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HU-ACE NEWS LETTER

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Activities of the Core

May 31, 2022	Pro. Fujiwara's Autonomous Shuttle operation test was completed with no accidents and no violations.
June 8, 2022	The 100th Hiroshima University Biomass Evening Seminar (co-organized)
June 17, 2022	The 72th HU-ACE Steering Committee Meeting
June 24, 2022	The 103th HU-ACE Seminar (co-organized)
June 28, 2022	The 6th Hiroshima University Biomass Premium Evening Seminar (co-organized)

Mr. Chary, visits Japan and joint research begins.

Nuclear Science Applications for Societal Wellbeing

Chary Rangacharyulu
Professor, Department of Physics and Engineering Physics, Univ. Saskatchewan, Canada

The theme of our research is nuclear science and its applications for the overall wellbeing of society. The latter aspect concerns nuclear radiation of various types and X-rays. Quantification of radiation dose is an important parameter if one employs radiation either for medical diagnostics or therapeutic purposes. This is also important when we need to know the physiological and ecological effects of nuclear emanations occurring naturally. Needless to say, this information is paramount in an era where unintended nuclear incidents can occur.
Prof. Endo and I have been engaged in these studies, not simply to provide dose estimates, but also to improve the methods of measurement and to understand the differences in interactions of various types of radiation within the material mediums.
This research involves experimentation and extensive Monte Carlo simulations with public domain software such as MCNP and GATE, which are programmed to meet our needs. Specifically, we are now working on three projects:

a) A search for a better diagnostic tool than the currently popular Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT). Our modality which makes use of non-collinear gamma ray angular correlations will determine the decay vertices of individual radioactive decays, inaccessible to PET and SPECT. We are working on the candidate isotopes to this end with experiments planned for July 2022.

b) Food shortage is a major a global concern. This problem can be mitigated to some extent by irradiation of agricultural produce to enhance their shelf life, cure them of toxins and increase the germination by treating the infested seeds. Currently, the most commonly used tools are gamma radiation from the 60Co, 137Cs decays or a few MeV electron beams. As the main aim is to induce photochemical reactions and not nuclear transmutations, we are experimenting with X-rays from the generators of ~ 200 kVp. The end goal is to establish the possibility of field-deployable irradiation facilities for easy access to farmers.

c) The after effects of nuclear radiation, due to the incident caused by the tsunami in Fukushima, on the natural habitat and, wild life is another topic of interest. Prof. Endo is the driving force behind this, and I am very glad to be able to engage with his group on this topic which has been my interest for quite some time.

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Research Topics No. 33

Experimental Investigation on Combustion Performance of Hydrogen Additions in Methane Fermentation Gas

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Research fields: **Mechanical Engineering/Fluid Engineering/Combustion Engineering**

Keywords: **Combustion performance, Methane Fermentation Gas, Hydrogen Additions , lean burn combustion**

Abstract

Background

In order to better promote carbon, neutrality and improve energy efficiency, a type of self-circulation system has been proposed for electricity generation. Excrement from animals can be used to ferment biogas. From that, CH4 and CO2 together are selected as the main fuels for combustion. On one hand, CO2 addition alleviates the emission problems. On the other hand, energy could be saved without separating CO2 from CH4 in the ferment biogas. Moreover, H2 can be obtained from electrolytic NH3. Finally, electric power can be generated from a co-combustion engine, which will be utilized in this system to reduce emissions.

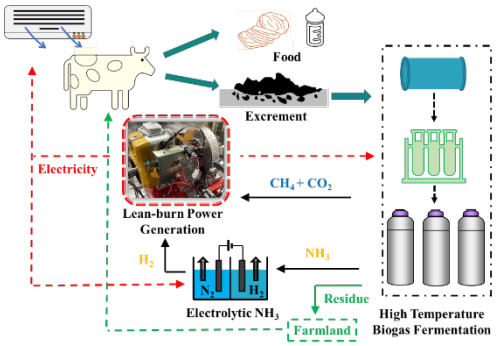

Figure Schematic diagram of regional energy system

Methods

Firstly, the ignition timing was decided through thermal efficiency and brake mean effective pressure (BMEP). Then, combustion characteristics of CH4, CH4+CO2 and CH4+CO2+H2 were compared with volume percentage of H2 changing from 5% to 30%. Finally, the H2 injection strategy was checked between closed and open valve injections. Among these discussions, thermal efficiency, power output, BMEP and fuel consumption were evaluated.

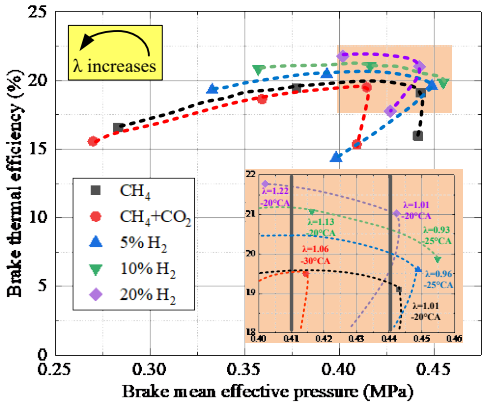

Figure Optimal combustion working region

Results

Large variation in torque can be seen when the ignition timing varies from -50 to -5 ° CA TDC. Besides, torque increases from λ=0.8 to 1.0 then decreases sharply. Maximum torque appears near the stoichiometric condition. Ignition timing affects the BMEP and BTE significantly. With H2 addition, high BMEP and large BTE can be obtained by advancing the ignition timing. However, with the addition of H2, higher BMEP and larger BTE can be achieved through delaying the ignition timing. With the addition of 20 % H2, ignition timing of MBT can be set constantly at -20° CA TDC to achieve high efficiency. The working region is mapped through BTE against BMEP. Maximum BTE can reach to near 22% and highest BMEP arrives at 0.45 MPa approximately. 20% H2 addition should be applied when BTE is the priority to be considered. When BMEP is the priority, 10% H2 addition should be used. Furthermore, in order to get higher BTE and BMEP with H2 addition, the ignition timing should be set in the range from -30 to -20 ° CA TDC. Pmax increases significantly from 1.0 to 3.5 MPa with advancing ignition timing from -5 to -50 ° CA TDC. Furthermore, H2 addition could improve the stable combustion and decreases COV and CCV in Pmax.

References

Luo, H., Chang, F., Jin, Y., Ogata, Y., Matsumura, Y., Ichikawa, T., ... & Nishida, K. (2021). Experimental investigation on performance of hydrogen additions in natural gas combustion combined with CO2. *International Journal of Hydrogen Energy*, *46*(70), 34958-34969.