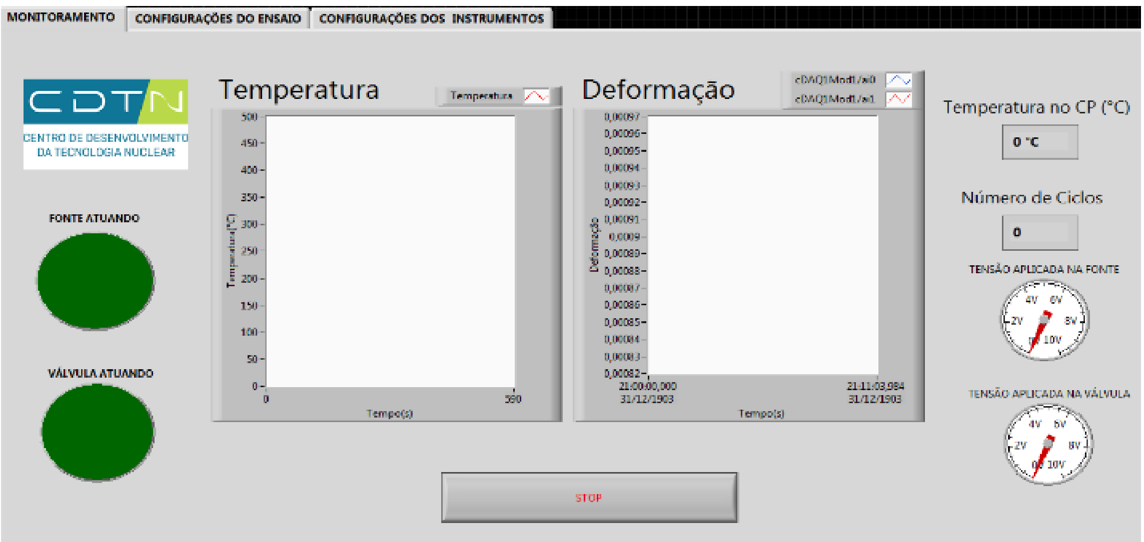

Figure 4: Main screen

As depicted in Fig. 5, various tools are available to users, allowing them to select the folder for storing data in an Excel spreadsheet and define the maximum and minimum temperature parameters according to their preferences.

Figure 5: Tools for the rehearsal

Besides, tools dedicated to the acquisition of strain gauge data, incorporating features like calibration and information pertaining to the material used to enhance the quality of data acquisition. Additionally, instructional prompts are provided regarding the connections made, offering users assistance in the event of hardware-related issues facilitating maintenance procedures.

4. Conclusions

The project has yielded positive results, showcasing success in a complex interdisciplinary technological development at CDTN. Collaboration across sectors was crucial, but some processes were inherently time-consuming. The thermal fatigue machine is fully instrumented, and the software mostly meets project requirements. However, adjustments to the control methodology are needed for more symmetric heating and cooling curves, improving user safety.

Acknowledgments

This work was supported by the following Brazilian institutions: Centro de Desenvolvimento da Tecnologia Nuclear (CDTN); Comissão Nacional de Energia Nuclear (CNEN); Financiadora de Inovação e Pesquisa (FINEP) and Fundação de Amparo à Pesquisa de Minas Gerais (FAPEMIG).

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