नवीन और
नवीकरणीय ऊर्जा मंत्रालय
MINISTRY OF
NEW AND
RENEWABLE ENERGY
सत्यमेव जयते

SARDAR SWARAN SINGH NATIONAL INSTITUTE OF BIO-ENERGY

(An autonomous institute of Ministry of New and Renewable Energy, GoI)

Quarterly Newsletter

Bio-ऊर्जा

January 2024

Issue 5

Word from the Director General, SSS-NIBE

The fifth issue of SSS-NIBE's quarterly newsletter is scheduled for release as we complete the third quarter of the new financial year 2023–24. The major event of this quarter was the successful conduct of the 4th International Conference on Recent Advances in Bio-Energy Research (ICRABR)" at our campus. The conference witnessed a confluence of minds from researchers, industry, and policymakers. The event served the purpose of sharing of knowledge, showcasing innovations, fostering collaboration in the field of bioenergy, and contributing to the advancement of sustainable and renewable energy solutions.

This quarter also witnessed discussions with several industries about the piloting of in-house biogas and 2G technologies developed at the institute. A few more NDAs were signed. The other major accomplishment was the signing of MoU with National Aerospace Laboratories (NAL), Bangalore for collaborative R&D in the area of high-temperature solid oxide fuel cells.

As it goes without saying, we appreciate your thoughts and recommendations to improve communication in the upcoming newsletter.

Dr. G. Sridhar
(Director General)
SSS-NIBE

Research and Innovation

Utilization of Hydrogen as a Green Fuel in Internal Combustion Engines

By Dr. Gurkamal Nain Singh, PDF

Fossil fuel-driven energy sources have been under crisis in recent decades due to the enormous and continuously expanding requirement for non-renewable energy utilization in daily human activities. New energy sources must be developed in order to replace or minimize the use of existing, non-renewable energy sources, as concerns over the emissions from internal combustion engines grow. In this regard, hydrogen appears to be a viable remedy for these problems in internal combustion engines.

According to some recent reports, the world's consumption of coal, natural gas, and oil increased to reach 4621.9, 3164.6 and 3731.5 million tonnes of oil equivalent, respectively. Furthermore, global greenhouse gas (GHG) emissions also showed corresponding rising tendencies. For example, during the course of five years, it was seen that global carbon dioxide (CO_2) emissions from the use of coal, gas, and oil increased alarmingly by 1126.2 million tonnes[1]. In reality, unless decisive action is made to stabilize GHG concentrations at 450 ppm CO_2, it is predicted that worldwide GHG emissions, or CO_2, would reach a level of 45 GT by 2035, raising the average global temperature by 5.6 ^{0}C.

The fuel combustion approach distinguishes between two types of internal combustion engines (ICEs): spark ignition (SI) and compression ignition (CI). In SI engines, spark plugs are often used in the engine cylinders to initiate the combustion of petrol that is introduced via a carburettor. Conversely, the high compression ratio design and diesel fuel usage in CI engines allow the fuel to auto-ignite during the compression stroke. However, because CI engines typically use diesel fuel with higher carbon content than SI engines, they often emit more damaging NOx and particulate matter. Since hydrogen is regarded as one of the most promising options for a clean burning fuel, the idea of using it as an ICE fuel traces back to the 1970's[2]. According to research, hydrogen is the most prevalent element both on Earth and in space. In addition, hydrogen, being a gaseous fuel, has a number of benefits over

[1] Yaqoob, H et al., (2021). Case Studies in Chemical and Environmental Engineering, 3, 100081.
[2] Iwasaki, H., Shirakura, H., & Ito, A. (2011). SAE Technical Paper.

liquid petrol and diesel in terms of cold start engine performance, generally lower emissions of pollutants, and contamination of lubricating oil[3]. A further advantage is that renewable and non-renewable resources, including natural sources, can be used to produce hydrogen. Numerous processes, such as gasification, electrolysis, and steam reforming from coal, biomass, water, and natural gas, can be used to manufacture hydrogen from a variety of sources. All things considered, hydrogen also possesses a number of highly desirable qualities that can improve engine in-cylinder combustion and, consequently, performance. Hydrogen contributes by high flame propagation speed, heating value, diffusivity, and short quenching distance. Furthermore, when compared to other fossil fuels, hydrogen performs better in terms of emission levels, combustion stability, and lean limit when used in internal combustion engines. Significant reductions in pollution from internal combustion engines (ICEs) are ensured by hydrogen, non-toxic and carbon-free petrol that does not contribute to the emissions of unburned hydrocarbon (HC) and carbon oxides[4]. Furthermore, when compared to traditional petrol or diesel motor vehicles, the usage of clean hydrogen in ICE was found to produce an equivalent driving range despite lower energy density. However, because hydrogen and other fuels have distinct properties, combustion in an engine employing hydrogen may lead to unfavourable anomalies including knock, pre-ignition, and engine backfire. Figure 1 shows schematic diagram of hydrogen utilization in the engine.

Several researches have shown that adding hydrogen to both SI and CI engines significantly increased their thermal efficiency. When the engines were powered solely by pure hydrogen, the same scenario happened.

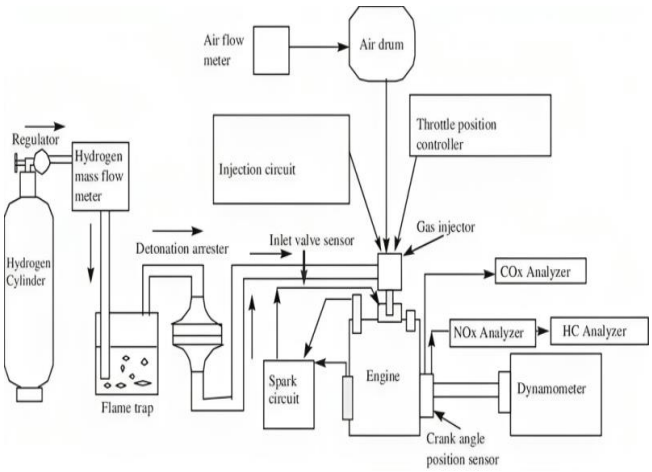

Figure 1: Schematic Diagram showing utilization of hydrogen in IC Engine [5]

Furthermore, compared to conventional fuels, the combined hydrogen-diesel fuels generally

[3] Unni, J. K., et al., (2017). SAE International Journal of Engines, 10(1), 46-54.
[4] Møller, K. T., et al., (2017). Progress in Natural Science: Materials International, 27(1), 34-40.

demonstrated lower fuel and energy consumption in both SI and CI engines, as measured by BSFC and BSEC, respectively. The exceptional qualities of hydrogen fuel, such as its higher calorific value and quick flame speed, which aided in combustion, were primarily responsible for the engine performance breakthrough. The reduced density and volumetric efficiency of hydrogen fuel, according to some researchers, has resulted in a decline in engine performance for SI engines. The majority of researchers came to the conclusion that, when it came to engine emissions, using hydrogen-diesel dual fuel in both SI and CI engines produced cleaner exhaust emissions than using traditional diesel fuel. For example, because there are no carbon atoms in hydrogen fuel, the carbon-related emissions for both kinds of engines CO, CO_2, and HC reduced. Additionally, the reduction of smoke, soot, and PM emissions in CI engines was facilitated by the improved combustion process. However, as stated by the majority of the researchers, the fast flame propagation and high combustion rate in SI engines tended to enhance the NOx formations. However, because some authors used an EGR device to lessen NOx accumulation, trends in NOx emissions from CI engines were inconsistent. Additionally, the majority of the researchers asserted that because hydrogen burns more quickly than traditional diesel fuel, the cylinder pressure and heat release rate for both internal combustion engines showed higher values for hydrogen-enriched fuels when compared to traditional diesel fuel operation. Most mixed hydrogen operation modes in CI engines indicated longer ignition delays and combustion times.

In summary, it has been determined from various research studies that using hydrogen fuel in internal combustion engines, either for single or dual-fuel operation, is feasible. When operating conditions were right and modest adjustments were made to the engines such as replacing the ignition system and the iridium spark plug for the SI engine hydrogen utilization in internal combustion engines helped to improve engine performance, exhaust emissions, and combustion behaviours.

[5] Ganesh, R. H., et al., (2008). Renewable energy, 33(6), 1324-1333.

Design and development of smart hybrid anaerobic digester

By Rakesh Godara, SRF

Anaerobic digestion is a process by which organic waste is decomposed to provide us with biogas and bio-manure. In order to propagate the use of renewable energy such as biogas to the masses, it is imperative to concentrate on household and medium-scale biogas plants, which is an overlooked domain within the Biogas sector. Globally, there are 50 million installed small-scale biogas plants. However, many of them shut down or remain non-functional due to uncontrolled temperatures, handling, lack of service, maintenance and operational information. In many regions low temperature or higher temperature variations due to changes in weather is a major problem for optimum biogas production. The heating cost to maintain temperatures in domestic and medium scale biogas plants comes out to be uneconomical.

At NIBE, research has been conducted in two phases to overcome temperature restrictions and optimize energy requirements for an anaerobic digester. An innovative thermal analysis system is developed in Phase 1, accurately calculating the energy required to maintain anaerobic digesters. Strategically located sensors, coils, and flow meters ensure precise thermal requirements regardless of source of heat. The uniqueness of this system lies in its ability to integrate data from these components and factor in source-specific efficiencies. Drawing insights from simulations using ANSYS, the system design is fine-tuned for optimal performance. Economical in-house coded automation takes charge of parameter control and computes the ultimate energy outcomes. This holistic approach, illustrates the commitment to a meticulously designed and technologically advanced biogas system. Analyzed data provides valuable information for designing, managing, and enhancing the efficiency of the digester. The digesters are capable of continuously maintaining both mesophilic and thermophilic phases of digestion. The output plots from the system show how efficiently constant temperature is maintained over the period of time with a minimal variation of ±0.5°C. The agitation is set for 15 minutes after every 6 hours, which can be altered as desired. While

maintaining these temperatures, the system also calculates thermal energy demand to maintain it inside digesters. Real-Time heat energy demand during digestion can be depicted per hour, per day, and for the whole batch of digestion. Such data not only helps to optimize plant design but also enables to forecast fuel demand for smooth and efficient operation of biogas plants.

Smart hybrid anaerobic digester

Phase 2 will focus on developing a thermal energy system for larger field-level anaerobic digesters (1000L) incorporating multiple energy sources like solar, biomass, and waste heat heating sources. The system will feature reliability, scalability, flexibility, and integration with waste heat recovery and storage systems, ensuring economical and commercially viable biogas production, via a smart hybrid biogas system. The Field-ready smart hybrid biogas setup will have mainly three parts; First, the digester, in-between that is pH and temperature controlled; Second controller-cum data acquisition and monitoring System; Third the hybrid heating system. As the design will be modular any heating source can be incorporated like biomass, solar and/or waste heat, out of which the system will automatically choose the most economical one based on availability.

Study advantages include improved biogas production efficiency, energy management, cost savings, improved waste management, and environmental sustainability. The Smart Hybrid Anaerobic Digester not only improves thermal energy systems technology but is also capable of potential commercial applications, contributing to small stakeholders and fostering local livelihoods and sustainable development. By tackling temperature challenges and optimizing biogas production, the research contributes to the development of a sustainable and economically viable renewable energy solution, which is crucial to the pursuit of net zero energy.

News and Events

ICRABR 2023

SSS-NIBE successfully organized the "4th International Conference on Recent Advances in Bio-Energy Research (ICRABR)" from October 9th to 12th, 2023, in Kapurthala, Punjab, India. The conference was meticulously designed to be a holistic learning event, drawing together stakeholders from diverse backgrounds within the bioenergy sector, including policymakers, government officials, industry leaders, UN agencies, academia, and researchers. The conference attracted over 300 participants from national and international arenas, achieving its goal of creating a robust platform for dialogue and collaboration. The diverse array of participants, representing various sectors such as policymaking, government, industry, academia, and research, contributed to the conference's success in facilitating meaningful dialogue and exchange of ideas. Shri. Bhupinder Singh Bhalla, Secretary of MNRE, inaugurated the conference with a compelling address, emphasizing the pivotal role of bioenergy in addressing the escalating global energy demand. The Hon'ble Minister of State, Shri Bhagwanth Khuba, through a pre-recorded insightful video, emphasized the significance of bioenergy in the Indian context and the associated opportunities. Key figures such as Prof K. K. Pant, Director, IIT Roorkee, added depth to the discussions by highlighting the importance of research and innovation in building a sustainable bio-based economy. Delegates had the opportunity to explore cutting-edge bioenergy solutions showcased at exhibition stalls, where prominent industries and organizations presented their technological advancements and projects. The conference, spanning three days, featured plenary and technical sessions covering a range of themes, including biomass resource management, waste conversion to energy, biomass valorization, and biorefinery. A notable highlight of the conference was the Bioenergy Industry Exposure Visit to Sukhbir Agro Energy Ltd. Biomass Power Plant in Punjab. Participants gained firsthand experience of the operations of a commercial

bioenergy plant, including aspects such as storage, handling, and transport of biomass. The discussions emphasized the imperative need for collaboration among government bodies, industries, societal organizations, farmers, and research institutions. This collective effort is considered essential for progress and aligns with the launch of the Global Biofuels Alliance during the G20 by the Hon'ble Prime Minister Shri Narendra Modi. The conference stood as a testament to the power of collaboration and knowledge exchange in driving advancements in sustainable bioenergy solutions on a global scale.

Hindi Pakhwada

During the Hindi Fortnight celebration, the institute organized various competitions and a Kavi Sammelan. Prominent among these competitions were the Hindi essay competition, quiz competition, and debate competition, all of which saw active participation from institute employees. The Kavi Sammelan commenced with the lighting of the lamp on the portrait of Mother Saraswati by the poets and distinguished guests. The event featured the participation of esteemed poets, Mr. Rajesh Chetan and Mrs. Baljeet Kaur, who have presented their works on both national and international platforms. Their presentations, filled with humor and satire, thoroughly entertained and engaged the audience.

Hindi Pakhwada

Vigilance Awareness Week

In accordance with the directives of the Central Vigilance Commission (CVC), SSS-NIBE observed the "Vigilance Awareness Week" from 30.10.2023 to 05.11.2023. As part of the observance, a debate and quiz competition was organized on 02.11.2023 at Dr. A.P.J. Abdul Kalam Auditorium, SSS-NIBE, with active participation from all staff, research scholars, and students. During the events, an integrity pledge

was taken by all participants. Additionally, a guest lecture was organized on 03.11.2023, featuring Mr. Inder Raj Singh Bains, a retired P.C.S. Officer from the Cooperative Department, Government of Punjab. The lecture focused on "Vigilance Awareness & PIDPI." The program concluded with a tree plantation ceremony conducted by the guest and the Director-General of NIBE.

Inauguration of Innovation and Computational facility

On 02/11/2023, DG, SSS-NIBE inaugurated the Innovation and Computational Centre located at the Technical Block, SSS-NIBE. This state-of-the-art facility is designed to support advanced computational work within the institute. Moreover, it serves as a collaborative environment, fostering interactions among staff, students, and organizations. The center aims to be a hub for idea exchange and innovation, for the development of various projects in relevant areas.

Signed MoU between SSS-NIBE and National Aerospace Laboratories (NAL)

An MoU was signed with the Surface Engineering Division of NAL, Bangalore, establishing collaboration for joint research and development activities. The focus of the partnership is on exploring the application of biofuels in gaseous forms for power generation in high-temperature solid oxide fuel cells.

Glimpses from ICRABR-2023

Upcoming Events

- National Workshop on Biomass-based Clean Cooking Solutions from 29th February to 1st March, 2024 organized by SSS-NIBE. The objective of this workshop is to highlight the need and relevance of biomass-driven solid, liquid and gaseous fuels-based clean cooking solutions, particularly in the Indian context.
- National Hands-on Training Programme On Biogas Technology and its Implementation from 19-23 February 2024 is jointly organized by SSS-NIBE and Indian biogas association. The main objective of this training is to create awareness and understanding of biogas, consortium development, advancements in biogas production, policy formulation, and financing for industrial biogas projects.

  For more details: https://www.nibe.res.in.

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