College of Engineering

TENNESSEE TECH

The Department of

Mechanical Engineering

Announces the Dissertation Defense

Qinghua Lin

of

In Partial Fulfillment of the Requirements

For the degree of

Doctor of Philosophy in Engineering

April 8, 2020

2:00 p.m.

Held in

Brown Hall 241

Tennessee Tech University

Zoom Link: https://tntech.zoom.us/j/137842221

BIOGRAPHICAL SKETCH

Qinghua Lin was born in Guangxi Province, China. She received her B.Eng. in Engineering Thermophysics from the University of Shanghai for Science and Technology (USST) in China in 2010. She earned her Master of Science in Power Engineering from the University of Chinese Academy of Sciences (UCAS) in Beijing in 2013. After that, she spent a couple years as an engine CFD analysis engineer at Changan Automobile Powertrain R&D Institute in China. She started her Ph.D. study in Mechanical Engineering at Tennessee Technological University in August 2016 and plans to receive a Doctor of Philosophy in Engineering with an area of focus in Mechanical Engineering in May 2020.

EDUCATION

Ph.D. Engineering
Tennessee Tech University, 2016-Present

M.S. Power Engineering
University of Chinese Academy of Sciences, 2010-2013

B.S. Engineering Thermophysics
University of Shanghai for Science and Technology, 2006-2010

FUNDING ACKNOWLEDGEMENTS

I deeply appreciate the financial support from the Center for Manufacturing Research (CMR) at Tennessee Tech University, as well as the Graduate Research Assistantship from the State of Tennessee funds.

FIELD OF STUDY

Mechanical Engineering

DISSERTATION TOPIC

Non-Uniform Combustion Control and Configuration Design for Lean Gasoline After-Treatment System

EXAMINING COMMITTEE

Dr. Pingen Chen (Chair), ME

Dr. Stephen Canfield, ME

Dr. Vahid Motevalli, ME

Dr. Ghadir Radman, ECE

Dr. Mohan Rao, ME

ABSTRACT

Lean combustion is a promising technology for gasoline engines to achieve high engine efficiency due to reduced pumping loss during part-load operations. To commercialize lean burn gasoline engines in the U.S. market, the following challenges need to be addressed: 1) control NOx to regulated levels in oxygen rich environment; 2) minimize the fuel penalty associated with emissions control; 3) reduce torque imbalanced and engine operation mode switching frequency. This dissertation aims at overcome these challenges through the aftertreatment system design and combustion control. To address these challenges, the following work has been done, which include:

1) A model predictive control (MPC) was developed for the lean-burn gasoline engine to minimize the total equivalent fuel penalty associated with passive SCR operation while satisfying stringent NOx and NH3 emission requirements. Simulation results demonstrate that the proposed MPC controller is capable achieving high engine efficiency and stringent emissions requirements for lean gasoline engines with passive SCR system. Furthermore, with a new passive SCR design and non-uniform combustion strategy, the MPC controller can reduce the number of modes switching events by 41.18% and reduce the fuel penalty associated with NH3 production by 3.40%.

2) To reduce fuel penalty caused by NOx control new TWC-LNT and passive SCR configurations were designed. Cooperating with non-uniform strategy the proposed new systems have potential to further reduce fuel cost. Simulation results verified the effectiveness of the new aftertreatment systems in reducing fuel penalty.

3) To implement non-uniform combustion strategy, a systematic torque balance method was presented and validated in simulation. The simulation results verified the effectiveness of the method. In addition, a methodology of controlling non-uniform combustion with balancing torque was proposed. The method was coded in the in-house ECU and validated in Toyota V6 gasoline engine. The experimental results illustrated the validity of the designed control method. Besides, a series of experiments were conducted to understand the characteristics of the developed passive SCR system.