ADVANCED ENGINE RESEARCH LABORATORY

Improving Control Methods for Pipeline Engines to Account for Variable Natural Gas Composition

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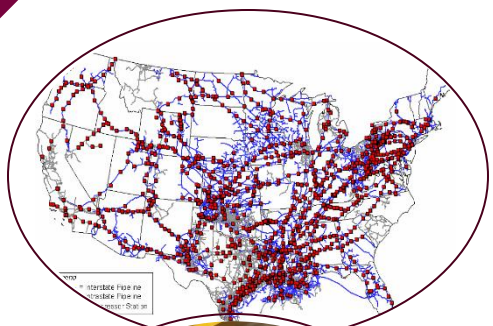

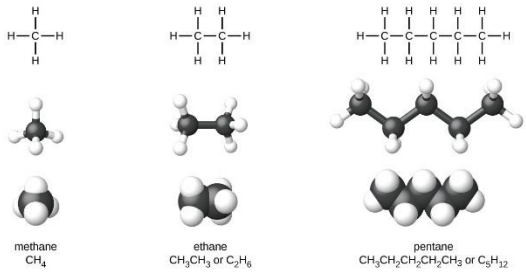

Motivation

Typically, pipeline natural gas comprises mostly methane, a small amount of ethane, and even smaller amounts of heavier hydrocarbon species (propane and larger). However, the increase in natural gas extracted from unconventional sources, like shale, has led to wide, observed variations in this composition. These fluctuations alter the chemical properties of the bulk gas mixture and can ultimately affect the operation of the natural gas compressor engines which use the gas as a fuel source. Among several possible ramifications, and of most interest to this work, is that of unacceptably high engine-out NO_x emissions.

Background

Along the over 300,000 miles of natural gas transmission pipelines in the United States, compressor stations are used to provide the necessary pressure to keep the gas moving. While several types of engines are used at these stations to provide power for compression, the large bore, two-stroke, integral compressor engine is the most ubiquitous. These engines are currently controlled with methods that can account for primary effects of natural gas composition (energy density, etc.) but do not account for increased fuel reactivity which quickens combustion in the cylinder, leading to increased NO_x when not accounted for.

Approach & Expected Outcomes

This work aims to improve the current engine control strategies to account for fuel reactivity, thereby improving emissions compliance. To achieve this goal, in-cylinder pressure data is collected from a typical pipeline engine operating on various blends of natural gas, including more reactive mixtures. Analysis of this data reveals the rate at which the fuel oxidizes within the cylinder. Additionally, the combustion of many natural gas mixtures are simulated using Cantera, an open-source chemical kinetics solver. From this software, the ignition delay of the fuel can be obtained which indicates the time needed for a fuel/air mixture to begin combustion at certain thermodynamic conditions.

It is expected that correlations can then be drawn between the simulated ignition delay and combustion within the engine cylinder for various fuels. These relationships will allow for modified engine control to predictively and preemptively counter any adverse emissions resulting from increased natural gas reactivity.

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