A Study on Diesel Engine Combustion

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Abstract

The application of diesel engine has been rising dramatically since it's invention and the usages have speared in the field of transportation, agriculture, constructions and what not. Due to its colossal power, this engine has become prominent whenever thinking about heavy duty performances. Diesel engine ignites fuel into combustion chamber, where air is pressurized by the upward stroke of the piston. As it is an internal combustion engine, the operation follows the order that can be obtained by two stroke or four stroke cycle. However, in both cycles the fuel energy converted into machinery energy to produce power. The present study indicates the factors which need to be prioritized for appropriate combustion and the fuel characteristics on which the engine's efficiency depends. Moreover, in order to carry appropriate combusting and the safe operation of engine some effective measures are identified by scrutinizing the diesel engine used for heavy duty performance.

Keywords: Diesel engine, Combustion, Fuel, Air-fuel Ratio, Efficiency.

1. Introduction

Diesel engine uses the fuel energy for producing thermal energy which further converted into mechanical energy and the process occurred in the combustion chamber. The operation based on burning of fuel-air mixture inside a confined cylinder, which results in high pressure that is responsible for moving the piston. As the connecting rod attached to the crankshaft, a rotary power is achieved to accelerate the vehicle. During this whole process of combustion, the fuel burns and produces heat energy which divided into kinetic energy that makes the work done and other portion losses in terms of exhaust and cooling system. The number of the cylinder may vary according to the demand and engine size. The four-stroke diesel engine completes 2 cycle for 1 revolution whereas two stroke completes one revolution for each cycle. However, several conditions are required for carrying out perfect combustion for instance- adequate air supply, fuel-air ratio, fuel properties, atomization ,injection time ,cooling system and the condition of the machineries. Hence ensuring aforementioned criteria can lead a engine to operate in an effective and long-lasting way.

2. Research Methodology

Data has been collected by experimenting the Sulzerseven-cylinder diesel engine while working onboard. The experimenting data was cross checked with available data. Importance of different parameters is ascertained from various deviation of running engine and their remedy. Fuel characteristics are mentioned which are found essential during the voyage. Adequate air-fuel ration is measured from the engine control room. Finally, the structure of engine is observed during the engine overhauling.

3. Discussion

3.1Combustion and energy transformation: From Figure 1, the fuel is supplied by the nozzle through the atomization hole when the piston riches at the extreme compression stroke which leads fuel to be mixed up with air adequately. When the piston riches close to the TDC, the temperature of the mixture exceeds the ignition temperature and the combustion occurred. Technology reduced the time of ignition delay for direct injection diesel engine, hence ensures adequate turbulence followed by perfect combustion and less soot deposit. Heat release fluctuates throughout the cycle of combustion. The heat energy which is produced by combustion need to be

converted quickly for getting the highest efficiency and avoid the loss of heat energy. The following graph depicts the rate of heat release considering the different angle of crankshaft.

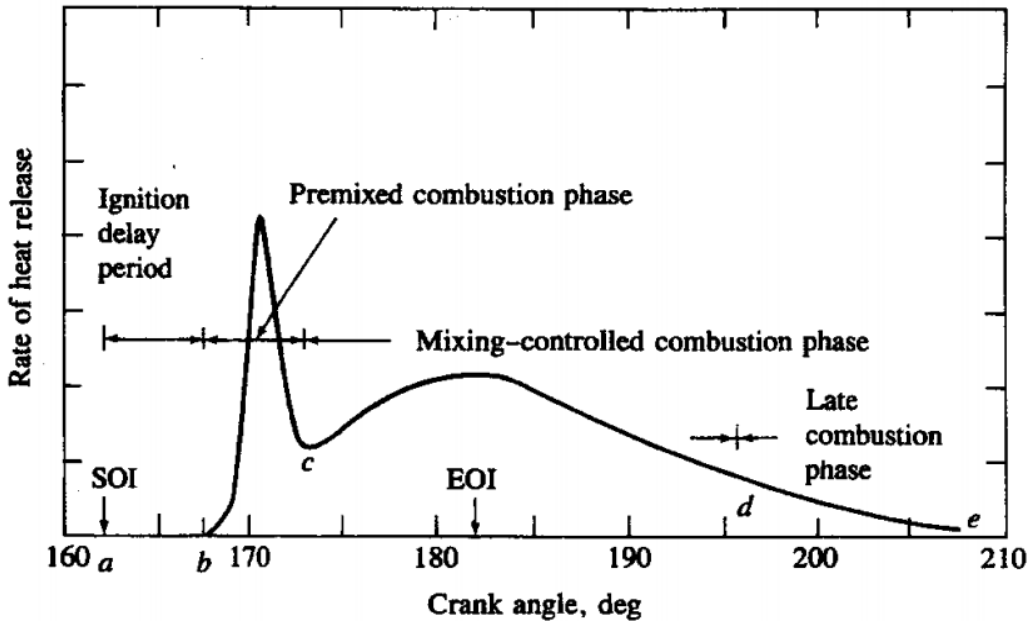

Figure 1. Amount of heat energy in different crank angle [1]

1. The time between the feul injection and the starting of combustion represented by a-b indicates the ignition delay period.
2. Combustion of fuel-air mixture occurred in b-c phase while the rate of heat releasing reached a peak.
3. During the 3rd phase c-d, the releasing rate depends on the mixture availability.As the phase procedes the heat releasing rate started declining consistently.
4. Considering the last phase of the diagram(d-e) which is the expansion stroke, there may present trivial amount of mixture that can be left for burning but the releasing rate is slower than that of other phases because at this time of expansion stroke the temperature falls.

Above diagram illustrates the heat releasing rate for a perfect combustion. The appropriate combustion can be observed through the exhaust smoke. Table 1 shows some condition of combustion which are gained by experimenting the exhaust of a diesel engine. However, apart from the mechanical condition of engine there are certain types of criteria which need to emphasize to ensure such perfect combustion. The rest of the article will be discussed about such parameters.

Table 1. Identification of combustion through Exhaust color.

Exhaust color	**Indication of combustion**
Black	Less air supply, bad combustion
Blue	Lub oil contamination
White	Water in the fuel
Yellow	High sulfur containing in fuel

3.2 Fuel characteristics.

Fuel of any engine is prominent contributor for a perfect combustion. Different types of fuel have different specification. While considering the diesel as fuel the following properties must be ensured [2].

a. Sulfur: Sulfur content must be limited for the sake of engine life expectancy and efficiency. If sulfur content exceeds its desired value, it can contaminate the engine oil and attack the piston ring and cylinder liner. Overall, the consumption of fuel and engines efficiency decreases proportionally.

b. Foreign materials: Fuel must be purified and free from particles, for instance- ashes, metal chips, water and carbon before storing it into the service tank. Foreign particles can deposit soot in the combustion chamber, choke the fuel line, cause faulty penetration and sometime engine jerks off due to the presence of this particles.

c. Flash point: Flash point is the temperature when the fuel can produce flammable vapor, which is needed for proper fuel-air mixture .hence, adequate mixture can lead perfect combustion, flash point is an important property of fuel. Normally fuel is preheated below the flash point before injecting it in the combustion chamber.

d. Centanenumber: Centane number of diesels identifies the ignition delay period which is disproportional to the period**.**Ignition delay is an important parameter for this type of engine that is responsible for the improper combustion, irregular running of engine and excessive emission**.** Table 2 shows Centane number depicts ignition period.

Table 2. Centane number depicts ignition delay period.

Centane number	Ignition
30	Fast
40	Fast
50	Fast
60	Moderate
70	Slow
80	Slow
90	Slow
100	Highest ignition delay

e. Heating value: Two types of heating values are considered during combustion. the water converted to steam by absorbing heat energy during combustion. The value which mentions the energy including the energy used by the water is called higher heating value and the value which excludes that energy is known as lower heating value. The amount of water produced during combustion depends on the hydrogen present in the fuel. Hence, more water or steam means more loss of energy as the steam passes through the funnel with exhaust.

f. Viscosity: Viscosity needs to maintain while considering the atomization. Improper atomization leads to faulty penetration and inadequate mixture of fuel-air. Merchant vessel while passing through the cold region heated the fuel for maintaining viscosity.

3.4 Fuel-Air ratio: For burning the injected fuel and getting the perfect efficiency of diesel engine , adequate air must be supplied. Choking of scavenge ports or exhaust valve late opening both lead scarcity of fresh air in the combustion chamber which leads to bad combustion resulting excessive pollutants.In diesel engine the fuel-air ratio has a trivial deviation from the stoichiometric A/F ratio. The ratio between the actual and the ideal A/F ratio is known as equivalence of such ratio or lambda [4].

λ = Actual air-fuel ration/Idea air-fuel ratio

For diesel engine the ideal air-fuel ratio is 14.5:1 [3]. The lean value means where there is surfeit of air for combustion and the reach value is smaller than the idea value. The diesel engine runs at higher than the idea value that means for diesel engine λ is always higher than 1. As is observed from the figure 2, when the air-fuel efficiency is equal to the ideal ratio the efficiency is at .55 and the figured steadily increasing for the positive inclination of lambda. Hence, the best efficiency is obtained when the lambda is equal to 2.

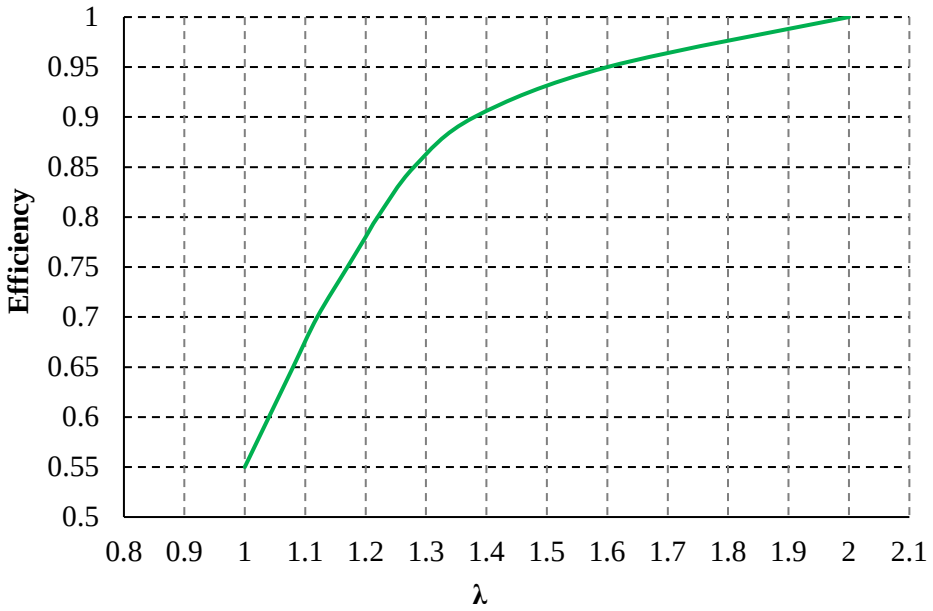

Figure 2. Engine performances in different air-fuel ratio.

3.4Condition of machinery: Its noticed despite of having sometime engine doesn't correspond with appropriate fuel and Air-fuel ratio. This case some other misalignments are responsible for such defective operation. Some of the reasons are mentioned below:

a. Cam shaft: Cam shaft controls the opening and closing of valves. Wrongly set camshaft causes loss of power, inadequate burning of fuel and irregular running of engine.

b. Lub oil: Lub oil makes a film between the liner and the piston. Contamination of oil or scarcity may cause piston scuffing which acts as a obstacle or sometime blow past results.

c. Piston ring: Broken piston ring is responsible for blow past and corroding the liner by scuffing.

d. Exhaust valve: Early opening of exhaust valve let the fuel to be improperly burned and late opening of this valve causes inadequate emission of exhaust which affects the upcoming combustion.

e. Fuel-rack : Fuel-rack stuck up causes insufficient or excessive supply of fuel and for both cases bad combustion occurs.

f. Injector: It is recommended that the injector must be periodically checked and examined. Injection holes choking obstruct the atomization system and supply less fuel in the combustion chamber.

g. Booster pump: Booster pump ensure the fuel to be supplied at a appropriate speed in the combustion chamber, hence failure of such system may imbalance the generation of power and load.

4. Conclusion

From the beginning of the invention of diesel engine it has been a common platform for the researcher to investigate for ameliorating the operation for more perfection and efficiencies. However, the aforementioned traits can be the major factors which need to be emphasized on. But there is abundance of remarks that can influence an operation of diesel engine. If the condition of an engine supports a good combustion which is prerequisite for a perfect combustion, then it is evitable the combustion relies on the discussed criteria of this paper.

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Biography

Md Mohaimeen-Ul Islam is a marine engineer who is an ex-cadet of Bangladesh marine academy (BMA), Chittagong, Bangladesh. Afterwards, he earned his Bachelor of maritime science (engineering) degree from Bangabandhu Sheikh Mujibur Rahman Maritime University(BSMRMU). In 2019, he designated as merchant 3rd Engineer .While completing his sea time (degree requirements) as an Engine Cadet in VLCC (very large crude carrier) at NITC, he gathered some valuable experiences. The experience which was something like starting from zero and an unknown position to something greater and reaching to the desired destination. His realization brought him to the intersection of his future plan and that was performing something new with desired destination which is only possible by stepping to the world of research. His research interest includes- Fuel cell, combustion, propulsion system and heat transfer.