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Pre-and post-combustion NOx control system with hydrogen assistance and using microwave technology for biogas engines

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Statement of the Problem: The internal combustion (IC) engine exhaust contains harmful pollutants such as NOx, CO, and VOCs. These air pollutants need to be removed to comply with air quality control regulations. This project used pre-and post-combustion NOx control to reduce air pollutants in the exhaust from biogas powered IC engine. The pre-combustion NOx control system has a microwave hydrogen sulfide (H_2S) removal unit followed by a microwave steam reformer. Approximately 10% of the biogas used to fuel the engine is process to generate hydrogen (H_2). The H_2 is injected back into the fuel stream prior to combustion to create H_2 enriched fuel gas. Hydrogen Assisted Lean Operation (HALO) is used to ignite ultra-lean air-fuel mixtures. It reduces the peak flame temperatures and significantly decreases NOx emissions. Pre-combustion NOx control using HALO, followed by post-combustion NOx removal with carbon adsorption is the best approach to ensure that the CARB 2007 NOx emission standards will be consistently met. HALO, may not meet emission standards alone, but will reduce the NOx concentration in the engine exhaust significantly to minimize the amount of NOx that must be removed by adsorption. The post-combustion NOx removal system consists of an exhaust cooler and two carbon adsorbers in series. These adsorbers are filled with granular activated carbon (GAC) to remove NOx and VOCs from the exhaust. The beds are operated in a standard Lead-Lag cycle. When the average NOx concentration in the exhaust leaving the Lag bed reaches 5 ppm, the saturated GAC is replaced with the newly regenerated GAC. Then that adsorber is switched to the Lag bed. The saturated GAC is transported to the microwave facility for processing. We expect the adsorbent will be replaced and regenerated once every 2-3 months. An additional benefit is that the GAC also removes sulfur dioxide (SO_2) and VOCs from exhaust. Under the grant awarded by California Energy Commission, CHA Corp built and field tested this pre-and post-combustion NOx control system at Clean World's Bio Digester Facility at SATS in Sacramento. A six-month long field-testing was successfully completed in January 2017. Throughout the field-testing period, the average NOx emission did not exceed 5 ppm to confirm that pre-and post-combustion NOx control would meet not only the Rule 1110.2 but also CARB 2007 NOx control standards. The result from this field demonstration will be presented.

Biography

Dr. Valentino Tiangco has over 30 years of broad experience in engineering, program & project management, energy specialist, designer, test engineer, professor and researcher. He is currently the Biomass Program Manager at Sacramento Municipal Utility District (SMUD), Energy Research & Development Department. He leads, plans, and coordinates the biomass activities that include research, development, demonstration, deployment and commercial applications of biomass for power and with co-production of value-added products. His other responsibilities include RD&D efforts in geothermal, hydro, hybrid solar and other renewable and distributed generation technologies. Prior to his job at SMUD, he was a Program Manager of Advanced Generation Program with over $100 million budget over the last ten years in service at the Public Interest Energy Research (PIER) Program.

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