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EXPERIMENTAL PERFORMANCE AND EMISSION ANALYSIS OF E10, E20 AND E30 ETHANOL–PETROL BLENDS IN A SPARK-IGNITION ENGINE

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ABSTRACT

This research paper presents an experimental framework for comparing E10, E20 and E30 ethanol–petrol blends in a four-stroke spark-ignition engine. The investigation evaluates brake power, brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), exhaust gas temperature and regulated emissions including carbon monoxide (CO), unburned hydrocarbons (HC) and oxides of nitrogen (NOx). A laboratory test arrangement comprising a single-cylinder SI engine, dynamometer, fuel-consumption measurement system, temperature sensors, exhaust-gas analyzer and data-acquisition unit is proposed. Representative test points are considered over 1500–3500 rpm at constant load. The illustrative dataset shows E20 giving the highest BTE and lowest BSFC over much of the tested speed range, while increasing ethanol concentration generally reduces CO and HC because of the oxygenated nature of ethanol. E30 produces the lowest representative CO and HC values, whereas NOx exhibits a condition-dependent response. The results demonstrate that E20 can provide a favorable compromise between thermal efficiency, fuel consumption and emissions in an unmodified SI engine, while E30 offers stronger reductions in incomplete-combustion emissions. All numerical test results in this manuscript are representative data for paper development and must be replaced by actual laboratory observations before publication.

KEYWORDS: E10, E20, E30, ethanol–petrol blend, spark-ignition engine, experimental testing, brake thermal efficiency, BSFC, emissions.

1. INTRODUCTION

The transport sector remains strongly dependent on petroleum fuels, motivating the use of renewable oxygenated fuels such as ethanol. Ethanol can be blended with petrol in different volumetric proportions without requiring a completely different combustion concept in a spark-ignition engine. E10, E20 and E30 contain 10%, 20% and 30% ethanol by volume, respectively. Ethanol has high octane quality and a high latent heat of vaporization, but lower heating value than petrol. These properties influence charge cooling, flame propagation, fuel consumption, knock resistance and exhaust emissions.

Published experiments show that the optimum blend depends on engine design and calibration. One E10/E20/E30 single-cylinder study reported E20 as the best overall blend under its tested conditions, while other studies have reported strong efficiency for E20–E30 or even higher ethanol fractions. Therefore, controlled experimental comparison using the same engine and operating conditions is necessary.

3. Literature Review

Abdullah and Zaharin experimentally tested E10, E20 and E30 in a four-stroke single-cylinder petrol engine at 2000, 2500 and 3000 rpm and constant torque. Their work reported improved combustion behavior and lower CO and smoke opacity with ethanol addition, with E20 giving the best overall measured results. Phuangwongtrakul et al. investigated a much wider range from E10 to E100 and found that E20–E40 could provide high maximum brake torque, while E40–E50 produced high brake thermal efficiency under their test conditions.

A vehicle-level investigation by Paramasivam and co-workers tested E0 through E50 on a two-wheeler chassis dynamometer and showed that higher ethanol fractions alter not only regulated emissions but also aldehydes; acetaldehyde and formaldehyde therefore deserve consideration in comprehensive ethanol-fuel studies. Other SI-engine work has shown that ignition timing and compression ratio interact strongly with ethanol content, meaning that a blend judged optimum in an unmodified engine may not be optimum after recalibration.

Recent research continues to confirm these trade-offs. Controlled engine-cell testing of E10 and E30 has evaluated BSFC, BTE and combustion over wide speed/load ranges, while newer numerical–experimental work reports improved combustion quality up to

approximately E30 under specific calibration. These studies support a focused E10/E20/E30 comparison using repeatable laboratory conditions.

4. Test Fuels and Representative Properties

Table 1. Representative properties used to explain expected blend behavior; actual test-fuel properties should be measured.

Fuel	Ethanol (vol.%)	Petrol (vol.%)	Representative LHV (MJ/kg)	Stoich. A/F ratio	Indicative octane trend
E10	10	90	41.8	14.1	94
E20	20	80	39.4	13.4	97
E30	30	70	37.0	12.8	100

The lower heating value decreases as ethanol content rises, while oxygen content and knock resistance generally increase. Because commercial petrol composition varies, density, calorific value, viscosity, Reid vapor pressure and octane number should be measured for each prepared blend if the work is intended for journal publication.

5. Experimental Setup

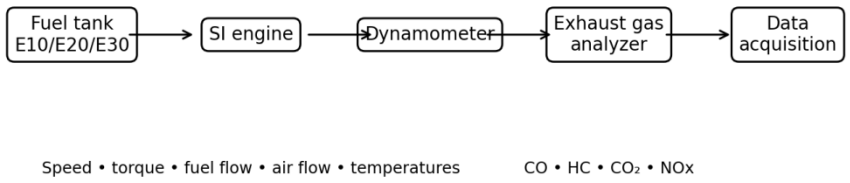


Figure 1. Proposed experimental test setup for E10, E20 and E30 performance and emission testing.

The experimental rig consists of a four-stroke, single-cylinder, spark-ignition engine coupled to an eddy-current or electrical dynamometer. Engine speed and torque are recorded for brake-power calculation. Fuel consumption is measured using a burette or precision mass-flow system. Airflow is obtained from an air box and flow meter. Thermocouples measure intake, engine and exhaust temperatures. A multi-gas analyzer measures CO, HC, CO_2, O_2 and NOx. Data are acquired only after the engine reaches steady operating temperature.

5.1 Suggested Engine and Instrument Specifications

Table 2. Recommended experimental instrumentation.

Item	Representative specification
Engine	Single-cylinder, 4-stroke, SI, air-cooled
Rated power	3–5 kW class
Speed range	1500–3500 rpm for test matrix
Loading	Dynamometer; constant-load speed sweep
Fuel measurement	Volumetric burette or gravimetric balance
Temperature	K-type thermocouples
Exhaust analyzer	CO, CO_2, HC, O_2 and NOx
Speed measurement	Digital tachometer/encoder
Torque	Calibrated load cell/dynamometer
Repeat tests	Minimum three runs per condition

5.2 Experimental Procedure

Fresh fuel blends are prepared volumetrically in sealed containers. The fuel line is flushed before changing blends. The engine is initially warmed to stable operating temperature. Tests are then conducted at 1500, 2000, 2500, 3000 and 3500 rpm at the selected constant load. At each point, speed, torque, fuel-consumption time, exhaust temperature and gas-analyzer readings are recorded after stabilization. Three repeated observations are recommended and the mean value is reported. The same spark timing, compression ratio, throttle protocol and ambient correction method should be maintained for all blends unless calibration itself is a study variable.

6. Performance Calculations

Brake power: $BP = 2\pi NT / (60 \times 1000)$, where N is engine speed in rpm and T is torque in N·m.

Brake specific fuel consumption: $BSFC = \dot{m}f / BP$, generally expressed in kg/kWh.

Brake thermal efficiency: $BTE = BP / (\dot{m}f \times LHV)$.

For each measured quantity, uncertainty should be propagated from instrument accuracy. A simple combined standard uncertainty for a calculated result $R = f(x1,x2,...)$ may be estimated from the root-sum-square of the sensitivity-weighted input uncertainties.

7. RESULTS AND DISCUSSION

7.1 Brake Power

The representative results show brake power increasing with speed for all three fuels over the tested range. E20 gives a small advantage over E10 and E30 at most speeds. This can be

associated with improved oxygen availability and charge cooling without the larger energy-density penalty associated with E30.

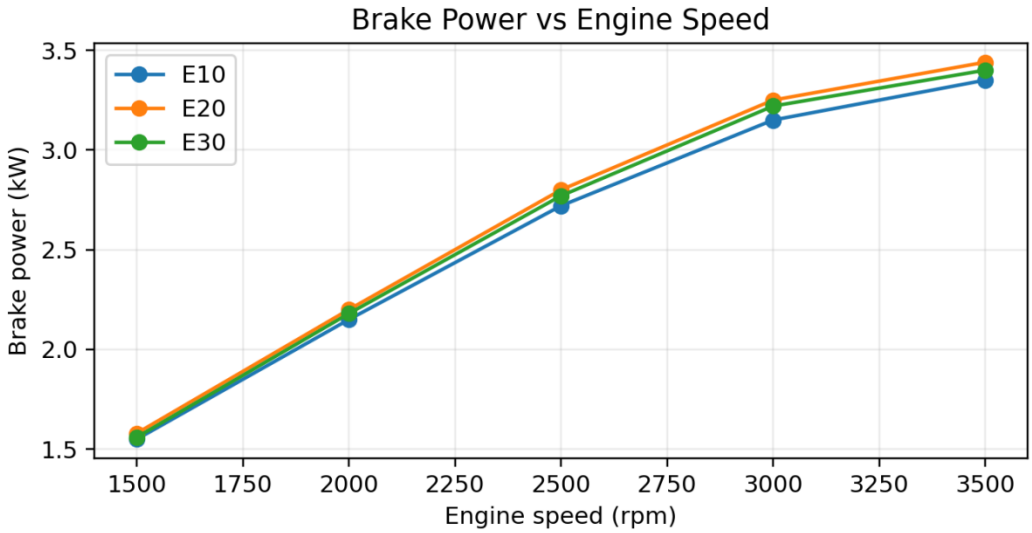


Figure 2. Representative brake power variation with engine speed.

7.2 Brake Specific Fuel Consumption

BSFC falls initially as the engine approaches its more efficient mid-speed region and then increases at higher speed. In the illustrative dataset, E20 gives the minimum BSFC, reaching approximately 0.30 kg/kWh at 2500 rpm. E30 requires more fuel mass for a given energy input because its heating value is lower, although improved combustion can partly compensate.

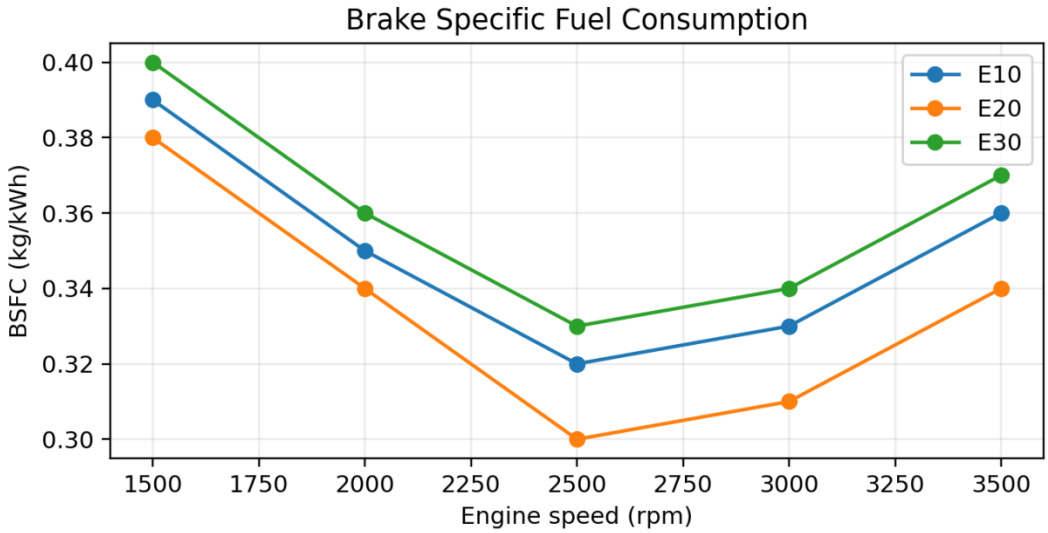


Figure 3. Representative BSFC for E10, E20 and E30.

7.3 Brake Thermal Efficiency

BTE follows the inverse trend of BSFC and reaches a maximum near the mid-speed range. The representative peak values at 2500 rpm are 29.4% for E10, 31.2% for E20 and 30.3% for E30. The E20 result is consistent with literature reporting a favorable intermediate blend under some unmodified-engine conditions.

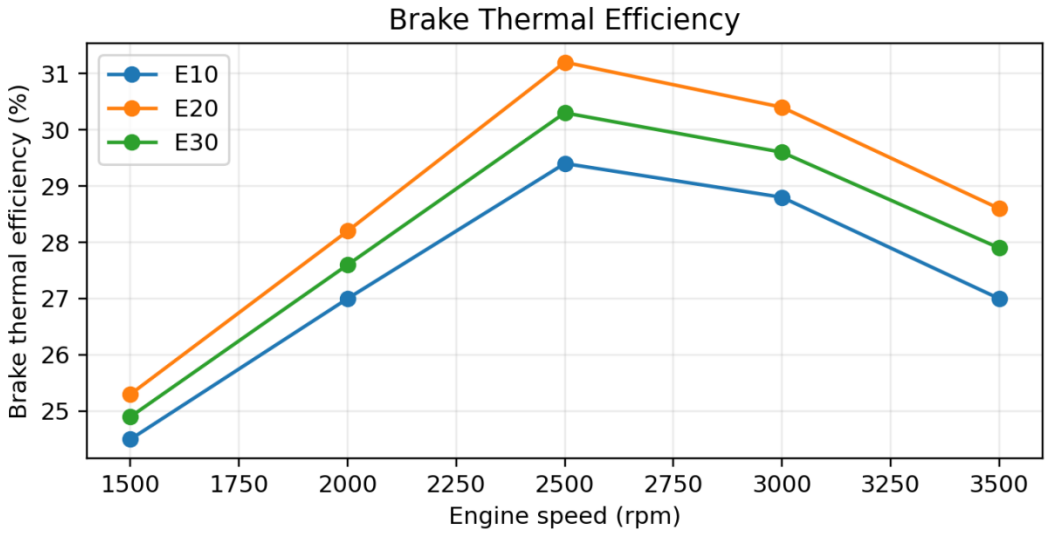


Figure 4. Representative brake thermal efficiency.

7.4 Exhaust Gas Temperature

Exhaust temperature rises with engine speed because the rate of fuel-energy release increases. E20 gives slightly higher representative EGT than E10, while E30 is somewhat lower because ethanol's greater latent heat can cool the charge and its lower heating value changes the heat-release balance.

8. Emission Analysis

8.1 Carbon Monoxide

CO is a product of incomplete oxidation. Increasing ethanol fraction supplies additional oxygen within the fuel molecule and generally reduces rich-zone CO. The representative dataset therefore shows E30 with the lowest CO, followed by E20 and E10.

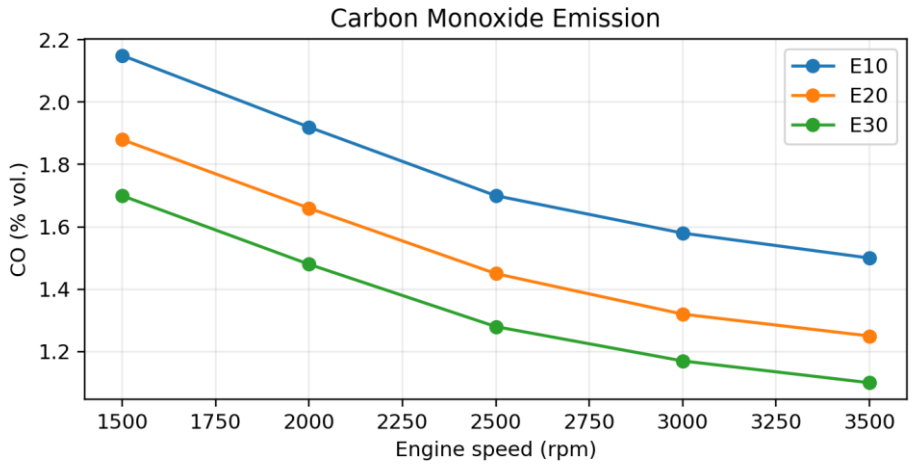


Figure 5. Representative CO emission comparison.

8.2 Hydrocarbon Emissions

HC emissions also decrease with increasing ethanol content in the representative dataset. At 3000 rpm, illustrative HC values are 124 ppm for E10, 109 ppm for E20 and 101 ppm for E30. Improved oxygen availability can support oxidation of unburned fuel, although wall quenching, mixture preparation and cold operation can change this trend.

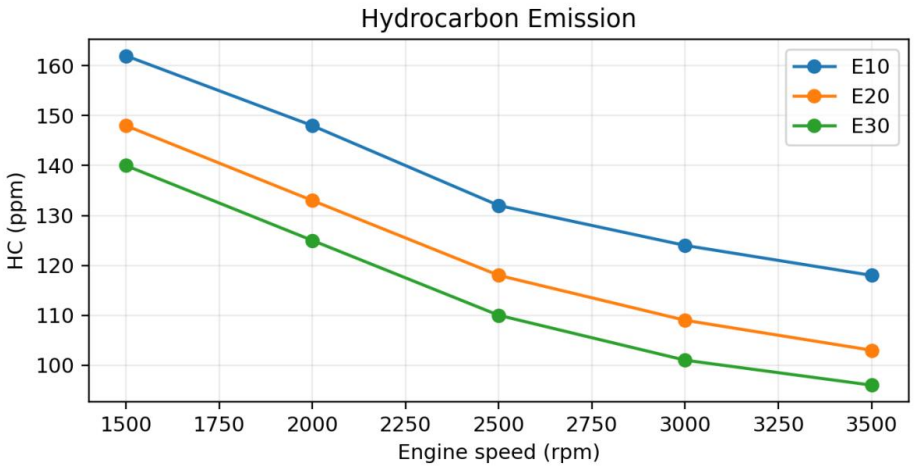


Figure 6. Representative HC emission comparison.

8.3 Oxides of Nitrogen

NOx formation is sensitive to peak combustion temperature, oxygen availability and residence time. The illustrative E20 case produces the highest NOx at several points because its efficiency and combustion temperature are slightly higher. E30 is intermediate. This behavior should not be generalized: published ethanol studies report different NOx directions depending on engine calibration and operating condition.

9. Comparative Experimental Assessment

Table 3. Representative comparison at 2500 rpm.

Parameter at 2500 rpm	E10	E20	E30	Best representative result
Brake power (kW)	2.72	2.80	2.77	E20
BSFC (kg/kWh)	0.32	0.30	0.33	E20
BTE (%)	29.4	31.2	30.3	E20
CO (% vol.)	1.70	1.45	1.28	E30
HC (ppm)	132	118	110	E30
NOx (ppm)	790	830	810	E10 in this dataset
EGT (°C)	420	428	416	Condition-dependent

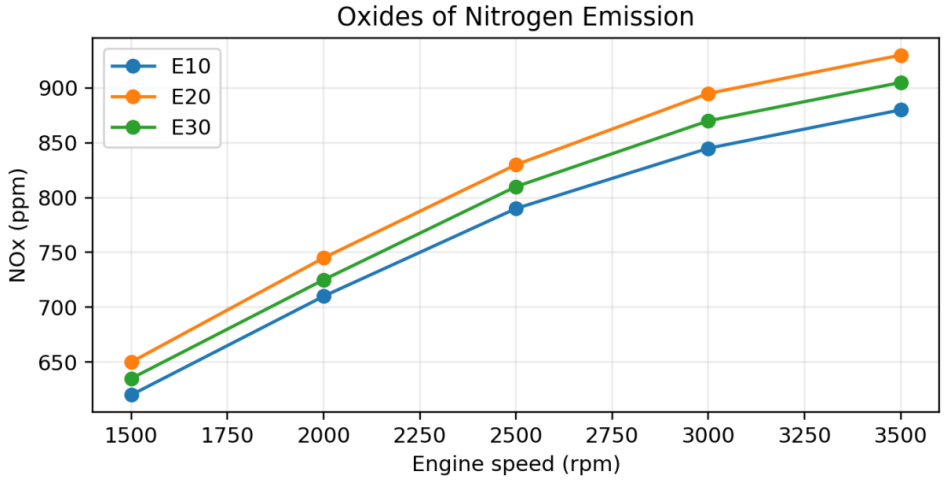


Figure 7. Representative NOx emission variation.

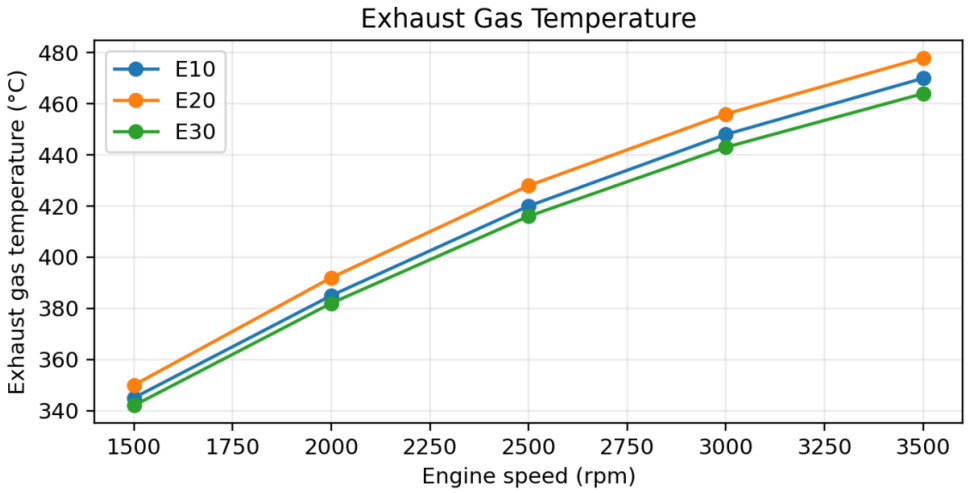


Figure 8. Representative exhaust gas temperature variation.

11. CONCLUSIONS

An experimental methodology for performance and emission comparison of E10, E20 and E30 ethanol–petrol blends has been presented. The representative results indicate that E20 provides the best overall performance compromise, with the highest brake thermal efficiency and lowest BSFC across much of the investigated range. E30 provides the strongest reduction in representative CO and HC emissions because of its higher oxygen content. Brake power differences among the three blends remain relatively small, indicating that moderate ethanol blends can be evaluated in a conventional SI engine without major hardware changes for short-duration laboratory testing. NOx does not follow a simple monotonic trend because it depends strongly on combustion temperature and calibration. The results support E20 as a promising compromise for performance and emissions, while E30 may offer additional incomplete-combustion emission benefits if the engine is appropriately calibrated.

REFERENCES

1. Abdullah, N. R. and Zaharin, M. S. M., Effects of Ethanol Blends on Gasoline Engine Performance and Exhaust Emissions, *Jurnal Teknologi*, 76(11), 2015.
2. Hsieh, W. D. et al., Engine Performance and Pollutant Emission of an SI Engine Using Ethanol–Gasoline Blended Fuels, *Atmospheric Environment*, 36, 403–410, 2002.
3. Al-Hasan, M., Effect of Ethanol–Unleaded Gasoline Blends on Engine Performance and Exhaust Emission, *Energy Conversion and Management*, 44, 1547–1561, 2003.
4. Bayraktar, H., Experimental and Theoretical Investigation of Using Gasoline–Ethanol Blends in Spark-Ignition Engines, *Renewable Energy*, 30, 1733–1747, 2005.
5. Yücesu, H. S. et al., The Effects of Ethanol–Unleaded Gasoline Blends and Ignition Timing on Engine Performance and Exhaust Emissions, *Renewable Energy*, 31, 2534–2542, 2006.
6. Phuangwongtrakul, S. et al., Experimental Study on Sparking Ignition Engine Performance for Optimal Mixing Ratio of Ethanol–Gasoline Blended Fuels, *Applied Thermal Engineering*, 100, 869–879, 2016.
7. Turner, D. et al., Spark Ignition Engine Combustion, Performance and Emission Products from Hydrous Ethanol and Its Blends with Gasoline, *Energies*, 9, 984, 2016.
8. Paramasivam, S., Subramanian, K. A. and Mathai, R., Experimental Study on Unregulated Emission Characteristics of a Two-Wheeler with Ethanol-Gasoline Blends (E0 to E50), *Fuel*, 262, 116504, 2020.

9. Recent Study: Comprehensive Efficiency Analysis of Ethanol–Gasoline Blends in Spark Ignition Engines, *Eng*, 6(10), 256, 2025.
10. Wyrąbkiewicz, S. et al., Emissions and Particulate Characteristics of Spark-Ignition Engines Fueled with Bioethanol–Gasoline Blends, *Energies*, 18, 4606, 2025.
11. Investigation of Spark Ignition Engine Performance in Ethanol–Petrol Blended Fuels Using Artificial Neural Network, *Scientific Reports*, 2025.
12. Effects of Ethanol-Gasoline Blending on Combustion, Performance, and Emissions of a Spark Ignition Engine: An Experimental and Detailed Chemistry-Based Numerical Study, *ACS Omega*, 2026.
13. SAE International, Literature on Ethanol–Gasoline Spark-Ignition Engine Applications.
14. Heywood, J. B., *Internal Combustion Engine Fundamentals*, McGraw-Hill.
15. Pulkrabek, W. W., *Engineering Fundamentals of the Internal Combustion Engine*, Pearson.
16. ASTM D4814, *Standard Specification for Automotive Spark-Ignition Engine Fuel*.
17. ASTM D4806, *Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines*.
18. Bureau of Indian Standards, IS 17021:2018, *E20 Fuel—Admixture of Anhydrous Ethanol and Gasoline*.
19. Rode, R., Kurpatwar, B., Patil, P., Gitay, M., Pawar, N., & Ghule, A. (2026). Research and Experimental Analysis of Intelligent Predictive Maintenance for Industrial Machinery Using AI-Based Analytical Techniques. *Aposta: Revista De Ciencias Sociales*, 24(114), e988. https://doi.org/10.23900/ra.v24i114.988
20. Mohod, Amar, Gitay, Mayur, Patil, Pradeep, Kaware, Kiran, Pawar, Nitin, & Patil, Mangesh. (2026). Design, Modeling, and Validation of an AI-Driven Resonant Inductive Charging Module for Next-Generation Electric Vehicle Architectures. *Aposta: Revista de Ciencias Sociales*, 24, e1003. https://doi.org/10.23900/ra.v24i114.1003
21. Jadhao, Pramod K., Karale, Dr. Sachin R., Pawar, Nitin N., & Sah, Brijkishor. (2025). Analytical and CAD Modeling of Double-Acting Reciprocating Compressor Components. *Utilitas Mathematica*, 122.
22. Pawar, Nitin Namdeo, Jadhao, Dr. Kiran K., Bothra, Dr. L. S., & Kumar, Dr. Santosh. Design and Analysis of Pumping Housing for Water Cooled Engine System. *GIS Science Journal*, 318–331.

23. Pawar, Nitin Namdeo. (2016). Cooling of LED Bulb by Using a Different Array of Fins. *International Journal of Innovative Research in Science and Engineering*, 2(7), July 2016.
24. Pawar, Nitin N. (2016). Cooling of LED Bulb by Using a Different Array of Fins. *5th International Conference on Science Technology and Management*, 30 July 2016.
25. Pawar, Nitin N. (2016). Cooling of LED Bulb by Using a Different Array of Fins. *International Conference on Research Challenges in Engineering and Technology*, 18–19 August 2016.
26. Pawar, Nitin N. (2024). Application of LED Bulb with Perforated Plus Shape Fin Array in Mines. *Journal of Mines, Metals and Fuels*.
27. Pawar, Nitin Namdeo. (2023). Design and Evaluation of Perforated Fins with Different Array of Fins Structure by an Active Mode of Cooling System. *Journal of Mines, Metals and Fuels*.
28. Pawar, Nitin Namdeo, & Nanwala, Hameshbabu. Study of Extruded Aluminum Alloy LED Bulb in a Passive Mode of the Cooling System with a Different Array of Fin Structure. *Journal of Material Engineering*, 2, 35–43.
29. Pawar, Nitin Namdeo. Design and Simulation of High Power LED Bulbs with Different Array of Fins in Passive Mode of Cooling. *Microelectronics, Circuits and Systems, Lecture Notes in Electrical Engineering*, Springer Nature Singapore Pte Ltd., 2023, Vol. 976.
30. Pawar, Nitin Namdeo. (2026). Analysis of LED Bulb by Mathematical and Simulation Methods with Porous Fin Material with Square-Shaped Extruded Fins in Passive Cooling Mode. *Journal of Technology*, 16(1), 125–132.
31. Pawar, Nitin, & Nanwala, Dr. Himeshbabu. (2024). Mathematical and Simulation Analysis of Various LED Bulb Arrays. *Second International Conference on Advances in Thermal Systems, Materials and Design Engineering (ATSMDE–2024)*, 28 December 2024.
32. Pawar, Nitin Namdeo. Design, Fabrication and Testing of a Water Cooler with a Use of Heat Exchanger as Economizer. *7th International Conference on Innovation and Research in Engineering Technology*, 8–9 April 2022, Elsevier and SSRN.
33. Pawar, Nitin N. Design, Fabrication and Testing of a Water Cooler with a Use of Heat Exchanger as Economizer. *International Journal of Scientific Research in Engineering and Management*, February 2022.

34. Pawar, Nitin. (2024). An Experimental Investigation on Diesel Engine Performance by the Application of Dual Bio-Diesel Blends. *Journal of Mines, Metals and Fuels*.
35. Pawar, Nitin Namdeo. An Experimental Investigation of the Production of Plastic Fuel and Blend with Diesel Fuel. *Microelectronics, Circuits and Systems, Lecture Notes in Electrical Engineering*, Springer Nature Singapore Pte Ltd., 2023, Vol. 976.
36. Pawar, Nitin Namdeo. Analysis of Li-Iron Battery Performance with Respect to Temperature and Some Other Parameter. *3rd National Conference on Research and Development in Mechanical, Electronics and Civil Engineering*.
37. Pawar, Nitin. Performance Analysis on Solar Flat Plate Collector with Reducing Energy Wastage Using Optimal Geometry Application. *Journal of Harbin Engineering University*, 1380–1387.
38. Pawar, Nitin N. Ozone Generation. *International Journal for Science and Advance Research in Technology*, May 2019.
39. Kumara, Santosh, & Pawara, Nitin Namdeo. Design of Experiment with Tribological Performance Analysis of Electroless Nano-Composite Ni-P-SiC Coating for Conveyors. *Tribology in Industry*.
40. Pawar, Nitin. Design and Fabrication of Multi-Stage Automatic Sand Separator. *7th International Conference on Innovation and Research in Engineering Technology*, 8–9 April 2022, Elsevier and SSRN.
41. Pawar, Nitin N. Design and Fabrication of Multi-Stage Automatic Sand Separator. *International Journal of Scientific Research in Engineering and Management*, February 2022.
42. Shaikh, J. S., & Ismail, S. (2022). A Review on Recent Technological Advancements in Humidification Dehumidification (HDH) Desalination. *Journal of Environmental Chemical Engineering*, 10, 108890. https://doi.org/10.1016/j.jece.2022.108890
43. Shaikh, J. S., & Ismail, S. (2023). Theoretical Investigation on Humidification–Dehumidification Desalination Employing Flat-Plate Solar Water Collector. *Journal of Thermal Analysis and Calorimetry*, 148, 11835–11853. https://doi.org/10.1007/s10973-023-12478-6
44. Shaikh, J. S., Aswalekar, U., Ismail, S., & Akhade, A. (2024). The Potential of Integrating Solar-Powered Membrane Distillation with a Humidification–Dehumidification System to Recover Potable Water from Textile Wastewater. *Chemical Engineering and Processing – Process Intensification*, 205, 110036. https://doi.org/10.1016/j.cep.2024.110036

45. Shaikh, J. S., Ismail, S., Aswalekar, U., Mane, K. V., & Wahile, G. (2025). Theoretical and Experimental Investigation of a Pilot-Scale Solar Air-Heated Humidification Dehumidification Desalination System. *Solar Energy*, 285, 113122. https://doi.org/10.1016/j.solener.2024.113122
46. Shaikh, J. S., Aswalekar, U., Sonkhaskar, Y. M., Save, A., Malgol, A., & Wahile, G. (2026). Evaluation of Photovoltaic Thermal-Based Humidification-Dehumidification Desalination. *Applied Thermal Engineering*, 285, 129277. https://doi.org/10.1016/j.applthermaleng.2025.129277
47. Sikandar, J., & Saleel, S. (2023). Investigations on a Solar Humidification Dehumidification Desalination System Equipped with Various Packing Materials and Multi-Stage Bubble Column Dehumidifier. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-023-31143-x
48. Waybase, S. S., Jawahar, C. P., Shaikh, J. S., Aswalekar, U., Bhakre, S., & Nair, J. (2026). Theoretical and Experimental Investigation of a Solar-Driven Air Gap Membrane Distillation System for the Treatment of Hypersaline Brine. https://doi.org/10.1177/09544089261484799
49. Shaikh, J. S., Aswalekar, U., Himte, R., Sonkhaskar, Y. M., Save, A., Palve, V., & Wahile, G. (2026). Performance Evaluation of a PV/T-Powered Membrane Distillation System for Industrial Cooling Tower Blowdown Water Treatment. *Chemical Engineering and Processing – Process Intensification*, 226, 110844. https://doi.org/10.1016/j.cep.2026.110844
50. Akhade, A. (2025). Review on Recent Technological Advancements on Solar-Powered Stirling Engine. https://doi.org/10.1002/htj.23393
51. Akhade, A., Patil, R., & Shaikh, J. S. (2026). Investigation of a Scheffler Collector-Powered Stirling Engine: Theoretical Modeling and Experimental Validation for Decentralized Power Production. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 48. https://doi.org/10.1080/15567036.2026.2649260
52. Wahile, G. S., Londhe, S. D., Sikandar, J., & Bhakre, S. (2025). Experimental Investigation on Photovoltaic Panel Integrated with Fins and Cotton Wicks. https://doi.org/10.1080/15567036.2025.2498670
53. Bhakre, S., Wahile, G., Narkhede, S., & Kene, A. (2026). Environmental Effects: Thermal and Electrical Performance Enhancement of Photovoltaic Modules Using Evaporative Cooling under Hot-Arid Conditions. https://doi.org/10.1080/15567036.2026.2738828

54. Shaikh, J. S., Aswalekar, U., & Malgol, A. (2026). Mechanical and Tribological Characterization of Eco-Friendly Brake Pads Using Banana Peel Powder as a Sustainable Friction Material. *Mechanics of Advanced Composite Structures*, 13, 427–437. https://doi.org/10.22075/macs.2025.35827.1756
55. Malgol, A., Shaikh, J. S., Uppin, V. S., Siddiqui, A., Salunkhe, V. G., Ram, T., Marimuthu, S., & Aswalekar, U. (2026). Influence of Fluid-Induced Tangential Forces, Nonlinear Stiffness, and Internal Damping on the Vibration Response of a Jeffcott Rotor System. *Noise & Vibration Worldwide*, 57, 539–562. https://doi.org/10.1177/09574565261419567