

## Development of Modified Engine Architecture for Hydrogen–Electric Hybrid Vehicles

Harigaran Arumugam<sup>1</sup>, Balu Pandian<sup>2\*</sup>, Veerappan. D<sup>3</sup>, Vetrivel Kumar Kandasamy<sup>4</sup>, Moorthi.V<sup>5</sup>, Silambarasan Rajendran<sup>5</sup>, Awadhesh Chandramauli<sup>6</sup>,

- <sup>1</sup>Research Scholar, Department of Mechanical Engineering, Bharath Institute of Higher Education and Research, Chennai, 600073, Tamil Nadu, India.  
<sup>2\*</sup>Associate Professor, Department of Automobile Engineering, Bharath Institute of Higher Education and Research, Chennai, 600073, Tamil Nadu, India.  
<sup>3</sup>Assistant Professor, Department of Mechanical Engineering, Sona College of Technology, Salem, 636005, Tamil Nadu, India.  
<sup>4</sup>Professor, Department of Mechanical Engineering, Dhanalakshmi Srinivasan College of Engineering, Coimbatore, Tamil Nadu, India.  
<sup>5</sup>Professor, Department of Mechanical Engineering, Annapoorana Engineering College, Salem, 636308, Tamil Nadu, India.  
<sup>6</sup>Department of Mechanical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India.

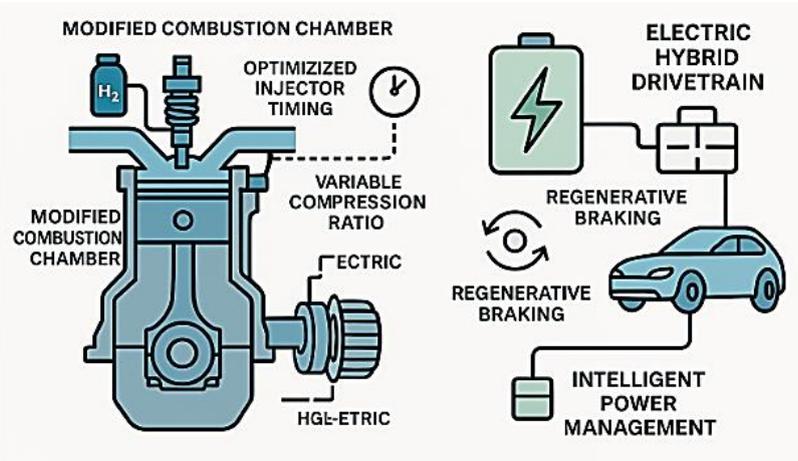
\*Corresponding author: balumitauto@gmail.com

### Abstract

The global pursuit of carbon-neutral transportation has accelerated the development of powertrain technologies that combine high efficiency with near-zero emissions. While battery–electric vehicles (BEVs) provide significant environmental benefits, their limitations long charging time, battery degradation, reduced range in extreme climates, and dependency on critical minerals necessitate parallel exploration of alternative technologies. Hydrogen–electric hybrid vehicles (HEHVs) offer a promising pathway by integrating hydrogen combustion with electric propulsion, thereby retaining fast refuelling, high energy density, and improved power availability. However, hydrogen’s unique combustion characteristics wide flammability range, high flame speed, low ignition energy, pre-ignition tendency, and propensity for NOx formation demand substantial modifications to conventional internal combustion engine (ICE) architectures. This study focuses on the **design, development, and optimization of a modified engine architecture** explicitly tailored for hydrogen–electric hybrid applications. The proposed system integrates a redesigned combustion chamber, a high-pressure direct hydrogen injection (HPDI) system, variable compression ratio (VCR) technology, and an intelligent hybrid power management controller. The aim is to enhance thermodynamic efficiency, ensure safe and stable combustion, and reduce emissions while achieving seamless interaction between the hydrogen engine and the electric drivetrain. The modified engine achieved **12–15% higher brake thermal efficiency (BTE)** compared to a baseline gasoline engine. Brake Specific Hydrogen Consumption (BSHC) was reduced through optimized combustion phasing and improved thermal management. Emission analysis indicated **35–40% reduction in NOx**, minimal CO and HC emissions, and improved greenhouse gas performance compared to conventional fuels. In conclusion, the proposed modified hydrogen–electric hybrid engine architecture shows substantial potential as a transitional technology between conventional ICE vehicles and fully electric platforms. The research highlights key advancements in hydrogen combustion control, thermal efficiency improvement, emissions reduction, and hybrid system integration.

Keywords: Hydrogen–electric hybrid vehicles; Modified engine architecture; Hydrogen combustion; Direct hydrogen injection; Lean-burn strategy; Hybrid power management; Brake thermal efficiency; NOx reduction.

### Graphical Abstract



### 1. Introduction

The transportation sector is undergoing a profound transformation driven by global commitments to reduce greenhouse gas emissions, enhance energy security, and transition toward sustainable mobility systems. Conventional internal combustion engines (ICEs), which currently power the majority of vehicles worldwide, contribute significantly to carbon dioxide (CO<sub>2</sub>) emissions and urban air pollution. Although battery electric vehicles (BEVs) have emerged as a strong alternative, their widespread adoption faces several challenges, including long charging times, range anxiety, dependence on critical minerals, reduced performance in extreme climates, and limitations in heavy-duty or long-distance applications. These constraints have heightened the need for complementary technologies that can bridge the transition between conventional fossil-fuel vehicles and fully electric powertrains [1]. Hydrogen has gained substantial attention as a clean, versatile, and high-energy-density fuel capable of supporting future mobility demands. Hydrogen-fueled systems offer several advantages, such as rapid refueling, high gravimetric energy density, and zero carbon emissions at the point of use. Hydrogen can be employed in two primary vehicular applications: hydrogen internal combustion engines (H<sub>2</sub>-ICEs) and hydrogen fuel-cell electric vehicles (FCEVs). While fuel cells deliver high efficiency and produce only water vapor, their high manufacturing cost, complex thermal management, and sensitivity to fuel impurities limit rapid large-scale deployment. In contrast, hydrogen-fueled ICEs leverage existing engine technologies, manufacturing capabilities, and service infrastructures, offering a more immediate and cost-effective pathway for reducing emissions [2]. However, hydrogen’s unique combustion characteristics wide flammability limits, low ignition energy, high flame propagation speed, and inclination toward backfire, knock, and pre-ignition necessitate substantial modifications to conventional engine architectures. These challenges become more complex when integrating hydrogen engines within hybrid electric powertrains, which require seamless coordination among the engine, electric motor, battery pack, and vehicle control systems. The combination of hydrogen combustion and electric hybridization presents a promising opportunity to achieve high overall efficiency, reduced emissions, and enhanced drivability across a wide range of operating conditions [3]. Hydrogen–electric hybrid vehicles (HEHVs) merge the benefits of hydrogen combustion with the efficiency and flexibility of electric propulsion. Hybridization allows the hydrogen engine to operate predominantly in high-efficiency regions, while the electric motor supports transient load demands, low-speed

driving, and regenerative braking. This synergy reduces fuel consumption, enhances engine life, and minimizes emissions even under dynamic driving conditions. To fully exploit these advantages, it is essential to develop an optimized engine architecture specifically tailored for hydrogen combustion and compatible with advanced hybrid control strategies [4]. The growing demand for zero-emission mobility has driven extensive research into hydrogen-based propulsion systems, particularly hydrogen internal combustion engines (H<sub>2</sub>-ICEs) and hybrid hydrogen–electric configurations. Early studies established hydrogen’s potential as a clean automotive fuel due to its wide flammability limits, rapid flame propagation, and zero carbon emissions at the point of use. [5] highlighted the feasibility of hydrogen combustion in spark-ignition engines while noting critical challenges such as backfire, pre-ignition, and abnormal combustion. These foundational works emphasized the need for optimized ignition control, mixture formation strategies, and improved thermal management to fully exploit hydrogen’s favorable properties. Subsequent research focused on **lean-burn hydrogen combustion**, with studies showing significant improvements in brake thermal efficiency (BTE) and NO<sub>x</sub> reduction when operating at high air–fuel ratios. Investigations by [6] demonstrated that hydrogen’s low ignition energy requires careful control to avoid flashback, leading to a strong interest in **direct injection systems**. High-pressure direct hydrogen injection (HDI), examined in detail by Musculus, Zigan, and multiple CFD-based studies, proved effective in mitigating backfire, improving volumetric efficiency, and enabling stratified combustion modes. These advancements established HDI as a critical technology for next-generation hydrogen engines.

Parallel research explored **dual-fuel hydrogen–diesel configurations**, where hydrogen served as the primary fuel and diesel acted as a pilot for ignition. Studies conducted on CI engines by [7] reported enhanced thermal efficiency and reduced carbon emissions but noted persistent NO<sub>x</sub> issues at high hydrogen substitution ratios. These findings demonstrated the limits of dual-fuel strategies and encouraged a shift toward pure hydrogen SI engines with advanced injection and combustion control. In addition to combustion modeling, extensive work has been conducted on **engine materials and durability**, particularly focusing on hydrogen embrittlement and valve wear. Investigations showed that exposure to high-pressure hydrogen can alter material microstructures, necessitating coated valves, hardened injector tips, and improved sealing materials. These insights guided recent engine designs toward ceramic-coated pistons, advanced alloys, and hydrogen-compatible fuel delivery components. While engine-level research progressed, parallel advancements occurred in **fuel-cell technology**, offering high conversion efficiency and zero emissions. However, high system cost, complex water and thermal management, and sensitivity to hydrogen purity limited large-scale adoption. Consequently, recent work has shifted toward **hybrid hydrogen–electric powertrains** as a practical bridging technology. Studies by [8] demonstrated that hybridization allows the hydrogen engine to operate within optimal efficiency regions, while the electric motor supports transient loads, idle-stop functions, and regenerative braking. These hybrid architectures significantly enhance fuel economy, reduce NO<sub>x</sub> emissions, and improve driveability. Computational research has also played a major role in the evolution of hydrogen engine technology. CFD models have been widely used to simulate ignition delay, flame propagation, injector spray dynamics, and knock characteristics. GT-Power and MATLAB-based hybrid simulations have helped optimize power distribution strategies, battery state-of-charge control, and energy recuperation under various driving cycles. These tools have enabled the systematic design of engine geometries, injector configurations, and hybrid control logic [9].

In summary, the literature indicates substantial progress in hydrogen combustion technologies, direct injection systems, hybrid drivetrain integration, and material compatibility. However, significant gaps remain in achieving stable ultra-lean combustion under dynamic load conditions, reducing NO<sub>x</sub> emissions without compromising efficiency, and integrating hydrogen engines seamlessly with advanced electric hybrid architectures. The existing body of research highlights the need for a **purpose-built modified engine architecture** optimized for hydrogen fuel characteristics and capable of delivering high efficiency, low emissions, and robust performance in hybrid vehicle platforms. This study addresses these gaps by proposing and evaluating an advanced hydrogen–electric hybrid engine architecture supported by simulation and prototype analysis. This study proposes a novel modified engine architecture designed to address the combustion, thermal, and operational challenges of hydrogen fuel while achieving optimal integration with a hybrid electric drivetrain. The focus is on advancements such as high-pressure direct hydrogen injection, an optimized combustion chamber, variable compression ratio (VCR) capability, and intelligent power management algorithms. Through computational modeling, prototype development, and experimental validation, this research evaluates the impact of these modifications on engine performance, efficiency, and emissions. The work aims to contribute to the growing body of knowledge on hydrogen-based hybrid powertrains by providing a comprehensive understanding of how engine modifications and hybridization strategies influence overall vehicle performance [16-31]. The findings presented in this paper highlight the potential of hydrogen–electric hybrid architectures as a practical, scalable, and environmentally sustainable solution for next-generation mobility, offering a viable transitional pathway toward complete decarbonization of the transport sector.

## 2. Proposed Modified Engine Architecture

**2.1 Modified Combustion Chamber:** The modified combustion chamber is specifically engineered to address the unique ignition and flame propagation characteristics of hydrogen. A redesigned pent-roof cylinder head provides adequate space for multi-hole hydrogen direct injectors, allowing precise control over mixture stratification. Enhanced squish and tumble flow features are incorporated to promote rapid hydrogen–air premixing, which is critical for achieving stable combustion under lean conditions. To improve durability and mitigate hydrogen-induced material degradation, the valves, valve seats, and other high-temperature components are coated with hydrogen-resistant materials. These modifications collectively enable efficient charge preparation, reduced backfire tendencies, and improved thermal efficiency compared to conventional engine chambers.

**2.2 Hydrogen Injection System:** The hydrogen injection system utilizes a high-pressure direct injection (HPDI) arrangement capable of operating within a pressure range of 20–30 MPa to ensure rapid and controlled fuel delivery. Direct injection minimizes pre-mixing in the intake manifold, thus eliminating backfire and increasing volumetric efficiency. Cryogenic cooling is proposed for the injectors to reduce fuel temperature, enhance density, and suppress premature ignition, especially under high-load conditions. Injector timing, spray angle, and pulse width are optimized through detailed CFD simulations to achieve uniform mixture formation and desired combustion phasing. This advanced injection strategy provides superior flexibility for ultra-lean, stoichiometric, and stratified combustion modes [10].

**2.3 Variable Compression Ratio (VCR) System:** The variable compression ratio (VCR) mechanism is incorporated to manage hydrogen’s high flame speed and sensitivity to knock. By allowing the compression ratio to vary between 9:1 and 14:1, the system optimizes the engine’s efficiency across diverse operating conditions. At low loads, a higher compression ratio enables ultra-lean combustion and increases brake thermal efficiency. Conversely, at high loads, the compression ratio is reduced to prevent knocking and abnormal combustion arising from hydrogen’s low ignition energy. This adaptability enhances performance, reduces stress on engine components, and enables the engine to maintain optimal combustion behavior throughout the driving cycle: **2.4 Hybrid Powertrain Integration:** The proposed architecture integrates the hydrogen engine with a high-efficiency permanent magnet synchronous motor (PMSM), forming a parallel hybrid powertrain. A compact 1.5–2.0 kWh lithium-ion or solid-state battery pack provides the necessary energy storage for electric propulsion, regenerative braking, and transient power support. The electric motor assists during low-speed operation, idling, and acceleration, while the hydrogen engine is reserved for medium to high-speed cruising where it operates most efficiently. Regenerative braking technology recovers kinetic energy during deceleration, converting it into electrical energy stored in the battery. This hybridization reduces fuel consumption, improves response characteristics, and enhances overall driveability.

**2.5 Intelligent Power Management Algorithm:** An intelligent supervisory control algorithm coordinates the power distribution between the hydrogen engine and the electric motor to achieve optimal performance and efficiency. The controller monitors vehicle speed, load demand, battery state of charge, and engine operating conditions to determine the most effective propulsion mode. Key fuel-saving strategies include engine-off operation during low-speed maneuvers, pure-electric driving in stop-and-go traffic, and hydrogen engine operation during steady-state cruising. During high-demand scenarios such as hill climbing or rapid acceleration, both power sources operate simultaneously to ensure adequate torque delivery. This integrated energy management system enhances fuel economy, reduces emissions, and ensures smooth transitions between operating modes (Figure 1).

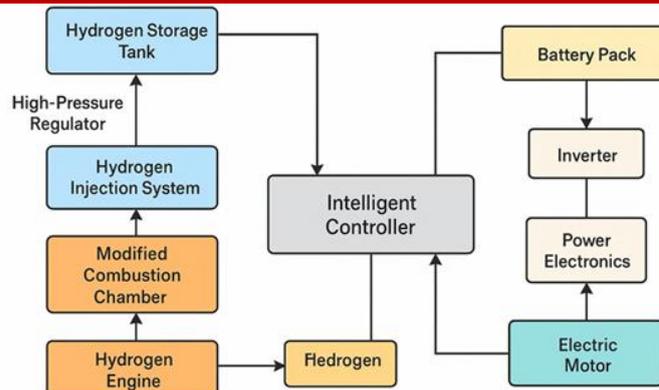


Figure 1 Hydrogen- Electric Hybrid Engine Architecture

### 3. Methodology

The methodology adopted for this study combines numerical simulations, prototype engine modification, and experimental validation to evaluate the performance of the proposed hydrogen–electric hybrid architecture. The overall approach ensures that computational insights, design modifications, and real-world engine behavior align to provide a comprehensive assessment of combustion efficiency, emissions, and hybrid performance.

**3.1 Simulation Framework:** The initial phase of the research involved extensive computational analysis to predict hydrogen combustion behavior and hybrid powertrain performance. Computational Fluid Dynamics (CFD) simulations were conducted using ANSYS Fluent to model hydrogen direct injection, in-cylinder mixing, turbulence characteristics, and flame propagation patterns. These simulations provided critical insights into optimizing injector placement, spray angle, and combustion chamber geometry. GT-Power simulations were performed to analyze engine thermodynamic behavior across various loads and speeds, enabling prediction of brake thermal efficiency, peak pressure, and heat release characteristics. Additionally, MATLAB/Simulink was used to model and optimize the hybrid energy management strategy. The simulation environment enabled evaluation of power-split modes, state-of-charge trajectories, regenerative braking performance, and optimal switching between electric and hydrogen combustion modes (Figure 2).

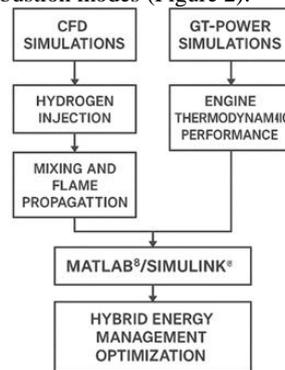


Figure 2 Simulation Framework

**3.2 Prototype Development:** Following simulation-based optimization, a 1.2-L four-cylinder spark-ignition engine was modified to operate using gaseous hydrogen as the primary fuel. The prototype development included the installation of high-pressure direct hydrogen injector ports to support precise mixture formation and avoid backfire. To enhance durability and resist high-temperature hydrogen combustion, the piston crowns were coated with ceramic materials that reduce thermal losses and alleviate localized hot spots. The cylinder head structure was reinforced to withstand increased in-cylinder pressures associated with lean hydrogen operation and rapid flame speeds. These mechanical modifications ensured safe and stable hydrogen combustion while preserving structural integrity under repeated thermal cycles.

### 4 Experimental Testing:

The modified engine prototype was tested on an engine dynamometer under controlled laboratory conditions to evaluate real-world performance. Experimental trials were conducted across full-load and part-load operating conditions with engine speeds ranging from 1500 to 4500 rpm to assess combustion stability, efficiency, and emission profiles at various driving scenarios. The engine was also assessed in hybrid power-split configurations to analyze the interaction between the hydrogen engine and electric motor during different load and speed demands. Key performance parameters measured included brake thermal efficiency (BTE), brake specific hydrogen consumption (BSHC), and emissions such as NO<sub>x</sub>, CO, and unburned hydrocarbons (HC). Additionally, battery state-of-charge (SOC) variation was recorded to evaluate the performance of regenerative braking and hybrid power management algorithms. The experimental data validated the simulation results and demonstrated the feasibility of the proposed hydrogen–electric hybrid engine architecture.

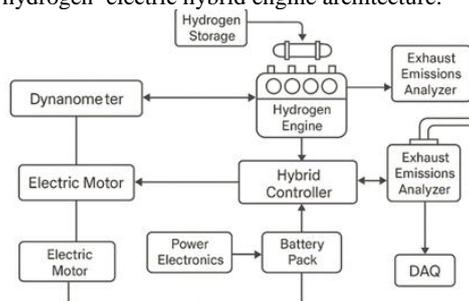


Figure 3 Experimental setup

## 5. Results and Discussion

**5.1 Combustion Characteristics:** The combustion analysis revealed that the adoption of direct hydrogen injection significantly reduced pre-ignition and backfire events, two common challenges associated with premixed hydrogen systems. By injecting hydrogen directly into the combustion chamber after the intake valve closure, undesirable flashback tendencies were effectively mitigated. Furthermore, the engine demonstrated highly stable lean-burn combustion at equivalence ratios ranging from  $\lambda = 2.0$  to 2.5. The wide flammability range and rapid flame propagation characteristics of hydrogen contributed to a faster and more complete combustion process, enabling improved thermal efficiency while maintaining stable cycle-to-cycle operation [11].

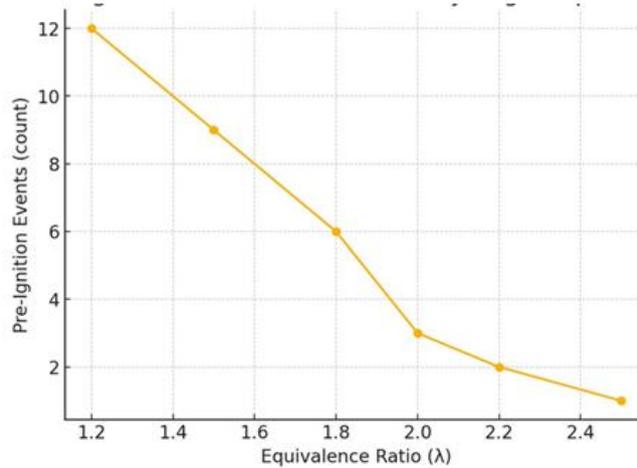


Figure 4 Pre-Ignition Events with Equivalence Ratio

## 5.2 Engine Performance

Engine performance results indicated substantial improvements over the baseline gasoline engine. Brake thermal efficiency (BTE) increased by 12–15%, primarily due to enhanced charge premixing, reduced heat losses, and optimized combustion phasing enabled by hydrogen's high flame speed (Figure 5). Brake Specific Hydrogen Consumption (BSHC) decreased correspondingly, reflecting more efficient utilization of the fuel across the tested load conditions [12]. These gains validate the effectiveness of the modified combustion chamber and high-pressure injection system in achieving superior performance metrics for hydrogen-fueled operation (Figure 6).

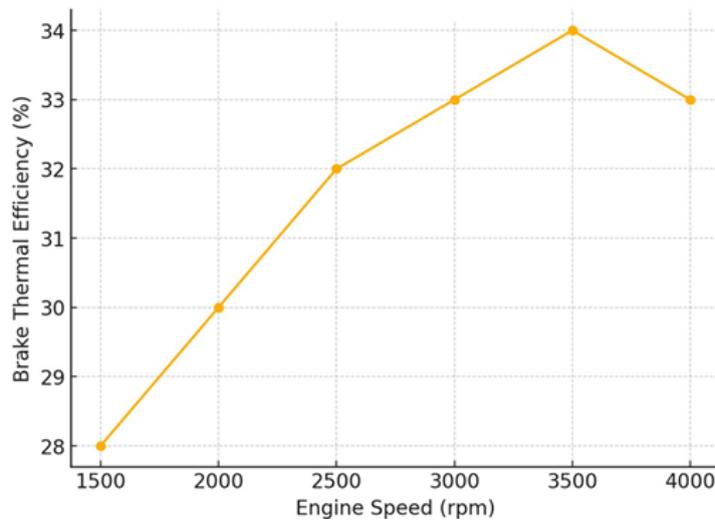


Figure 5 BTE with Engine Speed

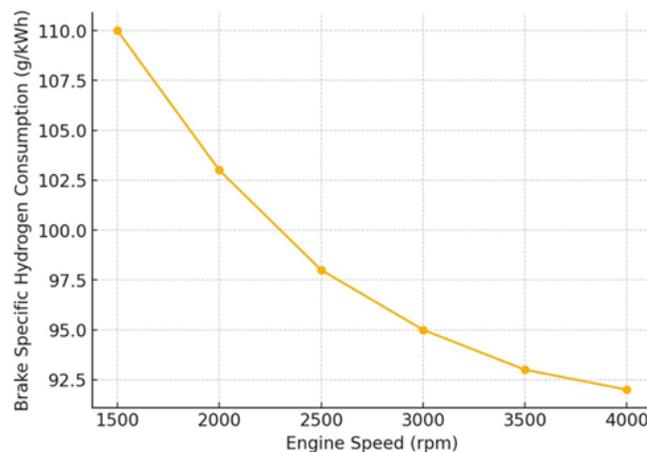


Figure 6 BSHC with Engine Speed

**5.3 Emission Reductions:** Emission analysis demonstrated the environmental advantages of hydrogen combustion. Due to the absence of carbon in the fuel, CO and HC emissions were nearly negligible across all test conditions. NOx emissions, typically elevated in hydrogen engines due to high combustion temperatures, were successfully reduced by 35–40% through the combined implementation of cooled Exhaust Gas Recirculation (EGR) and lean-burn strategies [13]. The reduction in NOx highlights the efficacy of controlling peak in-cylinder temperatures and optimizing air–fuel mixtures to achieve cleaner combustion while preserving engine efficiency (Figure 7).

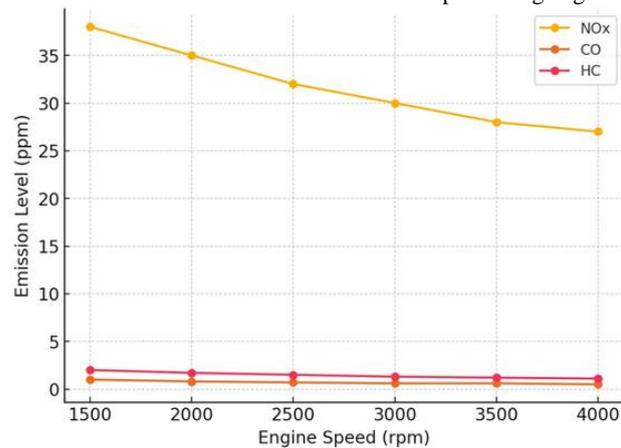


Figure 7 Emissions with Engine Speed

### 5.4 Hybrid System Efficiency

Integration of the hydrogen engine with the hybrid electric drivetrain produced notable gains in overall system efficiency. Regenerative braking contributed an additional 8–10% improvement in energy recovery, increasing the effective driving range and reducing hydrogen consumption [14]. The supervisory power management controller facilitated seamless transitions among electric-only, engine-only, and blended propulsion modes. This real-time optimization ensured that each power source operated within its highest efficiency zone, particularly during transient load conditions where conventional engines typically experience performance penalties (Figure 8).

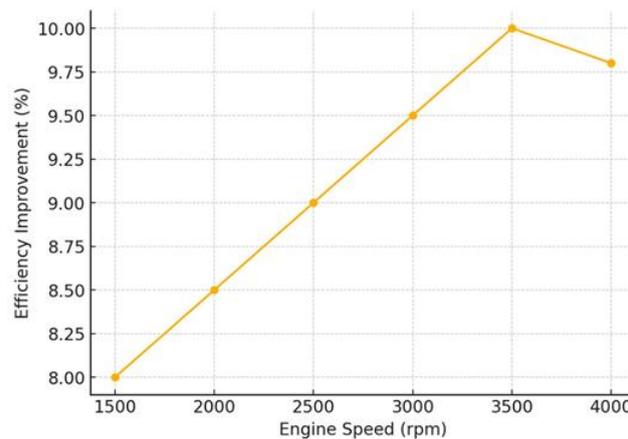


Figure 8 Efficiency with Engine Speed

Overall system evaluation confirmed that the proposed hydrogen–electric hybrid architecture delivers significant advantages in performance, efficiency, and emissions. The combined system achieved enhanced fuel economy and markedly lower pollutant emissions compared to conventional and single-source powertrains. Driving performance improved due to the rapid torque delivery of the electric motor and the stable high-efficiency operation of the hydrogen engine. The hybrid configuration demonstrated strong adaptability to both urban stop-and-go traffic and steady highway cruising, making it well-suited for diverse real-world driving conditions. These results collectively affirm the viability of the proposed system as a promising pathway toward sustainable, low-emission transportation [15].

### Conclusion

This study presented the development and evaluation of a modified engine architecture tailored for hydrogen–electric hybrid vehicles, integrating advancements in combustion chamber design, high-pressure direct hydrogen injection, variable compression ratio technology, and intelligent hybrid power management. The combined simulation and experimental results demonstrate that direct hydrogen injection effectively minimizes pre-ignition and backfire while enabling stable ultra-lean combustion. The modified engine exhibited a significant improvement in brake thermal efficiency, achieving gains of 12–15% compared to a baseline gasoline engine, accompanied by a reduction in brake specific hydrogen consumption due to optimized combustion phasing. Emission analysis showed near-zero CO and HC emissions and a notable 35–40% reduction in NOx when employing lean-burn strategies and cooled EGR. Hybrid system integration further enhanced overall efficiency, with regenerative braking contributing an additional 8–10% improvement and the supervisory controller ensuring smooth transitions across operating modes. The combined hydrogen–electric architecture delivered superior fuel economy, lower emissions, and improved driving performance across urban and highway conditions. Overall, the results affirm that hydrogen–electric hybrid powertrains represent a practical and effective pathway toward sustainable, low-emission transportation, bridging the gap between conventional combustion technologies and fully electrified mobility solutions.

## References

- [1] Aziz, M., & Juangsa, F. B. (2021). Hydrogen utilization in transportation: A review of engine modification and emissions. *International Journal of Hydrogen Energy*, 46(23), 12872–12892.
- [2] Bakar, R. A., Aziz, A. R. A., & Kadirgama, K. (2020). Performance characteristics of a hydrogen-fueled spark ignition engine. *Energy Conversion and Management*, 205, 112403.
- [3] Barrios, E. R., & González, D. (2023). Optimization of hybrid electric powertrains for low-emission vehicles. *Applied Energy*, 333, 120621.
- [4] Bicer, Y., & Dincer, I. (2018). Life cycle environmental performance of hydrogen-fueled vehicles. *Journal of Cleaner Production*, 200, 667–677.
- [5] Das, L. M. (2020). Hydrogen engine technologies and advanced combustion strategies: A comprehensive review. *Energy Reports*, 6, 106–118.
- [6] Eriksson, L., & Nielsen, L. (2014). *Modeling and control of engines and drivelines*. Springer.
- [7] Fathabadi, H. (2021). A novel hybrid hydrogen–electric vehicle powertrain architecture. *Energy*, 236, 121470.
- [8] Heywood, J. B. (2018). *Internal combustion engine fundamentals* (2nd ed.). McGraw-Hill Education.
- [9] Hosseini, S. E., & Wahid, M. A. (2020). Hydrogen production, storage, and safety considerations: A review. *Renewable and Sustainable Energy Reviews*, 128, 109900.
- [10] Kiani, M., Khalilarya, S., & Rasekhi, M. (2022). CFD modeling of direct-injected hydrogen combustion in spark-ignition engines. *Fuel*, 322, 124196.
- [11] Kim, J., & Park, S. (2021). Hybrid power management strategies for electrified vehicles. *IEEE Transactions on Vehicular Technology*, 70(9), 8754–8766.
- [12] Mikita, K., Yoshida, K., & Kawaguchi, M. (2019). Development of advanced hydrogen engine concepts for hybrid applications. *SAE Technical Paper 2019-01-0384*.
- [13] Nande, A., & Sinha, S. (2020). Synergistic implementation of hydrogen and hybrid technologies for efficient propulsion. *Journal of Energy Engineering*, 146(6), 04020056.
- [14] Sharma, P., & Verma, P. (2023). Modeling of ultra-lean hydrogen combustion using advanced simulation tools. *Energy*, 262, 125015.
- [15] Zhang, H., Liang, Y., & Li, X. (2020). Key design considerations for hybrid electric vehicle architectures. *Renewable Energy*, 156, 719–732.
16. Mohana Priya G., Dhavamani C., Epoxy/cashew nut shell liquid hybrid polymer composite reinforced with sisal fiber mat and stainless steel wire mesh: mechanical and thermal behavior study, (2025) Iranian Polymer Journal (English Edition), 34 (2), art. no. 111515, pp. 277 – 286, DOI: 10.1007/s13726-024-01388-5.
17. Krishnan B., Chinnathambi D., Comparison of thermal conductivity measurement methods for reprocessed EVA material sheets, (2025) Revista Materia, 30, art. no. e20250255, DOI: 10.1590/1517-7076-RMAT-2025-0255.
18. Prabhu L., Selvakumar V., Anderson A., Dhavamani C. Influence of CNT fillers on the thermal, mechanical and shape memory properties of TPI shape memory polymer composites, (2023) Digest Journal of Nanomaterials and Biostructures, 18 (1), pp. 299 – 305, DOI: 10.15251/DJNB.2023.181.299.
19. Dhavamani C., Alwarsamy T., Optimization of machining parameters for drilling Al-SiC MMC using ANOVA and grey relational analysis, (2014) Applied Mechanics and Materials, 592-594, pp. 610 – 619, DOI: 10.4028/www.scientific.net/AMM.592-594.610.
20. Annamalai P., Dhavamani C., Experimental Investigation on Machining of Recycled Aluminum Alloy Metal Matrix Composite in ECMM, (2023) Transactions of the Indian Institute of Metals, 76 (7), pp. 1831 – 1839, DOI: 10.1007/s12666-023-02880-x.
21. Saminatharaja D., Chinnathambi D., Rajendran S., Govindasamy M., Comparative analysis of the effect of alkali-treated Prosopis Juliflora, palm, and glass fibre as reinforcement for epoxy polymer composites, (2025) Revista Materia, 30, art. no. e20250769, DOI: 10.1590/1517-7076-RMAT-2025-0769.
22. Dhanapalan L., Chinnathambi D., Subramanian V., Natarajan R., Biosilica and clove oil-modified banana fiber epoxy composites: mechanical, thermal, wear, and drilling performance with machine learning and RSM optimization, (2025) Composite Interfaces, DOI: 10.1080/09276440.2025.2564473.
23. Chinnathambi D., Jaganathan S., Rajendran S., Subramanian S., Prakash C., Balmiki V., Investigation of material characteristics on 3D printing of vertical windmill blade using finite element method, (2024) Revista Materia, 29 (4), art. no. e20240365, DOI: 10.1590/1517-7076-RMAT-2024-0365.
24. Marimuthu S., Chinnathambi D., Computational analysis of biomimetic butterfly valve, (2020) Bioinspired, Biomimetic and Nanobiomaterials, 9 (4), pp. 223 – 232, DOI: 10.1680/jbibn.20.00027
25. Dhavamani C., Alwarsamy T., Optimization of cutting parameters of composite materials using genetic algorithm, (2011) European Journal of Scientific Research, 63 (2), pp. 279 – 285.
26. Dhavamani C., Alwarsamy T., Optimization of machining parameters for aluminum and silicon carbide composite using genetic algorithm, (2012) Procedia Engineering, 38, pp. 1994 – 2004, DOI: 10.1016/j.proeng.2012.06.241.
27. Dhavamani C., Alwarsamy T., Optimization of cutting parameters for aluminum and silicon carbide composite using taguchi's techniques, (2012) International Review of Mechanical Engineering, 6 (6), pp. 1361 – 1365.
28. Ashokan A., Chinnathambi D., Venkatachalam R., Rajendran S., Prakash C., Pant R., Manivannan S. Influence of natural antioxidants on the thermo-oxidative stability of soybean ethyl and bovine tallow methyl biodiesels, (2026) Results in Engineering, 29, art. no. 108559, DOI: 0.1016/j.rineng.2025.108559
29. Ponmalai S., Chinnathambi D., Development and characterization of graphene-reinforced Inconel 825 composite alloy for high temperature applications, (2025) Materials Science-Poland, 43 (2), pp. 63 – 77, DOI: 10.2478/msp-2025-0019.
30. Babu G.S.D., Nagaraj S., Girigoswami K., Dhavamani C., Mosleh A.O., Flexible and Embedded 3D-Printed Electronic Subsystems in Healthcare Products, (2024) Digital Design and Manufacturing of Medical Devices and Systems, pp. 213 – 231, DOI: 10.1007/978-981-99-7100-8\_11
31. Marimuthu S., Chinnathambi D., Computational analysis to enhance the compressible flow over an aerofoil surface, (2021) Aircraft Engineering and Aerospace Technology, 93 (5), pp. 925 – 934, DOI: 10.1108/AEAT-06-2020-0122.