

Upgrading a control system to improve efficiency and functionality

Tomos Hall - 2219188@student.uwtsd.ac.uk

Electrical and electronic engineering (BEng)

Independent Project (ACCA6020 - EEE)



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

1. Abstract

In the motor repair industry, electric motors experience efficiency losses when rewound. This project was carried out to determine the cause of these efficiency losses and to design a new control system to prevent them. Burn-off ovens, Figure 1, are used to break down the insulation and varnish on windings. Poor cycle control leads to the stator core overheating, having a negative effect on motor efficiency. A PLC system was designed to efficiently control temperature set points in burn-off ovens. Safety features were implemented into the control system as well as datalogging.

2. Aim and objectives

Aim:

- To limit efficiency losses in rewound motors.

Objectives

- To research why efficiency losses occur in rewound motors
- Analyse current workplace procedures to highlight shortcomings
- To analyse the functionality of a burn-off oven in the rewind procedure
- To design a new control system to limit efficiency losses
- To build a prototype to showcase the designed control system
- To implement proposed upgrade into the workplace

3. Literature review

Research from the US department of energy confirmed the main cause of efficiency losses to be overheating of the motor core [1]. The study concluded that most workshops had their burn-off ovens set too high, with some not having any water suppression or monitoring of the motor's core temperature [1]. The AEMT and IEEE standards state the required set temperature for the main chamber to be 370°C and the afterburner to be 800°C [2]. From the burn-off oven's manufacturer, the gas pressure must be 0.0149-0.027 bar. The water pressure must be 2.76-6.9 bar [3].

4. Design simulation

A simulated burn-off oven was designed in Factory IO to test the PLC program. Conveyors were used to represent gas and water valves. Potentiometers were used to toggle temperature and pressure readings. This is shown in Figure 2. The program was written using siemens TIA, controlled by a siemens S7-1200 PLC.

An HMI screen, Figure 3, was designed allowing the operator to choose from a pre-set menu of cycle parameters. A password protected engineer's screen was designed to allow full cycle customisation. An alarm and warning screen was designed to assist with fault finding.

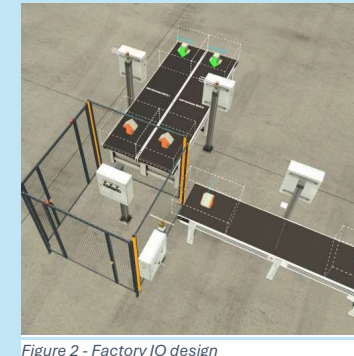


Figure 2 - Factory IO design

5. Design prototype

A proof-of-concept prototype was designed as shown in Figure 4. Potentiometers were used to toggle temperatures and pressures. All system outputs were shown by red indicator lamps. The system was controlled using the designed HMI screen, and push buttons.

6. Evaluation

The prototype was tested by simulating all possible cycle parameters, ensuring the design was capable of safely and effectively controlling the system. The system offered efficient control over the oven's temperatures and set points as required. The cycle menu prevents operators from inputting temperatures over the recommended limits. The implemented safety features improved the system, employing password protection and alarm triggered cycle termination. If implemented the design would adequately protect the motor against overheating, therefore meeting the project aim of limiting efficiency loss in rewound motors. The project objectives were met through the research carried out in the literature review.

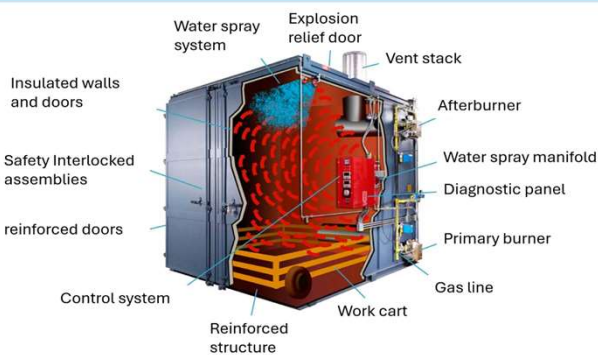


Figure 1 - Burn-off oven construction [3]

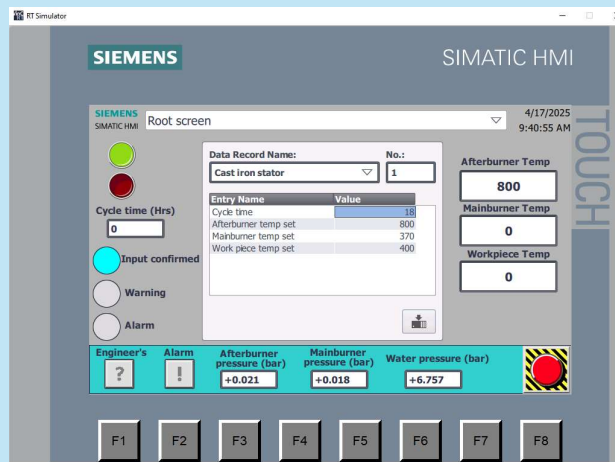


Figure 3 - HMI design



Figure 4 - Prototype build



Figure 5 - Controls for thermocouples, pressure gauges, door interlock and pressure relief panel



Figure 6 - Output indicators

References: [1] V. Schueler, P. Leistner and J. Douglass, "Industrial motor repair in the United States: Current practice and opportunities for improving customer productivity and energy efficiency," Bonneville power administration, Olympia, 1995. [2] IEEE Industry Applications Society, "IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries," IEEE, New York, 2015. [3] Pollution control products co., "PCPC burn off oven diagram," Pollution control products co., 22 10 2024. [Online]. Available: <https://www.pcpconline.com/burn-off-oven-diagram.html>. [Accessed 22 10 2024].