BIOGRAPHICAL SKETCH

Brian R. Brown was born in Shelbyville, TN, USA, and is a licensed Professional Engineer and member of IEEE. Currently, Mr. Brown is a government contractor with Axient LLC at the Arnold Engineering Development Complex (AEDC) on Arnold, AFB. Here his research interests include digital engineering, modeling and simulation, model-based systems engineering, plasma physics, systems engineering, and control engineering.

EDUCATION

Doctor of Philosophy
Engineering
Tennessee Tech University, December 2021 *(expected)*
Cookeville, Tennessee

Master of Science
Electrical Engineering
University of Arkansas, 2016
Fayetteville, Arkansas

Bachelor of Science
Electrical Engineering
University of Alabama – Huntsville, 2014
Huntsville, Alabama

College of Engineering
TENNESSEE TECH

The Department of

Electrical and Computer Engineering

Announces the Dissertation Defense of

Brian R. Brown

In Partial

Fulfillment of the Requirements

For the degree of

Doctor of Philosophy in Engineering

November 10, 2021

2:30 p.m.

Tennessee Tech University

Zoom Link:
https://tntech.zoom.us/j/86711042104?pwd=ZzlEYng1cDI5aDZad2N4SXhXT2JsUT09

Meeting ID: 867 1104 2104

Passcode: 425974

FIELD OF STUDY

Arc Heater Control

DISSERTATION TOPIC

Circuit-Based Mathematical Model of an Arc Heater for Control System Development

EXAMINING COMMITTEE

Dr. Satish Mahajan
Director, Center for Energy Systems Research (CESR); Professor, Electrical & Computer Engineering

Dr. Ghadir Radman
Professor, Electrical and Computer Engineering

Dr. Charles Van Neste
Associate Professor, Electrical and Computer Engineering

Dr. Douglas Talbert
Associate Professor, Computer Science

Dr. Jie Cui
Assistant Chair & Professor, Mechanical Engineering

AN ABSTRACT OF A DISSERTATION

A novel circuit-based mathematical model of an electric arc heater is presented so that an arc heater system can be modeled, and a control algorithm can be developed and simulated. Due to inherent arc nonlinearities and complexities, as well as low amounts of arc heater data, the new model was developed by establishing a holistic approach to implementing the arc as a circuit element, where common circuit analysis and control techniques can be easily applied. The response of the arc heater system was examined at various voltage and current operating points that represent different regions of operation within the arc's characteristic curve. The simulated data of the arc heater model were compared to the arc characteristics of the experimental data. The simulations performed demonstrate a strong correlation between these datasets, indicating the model's ability to accurately replicate the physical system, while also allowing initial control system development to begin with simplistic proportional-integral-derivative (PID) control of the arc heater.

The arc heater current ranged between 275A and 400A, while the voltage ranged from 650V to 600V respectively. The voltage standard deviation between the experimental data and the circuit-based model produced a value of 3.001V, or +/- 0.5%, while the resistance standard deviation, from comparing the Cassie model to the circuit-based model, produced a value of 30mΩ, or +/- 0.2% at the largest span. This research is expected to advance the ability to successfully model and simulate an electric arc heater system for control system development.

The research was performed at the Arnold Engineering Development Complex (AEDC) on Arnold Air Force Base, with experimental data collected at the Hypersonic Materials Environmental Test System (HyMETS) arc-jet wind tunnel located at the NASA Langley Research Center in Hampton, Virginia, for the partial fulfillment of the Doctor of Philosophy degree at Tennessee Technological University.