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CURING SYSTEM FOR PARTS MADE WITH RESIN CARBON FIBER

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Abstract: This research presents an innovative system for heating parts made with carbon fiber and resin, enabling their curing. The system, in which heat production is carried out by the Joule Effect, aims to establish precise, efficient and autonomous control, using relationships between electrical parameters and thermal results.
Keywords: Carbon fiber, curing, Joule effect, control and automation, efficiency.

INTRODUCTION

With the advancement of technology in recent years, the so-called "Fourth Industrial Revolution" began to be disseminated and more widely used to describe the major changes and impacts that are happening in the world today. Internet of Things (IoT), blockchain, cloud, artificial intelligence, machine learning and automation are some of the technologies that underpin this new industrial era (MCKINSEY & COMPANY, 2022).

Along with technological development, the world has also advanced in the concepts of sustainable development. Established in 2015 at the United Nations General Assembly, the 2030 Agenda is a collection of 17 global goals for sustainable development. The Sustainable Development Goals (SDGs) aim to strike a balance between the technological advancement of humanity and nature, preserving and expanding it (UNITED NATIONS, 2024).

GOALS

Focusing on the 2030 Agenda and the "Fourth Industrial Revolution", this research aims to develop an innovative system for heating parts made with carbon fiber and resin, enabling their curing. The system, in which heat production is carried out by the Joule Effect, aims to establish precise, efficient and autonomous control, using relationships between electrical parameters and thermal results.

METHODS

To achieve the proposed objective, the resined carbon fiber piece is subjected to electrical voltage, and the passage of electrical current through the carbon provides thermal energy through the Joule Effect. As a central controller, a Raspberry Pi 4 is used. Temperature sensors operating on an infrared measurement principle are installed to monitor the temperature of the carbon parts in real time. The control system is responsible for adjusting the heating power based on data measured by the sensors, modifying the voltage and electrical current conducted through the part. Furthermore, safety mechanisms are implemented to interrupt the process in case of overheating of the part or signs of fire, which can be identified by temperature sensors or smoke sensors, and software is implemented that allows the monitoring of the process.

PROCEDURES

Tests were carried out to cure a piece of carbon fiber tube measuring 1.30 m in length, 0.75 mm in wall thickness and 29 mm in diameter. The carbon fiber piece was inserted into a PVC tube, which serves as the external structure of the oven, with an internal volume of 0.07 m^3 (Figure 2). In this test piece, a power source was used (Figure 1), which provided an electric current of 4.97 A and an electric voltage of 0.64 V, resulting in an increase in temperature by 30ºC, reaching 55ºC, in 8 minutes. This temperature was maintained for 2 hours. The amount of heat generated during the curing of the part was 22902 J. Compared to a case of heating conventional composite ovens, an energy use of 57708 J would be required.

Figure 1: source of power

Source: the own author

RESULTS

Using the Joule effect heating furnace, the amount of heat generated during the curing of the part was 22902 J. Comparing with a case of heating conventional composite furnaces, an energy use of 57708 J would be required (ÇENGEL; BOLES, 2014) (INCROPERA et al., 2011).

CONCLUSIONS

Therefore, in this first phase of research, we can conclude that heating through the Joule Effect represents 40% of the energy use necessary to maintain the temperature difference with the external environment at 30ºC, when compared to conventional heating using resistors or burning fossil fuels.

Figure 2 – Experimental carbon tube and Joule effect furnace

Source: the own author

UPCOMING ANALYSIS

With the promising results between the two types of ovens compared, it becomes viable to develop research into the implementation of a data acquisition and remote monitoring system, using the Raspberry Pi 4. Furthermore, the software for remote control and monitoring needs be developed.

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