

A REVIEW PAPER ON INTERNAL COMBUSTION ENGINE DIESEL FUEL

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ABSTRACT

The efficiency of different fuels for internal combustion engines is the primary emphasis of this analysis. Diesel, gasoline, and compressed natural gas are the three most used conventional fuels, while biodiesel, hydrogen, ethanol mixed with gasoline, and diesel are some of the newer alternatives. The impact on the efficiency of internal combustion engines of each of these options varies. Because of the scarcity of petroleum, several alternatives are being used. Fuels like hydrogen are available, while fuels like ethanol may be created according to demands and requirements; this means that these alternative fuels can help petroleum last longer. When compared to liquid fuels, gas fuels are far more practical. To begin with, unlike liquid fuels, gaseous aggregates do not require evaporation; mixing is easy, and the result is a more uniform mixture than would be possible with liquid fuels. Additionally, gas fuels are thought of as more prospective fuels because to their chemical makeup. The chemical makeup of gas fuels often contains less carbon, which is beneficial from an ecological perspective. A gasoline engine's efficiency is directly proportional to its compression ratio. When raised beyond 9, the contraction rate of gasoline machine often falls within the 6 to 9 range. The likelihood of an eruption will rise by three. Brake thermal effectiveness, energy mass input rate, specific energy consumption, and affair value from trials were used to calculate brake power and particular energy consumption rates.

Keywords: fuel injection, gasoline, diesel, internal combustion engines

INTRODUCTION

An ICE or IC machine is a heat engine that uses an oxidizer—typically air—in a combustion chamber that is a component of the working fluid intake circuit to burn energy. The expansion of the high-temperature and high-pressure vapors generated by burning exerts a direct force on an internal combustion machine component. Common targets for this type of force include pistons in piston machines, gas turbine blades, rotors, or snoots in spurt machines. The output of renewable fuels has grown at a rate of 8% per year during the last ten years. The problem is that this growth won't even cover half of the increase in energy use throughout the world. Despite the growing need for alternative energy sources, heavy-duty vehicles on land and sea still rely on combustion engines as their principal means of propulsion. Their role as peak-shaving facilities for renewable energy sources like wind and solar, which generate power quickly, is also expanding in prominence. With the world's energy demand on the rise, researchers are working to reduce emissions of harmful gasses and the quantity of petroleum used in power generation. problems with the environment and increased energy expenses. The burning of fossil fuels has a negative impact on the environment, especially in the transportation sector, which is why these problems must be addressed.

Figure (1): Components of IC Engine

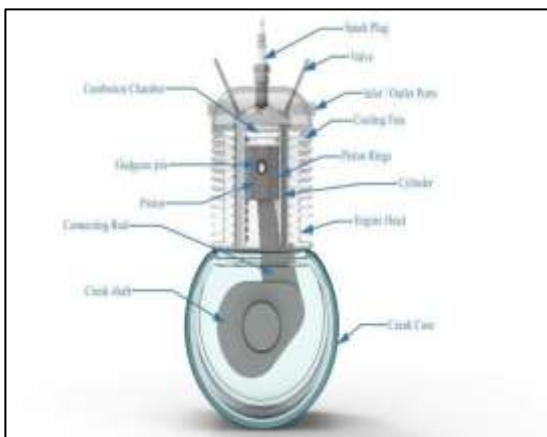
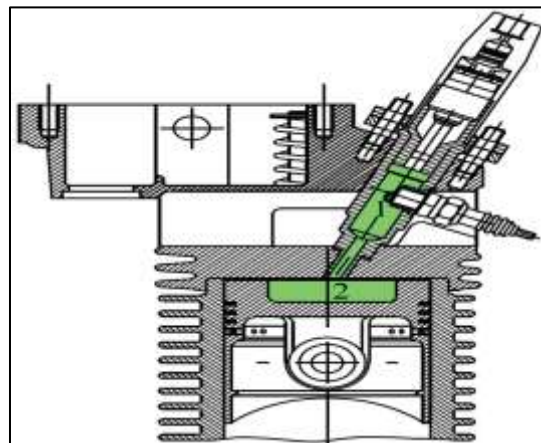


Figure (2): Test engine working



space1. Pre-chamber, 2. cylinder

When compared to diesel fuel, biofuels made from rendered animal fat have lower amounts of particulate matter and unburned hydrocarbons, according to research by **Kuczynski et al. (1)**. Using methanol conversion products might be a cost-effective alternative, as shown by **Kryshtopa et al. (2)**. In their discussion of emission reduction strategies, **Shepel et al. (3)** emphasize the use of hydro-treated vegetable oils (HVO) in conjunction with fatty acid methyl esters (FAME). Diesel engines produce less CO and UHC emissions when they mix FAME with HVO, which lowers the viscosity while keeping the cetane number high. The nitrogen oxide emissions from oxygenated biofuels are still rather high. In order to decrease nitrogen oxide production and increase kinetic combustion rate, **Cisek et al. (4)** studied the effects of commercial gasoline additives. Particulate matter generation can be decreased with the use of additives that enhance combustion diffusion. The combustion process of diesel surrogates may be greatly altered by using two injectors, according to **Pielecha et al. (5)**. When comparing the effects of using individual additives on nitrogen oxides and particulate matter, **Cisek et al. (4)** discovered that additive combinations were more effective. The potential uses of dimethyl ether are discussed by **Fabi et al. (6)**.

Powered by SI engines, **Gorski et al. (7)** studied the physicochemical properties of fuel blends using diethyl ether and linseed oil at different concentrations. The low-temperature characteristics, surface tension, density, and viscosity of bio-oils are improved by diethyl ether. Using alternative fuels, **Karczewski et al. (8)** provide new combustion models. Using HCNG and HVO as a pilot dose, the authors examine Reactivity Controlled Compression Ignition (RCCI) combustion. Improved efficiency for alternative fuels is possible with low-temperature combustion, however there are control issues and the possibility of increased N₂O emissions. Together with methane slip, this component has a greenhouse gas factor more than a hundred times that of CO₂, casting doubt on the potential climatic effects of modern combustion methods. In order to determine how adding kerosene to diesel fuel affected the engine's combustion, performance, and emission characteristics, **K. R. Patil and S. S. (9)**. Thippes conducted an experimental research. Under varying loads, the engines were tested using the five-mode test cycle approach outlined in ISO 8178-D2. The fuels tested included baseline diesel and three blends. K5D, K10D, and K15D are diesel blends that contain 5%, 10%, and 15% kerosene by volume, respectively. In comparison to the K10 D and K15D blends, the trial findings demonstrated that the K5D blend had lower levels of smoke, NO_x, brake thermal efficiency, and brake specific fuel consumption. As an alternative to fossil fuels, **T. Elango and T. Senthil Kumar (10)** conducted experimental investigations into the performance and emission characteristics of a diesel engine that is powered by various mixes of jatropha oil and diesel (10-50%). At varying loads, experiments were carried out using diesel blends including esterified jatropha oil in concentrations of 10%, 20%, 30%, 40%, and 50% (B10-B50). Diesel brake thermal efficiency was found to be greater across the board. Results showed that blends with up to 20% Jatropha oil had the lowest specific fuel consumption and the best brake thermal efficiency.

Fuel Properties

Engine in a direct manner. At 40°C, the researchers recorded kinematic, dynamic, and density data using a stabinger viscometer to analyze density. Next, an LECO AC-350 digital bomb calorimeter (11) was used to determine the biodiesel's calorific value in the research. Scientists measured biodiesel's kinematic viscosity at 40 °C and found it to be 3.5–5 (mm²/s). The density value is 0.888 g/ml, as found by the scientists at 15 °C. According to this study, biodiesel has a flash point that is 156 °C, which is far higher than diesel's 72 °C (12). The cetane number, density, viscosity, and calorific value are four diesel fuel characteristics that are critical for engine efficiency and pollution. Combustion, emissions, and engine efficiency are all greatly affected by these characteristics and others like aromaticity and sulfur concentration.

Important Features of Diesel Fuel:

Combustion speed and engine noise are affected by the cetane number, which indicates the fuel's ability to ignite under compression. A lower level of combustion noise and faster ignition are the usual results of a higher cetane number.

Density: Affects fuel flow and atomization in the engine. Fuel density influences the mass flow rate through the injector, which in turn can affect spray characteristics.

Fuel atomization and flow rate are affected by viscosity, which in turn affects engine performance. An increase in fuel pump drag and a decrease in power production are both caused by a rise in viscosity.

The calorific value, often known as the heating value, is a measure of the fuel's energy content that affects the power output of the engine.

The concentration of sulfur has an effect on emissions, especially of the dangerous sulfur oxides.

Characteristic Aromatic Components: Affects Cetane Number, Engine Performance, and Emissions.

The distillation points of a fuel affect its volatility and combustion by revealing its boiling range.

Surface tension influences spray properties and fuel atomization.

Proper lubrication of engine components is ensured by lubricity.

Fuels have flash points, which are the absolute minimum temperatures at which they catch fire when placed in an open flame.

Problems with fuel distribution and engine performance might be caused by water and sediment content.

The percentage of incombustible materials in the fuel is indicated by its ash content.

Effects on Emissions and Engine Performance: Fuel qualities affect engine performance metrics like horsepower, torque, and fuel efficiency.

Properties	Diesel	Gasoline	Hydrogen	Ammonia	Methane
Autoignition Temp (°C)	180-320	260-460	585	651	540-630
Flame velocity (cm/s)	30	37-43	265-325	70	38
Lower heating value (MJ/kg)	42.5	44.0	120	22.5	50.0

Table 1: Standard values for biodiesel EN 14214 (12)

Properties	Standard values for biodiesel EN 14214
Flash point	≥120 °C
Dynamic viscosity	3.5–5 mm ² /s
Cetane number	>51
Density	0.86–0.90 g/ml

Table 2: Main properties of various fuels

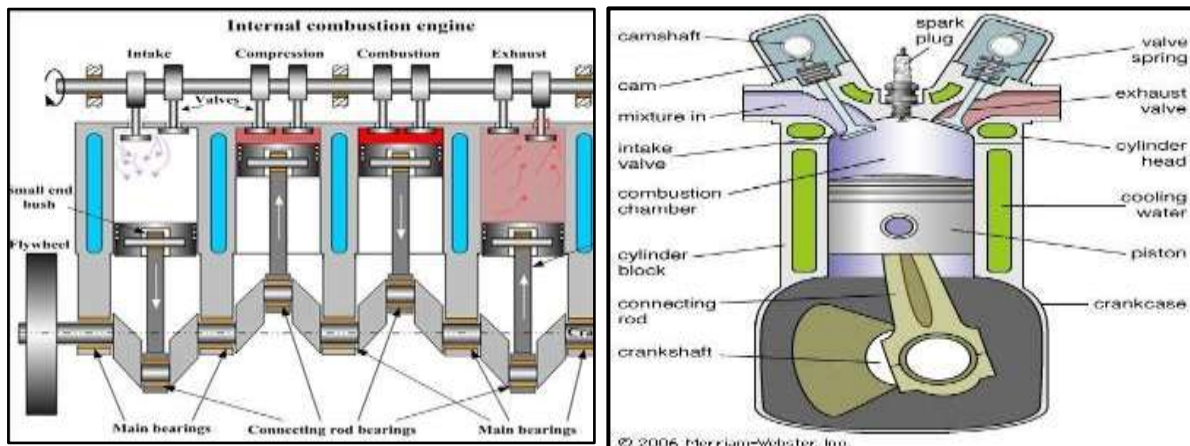


Table 3: Properties of Diesel fuels used in this study [13, 14, 15] Working and description of Internal combustion engine

Property	Iraqi diesel	Diesel EN590	Heavy diesel	Light Diesel
Carbon %	87.0	86.2	87.0	86.5
Hydrogen %	12.6	13.7	13.0	13.4
Oxygen%	00.4	00.0	00.0	00.0
Sulphur %	00.0	0.03	00.0	00.0
Density (kg/m ³)	830	810	981	838.3
Viscosity (Pa.s)	0.003	0.003	0.003	0.003
Cetane number	48.0	53.3	46.0	48.0
Heating value (MJ)	42.5	43.1	40.6	42.86
Molecular weight	190.0	182.0	190.0	190.0

If we take a heat source and transform it into mechanical energy, we have a basic engine. This is accomplished by the engine by means of internal or external combustion. The burning process is known as combustion. "Internal" denotes being inside or enclosed. Thus, gasoline is burned within the engine itself in an internal combustion engine. Specifically, the crankshaft is turned by the combustion process that takes place in the same cylinder. The process of burning fuel occurs outside the engine in steam engines and other types of external combustion engines. A boiler is a part of an external combustion engine; when heat is added to the water in the boiler, it boils and creates steam. When pressurized steam enters an engine cylinder, it pushes the piston downward. Combustion, which occurs within the cylinder of an internal combustion engine, is what really drives the piston to descend

An basic principle of physics underpins the engine's ability to transform thermal energy into mechanical energy. It says that when you heat gas, it will expand. Gases will be heated when compressed, according to the law as well. Heat applied to a gas in a closed system prevents it from expanding, leading to a rise in pressure. This force pushes down on the piston head of an engine, forcing it to travel lower. Combustion of fuel (often fossil fuel) and oxidizer (often air) in a combustion chamber is the basic principle of an internal combustion engine. Combustion produces gases with high temperatures and pressures, which in turn exert direct force on various engine components like pistons, turbine blades, or a nozzle in an internal combustion engine. The component is propelled along a distance by this force, which produces mechanical energy that may be used as fuel.

Improvements in Diesel Internal Combustion Engines

Improvements in diesel internal combustion engines focus on enhancing efficiency, reducing emissions, and improving overall performance. These advancements include technologies like direct injection, exhaust gas aftertreatment, and advanced combustion strategies.

1- Fuel Injection System

Combustion is the process by which an engine that runs on gasoline converts the thermal energy produced by the inhalation of air and fuel (gasoline) into usable mechanical energy. The heat that is produced when fuel is burned. The fuel injection system regulates the fuel-to-air ratio based on the engine's air intake and combustion demands. In order to regulate the fuel injection rate, an electronic control unit (ECU) takes readings from a sensor that measures the air intake and determines how long the injectors should remain open. It then uses these numbers to determine how much fuel should be injected. You may find out how much air is being taken in by using either the mass flow approach or the calculation method. The mass flow technique uses an air flow meter to measure the quantity of air that is injected

into the engine. The mass flow technique is commonly used by thermal air flow meters and other conventional sensors to correctly measure air mass, regardless of variations in air intake quantity caused by changes in air pressure, temperature, or exhaust gas recirculation (EGR). The intake air pressure sensor, also known as the manifold absolute pressure sensor (MAPS), measures the pressure at the air intake pipe in relation to the engine rotation speed, air temperature, and the amount of air intake that is estimated using the calculation technique. However, by positioning the intake air pressure sensor downstream from the throttle, this approach can monitor the quantity of air intake into the engine with greater reaction qualities, even during a time of transition.

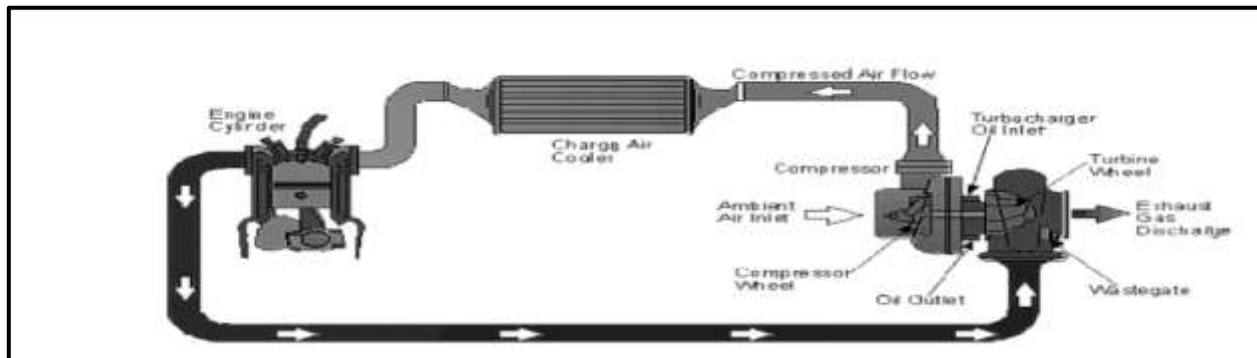


Figure (4): the shows fuel injection system

2- Turbocharging System

A mechanical device known as a turbocharger uses the exhaust gas from an internal combustion engine to power a turbine, which in turn drives a compressor, therefore increasing the air density that enters the combustion chamber of the engine. Turbocharging improves performance and reduces exhaust pollutants by increasing the amount of air entering the combustion chamber, which promotes lean combustion. Researchers have been working hard over the past several years to find ways to increase engine power while decreasing exhaust gas emissions via modifying the traditional turbocharger and adding new components like intercoolers and turbochargers. More studies will be conducted in this area to meet the growing need for powerful, environmentally friendly engines. Improvements in turbo charging technology can meet all these increased demands placed on IC engines. Engines frequently employ turbochargers to recover part of the energy wasted in the exhaust gasses **Corky Bell, 16**. The exhaust gasses going through a turbocharger spin a turbine, which increases the intake pressure. A rotor connects the compressor to the turbine, making them work together. A diesel engine's turbocharging system is schematically shown in Figure 4.

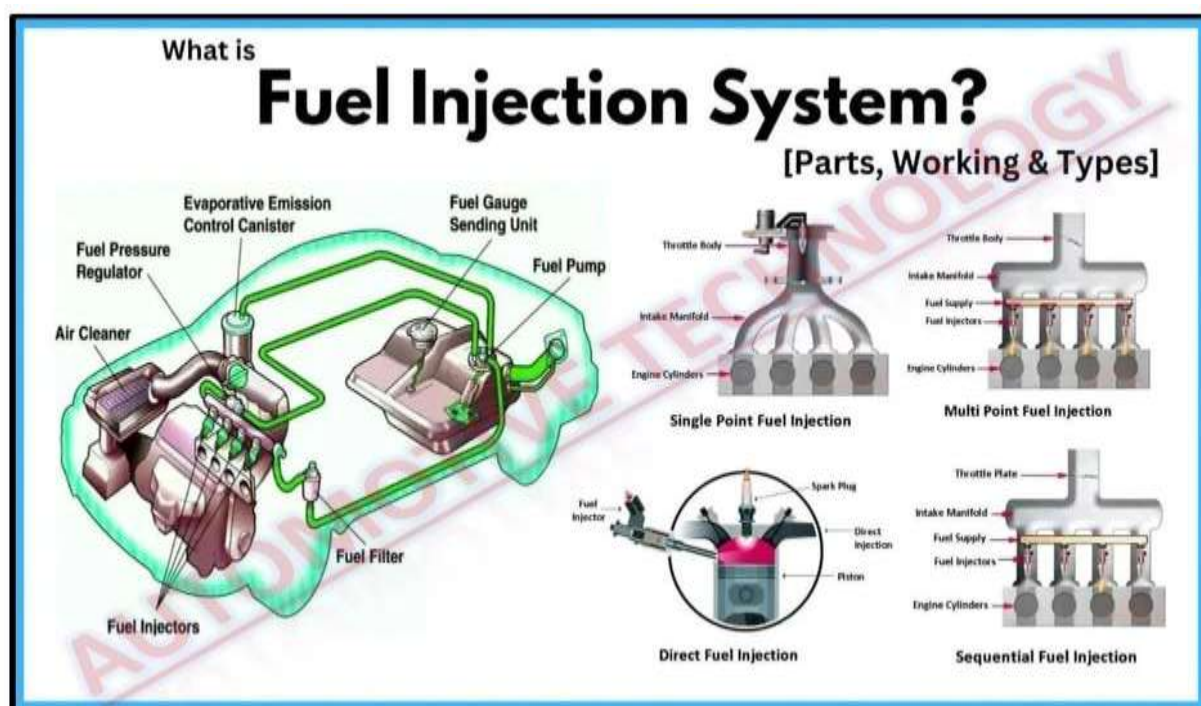


Figure (5): Typical schematic layout of turbocharger system of an IC engine

3- Intercooler Usage System

The job of the intercooler is to remove waste heat from a gas compressor or any other mechanical device that cools a fluid (gases or liquids) between stages of a multi-stage heating process. One of their most well-known uses is in forced induction (turbocharged or supercharged) internal combustion engines, where it increases the volumetric efficiency by increasing the intake air charge density through nearly isobaric (constant pressure) cooling. These engines are also found in air conditioners, gas turbines, refrigerators, and air compressors. Another technique that has been around for almost a century is the intercooling of filling media. It follows that the theoretical underpinnings and practical applications of turbo-charging and supercharging combustion engine fuel using liquid and gas fuels have been widely acknowledged and understood for some time. In recent times, turbo-charging and supercharging combustion engines have grown in both manufacturing and usage. For supercharged spark ignition engines as well as supercharged compression ignition engines, this is the situation.

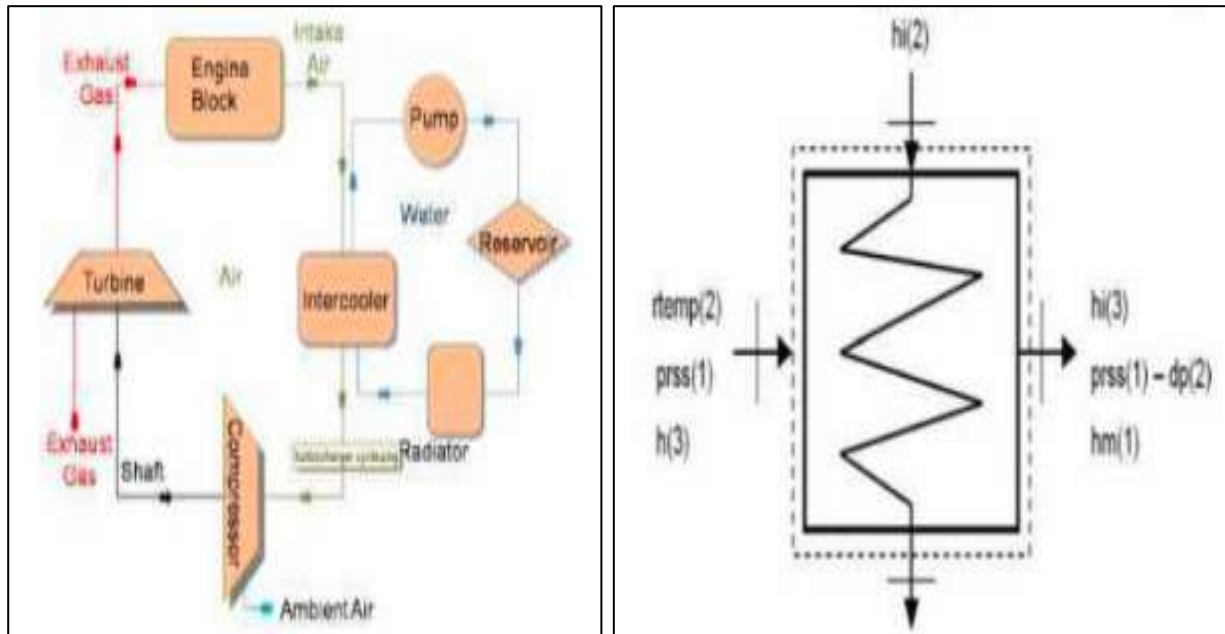


Figure (6): Turbo-charger system with intercooler system

4- Exhaust Gas Recirculation System

One of the methods that may be used to limit the emission of nitrogen oxides (NO) from mobile sources is exhaust gas recirculation (EGR), as shown in Figure 6. It accomplishes reducing NO and quenching part of the recirculated exhaust gases before they reach the intake air. It is common practice to limit recirculation of exhaust gas to 15% to 20% of the total. Whether it's a light-duty or heavy-duty diesel engine, EGR may be used with it. To control exhaust gas recirculation, most modern EGR systems employ electronic EGR valves. To prevent exhaust gas recirculation (EGR) from entering the manifold when the engine is idle, the EGR valve is closed. The EGR valve begins to open when the engine warms up while still being loaded. With a rise in both engine load and when the combustion temperature starts to rise, the valve opens and exhaust gases start to seep back into the intake manifold. The combustion temperature and (NO) can both be reduced by this process's cooling impact. The EGR method is widely used in both on- and off-highway vehicles due to its great efficiency in decreasing NO levels. Cylinder temperature quenching can increase engine life, particularly exhaust valve life. On the other hand, there are a few drawbacks to using the EGR system. More particulate matter (PM) is emitted into the recirculated gas from diesel engines using electronic gasoline recirculation (EGR) processes, leading to increased fuel consumption and lubricating oil contamination.

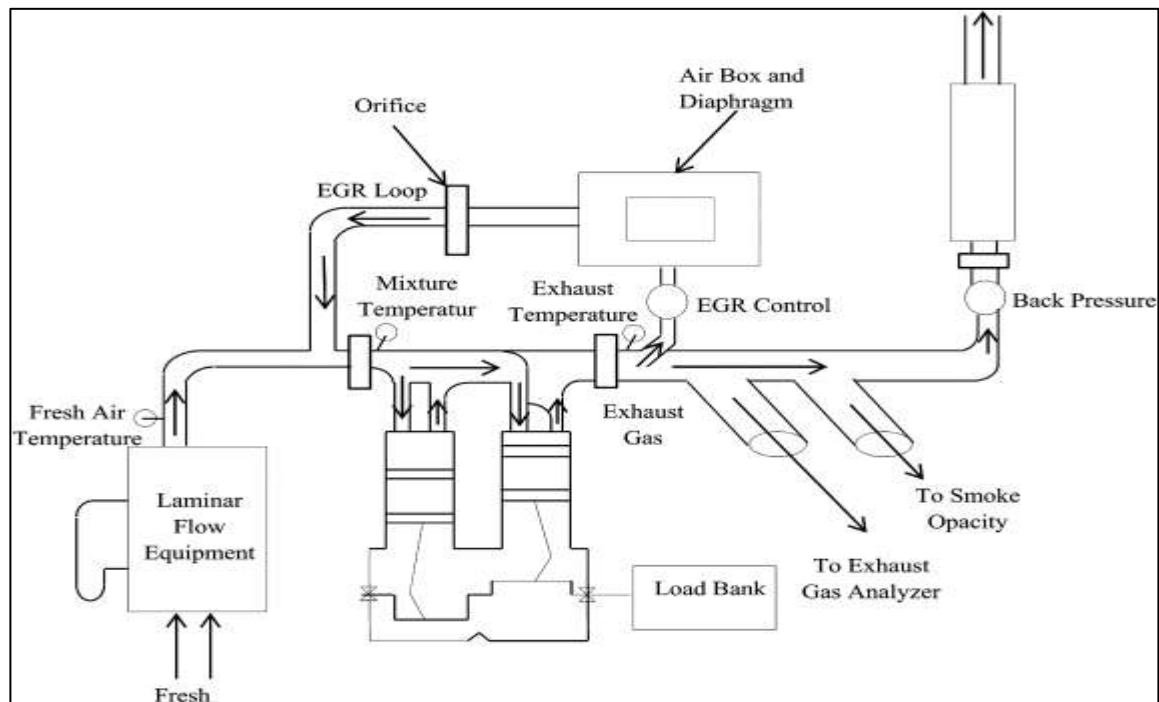


Figure (7): Schematic diagram of engine exhaust gas recirculation

5- Diesel Particulate Filters System

Devices that physically trap diesel particulates are known as diesel particulate traps, and their purpose is to restrict the discharge of these particles into the atmosphere. Diesel filter materials that have been developed have mechanical and thermal endurance that is satisfactory and often exceeds 90% in terms of filtration efficiency. When it comes to efficiently reducing particle emissions, diesel traps are head and shoulders above the competition. Traps are useful for reducing emissions of black smoke and elemental carbon (soot) and other diesel particulate solids because of the particle deposition techniques they employ. Keep in mind that traps could not work at all or only work partially when it comes to regulating particulate matter (PM) that isn't solid, like sulfate or SOF particles. This is why sulfate particulate and SOF emission-targeting functional components, such as oxidation catalysts and ultra low sulfur fuels, are likely to be included in trap systems that aim to reduce overall PM emissions. Methods for diesel particulate filters At now, the diesel particulate filter is the most well-established and efficient tool for controlling diesel particle emissions. The diesel particulate filter, or DPF for short, is the gold standard for controlling diesel particle emissions, and it's also one of the most advanced devices on the market. Particulate filters regenerate by collecting particulate matter from exhaust gas, which is then oxidized and burnt to release new particulate matter. Filter material selection and filter regeneration constitute the core technologies of the particulate filter, which is primarily comprised of a filtering device, a regeneration device, and a control device. The following filters are now the most heavily researched both domestically and internationally.

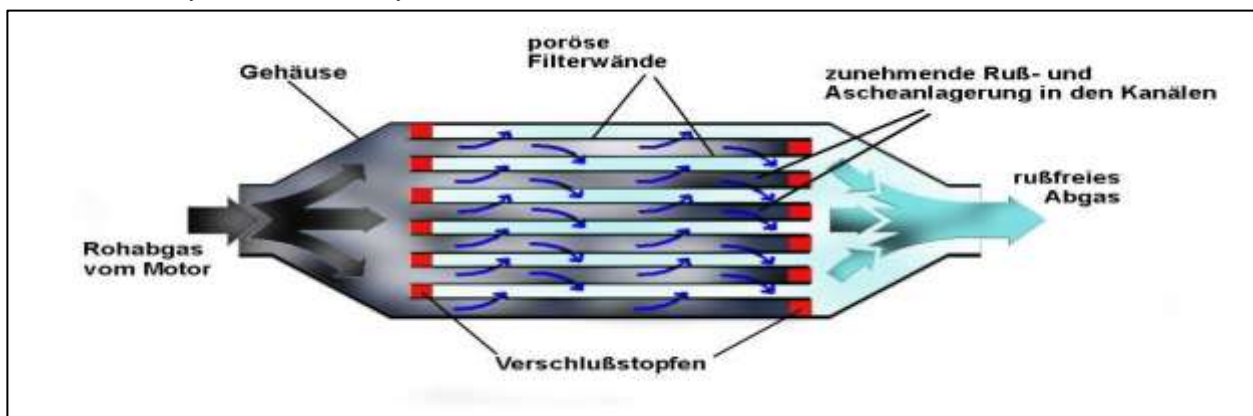


Figure (8): Schematic diagram of diesel particulate filters

Different Alternative fuels used in Engine

1- Bio-Ethanol

Whatever can be converted into molasses or synthesis gas—which contains carbon monoxide and hydrogen gas—can be converted into ethanol (17). Most people find ethanol to be rude. The manufacturers permit the direct mixing of tiny amounts of ethanol with gasoline, so there's no need to adjust the machine setup (18). From 2007 to 2015, the global output of bio-ethanol rose from 50 billion liters to almost 97 billion liters (19). A gallon of gasoline may be replaced with 1.5 US gallons (5.7 L) of ethanol, thanks to the fuel's "gasoline gallon equivalency" (GGE) value (20).

2- Petrol/Gasoline

The majority of its components are organic composites that are obtained by fractional distillation of petroleum and then improved with various additives. The most common source of energy for most spark-ignition internal combustion engines, also called petrol machines, is gasoline, a clear, flammable liquid derived from petroleum (21).

3- Biodiesel

Theoretical studies indicate that adding biodiesel to diesel fuel will increase CO₂ emissions from CI engines because to the molecular structure's oxygen content, which facilitates combustion. Nevertheless, due to biodiesel's lower carbon to hydrogen ratio, CO₂ pollutants tend to decrease. A greater ignition point, reduced toxicity, and biodegradability make it a safer material to work with. Using biodiesel instead of CI reduces emissions of pollutants including PM, CO₂, CO, HC, and SO₂, which is a huge plus for the environment. Biodiesel might boost the vehicle's performance because to its higher cetane number. Engine life is extended and maintenance needs are decreased by using biodiesel. All things considered, biodiesel outshines CI in terms of biodegradability, aromatic content, flash point, and sulfur concentration. In cold weather, freezing rain and cloud points bring in cold weather¹⁸. Palm biodiesel produces 8.76% more carbon dioxide gas than diesel at all loads. Contrarily, a maximum decrease of 10.88% was seen with apricot seed kernel biodiesel.

4- Hydrogen

While hydrogen is the most abundant element on Earth, it cannot be found in its pure form in nature and must be synthesized from other materials such as water and natural gas. How hydrogen is produced determines its influence on the environment and its efficiency in terms of energy use. One major benefit of hydrogen is that it does not contribute to the production of carbon monoxide gas, a major contributor to climate change. Hydrogen also has a lower ignition point than diesel, gasoline, and natural gas. Hydrogen has long been an alluring prospect for a number of reasons, including the ease with which it mixes with air, the wide range of temperatures at which it may be ignited, the speed with which it burns, and the high honeycomb structure it exhibits. Research into hydrogen as a crucial gas energy source has been ongoing for quite some time. When it comes to liquid energies, hydrogen doesn't have any issues like vapor constriction, cold wall quenching, shy vaporization, or spare mixing. Gases containing hydrogen burn cleanly. When hydrogen is burnt, it releases a lot of water. Hydrogen, unlike hydrocarbons, carbon monoxide, and carbon dioxide, does not produce toxic byproducts when burned (22).

Table 4: Comparison of alternative Fuels with Petrol and Diesel [18]

R.P.M. (Rev/min)	Fuels	Torque (Nm)	Temperature °C	Brake Power (kW)	Time for Start(s)	Brake Power Rate(kg/hr)	Brake Power (g/kWh)	BrakePower%
1200	Petrol	2.80	220	0.35	61.45	0.35	1000	8
	Bio-ethanol	2.60	160	0.33	63.3	0.34	1030.3	9
	Diesel	3.15	235	0.40	58.45	0.41	1025	9
	CNG	2.40	250	0.30	-	-	-	-
1400	Petrol	3.20	250	0.47	53.76	0.4	851.66	10
	Bio-ethanol	3.10	190	0.45	57.87	0.37	823.23	11
	Diesel	3.40	260	0.50	51.12	0.47	940	10
	CNG	2.85	280	0.41	-	-	-	-
1600	Petrol	3.70	280	0.61	49.5	0.43	704.91	12
	Bio-ethanol	3.55	215	0.60	52.44	0.41	693.33	13
	Diesel	3.90	280	0.65	46.45	0.52	800	11
	CNG	3.35	315	0.56	-	-	-	-
1800	Petrol	4.10	295	0.77	39.87	0.53	688.31	12
	Bio-ethanol	3.95	230	0.74	44.12	0.49	662.16	14
	Diesel	4.50	300	0.84	37.22	0.65	773.8	12
	CNG	3.90	355	0.72	-	-	-	-
2200	Petrol	4.90	315	1.13	36.9	0.68	531.27	17
	Bio-ethanol	4.80	250	1.11	40.18	0.53	477.48	19
	Diesel	5.10	325	1.17	34.15	0.71	606.84	15
	CNG	4.60	405	1.06	-	-	-	-
2500	Petrol	5.50	330	1.43	33.25	0.64	447.53	19
	Bio-ethanol	5.30	280	1.39	38.21	0.56	402.88	22
	Diesel	5.70	350	1.49	30.18	0.8	536.91	17
	CNG	5.10	445	1.33	-	-	-	-
3000	Petrol	6.40	360	2.01	27.45	0.78	388.66	22
	Bio-ethanol	6.10	300	1.92	30.14	0.71	369.79	24
	Diesel	7.00	410	2.20	26.11	0.92	418.18	22
	CNG	5.90	490	1.93	-	-	-	-
3500	Petrol	5.90	340	2.16	23.3	0.91	421.3	20
	Bio-ethanol	5.70	295	2.09	25.66	0.84	401.91	22
	Diesel	6.30	380	2.31	22.45	1.07	463.2	20
	CNG	5.40	455	1.98	-	-	-	-

CONCLUSION

We learned in the big picture that different fuels perform differently in an internal combustion engine. Among these fuels, diesel offers superior braking power and torque, bio-ethanol produces the lowest exhaust temperatures and uses the least fuel per unit, and hydrogen is the most environmentally friendly. According to the literature review, diesel engines are popular today due to their many advantages, including low fuel consumption, reliability, durability, high compression ratio, and cleaner fuel-air mixture. However, diesel engines also have certain drawbacks that could be improved, such as their combustion and emission characteristics, as well as their high compression ratio and high fuel-air ratio. Based on what we know from the literature review, numerous studies have attempted to improve diesel engines' performance, combustion, and emissions by implementing various changes, such as switching to different fuels, adding fuel additives, recirculating exhaust gas, varying compression ratios, enhancing turbo charging and injection systems, modifying external designs, and so on.

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