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Effect of Various Injection Pressures on Performance and Emission Characteristics of a Four Stroke CI Engine Fuelled With Algae Biodiesel

Araveti Vasavi[1], Dr. B. Omprakash[2], Dr. R. Ganapathi[3]
[1]*M. Tech student, Dept. of Mechanical Engineering (AICE), JNTUACE, Anantapuramu, AP India 515002,*
[2]*Asst.Prof, Dept. of Mechanical Engineering, JNTUCE, Anantapuramu, AP India 515002*
[3] *Prof, Dept. of Mechanical Engineering, Anurag Engineering College, Kodada, Telangana, India*

Abstract*: *There is a lot of need to search for an alternative fuels in place of conventional fuels as the reserves of conventional fuels are decreasing due to increase in their consumption in day to day lives and these fossil fuels in near future will become rare due to its indiscriminate extraction as well as utilization. Diesel fueled vehicles are releases number of harmful emissions like CO, UHC, NO_X , CO_2, sooth and particulate matter etc. in considerable quantities which are very harmful to environment as well as human beings. To provide a healthy environment to our next generations we should reduce the releasing the emissions from automobiles. However, to overcome this problem the bio-fuels are being used in the field of IC engines as alternate fuels. Therefore Algal biodiesel is considered as a promising option as they are clean renewable fuels and best substitute for now day's conventional fuels in internal combustion engines. The important advantages of using algal biodiesel are its renewability and better quality of exhaust gas emissions. Depending on the species and cultivation conditions, algae can contain extremely high percentage of lipids or carbohydrates that can be easily converted into whole range of biofuels including biodiesel or bioethanol. The main focus of this work is to replace the conventional fuels with the algal oil which is directly injected into the combustion chamber and also blended with non-renewable fuels at 20% by volume in a single cylinder four stroke water cooled light duty injection CI engine at different injection pressures like 180,190 and 200 bars. The tests were conducted for pure diesel and B20 algae oil in diesel engine at constant speed of 1500 rpm with varying the loads. The performance results at 180 to 190 bars of blend very closer to pure diesel results. The emissions UHC, CO and CO_2 are very less at 180 bars than pure diesel. The NO_x emissions are lesser at 200 bars compare to pure diesel. The overall performance is good at 180 and 190 bars. But the emissions are decreased when increasing injections pressure.

Keywords - Algae oil, BTE- Brake thermal efficiency, CI engine, Engine emissions and performance, Fuel injection pressures, Nox emissions and UHC- Unburnt hydrocarbons.

I. INTRODUCTION

The definition of Engine can be given as which is having the ability to convert heat into useful work. Here the work is a high grade energy and heat is a low grade energy. This IC engines broadly classified as two types like external and internal combustion engines (EC and IC). The efficieny is high for inernal combustion engines than external combusion engines. The emissions also released in smaller quantities from IC engines than EC engines. The main idea of alternative fuels is good reserves in the sector of transportation because they will not only assist to the environmental quality but also has distinct positive socioeconomic results. From last century many number of scientists had proposed that the bio-fuels are good alternatives to fossil fuels. In present research we will introduce Algae oil as an alternative fuel. In present experimental investigation we are purchased Algae oil at Shree Kumarasamy Poly chemicals Ltd in panruti. It is in Cuddalore district at Tamil Nadu. The Algae oil is very cheap and easy available alternative fuel in the world. In present day's major pollutants from automobiles are unburned hydrocarbons (UHC), Nitrogen oxides (NO_x), Carbon monoxide (CO), sulfur compounds and lead compounds and particulates.

The total human beings are 7 million in the world. Out of the total population the number of automobiles which we are having 1 billion i.e., every 7th person having vehicle in the world. The daily population of human beings will be increasing 4% for every year. But number of vehicles is increasing 24% .The total energy which world is having petroleum products, USA using 50% but there

population is 4% of the world. We people are consuming 1.5% but our population is 121 crore. When we people are consuming 1.5% of petroleum products only but still we saying pollution of India is very high. At present the Indian people having 15% of vehicles. But in USA each and every person having a vehicle. The Indian people have per capital income is one thousand dollar. In India 40 crore people are earning less than 1 dollar and 10% are earning people who are richer than the USA that much difference we people are having. The petrol engine's efficiency is 11% only then remaining 89% destroy the environment but the efficiency of diesel engine is 30 to 35%. In India highest number of vehicles is 2-stroke two wheeler engines. In many countries these vehicles banned because there emit large number of pollutants. One of the authors conducted experimental test on I.C engine with different blends of Cashew nut shell oil with Diesel B20 to B100 i.e., B20, B40, B60, B80 and B100. He was found that the emissions and performance results are good and very nearer to pure diesel for B20 blend of cashew nut shell bio diesel among all of the remaining. Now a days in diesel engines the fuel injectors are designed to maintain very higher injection pressures in order to acquiring better performance results. The main intention of this design is decrease the exhaust emissions and increasing the efficiency of the engine. The fuel injection pressure is inversely proportional to the droplet size of the fuel. The fuel droplets diameter is increases at lower injection pressures then the ignition delay period is increases during the combustion. This further leads to increase the injection pressure. Engine performance will be reduce since combustion process goes to poor condition. When injection pressure improved the fuel particle size decreased. The air and fuel mixture formation becomes better from that complete combustion was done in the cylinder during the period of ignition. When injection pressure is high the ignition delay period is shorter. The homogeneous mixture is leads to increase in combustion efficiency.

II. ENGINE AND FUEL PROPERTIES

Properties	Diesel	Algae oil	B20
Density (Kg/M^3)	850	990	875
Kinematic Viscosity@ 45 ^{0}C	2.82	18.3	4.7
Calorific Value (KJ/Kg)	42570	40455	42100
Fire Point (^{0}C)	87	208	98
Flash Point (^{0}C)	81	200	88
Cetane Number	46	58	53
Lower Heating Value	42.3	39.9	42.9

Table 1: Properties of Diesel and Algae Oil

Make	KIRLOSKAR
Type	Single Cylinder, Four Stroke, Water Cooled
Capacity	5 HP
Bore Diameter	80 mm
Stroke Length	110 mm
Speed	1500 rpm

Table 2**:** Engine Specifications

The Experiments were taken out on a naturally aspirated, water cooled, single cylinder, direct injection diesel engine. The Engine specifications are shown in table2 and the fuel properties are listed in table 1.

III. VARIATION OF INJECTION PRESSURES

The desired amount of fuel should be measured by injection system of fuel, depending upon engine load and speed, and inject the fuel at desired rate in correct time. The appropriate shape and size of fuel particle obtained depends on the particular combustion chamber. In present experimental study the fuel injection pressure varied from 180 to 200 bars. Generally the injection pressure is 180 bars for high speed diesel engines. In this the injection pressure is varying by tightening or loosening the screw provided on the top of the injector. For measurement of injection pressure on fuel injector system by using fuel injector pressure tester.

IV. ENGINE PROCEDURE

The experimental work had conducted on 4-stroke diesel engine. In diesel engine four strokes are utilized namely suction, compression, power and exhaust strokes for completion of cycle. The four stroke diesel engine having two valves i.e. inlet valve and exhaust valve. Here the inlet valve is used for sucking the fuel charge or pure air in to the chamber at beginning of the suction stroke and the exhaust valve is used for removal of exhaust gases from engine cylinder at the end of combustion stroke. At the starting of the cycle, piston is moving from top dead Centre to bottom dead Centre. The piston begins from TDC to BDC at suction stroke the inlet valve opens and then the fuel charge is sucked in to the chamber of the combusion, then compressed at compression stroke between cylinder head and piston until piston reachs TDC at end of compression. At the end of compression fuel spray is injected in to the cylinder at power stroke. End of power stroke the exhaust gases are releases. The exhaust gases are sent to out through exhaust manifold at exhaust stroke. This cycle follows by 4-stroke diesel engine.

V. EXPERIMENTAL PROCEDURE

A. Allow the water to flow to the engine and calorimeter and adjust the flow rate to 6lpm & 3lpm.
B. Release the load if any on the dynamometer.
C. Open the three-way cock so that fuel can flow in to the engine.
D. Start the engine by cranking.
E. Allow to attain the study state.
F. Load the engine by switching on the loading switches.
G. Note the following readings for particular condition.
H. Engine speed
I. Time taken for 5cc of fuel consumption
J. Rotameter reading
K. Manometer readings, in cm of water
L. Temperatures at different locations
M. Readings of Voltmeter and Ammeter
N. Note pollution values from the pollution setup i.e., multi gas analyzer system
O. Repeat the same procedure for different loads at various fuel injection pressures i.e., 180,190 and 200 bars respectively and note down the above readings.
P. After the completion, release the load and then switch of the engine.

VI. RESULTS

A. Hydrocarbon Emissions

As the injection pressure increases the HC emissions are reduces because, higher injection pressures will cause to proper spray at the starting of injection. This will improve the performance by using B20 Algae oil which is having a high viscosity. Probably it happened because of the improvement in the fuel spray, which can results a lesser delay period. The improved spray also gives a good combustion and thermal efficiency. The unburned HC Emissions are high at 180 bars and it is lower at 200bar. The reason behind this is at 200bar proper diffusion, combustion of the biodiesel takes place which results low emissions. At 180 and 200 bars there is very short time for the diffusion of the fuel to takes place which gives higher emissions. The quantity of biodiesel increases in the blend the UHCs are decreases due to presence of high oxygen content in the biodiesel and it leads to complete combusion in the cylinder.

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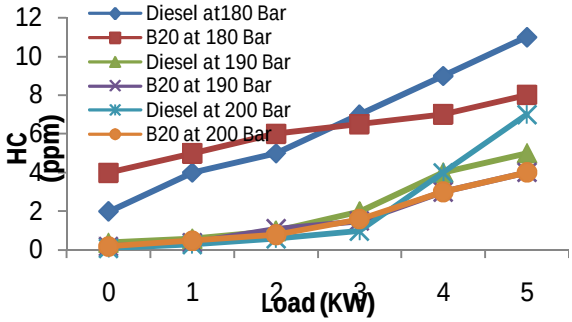

Figure1:Comparison of HC Emissions

B. Effect on Exhaust Gas Temperature (EGT)

The change of exhaust gas temperature with varying the applied load for diesel and B20 Algae oil tested is shown in Fig 2. It tells that the exhaust gas temperatures of Algae oil is decreases when compared to neat diesel. From that the exhaust gas temperature is slightly increases for both fuels from 180 to 200 bars injection pressure. The reason behind this the fuel atomization is increases then the complete combustion done in the combustion chamber. The complete combustion was done up to 200 bars injection pressure then decreases when increases the injection pressure. At higher injection pressure than 200 bars the scavenging efficiency is decreases due to that the knocking will occurs in chamber. Because of the fuel pre-ignition will obtain before the compression stroke. Finally it is observed that the exhaust gas temperatures for both fuels are higher at 200 bars of injection pressure.

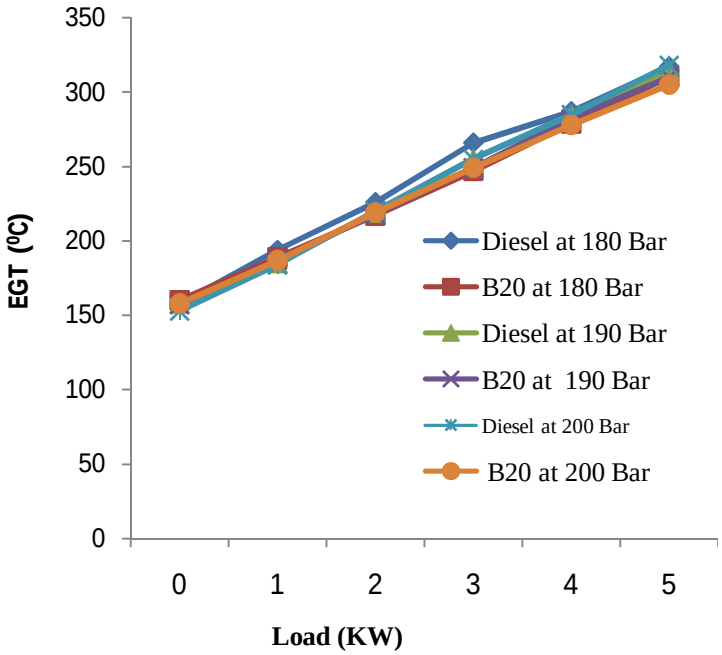

Figure 2: Comparison Exhaust Gas Temperature

C. Carbon Monoxide (CO) Emissions

At full load, for the injector opening pressure of B20 Algae oil, due to higher injection pressure, atomization and mixing process are improved. Due to high viscosity of Algae oil than diesel high injection pressures are required for improving atomization and better mixing of air and fuel resulting low CO emissions. This CO emission are decreased when increasing loads at all pressures. The CO emissions with B20 Algae oil are lower if compared to 100% of diesel. The Algae oil produces a greater combustion efficiency leading to lower amounts of CO. The CO emissions are very less at 180 bars for B20 Blend compared to diesel at all pressures and higher for diesel at 180 bars.

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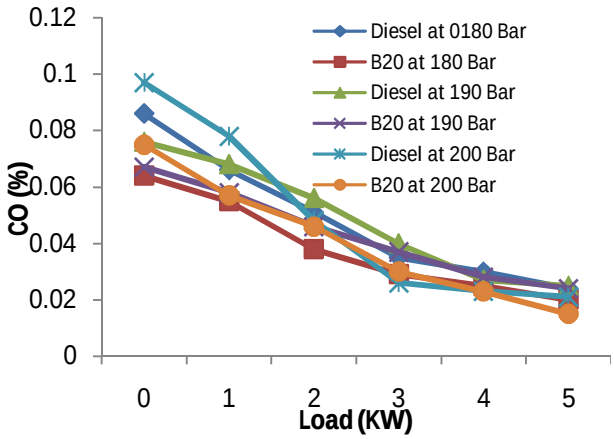

Figure3: Comparison of CO Emissions

D. Effect on Indicated Mean Effective Pressure (IMEP)

Fig.4 shows the variation of Indicated Mean effective pressure with load. Mean effective Pressure is the measured output. From the figure it can be seen that, Indicated mean effective pressure decreased from 180 to 190 bar and slightly increased to 200 bar. Since decreases friction power decreases Indicated Mean effective pressure. Compared to B20, Diesel has slightly higher in all injection pressures.

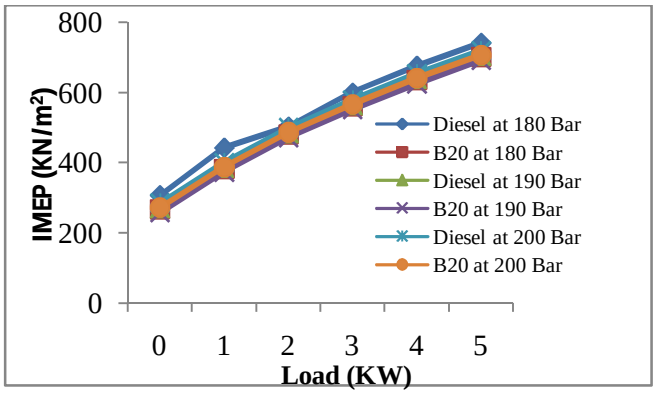

Figure4:Comparison of Indicated Mean Effective Pressure

E. Effect on Mechanical Efficiency

Mechanical efficiency indicates how good an engine is inverting the indicated power to useful power fig.5 shows that the Mechanical Efficiency increased from 180 to 190 bar and slightly decreased to 200 bar, because decrease indicated power increases mechanical efficiency. Compared to Diesel, B20 has slightly higher in all injection pressures. Maximum mechanical efficiency is obtained at B20 at 190 bar is 62.79%.

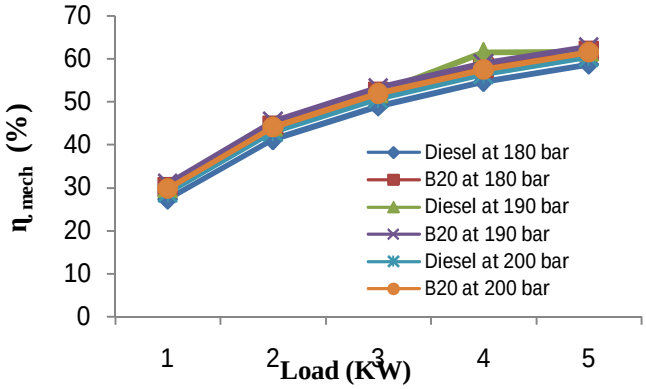

Figure 5: Comparison of ME

F. Effect on Brake Mean Effective Pressure (BMEP)

From the figure it can be seen that, Brake mean effective pressure slightly decreased from 180 to 190 bar and slightly increased to 200 bar, because brake power decreasing from 180 to 190 bar then increased. Compared to B-20, Diesel has slightly higher in all injection pressures. But the variation in BMEP is insignificant.

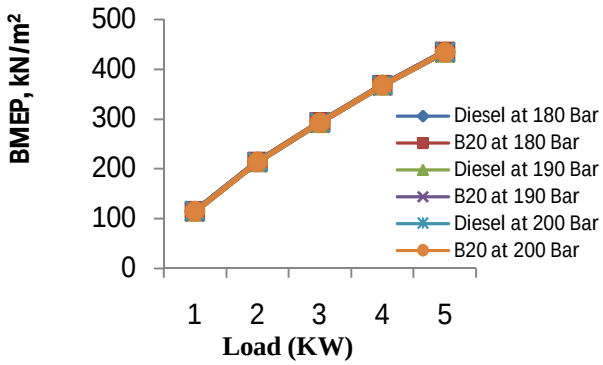

Figure 6: Comparison of BMEP

VII. CONCLUSION

The engine was made to run on diesel fuel mode, and blend of Algae oil and diesel mode. The experiments were conducted at three different fuel injection pressures of 180, 190 and 200 bar. The performance and emissions of the engine at full load were investigated. The following results were obtained.

Engine was able to run on 180, 190 and 200 bar fuel injection pressures on diesel fuel mode and blend of Algae oil and diesel.

A. The HC emission of B20 is less at all loads compared to diesel.
B. The CO emissions are low for B20 at 200 bars than diesel.
C. Lower exhaust temperatures were observed at higher injection pressures.
D. B20 have higher mechanical efficiency than diesel at all injection pressures.

Based on the experimental investigation it can be concluded that B20 of Algae oil can be adopted as an alternative fuel for CI engines.

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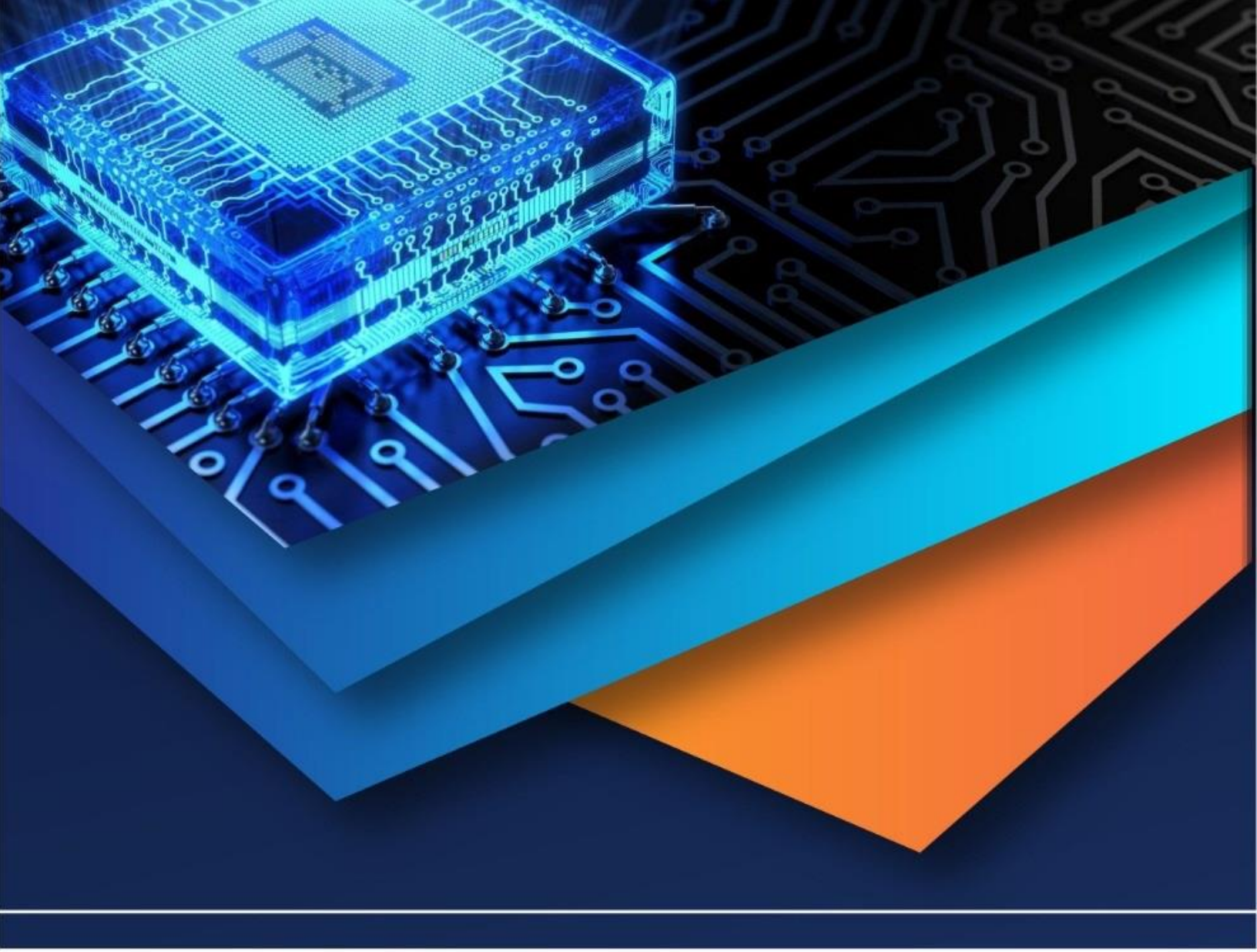

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