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Impact of Fuel Additives on Diesel Engine Exhaust Emissions and Performance

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Abstract: *Diesel engines are widely used in transportation and agriculture due to their high efficiency. However, diesel engines emit harmful exhaust gases such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter, which affect human health and the environment. One simple method to reduce exhaust emissions without major engine modification is the use of fuel additives. This study investigates the effect of commercial diesel fuel additives on engine performance and exhaust emissions. The analysis is based on experimental data reported by Laurinaitis and Mickevičius (2018). Results show that fuel additives influence combustion behavior by changing ignition delay and in-cylinder pressure. It is observed that while some additives reduce smoke and improve combustion, they may increase CO and HC emissions at low engine loads. Simple performance and emission calculations are included to understand the impact of additives on brake specific fuel consumption and emission variation.*

Keywords: Diesel engine, fuel additives, exhaust emissions, CO, HC, NOx, BSFC

I. INTRODUCTION

Diesel engines play a major role in modern transportation, power generation, and agricultural machinery. Despite their advantages, diesel engines contribute significantly to air pollution. Exhaust emissions such as carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NOx), and smoke are harmful to both human health and the environment.

Modern emission control technologies like catalytic converters and diesel particulate filters are effective but expensive and complex, especially for older engines. Therefore, fuel modification using chemical additives is considered a low-cost and practical solution. Fuel additives are mixed with diesel in small quantities to improve combustion characteristics, reduce ignition delay, and influence exhaust emissions.

This paper evaluates the impact of diesel fuel additives on engine performance and emissions using experimental results reported in earlier research

II. FUEL ADDITIVES AND THEIR ROLE

Fuel additives used in diesel engines generally contain compounds such as:

- Hydrocarbons (C10–C14)
- n-alkanes and iso-alkanes
- Cycloalkanes and aromatic compounds
- Ignition improvers such as 2-ethylhexyl nitrate

These additives affect:

- Ignition delay
- Rate of heat release
- In-cylinder pressure
- Exhaust gas composition

Shorter ignition delay usually improves combustion efficiency but may increase combustion temperature, leading to higher NOx emissions

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III. EXPERIMENTAL METHOD (BASED ON REFERENCE STUDY)

The reference experimental study was conducted on a **four-cylinder, turbocharged diesel engine** operating at constant speeds of **1800 rpm and 2200 rpm**. Different engine loads were applied and expressed in terms of **Indicated Mean Effective Pressure (IMEP)**.

Three different fuel additives were blended with diesel fuel in small proportions. Exhaust emissions such as CO, HC, NOx, and smoke opacity were measured using standard exhaust gas analyzers.

IV. HYDROCARBON (HC) EMISSION

HC emissions were observed to **increase significantly at low loads** due to incomplete combustion. At higher loads, HC emissions tended to stabilize.

This increase is attributed to:

- Poor air-fuel mixing at low loads
- Lower combustion temperature

V. NITROGEN OXIDES (NOX)

NOx emissions increased with increasing engine load for both diesel and additive-blended fuels.

Higher combustion temperature caused by additives leads to:

- Faster combustion
- Increased NOx formation

However, NOx values remained within older emission standards.

V. CONCLUSIONS

- Fuel additives influence diesel engine combustion and exhaust emissions.
- At low loads, additives tend to increase CO and HC emissions.
- NOx emissions increase due to improved combustion temperature.
- Pure diesel shows better fuel economy compared to additive blends.
- Fuel additives are more suitable for specific operating conditions rather than all-range usage.

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