Research on Engine's Performance and the Emissions of Hydrogen Diesel Fuel Engine with Exhaust Gas Recirculation.

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ABSTRACT

Amidst the 21st century, an increasing growth has been observed in the motor industry. This increase has nurtured a danger to the environment as a result of poisonous emissions

given off by machines that are powered by fuel. Amidst the investigation of the non-toxic engines driven by fuel and hazardous fuel engines, efficiency and environmental safety are the crucial factors of worry. This has been acute reflection for an improved efficiency and functioning of the engines.

The discharges from engines utilizing hydrogen as fuel as compare to other fuel are lesser than others. The research boundaries help improve the environment as the globe strives for a safer environment for the people. The hydrogen engines are efficient due to their thorough combustion, recycling capability, and enhanced functioning from the hydrogen-fueled engine. Previously, Exhaust Gas Recirculation has resolved difficulties facing the environment (Talibi, et al., 2017).

This research study examines the impacts of hydrogen diesel engine. Although the Gas Exhaust has shown to improve functioning in both the environment and the engine. Statically the joint impact for assessing the consequential results of hydrogen-added engines is made.

1. Introduction

1.1 Background

Due to stringent environmental regulations, Liquefied fossil fuel injection, putting to use the dual-fuel engines is an appealing substitute to the conventional propulsion plants of ship supported by diesel engines being powered by Heavy fuel for bringing about a decline in both plants operating costs and the footprint of the environment. This research is concerned with the numerical analysis concerning a large marine dual-fuel engine i.e. four-stroke engine to compare its functioning and rate of harmful discharges in modes of diesel operation and gas operation (Sokratis Stoumpos, 2018).

As people's environmental consciousness grows, the emission regulations for marine diesel engines become more rigorous. Particularly for marine diesel NOX pollutants, the International Maritime Organization has established specific emission limits. Most marine diesel engines employ exhaust gas recirculation (EGR) to effectively cause a decline in emissions of NOX pollutant as emission regulations become more stringent. (Domenico De Serio, 2017).

The goal of Exhaust Gas Recirculation technology is to solve the "exhaust gas backflow problem", while rationally controlling the rate of emissions from EGR. As the pressure of the air being taken in is much larger than that of the exhaust gas being emitted from the EGR, the exhaust gas at high pressures can normally not be introduced into the intake port. Currently, the most common method of implementing EGR is to install a throttle or a measuring system. (Xiang-huan Zu, 2019). The former is the simplest to implement, but it will damage the turbocharger and reduce the diesel engine's scavenging effect, affecting normal diesel engine operation.

1.2 Dual Fuel Engine

An engine based on diesel fuel, it can work on both liquid and gas-based fuels. It uses the Otto process in the gaseous kind that involves supplying a lean air-fuel mixture to the cylinders. Through the suction stroke, the efficiency increases by 47% (Alexandru

Cernat, 2020). In diesel mode, the engine operates in accordance to the Diesel process, which involves supplying diesel fuel to the cylinders at the termination of the compression stroke. The engine has improved and can work on both gaseous and diesel fuel, it is a backup fuel source.

As a result of this, a large number of researches were conducted on the usage, performance, and efficiency of unconventional fuels to replace the usage of conventional fuels. The research on the functioning of engine and discharges for engines whose fuel consumption is of hydrogen-diesel type motors with fumes gas distribution is a subject that has been under discussion over the years. Among the fuels under research, hydrogen has been proved to have exceptional gains over the other fuels in regards to the wide flammable range and, in addition to that, it does not give off a vast range of harmful and toxic waste byproducts into the atmosphere.

Various types of scientific research have also been conducted over time, with the most recent research focusing on the inclusion of exhaust gas recirculation, which was a fresh section added to the discussion. The Exhaust Gas Recirculation system works by sending back to the combustion chamber of the engine a fraction of exhaust gases through the intake manifold, lowering the temperature in the chamber as a result of combustion. This system is designed to reduce the amount of Nitrogen (I) oxide emitted during combustion.

Exhaust Gas Recirculation (EGR) returns exhaust gases to the cylinder by overlapping the intake and exhaust valve opening times. Exhaust gases are recirculated into the intake manifold via an extra valve and an external duct in External Exhaust Gas Recirculation EGR. Classification of the EGR systems is done as either before or after the turbocharger, based on whether the recirculation of the exhaust gas is done: High-pressure EGR and low-pressure EGR (Magı´n Lapuerta, 2018).

1.3 Hydrogen Diesel Engine

The environment faces a threat from toxic emissions and depleting fossil fuel reserves due to an alarming increase in vehicular density around the world. As a result, there is a continuous search for energy resources that are clean to fulfil the need of sustainable transportation. Hydrogen appears to be an encouraging substitute option of fuel due to its properties of clean combustion, recyclability, and enhanced engine performance. High NOx emissions, on the other hand, are regarded as a distinct threat to hydrogen-powered engines (Sarthak Nag, 2019). On the other hand, exhaust gas recirculation (EGR) has been shown to solve the previously mentioned problem.

A promising substitute to conventional fuels is hydrogen. Hydrogen has advantages as well as disadvantages when employed as a conventional fuel in an automobile engine system. In a diesel engine with EGR and a hydrogen flow rate of 20 l/min, hydrogen-enriched air is used as the intake charge (N.Saravanan G. Nagarajan K. M. Kalaiselvan, 2008). Studies are carried out in a single-cylinder, four-stroke, and direct-injection diesel engine linked to an electrical generator.

1.4 Aim of the Research

The research aims to address and refers to the increasing apprehension about the requirement of energy and the pollution caused by fossil fuels, which brings about an impact on the need for a substitute fuel for the establishment of a clean and healthy atmosphere. The use of hydrogen in the form of a fuel with a faster flame speed and lower ignition energy increases the peak cylinder pressure and rate of release of heat. By combining gaseous fuel with biogas, the calorific value of the fuel can be increased, resulting in a clean and green energy source (Chinmay Deheri, 2020).

Hydrogen has a lower density than diesel (Molloy, 2019), and this study also examines the compounds' efficiency and compatibility along with the engine's efficiency. Determine the properties of hydrogen concerning the inferior auto-ignition when evaluating the increase in performance by using hydrogen for marine propulsion in diesel engines. It necessitates the use of hydrogen fueling system-specific methods. The purpose of this study is to look into the trial results of hydrogen used in diesel engines. Decide the effect of a cyclic portion of hydrogen on the motor's elated and burning execution. This research is unique due to its aspect of discovering the optimal correlation between engine functioning administration, considerations encircling combustion, the cyclic dose of the and discharges of the pollutants to implement the findings through these statistics on the present design of the diesel engine.

1.5 Objectives of the Research

The purpose for the research is laid out before the implementation of the research work to bring about a fall of events in a sequential manner during its outlined time frame. The following are the objectives that define the outcome of the work being done. They define the expected outcome of the research study and establish a set of boundaries.

- To evaluate the effect of hydrogen gas, which has a lower energy density than diesel.
- The determination of the inadequate auto-ignition characteristics of hydrogen, which necessarily involve the use of techniques distinctive to hydrogen fueling systems.
- Acquiring investigational results for hydrogen use in a diesel engine.
- Determine the benefit of reduced reliance on traditional fuels.
- To investigate the effect of increasing the rate of heat release by burning hydrogen.

1.6 Scope of the Study

To ensure that the benefit of reduced reliance on the traditional fuels is realized, and the importance of hydrogen in offering the benefits to cause a decline in the utilizations of diesel fuel and an enhancement in the combustion taking place in engines driven by diesel. (Mohammdreza Nazemzadegan, 2019). The research investigates the impact of a decreased dependency on the utilization of diesel fuel, with a decrease of 1.32 kg/h in the amount of fuel consumed in diesel engine and usage at 55% of the load of engine, on engine efficiency and combustion process with efficiency. (Alexandru Cernat, 2020).

To ensure that the impact of speeding up the rate of heat discharge, more rapid burning of mass fraction during each cycle, higher values of peak pressure, and a faster rate of peak pressure rise under standard engine operating settings. An appraisal of this last feature is to be done by an examination of the reaction of the engine in regards to any variabilities in combustion when hydrogen is being used.

1.7 Research Questions

What effects are produced when Exhaust Gas Recirculation is combined with a hydrogen-diesel dual-fuel combustion engine?

What is the relationship between Synergy, Hydrogen, and Exhaust Gas Recirculation in terms of reducing emissions?

Determine the relationship between engine performance and the quantity and type of emissions from the combustion chamber.

Establish whether it is true that Exhaust Gas Recirculation, upon the introduction of Hydrogen, proves to be operative in causing a decrease in the discharge of Nitrogen Oxide as well as other discharges from the combustion chamber of the engine.

1.8 Properties of Hydrogen Engine:

Hydrogen (H2) is a 'zero' carbon fuel, which means that it does not discharge any matter of particulate nature, total hydrocarbons (THC), carbon monoxide (CO), or carbon dioxide (CO2) during combustion (Karim, 2003). Hydrogen, however, possesses a considerably lower cetane number compared to that of diesel fuel and is not combustible solely through compression in modern diesel engines, necessitating the use of an ignition source (G. Lilik, 2010). For a diesel engine, aspiration of hydrogen can be done into the engine or introduced directly into the cylinder, with the auto-ignition of diesel fuel spray acting as a pilot to ignite the hydrogen (S. Lambe, 1993).

In comparison to hydrocarbon fuels, hydrogen requires very little energy for ignition but possesses increased rates of propagation of flame within the engine cylinder, when the conditions are of lean mixture even. Branching chain reactions of H2 that are fast and thermally neutral, cause the high flame speeds, as opposed to the endothermic and thermally significant chain reactions that are relatively slower and are associated with the combustion of hydrocarbon fuel (Karim, 2003).

The rates of release of heat from the co-combustion of fuel based on H2-diesel combination are typically greater than the rates for the combustion of diesel fuel, giving birth to a shorter period of combustion involving a decreased transfer of heat to the surroundings and the ability to improve thermal efficiencies (N. Saravanan, 2008). However, Masood et al. (M. Masood, 2007) and Christodoulou et al. (F. Christodoulou, 2013) reported a minor decrease in thermal efficiency during the operation of the engine with an H2-diesel fuel mixture operating at conditions of low load and low-speed, which was credited by them to incomplete combustion of all hydrogen aspirated into the engine.

Hydrogen can also be included into diesel engines as an improving fuel to be used as the next option to fulfil the guidelines regarding emissions. The Worldwide Maritime Organization (IMO)/MARPOL Convention, which comes into place in 2005, distinguished these guidelines in 1997. (Level 1 guidelines). Level 2 guidelines (a decrease of 15 to 22 percent from Tier 1) followed these guidelines in 2011. Beginning in 2016, these guidelines were followed with Tier 3 (an 80% decrease from Tier 1) during execution for explicit oceanic areas. Likewise, to lessen ozone harming substance outflows, the energy proficiency configuration file (EEDI) for CO2 discharges was presented in 2013. (GHGs).

It's anything but a 10% decrease in CO_2 outflows by 2015 and an almost 20% decrease by 2020 (Alexandru Cernat, 2020).

Since the ignition power of hydrogen is very high (576 0C), fuel in hydrogen form cannot be added straight in engines that work on diesel. It creates the need for igniter energy to outshine the setback. It gives rise to the confederation of a special glow-plug-equipped gas injector to ignite it easily as well. The approaches and equipment's on burning hydrogen are used to reach finest use in the engine.

Recent developments in fuels, particularly diesel engines, have created pressure as fossil fuels become increasingly scarce, and alternative methods need to be developed to support the remaining fossils deposits. It has accelerated the research instincts' ability to come up with ways to substitute green fuel for a portion of fossil fuels while ensuring that the solution they propose is both viable and cost-effective. According to the European Union Commission's White Paper Report, emissions that are related to transportation are expected to reduce by more than 60% by 2050 compared to emissions in the 19th-century. The usage of machines powered by energy has increased 3.5% in 2010 in contrast to 3.8% in 2011 it is expected to touch 4.1% that is the desired percentage (Baowei Fana, 2018).

1.9 Different Fuel Engines

In essence, gas and diesel engines operate in the same way. Internal combustion and a series of rapid explosions within the engine are used by both engines to convert fuel into mechanical energy and propel a vehicle forward. The distinction is in the manner in which these explosions occur.

In a gasoline engine, fuel is mixed with compressed air by pistons. To move the vehicle, the spark plugs ignite this mixture. A diesel engine, on the other hand, compresses the air first. This heats the air. Ignition takes place when the hot air makes contact with the fuel.

Because gasoline and diesel engines operate in different ways, they necessitate different types of fuel. While both gasoline and diesel are extracted from the earth as crude oil, the refining process separates them into various types of fuels. Diesel fuel is thicker than gasoline, so it evaporates more slowly. Diesel fuel has a higher energy density as well (Website, 2020).

These characteristics are another reason why diesel engines typically outperform gas engines in terms of fuel economy. While diesel fuel is typically more expensive than gasoline, most diesel engines require less of it to perform the same tasks as a gasoline engine.

In addition, diesel engine owners will soon have a new fueling option: biodiesel. Biodiesel fuel is made from non-petroleum sources like vegetable oil. Converting a diesel engine to run on biodiesel necessitates some modifications, especially if the engine is older. However, as efficiency and sustainability gain popularity, biodiesel may become the next popular alternative fuel.

Researchers have massively researched other options for fuels which have the credibility to be used as an alternative in conjunction with gasoline and diesel fuels. Internal combustion engines also use substitute fuels for example: hydrogen, acetylene, natural gas, ethanol, and biofuels. During the occurrence of phase of gas, hydrogen is approximately

14 times lighter than air. Furthermore, among all kinds of fuels, it is considered to be the cleanest in the world. However, due to its high ignition limit (4–75 percent) and low ignition energy, it requires the employment of special kind of design as pure hydrogen in internal combustion engines. It has been demonstrated that adding 20% hydrogen to fuels improves combustion, brings about a reduction in emissions, and results in an enhanced performance (Mehmet Ilhan Ilhak, 2019). The primary composition of natural gas is of methane (85–96%) and both gasoline and diesel engines can employ it. In internal combustion engines, ethanol is capable of being employed as a pure fuel or in the form of a mixture with other fuels.

2. Literature review

The rapidly increasing global energy requirement, combined with the ongoing exhaustion of fossil fuels, has resulted in a frenetic search for renewable alternative fuels. Among the fuels under research for this purpose, there is Hydrogen. The first hurdle is in storing hydrogen in mobile engines. Fuel cells benefit from the ability to extract hydrogen fuel from hydrogen-rich fuels such as gasoline, gas, methanol, and biomass. It can also be produced by using wind and solar panels. (Rodriguez, 2002).

The ignition limits of hydrogen are extremely broad. This enables spark-ignited engines to operate with either extremely lean or extremely rich hydrogen-air mixtures. Because of hydrogen's requirement of little energy for ignition, it may cause pre-ignition and flashback problems in spark-ignited engines. It has a calorific value of 2305 kcal/m 3 at 760 mm Hg pressure and 303 K. As a result, the energy content per volume of hydrogen is very low energy and will most likely cause power loss in spark-ignited engines that use homogeneous fuel-air mixtures. It has a burning velocity of 265-325 cm/s, which is several orders of magnitude faster than flames in gasoline-air mixtures. As a result, hydrogen has a high affinity for speed.

The temperature at which hydrogen self-ignites is 858 K. As a result, igniting hydrogen with the compression ignition process is extremely difficult. Because of this property, conventional diesel (CI) engines do not support hydrogen as a fuel. This expectation has been confirmed by several research attempts (S.Murthy, 1982). Simultaneously, the development of a method to use hydrogen in diesel engines would be highly desirable, as a big chunk of the engines employed in transportation, power generation, agricultural machinery, etc., is accounted for by them. The injection of hydrogen under pressure into compressed air has been attempted, similar to how a diesel engine works. Glow plugs or extremely high compression ratios are required to start compression ignition (Rodriguez, 2002).

Exhaust Gas Recirculation is intended to reduce the amount of emissions of oxides of nitrogen. When the temperatures of combustion approach the adiabatic flame temperature, nitrogen oxides – more commonly known as NOx – are formed in high concentrations. It's a fuel that's used in internal combustion engines (Dr. Johannes Kech, 2014). The functionality of Exhaust Gas Recirculation is essentially the recirculating of a portion of the exhaust gases emitted by the engine back into the cylinders and into the intake manifolds, where it combines with the incoming air/fuel charge. This causes the oxygen in the incoming airflow to be diluted, and it allows gases that do not participate in combustion to act as combustion absorbents. The peak temperatures and pressures of combustion are reduced, resulting in a reduction in the overall NOx output (J.Charlton, 1998).

Typically, Exhaust Gas Recirculation flow should correspond to engine operating conditions; for example, higher Exhaust Gas Recirculation flow is required during cruising and mid-range acceleration, when combustion temperatures are frequently very high (Uehara, n.d.). Low Exhaust Gas Recirculation flow is required when the conditions are low speed and light load, and there should be no occurrence of Exhaust Gas Recirculation flow during engine warm-up, idle, and full-throttle conditions so that Exhaust Gas Recirculation does not negatively affect engine operating efficiency or vehicle drivability.

When it comes to the induction of atmospheric air, one of the primary advantages of Exhaust Gas Recirculation is that it significantly contributes to lowering the effective combustion temperature and volumetric efficiency. Methods and technologies for igniting hydrogen to maximize its use in the engine. In Mazda's turbocharged SkyActiv engine, the temperature of the combustion chamber is reduced (Alexandru Cernat, 2020). Exhaust gases are recirculated and cooled when they are recirculated and cooled, allowing the engine to run at higher boost levels.

Despite multiple extensive kinds of research, the entire world is waiting for developments that will aid in further reducing the impact on the environment. This body of work then implies that the presence of Exhaust Gas Recirculation is required for the operation of diesel engines as well as the reduction of poisonous substance emissions into the environment for a broad-spectrum drop in toxic emissions to the environment (Talibi, et al., 2017).

3. Methodology

3.1 Research design:

Exploratory research design is conducted for this research for finding a suitable solution for the problem of diesel fuel engines. The reason for carrying this research is to replace the use of fossil fuels from hydrogen as the traditionally used engines emit a huge amount of hazardous gases that negatively affect our environment.


Problem Identification
Designing Research Objectives
Understanding the importance of Study
Designing Research Question
Literature Review
Data Collection through Secondary Sources
Triangulation of the findings with secondary data
Reserch outcomes
Recommendations

3.2 Data collection Method and Sources

Regarding the problem identification, various scholarly articles, online articles, and blogs were thoroughly researched to find a suitable method of using hydrogen gas in diesel fuel engines. Different theories and models were considered for the study, and triangulation was used to conclude the research after gathering qualitative data.

3.3 Analyzing the data

Analysis of the collected data was performed qualitatively. In-depth scrutiny was done of the functioning, performance, efficiency, emissions, and other aspects of engines, their types, the fuel they consume, different types of fuels, etc. The obtained results about the mentioned parameters were then compared with each other and results were obtained.

3.4 Discussion of the finding and conclusions.

The findings of the research showed that introducing hydrogen in the form of fuel for dual-fuel marine engines results in a significant overall improvement in the engine's performance, efficiency, and functioning. It was concluded that Hydrogen is a promising substitute for fossil fuel and can prove to be much more efficient, environment-friendly, cost-efficient, and overall beneficial.

3.5 Data Collection

Substantive and fundamental data makes it possible for there to be a concrete ground for the conclusion which acts as an enabling environment for the assessment of the topic of the research. The methodology is said to be a standard using which certain techniques or procedures are acquired and implemented in the clarification of the problems. The data that is required will be gathered from various sources both secondary and primary.

A survey method is used for the gathering of the data. Collection of the required data is done from people of different financial prudence or states and studied according to the objectives of the study.

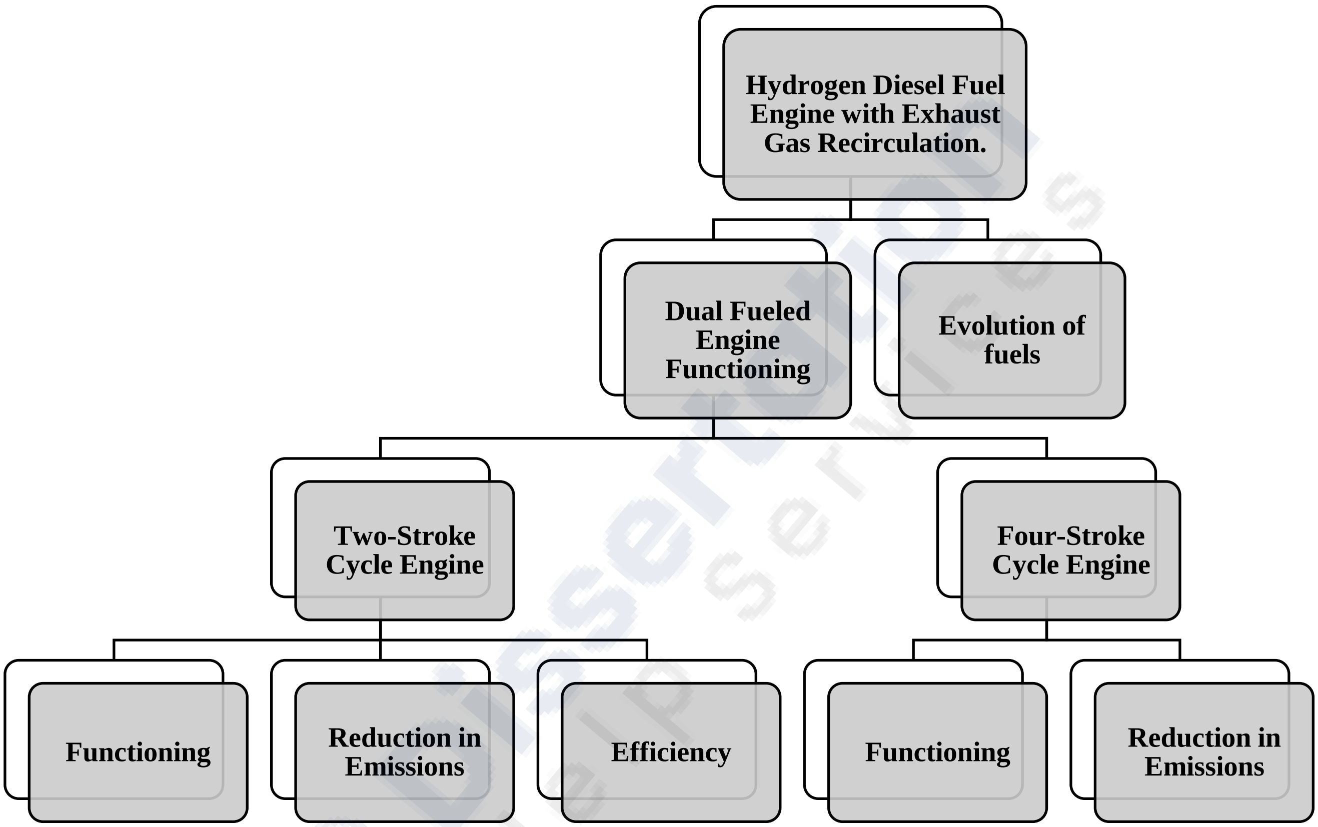
3.6 Research Paradigm

A research paradigm is a set of beliefs and assumptions about ontological, epistemological, and methodological issues that are held by a group of people in a research community. To respond to the above-mentioned questions and obtain the necessary data to reach a concrete conclusion, the research questions are reflected in the proposal, which is built on the foundation of the questions that contribute to the research's purpose. The impact of hydrogen-diesel fuel combustion on the atmosphere, correlation between synergy, hydrogen, and Exhaust Gas Recirculation decrease of discharges, and the type of discharges from the chamber are all strong grounds for this work, and they prove to be playing an important role in shaping it.

This is the motivation behind why the quantitative strategy is utilized all the more frequently in life sciences. Rather than this, the interpretive way of thinking thinks about that it's anything but suitable to take a wide perspective on discoveries starting with one investigation then onto the next, particularly on account of human conduct, as this can adjust following the different components of both situational and ecological nature. Our method is qualitative as we look into the qualities, functionalities, appropriateness, and impacts of the marine dual fuel hydrogen engines.

4. Data collection

Data collection:



Discussion/Analysis

Our research focuses on marine dual-fuel engines. Dual fuel engines are classified into two types based on their operating principles and mechanisms: two-stroke dual-fuel engines and four-stroke dual-fuel engines. Extensive research is conducted, including a comparative analysis of the two to determine which has the best compatibility with hydrogen and provides the best functionality, efficiency, and is also eco-friendly.

4.1 Evolution of Usage fuels:

An extensive history of gas-based engines (Stommel, 2000) exists in regards to scientific invention, which goes back to the early development that occurred just about twenty years when the invention of the modern steam engine was done by James Watt in the year 1785. This invention of a void piston engine substituted coal gas convection for steam. The title the world's first internal combustion engine is usually given to this.

According to historical facts and figures, ever since the Second World War, during which large quantities of low-cost petroleum oil were yielded in places like the Middle East, the employment of internal combustion engines grew at a breakneck pace. To put the natural gas provided by oil rigs into actual and active use as a derivative or a by-product of oil mining, the gas was mixed with the air that was being taken in and burned in the diesel engines.

This was the main double fuel motor innovation demonstrator at any point constructed. Various kinds of double fuel motors have been created. A significant number of these motors are diesel-touched off gas motors that utilization fluid fuel to consume the gas fuel or blended ignition motors that utilization Liquefied Natural Gas big hauler, bubble off gas, or subordinate gaseous petrol from oil extraction too extra fuel (Kampanart Theinnoi, 2017). These double fuel motors had the option to fulfill market need though the essential objective was the utilization of surplus petroleum gas as an incremental fuel, The functioning of the engines that make use of natural gas to reduce the impact held on the environmental must be done through the employment of natural gas as much as possible.

When it comes to marine dual-fuel engines, technical guiding principles are a necessity to be followed in order to use natural gas engines on ships for optimal results. This means that there is a requirement for the safe delivery of backup or standby if a gas-fueled function is lost as a result of a problem with the system of supply of fuel of the engine. This condition is met by dual-fuel engines that can shift between gas and liquid fuel.

The first development of these types of switchable dual-fuel engines was as four-stroke engines in the late 1990s. It wasn't until 2010 that working two-stroke dual-fuel engines were produced (Ohashi, 2015).

4.2 Dual Fueled Engine Functioning:

The basic functioning and mechanics of both types of dual-fueled engines is discussed separately after a thorough examination of the two categories based on the number of strokes.

4.2.1 Two-Stroke Cycle Engine:

From a mechanical aspect, a two-stroke engine is a sort of IC engine that carries out a single power cycle with two up and down movements, also called strokes, of its piston in a span of one power cycle.

4.2.1.1 Functioning:

The single power cycle is accomplished in a unit rotation of the crankshaft. This is the most fundamental working of a two-stroke engine. Fuel is circulated in big two-stroke engines to make sure that the system is completely prepared and at temperature. The oil typically comes back to a buffer/vent/mixing tank after it has been redistributed in a diesel engine fuel system.

So, the admission air is utilized for scavenging in a two-cycle motor, it can't jumble or consolidate with the gas fuel. As a trade for this, fuel is infused into the air blower in the form of gas in a similar manner as that of diesel fuel, and start is accomplished by infusing fuel by means of the miniature pilot fuel injector. The reason for diffusion and combustion, because diesel fuel will reduce, the result could be a reduction in CO2 emissions of up to 20% or more, as well as a reduction in unburned gas and CO emissions, all without knocking. Despite this, NOx emissions remain high for the same reasons.

The pressurized natural liquid is vaporized and then inserted into the cylinder to raise the pressure, to the value of 30MPA, of the gas fuel injected into the compressed air. In addition, due to the inexistence of a possibility of knocking, from a comparative point of view, it is easier to alternate between diesel fuel and gas fuel.

4.2.1.2 Reduction in Emissions

For lowering NOx emissions from a two-stroke dual-fuel engine is by using a low-pressure gas-fuel injection engine, which, despite having the functionality of a two-stroke engine, has the ability to work with a lean premixed fuel mixture. This includes the use of a fuel injection prediction results method that allows for a delay in the time of pre-mixing of air-fuel and air during the previously stated intake stroke, preventing the mixture of fuel and exhaust gas has direct contact from the air coming in the engine. This kind of engine is, at the time being, put under improvement to attain very low emission levels of NOx, which have a resemblance to that of a four-stroke engine.

Two-stroke engines of crankcase-compression type, for example, everyday small gasoline-powered engines, receive their lubrication through a mixture of petrol and oil – also known as petrol - in a total-loss system. A combination of oil is made with their petrol fuel ahead of the instance, in a fuel to oil ratio of about 32 parts to 1. Emissions are then produced by this oil, either by the means of combustion in the engine or as precipitation in the exhaust, causing an overall increase in exhaust emissions, above all hydrocarbons, when compared to four-stroke engines having power output that are similar. The shared time taken for the opening of the intake ports and exhaust ports in a models of few two-stroke pattern can also permit some quantity of the vapors of fuel that remains unburned to be discharged via the exhaust stream. Increased temperatures of combustion of small, air-cooled engines might also give off NOx emissions.

Despite this, with the aid of the direct injection of fuel and a sump-based system of lubrication, an advanced two-stroke engine can give rise to the quantity of pollution in the air in a similar manner to that of a four-stroke and can attain a thermodynamic efficiency which is higher.

4.2.1.3 Efficiency

Although two strokes' engines have a higher efficiency according to a relative point of view, they can still only reach about 50% efficiency. In other words, about 50% of the energy that is being produced by combustion is being transformed into a useful form, which is rotational energy at the output shaft of the engine. Meanwhile, what is left of the produced energy is being lost in the form of waste heat, friction, and engine accessories. There are quite a few ways to get back or regain a part of the energy that is lost to waste heat. One of these methods is the use of a turbocharger. The use of a turbocharger in diesel engines has been very impactful through boosting up the pressure of the incoming and in effect, the delivery of the same increment in performance as having more displacement. On two-stroke diesel engines, an auxiliary blower is typically made available.

This auxiliary blower is driven using electricity for the reason that the turbo blower, which is powered by exhaust gas, cannot offer an adequate amount of air at small speeds of the engine, and the pressed air is generally conditioned to a lower temperature to bring about a rise in the charge air density. Essentially, a turbo blower or turbocharger functions by performing the compression of the air which is powered by exhaust gas. Solitary shaft employs an exhaust gas turbine on the one end and the air compressor on the other. Casing design that are suitable, as well as suitable shaft seals, make sure that the two gases do not end up getting mixed. From the machinery space, the air is taken by the means of a filter. After that, it is pressurized prior to moving on to the scavenge space. Either straight from the engine or from a chamber operating under unchanging values of pressure, the exhaust gas might come into the turbine. Each shaft bearing possesses its lubrication system which is not dependent on any other parameters and works freely, and the end of the casing bearing the exhaust gas is usually cooled with the aid of water.

4.2.2 Four-Stroke Cycle Engine:

In comparison to the two-stroke dual-fuel engine is a very common variation of an IC engine in which four distinct strokes are finished by the piston while rotating the crankshaft. One stroke stands for or signifies the full cycle of the piston along with the cylinder, in one of both directions. Most of the internal combustion-powered automobiles in recent times employ four-stroke engines, and they draw their power by the means of either gasoline or diesel fuel.

4.2.2.1 Functioning

In the course of the action of the engine, pistons make use of 4 actions to accomplish each cycle of power. The explanation of a single event is the motion of the piston in an up or down manner. Upon the conclusion of the 4 events, one cycle is said to be accomplished and all set to start again for another cycle.

4-stroke engines ensure the provision of a decent equilibrium between power, reliability, and efficiency. When we talk about emissions, it is safe to say that four strokes split up every event from a mechanical point of view, which brings about a reduction in the emissions of unburned fuel. They are also capable of splitting up the oil from fuel, which has a noteworthy impact on the reduction of the emissions of carbon monoxide. This arrangement of features is highly sought after and it has brought the four-stroke engine among some of the top used engines in passenger vehicles in the present day.

In four-stroke engines with dual-fuel capacity, the fuel of gaseous form is delivered into the system at the time of the stroke of intake of the diesel engine. There is a variation in the emissions of exhaust, which functions directly following the quantities of both types of fuels - diesel and gas - in the total fuel.

The four-stroke engine usually rotates at a moderate speed, around 250 and 750 revolutions per minute. It is used for contingents such as alternators and, on occasion, for key propellant with a gearbox to deliver a rotary speed of 80 to 100 rev/min.

4.2.2.2 Reduction in Emissions

For the reason that the percentage of presence Carbon dioxide in the exhaust gas is directly dependent on the percentages of the constituents of the fuel, there can be a reduction made in the order of up to about 25% concerning the amounts of fuels in diesel and gas forms (Ohashi, 2015). Meanwhile, the degree of emission of NOx is directly dependent upon the temperature of combustion. The reduction in the emission of NOx can be attained by creating a reduction in the proportion of fuel of diesel form.

4.3 Four Stoke Cycle and Gas Engine:

A supply of gas fuel is made to the four-stroke engine via a flapper valve in the manifold of intake of air, from where it travels directly into the cylinder in the form of a combination with air. In the cylinder head, two injectors are used: one is the key fuel injector used for diesel mode and the other is the micro-pilot fuel injector used for gas mode. As a result, alternation between diesel and gas modes can be made by the engine without difficulty and with specific operating condition constraints.

Measured Parameter	Measurement Device	Unit	Uncertainties
Engine speed	Horiba Schenck E90	rev/min	±1 rev/min
Engine torque	Horiba Schenck E90	Nm	±0.2%
Diesel flow rate	Optima’s 3050 C	kg/h	±0.1%
Hydrogen flow rate	Ali’s cat Scientific	kg/h	±0.4%
Inlet air flow rate	MCR	m3/h	±0.35%
In-cylinder pressure	Kohen H 250	bar	±0.05%
Crank angle degree	AVL GU 12 P	° CA	±0.1%
	AVL 365 CC		

Table 1 : Engines (Adel Banawan. Mohamed M Elgohary, 2010)

Brake Specific Energetic Consumption vs. Engine Load at 2000 rotation per minute with various substitute ratios (Adel Banawan. Mohamed M Elgohary, 2010). Break Energy Consumption (BEC) and Brake Diesel Fuel Consumption (BDFC) as an element of motor speed at 2000 min1 and issue emerges proportions as an example for this, when the motor burden is at 55% (Pe = 18 kW), the mileage of diesel was 1.32 kg/h, and the proficiency of the motor has been expanded by 5.3 percent.

The range of fuel consumption load also expanded and there is an increase in the power of the engine from 15 kW to 22.5 kW utilizing an amount of fuel exactly equal to that of the diesel engine for hydrogen and diesel fueling.

Efficiency:

At 55 percent engine load and 2000 rpm, it displays the averaged pressure diagrams p- for traditional fueling (XC = 0) and hydrogen addition (XC = 6.76 percent, XC = 13.39 percent, and XC = 20.97 percent). The increase in combustion intensity and decrease in the duration for droplet combustion while the use of an air–hydrogen mixture is being made is correlated with the rapid growth in the tendency. The variation ratio (VC) according to Equation (1) is defined as:

$$VC = \frac{\sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} \left(x_i - \frac{\sum_{i=1}^{n} x_i}{n}\right)^2}}{\frac{\sum_{i=1}^{n} x_i}{n}}$$

Figure 1: The variation ratio

For each engine load regime, a total of three measurements were taken. For the results, the VC was used to assess the measurement error. Calculation was made to obtain the values of for all measures (torque of the brake of engine, speed of the engine, consumption of fuel by brake, and temperature of gas) and the results did not go past the low percentage of 1% discrediting to the operating regimes' steadiness. As a result, the data spread had been restrictive, the measurement sample was uniform, and the VC valuation for each measured dataset was less than the convergence limit. The variability in

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Brake Specific Energetic Consumption (BSEC) instead of XC substitute ratios at various engine loads.

The procedure for the mixing of hydrogen and air, when improved, will also improve combustion, whereas the specific energy consumption dropped with an increase in XC for each engine load. The BSEC decreased by 8.16 percent and 4.16 percent, respectively, at partial loads of 40 percent and 55 percent for maximum XC. Because the inlet air quantity dropped at high loads (85%), the BSEC gradually increased.

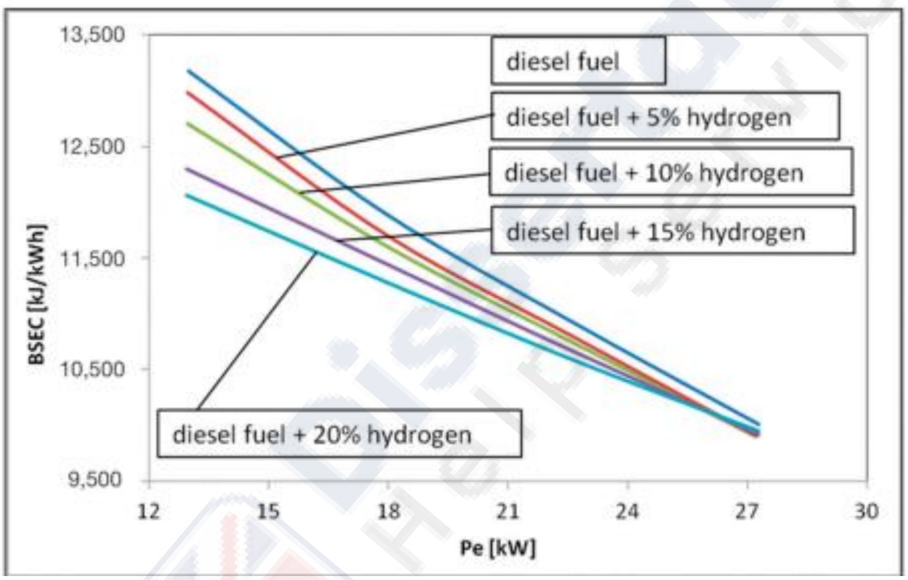

Figure 2: BSEC

Brake Specific Energetic Consumption vs. Engine Load at 2000 rpm with various substitute ratios. Break Energy Consumption (BEC) and Brake Diesel Fuel Consumption (BDFC), individually, as a component of motor burden at 2000 min1 and diverse substitute proportions. For instance, the diesel mileage was 1.32 kg/h at 55% motor burden (Pe = 18 kW), and the diesel motor productivity was expanded by 5.3 percent.

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For hydrogen and diesel filling, the motor working burden range expanded and motor force improved from 15 kW to 22.5 kW with same diesel fuel utilization as the diesel motor. The arrived at the midpoint of pressing factor charts p-for exemplary filling (XC = 0) and hydrogen expansion (xc = 6.76 percent, xc = 13.39 percent, and xc = 20.97 percent) were gotten at 55% motor burden and a speed of 2000 min1 (L Wang 2018). The increase in combustion intensity and decrease in the time taken for droplet combustion, when a mixture of hydrogen and air is present, is correlated with the continuous increase in the tendency. Peak pressure value and the rate of rise in maximum pressure were observed during our experiments.

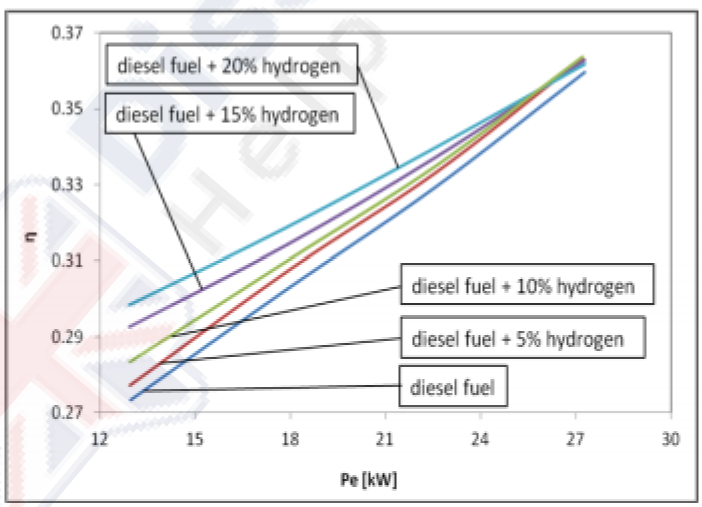

Figure 3: diesel and hydrogen effect-2019

The analysis of efficiency of the brake versus load on the engine is made at various substitute ratios and speed=2000 min.

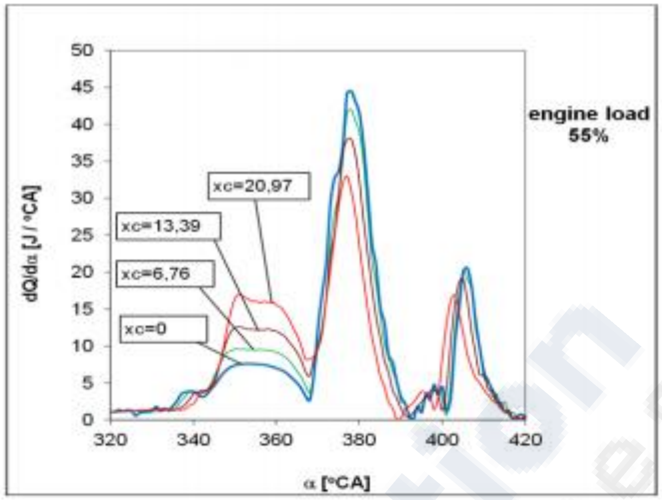

Figure 4: computational engine power efficacy with hydrogen load 2018

At the percentage of 55% in regards to the load of engine, and a speed of 2000, the rate at which heat is discharged for various additional ratios. The IMEP increased by 2.6 percent at peak XC due to an increase in hydrogen in the inlet air, and the dispersion in the middle of the values attained in burning consecutive cycles began to rise. As a result, the COV of IMEP was observed to be greater by a factor of 1.2 times for maximum XC in comparison to that of traditional fuel. Furthermore, the constant increase in inclination meant that COV values rose only slightly. (M. Norhafana1, 2018).

5. Ethical and Risks Evaluation

According to these findings, there are two major harms posed by the vehicles that employ fuel cell and are driven by hydrogen. Those hazards include electrical shock and fuel flammability. Fuel cells work on electrochemically mixing hydrogen and oxygen in gaseous forms, taken from the surrounding air to produce water and electrical energy.

An evaluation was carried after researching the working principles, obstacles, and functionality of both engines, a comparative study that paralleled both types of engines, namely two-stroke and four-stroke engines. The following contrasts were discovered:

Two-stroke engines have a divine creator ratio than four-stroke engines, and the availability power is has a slim range for the speeds of rotation known as the power band. Two-stroke engines that function with a single power-stroke per turn will theoretically produce double the amount of power compared to that of a four-stroke engine with the same swept volume. But from the other side, inefficient scavenging, as well as other losses, reduces the power advantage.

The number of moving parts in two-stroke engines is lesser when compared to that of four-stroke engines. For a specific value of the power of the engine, the two-stroke engine will be significantly lighter— which is a vital deliberation for ships.

- The two-stroke engine doesn't really have the need for complex valve working mechanism found in four-stroke engines (Alturki, 2017).
- The four-stroke engine can run at high speeds with ease. This compensates for its power disadvantage.
- The four-stroke engine consumes less lubricating oil than the two-stroke engine.
- The two-stroke outboard motor does not possess the same longevity as a four-stroke, which counts as a disadvantage on the two-stroke engine’s part.
- Two-stroke motors need a combination of oil and gas in the form of a mixture to provide lubrication to all of the moving parts. This can prove to be costly and, to a certain degree, hard to formulate (ProctorII, 2003).

- Two-stroke engines are relatively not as fuel-efficient as four-stroke engines. They give a lesser number of miles for each gallon and give out a greater number of emissions than four-stroke engines.
- A four-stroke engine is at a major disadvantage in comparison to a two-stroke engine when it comes to its size. It is bigger and weightier than its two-stroke counterpart.
- Four-stroke engines are more costly to construct and manufacture, though more space-efficient models are now being built by manufacturers.
- Four-stroke engines need a frequent change of oil and might be harder to fix in case of any rise in trouble or worn parts (Wolak, 2018).
- Four-stroke engines have difficulty burning lower-quality fuels while two-stroke engines are comparatively more compatible with cheap or low-quality fuels.

There are several conditions were making use of a two-stroke engine will prove to be of a higher benefit than using its counterpart, the four-stroke engine. Although a four-stroke engine provides some major and important advantages for instance higher speed, lesser space, an enhanced efficiency in regards to fuel, and lesser number of discharges of pollutants by design; some fundamental benefits exist of using the two-stroke counterpart.

5.1 Benefits of Stroke Engine

5.1.1 Simplicity of Design

Large two-stroke engines are commonly found on most ships. Heavy fuel oil is used on large ships to reduce the costs of operation and function. However, because only a two-stroke marine engine has the capability to combust low-grade heavy fuel oil, whereas a four-stroke marine engine cannot, marine vehicles are using two-stroke engines more than four-stroke engines.

Using a two-stroke design makes it possible to use cylinders that are large and as a result, a higher amount of power is created with each stroke. An understanding of this can be made in the form of high power to weight ratio – which means that for equal amount of weight, a higher amount of power is produced - and an enhancement can be made in the efficiency with regards to thermal or mechanical aspects.

Four-stroke drives are designed to be compressed and compact, with the number of moving parts being greater, at a high speed. During operation, this generates a great deal of vibration and noise. Both two-stroke and four-stroke engines produce significant amounts of noise, but one produces significantly more than the other.

5.1.3 Speed of Operation

Due to a lower speed and a lesser amount of vibration, the design of a two-stroke engine has an advantage in comparison to the four-stroke engine when it comes to ease of maintenance (Jinhui Liang, 2020). In addition to this, two-stroke engines have a lesser value for the frequency of upkeep and it is also very cheap.

A four-stroke drive's value of speed of operation is very high. As a result of this, the use of reduction gears is made in order to connect the propeller shaft with them. In regards to the two-stroke model, however, the need for separate gears that come with a coupling made with the propeller shaft straight does not exist and it is observed to be relatively simpler to start and reverse.

5.1.4 Efficiency

A two-stroke engine has greater mechanical efficiency in comparison to a four-stroke engine. This is because, from a theoretical point of view, a two-stroke engine produces the same amount of power in a single cycle of the crankshaft as that of the four-stroke engine in two revolutions.

A four-stroke engine has a higher Volumetric Efficiency (VE). VE is the ratio between the mass densities of the mixture of air and fuel drained into the cylinder during the stroke of intake at the pressure conditions kept at atmospheric standards, to the mass density of the identical volume of air in the intake manifold. Or, in simple words, it is the cylinder filling capacity of an engine at a certain rpm in the intake stroke. But pressure most definitely plays a critical part in this which is mostly overlooked.

A two-stroke engine has greater thermal efficiency in comparison to a four-stroke engine. It is known that thermal Efficiency is the ratio between work output and heat input. From a theoretical point of view, for the two-stroke engine, work output is twice as much as that of a four-stroke engine for a single rotation of the crankshaft, and so is the fuel input. From a practical point of view, the work output is less, and therefore, since there are no separate valves, so a fraction of the incoming fuel combines with the exhaust and exits the chamber before burning. As a result of this, the thermal efficiency will be less.

5.1.5 Power & Torque

For the consideration of power and torque produced, two-stroke engines have greater efficiency in comparison to four-stroke engines as they produce the same amount of power as that by the four-stroke engine for the same size in half the time.

5.1.6 Fuel Consumption

While in terms of fuel consumption, two-stroke engines have lower efficiency in comparison to four-stroke engines because two-stroke engines spray the fuel when the exhaust is open. This makes a fraction of the air-fuel mixture be emitted without being fully combusted. This, as a result, makes two-stroke engines more pollutant than four-stroke engines.

5.1.7 Emissions

In terms of emissions that are given off by each kind of engine, the emissions of a massively large number of combustion engines all across the planet have a critical influence on the atmosphere of the world. In the local environment, the Volatile Organic Compounds and oxides of nitrogen that are being emitted tolerate the duty for the procedure of a photochemical reaction sequence in the troposphere that becomes the reason for a growth in the concentration of ozone. Automobiles are fitted out with combustion engines and the emissions that are given off are released, for the most part, into the air, and similarly, large vessels also release their emissions into the atmosphere. On the other hand, the extensively used motorboats on inland lakes and shore possess inboard and outboard engines which are more often than not planned in such a way that the exhaust is released into the water.

The apparatuses of outboard engine exhaust demonstrate changed performances. The gases that are emitted, which are extremely volatile and have a weak ability to dissolve in water, are exposed by the powerful flow of gas from the water and are as a final point released into the atmosphere. In contrast to this, the fraction of the compounds which is less soluble in water and is fewer volatile stays for the most part in the water. As a result of this behavior, motorboat traffic can have an impact on water quality by accumulating emission products in the water. Sites along the coast and in lakes are frequently used for fishing while also serving as regeneration zones with all of the amenities that people seek.

In this case, clashes have given a rise between the two operations which are particularly severe when dirty freshwater aids as a supply of drinking water. Criticisms and protests from people who swim and those who sunbathe must be attended to when they are subjected to motorboat fumes of emission that especially hang around close to the water surface and disperse in a horizontal direction onto the beaches.

Even though the emissions of outboard engines can be controlled by law, as has been happening for emissions of automobiles (Johansson, 1992), such protocols are not known for motorboats in most countries. One of the reasons for this may be the deficiency of information on the emissions given off by outboard engines and their effect on the quality of air and water.

5.1.8 Exhaust Gas Recirculation

The use of Exhaust Gas Recirculation can significantly reduce these emissions. Exhaust gas recirculation (EGR) is an effectual policy for bringing about a reduction in the emission of NOx or oxides of nitrogen from diesel engines.

The Exhaust Gas Recirculation phenomenon reduces NOx emissions by bringing about a decrease in the percentage of oxygen in the combustion chamber and absorption of heat. A variety of designs have been planned, including high-pressure and low-pressure loops such as Exhaust Gas Recirculation and hybrid systems. Use of EGR is also made in gasoline engines, the primary function of it being the reduction of pumping work and bringing about an increase in the efficiency of the engine.

In the chamber of combustion, exhaust gas being there benefits emissions by lowering emissions of oxides of nitrogen, Hydrocarbons, and Carbon monoxide. Exhaust

Valve Closing and Intake Valve Opening timings can become the reason for the collection of exhaust gas in or reinserted into the cylinder. This phenomenon is "internal" Exhaust Gas Recirculation, it is usually dodged as a result of its effect on the torque at full load. Exhaust Gas Recirculation systems that are “external” are becoming more common. At part load, gas produced in the exhaust system is driven back into the inlet manifold in these systems. This reduces part-load emissions and increases efficiency by reducing inlet pumping losses. Due to the fact that the percentage of Exhaust Gas Recirculation can be altered to fit the speed of the engine and the conditions of load, there is no need for any detriment to the full load torque.

Internal Exhaust Gas Recirculation, nevertheless, does have two noteworthy gains over external Exhaust Gas Recirculation:

1) External systems do not come cheap and have a tendency to experience durability issues crediting to their frequent exposure to hot, dirty gases. The complex components of Exhaust Gas Recirculation control systems are prone to deposit accumulation, resulting in leakage or blockage.
2) In the case of internal Exhaust Gas Recirculation, the recirculated gas exits the cylinder in the last. This section typically contains gases from any crevice volumes in the cylinder and thus holds a considerable amount of un-combusted hydrocarbons from the combustion process. External Exhaust Gas Recirculation only recirculates a portion of all exhaust gases after they've been combined, so its ability to reduce hydrocarbon emissions is significantly reduced.

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Exhaust Gas Recirculation decreases the values of losses to pumping as the torque produced in the engine can be controlled by a decreasing the depression in the manifold in comparison to torque produced in that very engine without the installation of Exhaust Gas Recirculation. The value of losses due to pumping can be decreased by the use of reduced valve lift to throttle the cylinder or by altering the inlet valve closing timing. The engine thermodynamic cycle is complicated by throttling with the valve.

5.2 Cost Efficiency:

Two-stroke engines are lighter in weight, have a greater efficiency, are capable of employing lower-grade fuel, and cost far less than four-stroke engines. As a result, lighter engines have a higher power-to-weight ratio (more power for less weight) (Bethel Afework, 2018). Crediting to the very simple design of the two-stroke engines, they prove to be much easier to repair. They lack valves in favor of ports. Since there are more parts in a four-stroke engine, their cost is relatively much higher, and hence they are more expensive to repair (Author, 2017).

6. Conclusion

6.1 Hydrogen use in a diesel engine and reducing reliance on traditional fuels

The current paper made several contributions to the field of ICE research. They are found in the measurement of the best possible correlation coefficients between the reign of operation of engine, diesel-centered fuel, hydrogen cyclic quantities, , combustion peak pressure, emissions levels of pollutant, supercharging pressure and combustion chamber temperatures, all of which are measured as part of an investigational study into achieving maximum engine efficiency through the use of hydrogen. In comparison to the fueling system that is conventional, i.e., using hydrogen as fuel, an ultraclean mixture starts which is established in the cylinder prior to the beginning of combustion. This mixture brings about a small quantity of increase in the inconsistency of combustion, for the peak pressure with COV values and IMEP being increased by a factor of 2.1 and 1.2 times (Alexandru Cernat, 2020), in that order. In a more general narrative, hydrogen use offers a reduction in the emission of greenhouse gas and pollutant releases, but the degree of this decrement is dependent on the hydrogen cyclic dose.

6.2 Hydrogen gas lowering energy density than diesel.

Upon adding hydrogen, a rise is observed around the value of molar fraction of water vapors in the reactants taking part in the combustion process, having an influence on the temperature of combustion and causing a decreasing the levels of emission of NOx with 20%. In the mixture the reduction of the carbon content at the final level when diesel fuel was replaced by hydrogen gave rise to a 24% decrease in the smoke emission (Xinxing Shan, 2016).

Numerous studies exist that own the literature which show the impact of addition of gas on the functionality and emission outputs of the diesel engine, however, most of the do not take into account the influence that the speed of engine and the rate of gas hold parallel to each other on the discharge and burning characteristics. A decrease in CO, carbonic acid gas, and smoke emission is indicated by most of the studies, in relation to gas addition. However, the deviation and the discharge of total organic compound (THC) and BSFC, above all at conditions of half load remain undefined. For this research, the intake port was introduced with gas, employing a gas injection with the rates of 1/3, twenty-fifth, and five-hundredths of the total amount of energy (Alexandru Cernat, 2020).

6.3 Auto-ignition characteristics of hydrogen

Engine performance, tailpipe emissions, and burning characteristics were all thoroughly investigated. It is one of the most comprehensive and all-encompassing experimental works, incorporating excess air quantitative relationship, volumetric effectiveness, brake thermal potency, THCs, smoke, carbon monoxide gas, dioxide, exhaust gas temperature, in-cylinder stress, rate of heat transfer, and EGR results while considering the amount of gas energy at varying engine speeds.

7. Recommendations

The issues of knocking, low efficiencies, pre knocking, high levels of emissions, and other problems are faced by any diesel-based engine. These problems restrict the enhancement of the achievable load and efficiency of the engine. Direct injection of hydrogen in a dual-fuel engine can prove to be a promising solution for the above-mentioned limitations.

However, the thermodynamic efficiency of a hydrogen engine is limited due to the engine compression ratio of SI engines being low. The spark ignition is replaced by a pilot fuel engine for compression-ignition engines. It brings about speedy combustion of gaseous fuel by inducing multiple ignition kernels. This mode of combustion, also known as dual-fuel hydrogen-diesel direct injection, can alleviate the power and compression ratio limitations observed in hydrogen applications in spark-ignition engines.

Green hydrogen use can reduce our reliance on fossil fuels, crediting to such combustion mode. This will, in turn, reduce emissions of carbon-based substances significantly. However, there is a need for further work to be done and for certain developments to be made in the hardware domain to bring about commercialization. There is also a requirement for research to be conducted to improve understanding of the functioning and mechanisms that govern an engine's efficiency and are responsible for the formation of pollutants in such dual-fuel combustion mode.

Metal engine testing is also required. This is to demonstrate how effective this combustion concept is in terms of emissions and performance. This is also to investigate the impact of various operational parameters. Numerical simulations and fundamental optical and laser-based investigation are required to develop an understanding of the operating criteria to improve engine performance optimization. Furthermore, to achieve commercialization, there is a need for technological advancement toward a finished, simple, low-cost, and robust onboard fuel delivery system.

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