DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Investigations of the Effect of Humid Air on NOx and PM Emissions of a CNG Engine

Using current tablet and communication technologies, we will develop a system for tracking and analysis of drayage activities to gain insights on drayage inefficiencies.

Planning/Policy & Programming

SEPTEMBER 2015

Project Title:
Investigations of the Effect of Humid Air on NOx and PM Emissions of a CNG Engine

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WHAT WAS THE NEED?

About 29% of greenhouse gas (GHG) emissions in the U.S. are produced by the transportation sector. The major GHGs are carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and Hydrofluorocarbons (HFC). The Intergovernmental Panel on Climate Change (IPCC) predicts that if no additional measures are taken to reduce the GHG emissions, then from 2000 to 2030, human related GHG emissions will increase by a range of 25% to 90%, while human related CO2 emissions will have a 40% to 110% growth rate. The corresponding global temperature rise will be between 2° F to 11.5° F by 2100, with a 3-4 feet sea level rise. To limit the global warming to a range of 3.6° F (2° C) to 4.3° F (2.4° C), the GHG emissions must be reduced to 50% to 85% below year 2000 level by 2050. To meet this target, multi-disciplinary efforts must be undertaken, which includes transportation. Strategies for reducing transportation GHG emissions include: using low carbon fuels, improving vehicle fuel economy and transportation system efficiency, and reducing carbon-intensive travel activities. Among strategies for reducing transportation GHG emissions are introduction of low carbon fuels, improving vehicle fuel economy and transportation system efficiency, and reducing carbon-intensive travel activities. Natural gas is a low carbon fuel. Assembly Bill 1007 (AB 1007) required the California Energy Commission (CEC) and the California Air Resources Board (CARB) to work together and in consultation with the State Water Resources Control Board, the Department of Food and Agriculture, and other relevant agencies, for development and adaptation of a state plan to increase the use of alternative transportation fuels in California.

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DRISI provides solutions and knowledge that improves California's transportation system

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WHAT WAS OUR GOAL?

The goal of the investigation was to determine the feasibility of using a humid air system for reducing NOx emissions of CNG engines. Humid air system or fumigation has been an effective approach in reducing diesel NOx emissions. In this method, water vapor is injected in the intake air supplied to the engine cylinders. The process reduces the local temperature in the cylinder and raises the specific heat of the air-fuel mixture which also contributes to the elimination of the hot spots in the engine's cylinders. With decreased temperature, NOx reduction is achieved. With an optimized system, fumigation could reduce NOx emissions without significant increases in hydrocarbon emissions. Other benefits of this process include longer life of the engine components due to reduced cycle temperature and reductions in carbon deposits.

WHAT DID WE DO?

The study was divided into two parts. In part one, numerical investigations of the effect of humid air at different levels of relative humidity on NO, CO, and CO2 emissions of a non-premixed combustion of air and methane were performed. The study was performed using the existing combustion model of the Star CCM+ software by CD Adapco. Part two involved experimental investigations using a General Motors inline 4 cylinder, naturally aspirated engine with a maximum rated horsepower (HP) of 50.8 for natural gas fuel was used. The engine was connected to a water-cycled dynamometer from Land & Sea which is equipped with automated data acquisition for engine performance tests. A special mixing tube was designed to add humidity to the intake air. A Rasco Vapour machine with distilled water was used to generate the added fog to the intake air. The humidity level of the intake air before and after adding humidity was measured with two TSI VelocCalc model 9565-P anemometers.

WHAT WAS THE OUTCOME?

The outcome of the proposed investigation quantified the impacts of a humid air system on NOx and particulate matter (PM) emissions of a CNG engine. Quantifying the impact provides baseline information for development of portable humid air systems for adaptation to existing and new CNG engines.

WHAT IS THE BENEFIT?

The results of the investigation has the potential to significantly reduce transportation NOx emissions as the method could be applied to different modes of transportation that are used for goods movement across the state and the country.

We expect significant reductions in NOx emissions to make the CNG engine with the humid air system close to a "zero emission" engine.

LEARN MORE

View the Final Report
https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/f0016805-ca16-2932-finalreport.pdf

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