

Excessive Car Engine Smoking: Investigating the Causes and Remedial Strategies for Safety and Sustainability

Uwem Jackson Edemidiongs

Department of Reduction, QAL- Reduct. Industrial Maint, Nsit Ibom, Akwa Ibom State, Nigeria

Abstract: The phenomenon of excessive engine smoking in cars is a serious problem that not only affects the performance of the vehicle but also presents a significant risk to the environment and public safety. It is frequently caused by underlying mechanical failures, such as worn-out piston rings, malfunctioning valve seals, or clogged air filters, which allow fuel, oil, or coolant to burn within the engine. On the other hand, excessive engine smoke can lead to serious engine damage, decreased fuel economy, and increased emissions of dangerous pollutants if ignored. The study aims to identify the main factors causing excessive engine smoke, evaluate the effects on vehicle safety and environmental sustainability, and provide practical solutions. The paper also examines typical engine components and diagnostic techniques to emphasize preventative maintenance strategies, including using cleaner fuels, changing oil on time, and performing routine engine inspections. It also looks at innovative remedies, such as switching to low-emission vehicles and sustainable automobile technology that lessen environmental impact. In addition to being essential for road safety, making sure automobile engines are operating properly is a critical first step in developing sustainable transportation.

Keywords: Car Engine Smoking, Causes, Effects, Prevention, Control Safety and Sustainability.

Introduction

In terms of both vehicle safety and environmental sustainability, excessive automobile engine smoke has become a major problem. This phenomenon, which is frequently typified by observable exhaust fumes from a car may indicate underlying mechanical issues or inefficiencies that impair car performance and raise dangers to the public's health as well as air pollution. A study by Wang et al. (2021) highlights that the type of fuel used, along with inadequate engine maintenance practices, directly correlates with the severity of engine emissions. Their findings highlight the necessity for car owners and manufacturers alike to adopt stricter fuel standards and regular maintenance practices to reduce excessive smoking.

The World Health Organization states that one of the main causes of air pollution, which poses a serious danger to public health, is vehicle emissions. However, excessive automobile smoking is becoming more common, which calls for a detailed examination into its origins and the use of practical corrective measures to reduce the hazards involved. Additionally, according to recent research, a sizable portion of automobiles on the road show symptoms of engine smoke. This is frequently the result of a confluence of bad engine component wear and tear, inferior fuel quality, and inadequate maintenance.

Additionally, the environmental implications of such emissions are profound as it is estimated that vehicles contribute to over 20% of greenhouse gas emissions in urban areas (Smith & Jones, 2022). But tackling the issues of excessive automobile engine smoke necessitates integrating

technical improvements and regulatory frameworks intended to promote safer and cleaner vehicles in addition to comprehending the mechanical and operational origins of the problem. Engine pollution may be greatly decreased by using techniques including switching to cleaner fuels, doing routine auto checkups, and making use of innovative diagnostic tools. To further ensure the sustainability of automotive practices, it is imperative to promote public awareness and education on the significance of vehicle maintenance. In summary, the issue of excessive automotive engine smoke is a complex challenge involving the fields of public health, environmental science, and mechanical engineering.

Concept of Car Engine

The engine of an automobile is a heat engine that powers the wheels by converting gasoline into mechanical energy. The engine, which is the center of the vehicle, operates through a sequence of steps called the four-stroke cycle. A study by Xie et al. (2020) highlights that despite advancements in engine technologies, fuel consumption remains a challenge, particularly due to energy losses in the form of heat and friction Engine Efficiency and Optimization. The goal of recent research has been to increase internal combustion engine efficiency. But the engine is a sophisticated device designed to transform heat from burning gas into the force needed to spin the wheels of the vehicle. One of the most amazing and revolutionary feats in engineering is the vehicle engine, sometimes called the "heart" of an automobile. In order to convert gasoline into the mechanical power that moves a car forward, a sophisticated assemblage of carefully crafted parts must function in perfect unison. Machines intended to transform one or more energy sources into mechanical energy are also referred to as motors or vehicle engines.

Moreover, the car's engine is an internal combustion, positive displacement engine with an intake, compression, combustion, and exhaust stroke. It is also a sophisticated device designed to transform gasoline into mechanical energy by means of a sequence of regulated combustions, or explosions, in the cylinders. These combustions power the pistons, which spin the crankshaft and provide the rotary motion that propels the car's wheels. However, a study by Martínez et al. (2020) explored the use of alternative fuels such as biofuels and hydrogen to reduce emissions. According to the study, there are still issues with engine wear and fuel supply, but using biofuels in internal combustion engines can save carbon emissions considerably. Fuel conversion to operational power is the primary function of an intricate machine like an automobile engine. Modern automobile engines come in a range of cylinder designs, from four to eight, and many internal components work together to power the engine.



Fig 1: Picture of a Car Engine

Source: <https://unsplash>



Fig 2: Picture of a car Engine

Source: <https://auto.howstuffworks>

Concept of Car Engine Smoking

Numerous factors can cause an automobile's engine to smoke, and the nature of the smoke might reveal the issue. Car engines frequently produce smoke when they overheat. Faulty wire casings, hot residues on the engine block, and overheated fluids including braking, transmission, and oil can all be the cause of this. There may also be a defect with the coolant system, or the engine may not have enough lubrication. Mugglestone (2024) affirmed that, Smoke from an engine is caused by partially burned fuel. Inadequate fuel atomization may result in smoke. For the fuel to

burn efficiently, it must be combined with air in extremely minute droplets. Although blocked or broken injectors are the primary reason, inadequate fuel atomization can also contribute to smoke.

When smoke emerges from the vehicle, it might be coming from the exhaust system or the engine. This is known as car smoking. There are several methods for dealing with a burning automobile, depending on where the smoke is coming from and how dangerous it is. Mille (2024) explained that, any kind of smoke coming out of the exhaust pipe means that your car is under some sort of stress. Depending on the nature of the issue, the tailpipe may emit smoke in a variety of colors, which will help determine what sort of servicing or repairs the vehicle may require. Depending on whether the automobile is powered by a gasoline or diesel engine, there are many reasons why the smoke is visible.

Certain engine parts are already damaged when an automobile engine smokes. Remember that if the automobile is overheating, the reason of the overheating could also be the source of the smoke before blaming the smoking on an overheating engine. In jurisdictions with rigorous emissions rules, the most prevalent kind of smoke from an exhaust is not truly smoke at all. Smoking cars may be pulled over by law authorities, the driver may be penalized, and the vehicle may even be seized. A cold engine quickly starts to heat up, producing water vapor as a byproduct. As a result, condensation forms inside the exhaust system, which escapes through the exhaust as engine temperatures rise and condenses into steam.

According to Birch (2024) Car smoke can come in various different colors and thicknesses, all of which can be an indication of your engine's overall health and what's going on under the bonnet. Although car smoke is typically not a cause for concern, it can be black, blue, grey, or white. Understanding the meaning of the different hues will aid in identifying any potential mechanical issues. The primary reasons for exhaust smoke might differ based on the automobile, the type of gasoline it uses, and the technical state of the vehicle. Diesel vehicles are especially prone to smokey exhaust. However, if the car is frequently serviced and well-maintained, any visible exhaust emissions are probably nothing to worry about, but it is always a good idea to check.



Fig 3: Picture of a Car Engine Smoking

Source: <https://www.alamy>

Prevalence of Car Engine Smoking

Inadequate fuel atomization may result in smoke. For the fuel to burn efficiently, it must be combined with air in extremely minute droplets. Injector damage or blockage is the primary reason; however improper or subpar fuel might also be to blame. engine smoke is produced by partially consumed fuel and there are various causes of engine smoke in cars, and each one suggests a possible issue. These are some of the typical reasons:

Oil Leaks: Smoke may be released if engine oil spills over hot engine parts. Worn gaskets or seals are frequently the cause of this.

Coolant Leaks: White smoke from a coolant leak might be an indication of a burst head gasket, a broken engine block, or damage to the cylinder head.

Burning Oil: Blue smoke may come out of the engine if damaged valve seals or piston rings are causing the oil to burn. This usually means that the combustion chamber is being contaminated with oil.

Fuel Issues: Black smoke is a sign of incomplete combustion and may indicate an extremely rich fuel combination. A blocked air filter or a broken fuel injector might be the cause of this.

Overheating: If the engine overheats, it can cause various components to fail, leading to smoke. This could be due to low coolant levels, a malfunctioning thermostat, or a faulty water pump. (Bot, 2024)

Exhaust Problems: Smoke can also result from problems with the exhaust system, such as a blocked catalytic converter.

Transmission Fluid: Smoke may be produced if the gearbox leaks and the fluid gets on hot engine components. To save more engine damage, it is critical to identify and fix the problem as soon as a car starts smoking.

Lugging: Excessive smoke emissions are also a result of working the engine in a too-high gear, or lugging the engine. It is important to inform drivers of the minimum engine speed required to prevent smoke emissions. Smoke emissions can result by overloading a car or running the engine "on the governor," or at maximum RPM, for extended periods of time when the situation calls for less.

Crankcase breathers: Similar to gasoline-powered cars, cylinder gasses can enter the crankcase through the crankcase breather and out into the atmosphere when rings or pistons are worn down or fractured. When a diesel vehicle's crankcase breather produces an excessive amount of smoke, there are major engine issues.

Cracked engine block: The main components of an engine are held together by the engine block. Very low temperatures have the potential to cause minor cracks in the block because the coolant may freeze and press against the walls. While rare, manufacturing flaws might result in engine blocks having thinner parts than others, making them more prone to damage. Smaller cracks may be sealed using an engine block sealer, but larger ones may require a trip to a reputable shop. A technician may have to repair the block by cold metal stitching or by rewelding sections of it.

Failed piston rings: When the car accelerates and blue-grey smoke emerges from the exhaust, broken piston rings are typically the cause of this. When the seal on the components in cylinders breaks, oil may seep out of them. The fault is uncommon and will need the help of a professional to fix. (Khan, 2020)

Gray Smoke: The rarest of all the cases is gray exhaust smoke. But diagnosing it might be more difficult. It might indicate that the engine oil or transmission fluid has burned if the smoke has a solid gray tint. It is essential that one have their car inspected by a qualified mechanic to find out whether it requires any repairs.

Blue Smoke: Like gray exhaust, blue exhaust indicates burned oil. Before anything else, check the oil level and look for leaks around the car's engine as leaks might be caused by worn cylinder walls, fractured piston rings, or faulty valve seals.

Black Smoke: Black exhaust smoke is an indication that the car is consuming too much fuel, which might be caused by a fuel injector or air filter issue. In cars with diesel engines, exhaust smoke that is black or dark is more prevalent.

White Smoke: If someone notices thin, hazy white smoke, it's probably condensation occurring naturally. On the other hand, something more severe could be going on if the cloud is dense and white or light gray in color. Thick white smoke may indicate that the engine block or head gasket is in danger. However, in order for a professional to accurately assess the issue, one should speak with them right away.

Causes of Car Engine Smoking

Engine smoke in cars is a serious problem that may be a sign of more serious issues with the engine or other parts of the car. Comprehending the origins of engine smoke is vital for prompt diagnosis and fixing. These are a few typical reasons why car engines smoke:

➤ **Wear and Tear of Engine Components**

Over time, wear and tear on engine parts including cylinders, valve seals, and piston rings can result in higher oil consumption and smoke. The tight seals that keep oil out of the combustion chamber deteriorate with these components. As a result, engine oil can leak into the combustion process and cause exhaust to emit blue or gray smoke. The wear increases the friction between the moving parts, reducing engine efficiency and leading to increased heat generation, which further exacerbates the deterioration of engine components (Albarbar & Abdelkhalik, 2019). It is essential to perform routine maintenance and prompt replacement of these components in order to prevent high smoke emissions.

➤ **Incomplete Combustion**

When there is an imbalance in the air-to-fuel mixture inside the combustion chamber, extra fuel does not burn completely, leading to incomplete combustion. Black smoke coming from the engine might be caused by dirty fuel injectors, clogged air filters, or broken spark plugs. In addition to indicating improper fuel combustion, black smoke can also indicate carbon buildup inside the engine. This accumulation degrades engine performance overall and may lead to higher emissions of hydrocarbons and particulates, which pollutes the environment.

➤ **Poor Quality Fuel**

The use of tainted or low-quality fuel may result in smoke emissions and incomplete combustion. High impurity fuels, including those containing sulfur and water, decrease the combustion process' efficiency. Thick black smoke is released when contaminants block fuel injectors, causing an uneven fuel distribution in the combustion chamber. Furthermore, carbon deposits from low-grade fuels frequently build up in engine parts, shortening their lifespan and causing an increase in smoke emissions. Making the switch to premium fuels can drastically lower the frequency of engine smoke.

➤ **Faulty Valve Seals or Piston Rings**

According to Ramesh et al. (2020), valve seals and piston rings are designed to keep the combustion gases within the combustion chamber and prevent oil from leaking into it. Engine oil enters the combustion chamber and burns with the fuel when these parts wear out or get damaged. This causes the exhaust to emit blue or grey smoke, which is a sign that oil is burning. In addition to increasing smoke emissions, burning oil decreases engine performance and speeds up the deterioration of other engine parts. It is important to repair faulty seals and rings as soon as possible to avoid long-term engine damage and excessive smoke.

➤ **Oil Leaks into the Combustion Chamber**

When one of the engine's internal sealing mechanisms such as gaskets, seals, or piston rings breathes, oil seeps into the combustion chamber. This causes engine oil to mix with the fuel-air combination, resulting to incomplete combustion and the production of blue or grey smoke from the exhaust. One of the main causes of engine smoke is oil leaks, which may also result in more engine damage and higher repair costs if ignored. Regular engine maintenance, leak detection, and replacing deteriorated gaskets and seals before they totally fail are examples of preventative measures.

Effects of Car Engine Smoking

Car engine smoke, which is frequently linked to high emissions, can have a number of negative consequences for the environment and the efficiency of the vehicle. Incomplete fuel combustion,

which generates a combination of pollutants including carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NOx), and hydrocarbons, is frequently the cause of engine smoke emissions. These emissions have a detrimental effect on human health and air quality since they greatly increase air pollution. However, below are some key effects of a car engine smoke:

➤ **Air Quality Degradation**

When automobile engines emit dangerous pollutants including carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM), the air quality is dramatically deteriorated. These pollutants cause smog to develop, which makes people's respiratory problems worse. Higher concentrations of these pollutants are seen in communities close to busy roads, which increases the incidence of chronic respiratory illnesses like asthma. Extended periods of time spent in poor air quality can cause serious health problems, such as deteriorated lung function and a rise in respiratory hospital admissions. Furthermore, the buildup of these contaminants may result in more extensive ecological consequences, such acid rain, which damages local ecosystems and affects plants and wildlife.

➤ **Respiratory and Cardiovascular Health Issues**

Human health is significantly impacted by the presence of diesel engine fumes, which are especially well-known for their high smoke levels. Diesel smoke's fine particulate matter (PM_{2.5}) enters the bloodstream and permeates the lungs deeply, increasing the risk of lung cancer, cardiovascular illnesses, and inflammation. People who live in densely populated metropolitan regions are especially susceptible to these health problems. Chronic exposure to these emissions can result in long-term conditions, such as chronic bronchitis and emphysema, diminishing the quality of life (Muhaisen et al., 2020). The consequences of diesel smoke emissions for public health are further highlighted by the correlation between heightened diesel smoke levels and higher death rates from cardiovascular diseases.

➤ **Increased Hospital Admission**

There is a clear correlation between hospital admission rates for respiratory issues and car engine smoke. Significantly higher air pollution levels are found in areas with heavy traffic congestion, and this is correlated with an increase in emergency department visits for respiratory ailments such as asthma attacks and chronic obstructive pulmonary disease (COPD). One key element that increases the likelihood of these diseases getting worse is the presence of particulate matter and other dangerous pollutants from cars. Due to higher healthcare spending and reduced productivity among afflicted individuals, this influence on public health puts a pressure on healthcare systems and generates economic consequences.

➤ **Environmental Impacts on Ecosystem**

The health effects of car exhaust fumes are not the only ones that affect the environment. Emissions have a detrimental impact on the quality of soil and water by contributing to air pollution. Nitrogen molecules from car emissions can contribute to eutrophication in water bodies, resulting in hazardous algal blooms that deplete oxygen and destroy aquatic life. The build-up of toxins and heavy metals from engine smoke upsets regional food networks, which has an impact on biodiversity and wildlife populations. Prolonged exposure to these pollutants can degrade habitat quality and alter the natural balance of ecosystems, leading to a loss of flora and fauna diversity (Su, 2022).

Preventive strategies to Car Engine Smoking

Recent research suggests that a number of strategies may be used to successfully reduce excessive vehicle engine smoke and maintain sustainability. These are important preventive measures to take:

➤ **Regular Oil Changes and Monitoring for Leaks**

In order to stop oil from seeping into the combustion chamber, which is a major source of gray or blue smoke, frequent oil changes are essential. According to studies, disregarding the quality of the oil can cause internal engine wear, which lets the oil seep into the cylinders and burn during combustion. This problem can be lessened by utilizing premium synthetic oils and routinely checking the oil levels.

➤ **Replacing Air Filters to Prevent Black Smoke**

Maintaining clean air filters promotes appropriate airflow, enhancing combustion efficiency and lowering hazardous emissions. Clogged or filthy air filters restrict the air intake, resulting to incomplete combustion, which creates black smoke. According to Kim and Park (2021), maintaining clean air filters significantly reduces harmful emissions and improves engine efficiency.

➤ **Repair Faulty Gaskets and Cylinder Heads**

White smoke is frequently a sign that a deformed cylinder head or broken head gasket is allowing coolant to seep into the combustion chamber. Severe engine damage can be avoided by taking early action, such as performing routine engine checkups and replacing the gasket. However, studies have shown that engine smoke is mostly caused by gasket failures, especially in older cars.

➤ **Utilizing Advanced Fuel Additives**

Fuel additives can aid in reducing carbon buildup, which is a significant cause of engine smoke, and cleaning the combustion chamber. Additionally, the regular use of additives intended to clean fuel injectors and intake valves may dramatically reduce emissions of both blue and black smoke, as well as increase engine longevity and fuel economy.

➤ **Implementing Proper Cooling System Maintenance**

A number of smoke problems, including white smoke from coolant evaporation, can be brought on by an overheated engine. Overheating of the engine may be avoided by maintaining coolant levels at ideal levels and checking for leaks in the radiator and cooling system. Studies by Hernandez and Silva (2021) suggest that maintaining coolant levels and inspecting the radiator system regularly can prevent overheating and smoke emissions.

Control of Car Engine Smoking

To improve both vehicle performance and environmental results, automobile engine smoke must be controlled. Technology developments, maintenance procedures, and regulatory standards have all influenced the development and use of a number of solutions in recent years. They however include the following below:

➤ **Engine Maintenance and Efficiency**

In order to minimize engine smoke, proper maintenance is essential. Research highlights that the amount of exhaust smoke is directly impacted by engine efficiency. Increased smoke emissions are caused by poor combustion as a result of engine wear or neglect. Research by Joshi (2019) highlights the importance of hybridization, waste heat recovery, and optimizing engine cycles to reduce incomplete combustion and emissions. Regular car maintenance guarantees that gasoline burns cleanly and stops oil leaks, which greatly reduces smoke.

➤ **Advanced Emission Control Technologies**

Diesel particulate filters (DPF) and selective catalytic reduction (SCR), two recent developments in emission control, are essential in lowering the dangerous elements of engine smoke. SCR technology converts harmful nitrogen oxides (NO_x) into harmless nitrogen and water, while DPF captures soot particles that are a major source of black smoke from diesel engines (Johnson and

Joshi, 2018). Furthermore, gasoline particulate filters (GPF) also aid in lowering particle emissions from gasoline-powered vehicles, reducing pollutants in the environment and engine smoke.

➤ **CO₂ Capture and Emission Reduction**

Temperature Swing Adsorption (TSA) is another technical innovation that removes CO₂ from vehicle emissions. Though still under development, TSA shows potential for reducing overall emissions by absorbing CO₂ from exhaust gases before releasing it safely into the atmosphere (Hossain and Bari, 2019). This technique has the potential to be a useful tool for minimizing engine smoke in automobiles, particularly in heavy-duty cars.

➤ **Regulatory Compliance and Innovation**

In order to fulfill emission reduction targets, manufacturers have been pushed to develop and embrace new technologies in order to comply with regulatory requirements like Euro 6 and the soon-to-be Euro 7. These laws place a strong emphasis on lowering particle and NO_x emissions, which are directly linked to engine smoke. The automobile industry is still pushing for better pollution control systems and more efficient engines despite the stricter regulations.

Conclusion

Excessive car engine smoking poses significant challenges to vehicle safety, environmental sustainability, and public health. Through the investigation of its causes that is ranging from inadequate maintenance to poor fuel quality, it has become an evident that a multifaceted approach is essential for effective remediation. By embracing cleaner fuel alternatives, enhancing vehicle maintenance protocols, and leveraging advanced diagnostic technologies, stakeholders can significantly mitigate the risks associated with excessive emissions. Furthermore, public education also plays an essential role in promoting responsible vehicle ownership and maintenance practices. As the world advance toward a more sustainable automotive future, it is imperative that users prioritize these strategies to ensure safer roads, cleaner air, and a healthier environment for generations to come.

Recommendations

1. It is advised to regularly monitor and change engine oil Levels and Quality to prevent damage and ensure smooth operation as excessive engine smoking can be caused by burning oil due to leaks or improper lubrication.
2. It is recommended to Inspect the Cooling System as overheating engines often emit smoke.
3. It is advised to Guarantee Proper Maintenance of Turbocharger as it can help maintain engine efficiency and prolong its lifespan.

REFERENCES

1. Albarbar A. M., Abdelkhalik S. S. (2019). Impact of Engine Component Wear on Vehicle Emission and Performance. *International Journal of Vehicle Structures & Systems*, 11(2), 182-190.
2. Birch R. (2024) Car exhaust smoke: what do the different kinds and colors of smoke mean. <https://www.autoexpress.co.uk/car-news/102502/car-exhaust-smoke-what-do-the-different-kinds-and-colours-of-smoke-mean>
3. BOT (2024) What causes a car engine to smoke. <https://www.quora.com/What-causes-a-car-engine-to-smoke>
4. Hernandez, P., & Silva, M. (2021). Cooling system maintenance in preventing engine overheating and smoking. *Journal of Vehicle Technology*. 35(9): 440-451.
5. Hossain, S., & Bari, S. (2019). Carbon Dioxide Capture from Internal Combustion Engine Exhaust Using Temperature Swing Adsorption. *Frontiers in Mechanical Engineering*. DOI:

- 10.3389/fmech.2019.00042.<https://www.frontiersin.org/articles/10.3389/fmech.2019.00042/full>
6. <https://auto.howstuffworks.com/car-engine-pictures.htm>
 7. <https://unsplash.com/s/photos/car-engine>
 8. <https://www.alamy.com/stock-photo/smoking-car-engine.html>
 9. Johnson, T., & Joshi, A. (2018). Review of Vehicle Engine Efficiency and Emissions. *SAE Int. J. Engines*. 11(6): 1307-1330.
 10. Joshi, A. (2019). Review of Vehicle Engine Efficiency and Emissions. *SAE International Journal of Advances and Current Practices in Mobility*. 1(2): 734-761.
 11. Khan I. (2020) About Engine Smoke. <https://kiamotors-portqasim.com/about-engine-smoke/>
 12. Kim, H., & Park, J. (2021). Air filter efficiency and its impact on vehicle emissions. *Journal of Automotive Science and Engineering*. 62(1): 22-31.
 13. Martínez, G., Romero, L., & Sánchez, D. (2020). The Potential of Biofuels in Reducing Engine Emissions. *Renewable Energy Journal*. 34(3): 257-275.
 14. Mille J. (2024) Different Types of Car Smoke and What They Indicate – Auto Repair in Argyle, TX. <https://fifthgear.biz/fifthgear-blog/different-types-car-smoke-indicate-auto-repair-argyle-tx/>
 15. Mugglestone C. (2024) what causes a car engine to smoke? Available at: <https://www.quora.com/What-causes-a-car-engine-to-smoke>
 16. Muhaisen L. F., Ali S. A., Zainab T. A. & Abdulhusein A. A. (2020). The Effect of Smoke from Factories, Electricity Generator and Vehicles on Human Health and Environment. A Review. *Solid State Technology*, 63(6)
 17. Ramesh D. A., Chaudhary M. K. & Sharma P. (2020). The Role of Valve Seal Wear and Piston Ring Defects in Emission of Smoke in Internal Combustion Engines. *Materials Today: Proceedings*. 33: 2486-2491.
 18. Smith, J., & Jones, A. (2022). Impact of vehicular emissions on urban air quality: A comprehensive review. *Journal of Environmental Science and Technology*. 55(3): 189-204.
 19. Su J. (2022). Research on the Impact of Automobile Exhaust on Air Pollution. *Advances in Economics, Business and Management Research*, volume 654.
 20. Wang, L., Zhang, Y., & Chen, H. (2021). Investigating the relationship between fuel quality and engine emissions in gasoline vehicles. *International Journal of Automotive Engineering*. 12(4): 241-254.
 21. Xie, J., Zhang, Y., & Liu, F. (2020). Improving Internal Combustion Engine Efficiency: Challenges and Opportunities. *Journal of Automotive Engineering*. 58(7): 845-860.