DRISI

Caltrans Division of Research, Innovation and System Information

Research Notes

Investigations of the Effect of Humid Air on NO_x 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 so as to gain insights on drayage inefficiencies.

Environmental

SEPTEMBER 2015

Project Title:
UTC - Investigations of the Effect of Humid Air on NO_x and PM Emissions of a CNG Engine (METRANS)

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WHAT IS THE NEED?

About 29% of greenhouse gas (GHG) emissions in the U.S. is produced by the transportation sector. The major GHGs are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), 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 CO_2 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 are using low carbon fuels, improving vehicle fuel economy and transportation system efficiency, and reducing carbon-intensive travel activities. One of the low carbon fuels is natural gas. Assembly Bill 1007 (AB 1007) requires the California Energy Commission (CEC) and the California Air Resources Board (CARB) to work together. These two agencies work 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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A recent report prepared for CEC on full fuel cycle assessment, well to wheels energy inputs, and emissions and water impacts provides an assessment and impacts of different fuels, including gasoline, diesel, biodiesel, renewable diesel, ethanol, natural gas, electricity, hydrogen, and others. The report indicates that with adaptations of compressed natural gas (CNG) vehicles, GHG reduction for passenger cars is 20% to 30% and for heavy duty vehicles is 11% to 23%. Liquid natural gas (LNG) is an alternative fuel for heavy duty vehicles. With LNG vehicles, the GHG reduction for heavy duty vehicles would be between 12% and 16% by the year 2022.

WHAT ARE WE DOING?

Humid air system or fumigation has been shown to be an effective approach in reducing NO and NO_2 (NO_x) emissions of diesel engines. In this method, water vapor is injected into the intake air supplied for combustion. The process reduces the local temperature in the cylinders and raises the specific heat of the air-fuel mixture which also contributes to the elimination of the hot spots in the cylinders. With decreased temperature, NO_x emissions are reduced.

With an optimized system, the humid air system could substantially reduce NO_x emissions without significant increase in hydrocarbon emissions. The proposed research is to investigate and quantify the effectiveness of the humid air system on emissions of a CNG engine.

WHAT IS OUR GOAL?

The outcome of the proposed investigation quantify the impacts of a humid air system on NO_x and particulate matter (PM) emissions of a CNG engine which provide baseline information for development of portable humid air systems for adaptation to the existing and new CNG engines. This will result in reducing GHG emissions. We expect significant reductions in NO_x emissions to make the CNG engine with humid air system close to a “zero emission” engine.

WHAT IS THE BENEFIT?

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

WHAT IS THE PROGRESS TO DATE?

The investigations has two parts. The first is numerical modeling of the CNG combustion with dry input air as well as input air with different levels of humidity. The modeling is near completion and we are at the initial stage of simulations.

The second part of the study is experimental investigations of the impact of humid air intake on CNG NO_x and PM emissions. For this part of the study, the engine has been secured and in the process of installation on a portable dynamometer before experimentations begin.

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