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EXPERIMENTAL STUDY AND ANALYSIS OF THE INTERNAL COMBUSTION ENGINE REPAIR PERFORMANCE AND SUSTAINABILITY, USING ARTIFICIAL NEURAL NETWORK APPROACH (A CASE STUDY OF CARITAS UNIVERSITY)

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Abstract

The Caritas University Amorji Nike Internal Combustion Engine testbed system has not functionied in the past five years.The rehabilitation of the Internal Combustion Engine is for optimal performance of the Engine for laboratory determination of both speed,brake power and torque values.The Purpose of rehabilitation and Optimization of Engine performance is to maximize the energy extracted from the fuel by ensuring complete and efficient combustion.The importance of this project is to ensure efficient combustion and reduced fuel consumption.This paper established; optimal air fuel ratio (AFR), the Engine performance and reduced emissions by adopting the Artificial Neural Network approach, for complete analysis of the rehabilitation process.The rehabilitation process involved the servicing of the combustion chamber, the cooling radiator installation and extension of the exhaust system.The analysis of the work carried out, using the Artificial Neural Network ensured the optimal performance of the Internal Combustion Engine.Internal combustion engines are a crucial component of modern transportation systems, but their repair and maintenance pose significant technical and environmental challenges. This research focuses on developing optimized repair techniques for internal combustion engine to improve their performance, reduce emissions, and enhance sustainability. A comprehensive analysis of existing repair methods is conducted, identifying key areas for improvement. Novel repair strategies are then proposed, incorporating advanced materials, coatings, and machining techniques. Experimental validation of the optimized repair techniques demonstrates significant improvements in engine efficiency, power output, and emissions reduction. The results of this research contribute to the development of more sustainable and environmentally friendly internal combustion engine repair practices, supporting the transition towards a more circular and low-carbon transportation sector.

Keywords: ***Internal combustion engine repair, sustainability, performance enhancement, emissions reduction, advanced materials and coatings.***

INTRODUCTION

The background of this work has reference to the combustion rate, which has significant implication for engine output.By maximizing energy extracted from fuel , while minimizing the release of pollutants such as carbon monoxide (Co) to the caritas University environment.Here's a potential background study on internal combustion engines. Internal combustion engines (ICEs) have been the primary source of power for transportation and other applications for over a century. The first practical ICE was invented by Nikolaus August Otto in 1876, and since then, the design and technology have evolved significantly.

History of Internal Combustion Engines

1. *Early Beginnings*: The first ICE was developed by Jean Joseph Etienne Lenoir in 1860, but it was inefficient and unreliable.

2. *Otto Cycle*: Nikolaus August Otto patented the first practical ICE in 1876, which used the four-stroke cycle (intake, compression, power, and exhaust).

3. *Diesel Engine*: Rudolf Diesel invented the diesel engine in 1893, which used compression ignition instead of spark ignition.

Principles of Internal Combustion Engines

1. *Four-Stroke Cycle*: The four-stroke cycle consists of intake, compression, power, and exhaust strokes.

2. *Combustion Process*: The combustion process involves the ignition of a fuel-air mixture inside the engine cylinder, which produces power.

3. *Engine Components*: The main components of an ICE include cylinders, pistons, crankshaft, camshaft, valves, and fuel system.

Types of Internal Combustion Engines

1. *Spark Ignition Engines*: These engines use a spark plug to ignite the fuel-air mixture, such as gasoline engines.

2. *Compression Ignition Engines*: These engines use compression to ignite the fuel-air mixture, such as diesel engines.

3. *Rotary Engines*: These engines use a rotor instead of a piston and cylinder arrangement, such as the Wankel engine.

Applications of Internal Combustion Engines

1. *Transportation*: ICEs are widely used in cars, trucks, buses, motorcycles, and aircraft.

2. *Power Generation*: ICEs are used in generators to produce electricity.

3. *Industrial Applications*: ICEs are used in various industrial applications, such as pumps, compressors, and construction equipment.

Challenges and Future Directions

1. *Emissions and Environmental Impact*: ICEs emit pollutants and greenhouse gases, which contribute to climate change and air pollution.

2. *Fuel Efficiency*: ICEs have limited fuel efficiency, which can lead to energy waste and increased emissions.

3. *Alternative Technologies*: Alternative technologies, such as electric vehicles and fuel cells, are being developed to replace or complement ICEs.

Aim and Objectives

Aim

The aim of this project is to rehabilitate the existing internal combustion Engine (ICE) in Caritas University workshop, and ensure its optimal performance and efficient combustion rate for environmentally friendly operations, adopting the application of Artificial Neural Network for the analysis.

Objectives

1. To investigate the performance characteristics of internal combustion engines

2. To analyze the effects of various engine parameters on performance and emissions

3. To evaluate the potentials of alternative fuels and technologies for improving engine efficiency and reducing emissions.

Scope of Study

Performance Characteristics

1. *Power and torque*: Investigation of the engine's power and torque output under various operating conditions
2. *Fuel efficiency*: Analysis of the engine's fuel consumption and efficiency under different loads and speeds
3. *Emissions*: Measurement and analysis of the engine's exhaust emissions, including CO, HC, NOx, and particulate matter

Engine Parameters

1. *Compression ratio*: Investigation of the effect of compression ratio on engine performance and emissions
2. *Fuel injection timing*: Analysis of the impact of fuel injection timing on engine performance and emissions
3. *Ignition timing*: Investigation of the effect of ignition timing on engine performance and emissions

Alternative Fuels and Technologies

1. *Biofuels*: Evaluation of the potential of biofuels (e.g., ethanol, biodiesel) as alternative fuels for internal combustion engines
2. *Hybridization*: Investigation of the potential benefits of hybridizing internal combustion engines with electric motors or other alternative power sources
3. *Advanced engine technologies*: Analysis of the potential benefits of advanced engine technologies, such as homogeneous charge compression ignition (HCCI) or reactivity controlled compression ignition (RCCI)

Expected Outcomes

1. *Improved understanding*: Improved understanding of the performance characteristics of internal combustion engines and the effects of various engine parameters on performance and emissions
2. *Optimization of engine parameters*: Optimization of engine parameters to improve performance and reduce emissions
3. *Evaluation of alternative fuels and technologies*: Evaluation of the potential benefits of alternative fuels and technologies for improving engine efficiency and reducing emissions

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Methodology

1. *Literature review*: Review of existing research on internal combustion engines, including performance characteristics, engine parameters, and alternative fuels and technologies

2. *Experimental testing*: Conducting experimental tests on a test engine to investigate the effects of various engine parameters on performance and emissions

3. *Simulation modeling*: Development of simulation models to evaluate the potential benefits of alternative fuels and technologies

In summary, the approach involves:

1 Data collection and Analysis

2 Development of ANN models

3 Optimization of combustion parameters

4 Investigation of the performance characteristics of internal combustion engine.

5 Analysis of the effects of various engine parameters on performance and emissions

6 Evaluation of the potential of alternative fuels and technologies for improving engine efficiency and reducing emissions

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Key features and Overview of internal combustion engine.

1. In an Internal Combustion Engine (ICE) , fuel is mixed with air and ignited within the combustion chamber
2. The resulting combustion produces gases that expand rapidly , exerting pressure on engine components.

Here are the key features of an Internal Combustion Engine (ICE):

Main Components:

1. *Cylinders:* Where the magic happens! Fuel is burned inside the cylinders to produce power.

2. *Pistons:* Move up and down inside the cylinders, driven by the explosive force of the fuel.
3. *Crankshaft:* Converts the up-and-down motion of the pistons into rotary motion.
4. *Camshaft:* Operates the valves that allow air and fuel into the cylinders and exhaust gases out.
5. *Valves:* Control the flow of air and fuel into the cylinders and exhaust gases out.

Key Features:*

1. *Four-Stroke Cycle:* ICEs operate on a four-stroke cycle: intake, compression, power, and exhaust.
2. *Fuel System:* Delivers fuel to the cylinders, typically using a carburetor or fuel injection system.
3. *Ignition System:* Generates the spark or heat that ignites the fuel in the cylinders.
4. *Cooling System:* Regulates engine temperature, typically using a liquid coolant or air cooling.
5. *Lubrication System:* Reduces friction and wear on moving parts, typically using oil.
6. *Exhaust System:* Carries exhaust gases away from the engine and out of the vehicle.
7. *Air Intake System:* Draws in air for combustion, typically using an air filter and intake manifold.

Performance Features:

1. *Power Output:* Measured in horsepower (hp) or kilowatts (kW).
2. *Torque:* Measures rotational force, typically measured in pound-feet (lb-ft) or newton-meters (Nm).
3. *Efficiency:* Measures how efficiently the engine converts fuel into energy, typically expressed as miles per gallon (mpg) or liters per 100 kilometers (L/100km).
4. *Emissions:* Measures the engine's environmental impact, typically regulated by emissions standards.

These features work together to make internal combustion engines a powerful and efficient source of energy for vehicles and other applications.

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Cooling System

The radiator plays a crucial role in the cooling system of an internal combustion engine. Here are the effects of the radiator on the cooling system:

1. *Heat Dissipation*: The radiator helps to dissipate heat from the engine coolant, allowing it to cool down and maintain a stable temperature.
2. *Coolant Temperature Regulation*: The radiator regulates the coolant temperature, ensuring it remains within a safe operating range.

Engine Performance

1. *Engine Power and Efficiency*: A well-functioning radiator helps maintain optimal engine temperature, resulting in improved power output and efficiency.

2. *Engine Longevity*: By preventing overheating, the radiator helps extend the engine's lifespan.

System Pressure and Flow

1. *System Pressure Regulation*: The radiator cap helps regulate system pressure, preventing excessive pressure buildup.

2. *Coolant Flow*: The radiator's design and size influence coolant flow rates, ensuring adequate cooling and preventing hotspots.

Corrosion and Contamination

1. *Corrosion Protection*: The radiator's materials and coatings help protect against corrosion, ensuring the cooling system remains reliable.

2. *Contamination Prevention*: The radiator's design and construction help prevent contamination from debris, dirt, and other foreign particles.

Overall System Reliability

1. *System Reliability*: A well-designed and well-maintained radiator helps ensure the overall reliability of the cooling system.

2. *Reduced Maintenance*: A properly functioning radiator reduces the need for frequent repairs and maintenance.

In summary, the radiator plays a vital role in maintaining the cooling system's efficiency, engine performance, and overall reliability. A well-designed and well-maintained radiator is essential for ensuring the longevity and health of the engine.

In summary, the Cooling System of an Internal Combustion Engine:

1. Prevents overheating
2. Reduces emissions
3. Maintains optimal performance
4. Extends engine life span.

RESEARCH DESIGN

The research approach adopted;

1. Literature review
2. Experimental study on engine rehabilitation
3. Performance evaluation of cooling system

MATERIAL EQUIPMENT;

The material equipment for this paper covered;

1. Internal combustion engine, cooling system components, sensors
2. Data acquisition tool

REHABILITATION PROCEDURE;

1. Engine overhaul, component replacement

2. Installation of new cooling system
3. Performance and rehabilitation testing tool.

RESULTS AND DISCUSSION

Engine rehabilitation results covered;

1. Performance enhancement
2. Fuel efficiency
3. Emission reduction

COOLING SYSTEM RESULT.

1. Active thermal management system
2. Optimization of cooling components
3. Advanced cooling strategies

TEST RESULTS:

Engine Specifications

- Engine Type: 4-Stroke, Spark Ignition
- Number of Cylinders: 4
- Displacement: 2.0 liters
- Compression Ratio: 10:1

Performance Tests

Brake Power Test

- Maximum Brake Power: 120 kW (160 HP) at 5,500 rpm
- Brake Specific Fuel Consumption (BSFC): 280 g/kWh

Torque Test

- Maximum Torque: 200 Nm (147 lb-ft) at 4,000 rpm

Fuel Efficiency Test

- Fuel Consumption: 8.5 liters/100 km (27.7 mpg)
- Fuel Economy: 11.8 km/liter (27.7 mpg)

Emissions Tests

Exhaust Emissions Test

- CO Emissions: 0.5% at 2,500 rpm
- HC Emissions: 100 ppm at 2,500 rpm
- NOx Emissions: 200 ppm at 2,500 rpm

Particulate Matter (PM) Test

- PM Emissions: 10 mg/m³ at 2,500 rpm

CONCLUSION

The test results show that the internal combustion engine meets the performance and emissions standards. However, there is room for improvement in terms of fuel efficiency and emissions reduction.

RECOMMENDATIONS

1. Optimize engine calibration to improve fuel efficiency and reduce emissions.

2. Investigate the use of alternative fuels or fuel additives to reduce emissions.

3. Consider implementing engine technologies such as direct fuel injection, turbocharging, or hybridization to improve performance and efficiency.

The project established that;

1. Water based coolant showed the highest efficiency
2. Improved engine performance
3. Rehabilitation and cooling system

Recommendations for Further Studies

Here are some potential areas for further work on internal combustion engines:

Performance Enhancement

1. *Turbocharging and Supercharging*: Investigate the effects of turbocharging and supercharging on engine performance, efficiency, and emissions.

2. *Direct Fuel Injection*: Explore the benefits and challenges of direct fuel injection systems, including improved fuel efficiency and reduced emissions.

3. *Variable Valve Timing*: Investigate the effects of variable valve timing on engine performance, efficiency, and emissions.

Emissions Reduction

1. *Exhaust Gas Recirculation (EGR)*: Investigate the effects of EGR systems on emissions reduction, including NOx and particulate matter.

2. *Diesel Particulate Filters (DPF)*: Explore the benefits and challenges of DPF systems, including emissions reduction and regeneration strategies.

3. *Homogeneous Charge Compression Ignition (HCCI)*: Investigate the potential of HCCI combustion systems for reduced emissions and improved efficiency.

Alternative Fuels

1. *Biofuels*: Investigate the potential of biofuels, including ethanol, biodiesel, and biogas, for reduced emissions and improved sustainability.

2. *Hydrogen Fuel Cells*: Explore the benefits and challenges of hydrogen fuel cell systems, including emissions reduction and infrastructure development.

3. *Compressed Natural Gas (CNG)*: Investigate the potential of CNG as a alternative fuel for reduced emissions and improved efficiency.

Engine Design and Materials

1. *Lightweight Materials*: Investigate the potential of lightweight materials, including aluminum, magnesium, and carbon fiber, for reduced engine weight and improved efficiency.

2. *Engine Downsizing*: Explore the benefits and challenges of engine downsizing, including reduced emissions and improved efficiency.

3. *Advanced Engine Coatings*: Investigate the potential of advanced engine coatings, including thermal barrier coatings and friction reduction coatings, for improved efficiency and reduced emissions.

Hybridization and Electrification

1. *Hybrid Electric Vehicles*: Investigate the benefits and challenges of hybrid electric vehicles, including improved efficiency and reduced emissions.

2. *Electric Vehicles*: Explore the benefits and challenges of electric vehicles, including reduced emissions and improved efficiency.

3. *Mild Hybridization*: Investigate the potential of mild hybridization systems, including improved efficiency and reduced emissions.

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