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Impact of Emulsification of Bio Diesel Blends on a Diesel Engine- A Recent Review

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Abstract: In present world the diesel engines are widely used as a power source for in-sea and on-land transportation vehicles. Then the emissions from diesel engines are considered one of the major sources of air pollution and seriously affect the environment and the health of living beings. In this paper aims to review the possibilities of reducing the emissions from diesel engine. From this review it can be concluded that when biodiesel is used as a diesel engine fuel, sulfur levels, particulate matter (PM), (carbon monoxide) CO and unburned hydrocarbons in the exhaust gas are considerably less than those of conventional fuel and further emulsification of biodiesel with water will lead to significant reduction of NO_X emissions.
Key words: Bio-Diesel, Diesel engine, emulsification

I. INTRODUCTION

Biodiesel consists of mono-alkyl esters of fatty acids and can be obtained by transesterification treatment of vegetable oils, animal fats, and waste cooking oils. Vegetable oils can be obtained from both edible (palm oil, rapeseed oil, soybean oil, etc.) and non-edible (jatropha, cotton, castor, etc.) Transesterification is the process of exchanging the alkoxy group of an ester compound by alcohol and the reaction often catalyzed by an acid or a base. The transesterification of vegetable oil involves reaction of triglycerides (fat/oil) with bio-alcohol to form esters and glycerol.

Emulsification is a convenient, simple, inexpensive, and effective physical method to upgrade bio-oils for mixing diesel as a fuel. The addition of emulsifier (also called emulsifying agent) into two immiscible streams (e.g., bio-oil and diesel) with the help of agitation is an essential step to implement emulsification In an emulsion, the dispersed or droplet phase, also termed internal phase, is encapsulated with in a layer of the continuous or external phase.

$$
\begin{array}{llcll}
CH_2-COO-R & CH_3OH & & R-COO-CH_3 & CH_2\text{-}OH \\
| & & & & | \\
CH-COO-R & +\ CH_3OH & \xleftrightarrow{Catalyst} & R-COO-CH_3\ + & CH\text{-}OH \\
| & & & & | \\
CH_2-COO-R & CH_3OH & & R-COO-CH_3 & CH_2-OH
\end{array}
$$

$$
\begin{array}{llcll}
CH_2-COO-R & C_2H_5OH & & R-COO-C_2H_5 & CH_2\text{-}OH \\
| & & & & | \\
CH-COO-R & +\ C_2H_5OH & \xleftrightarrow{Catalyst} & R-COO-C_2H_5\ + & CH\text{-}OH \\
| & & & & | \\
CH_2-COO-R & C_2H_5OH & & R-COO-C_2H_5 & CH_2-OH
\end{array}
$$

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The hydrophilic–lipophilic balance (HLB) value, based on chemical structure and surfactant properties, is an important factor for choosing surfactants. In the system, the lipophilic surfactants are low HLB values, whereas hydrophilic surfactants are high HLB values

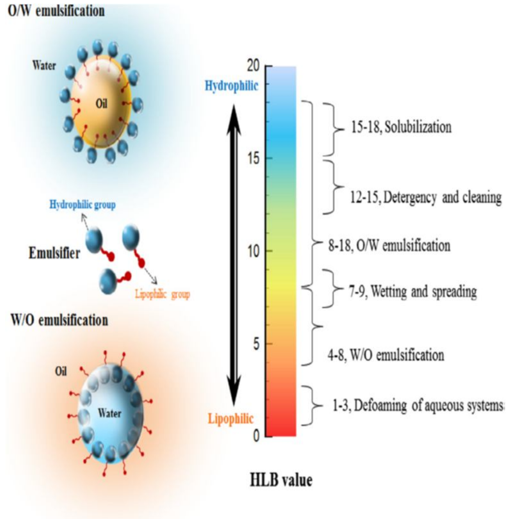

Fig. 1. HLB values for different emulsions and mixture behaviors.

II. REVIEW ON DIESEL –BIO DIESEL BLENDS

The functional groups in the emulsifiers, bio-oils, and diesel are analyzed by a Fourier transform infrared spectroscopy (FTIR) to recognize the characteristics of emulsions. The merit of HLB, and bio-oil/emulsifier , and diesel/emulsifier, ratios observed experimentally .where three commercial Emulsifiers (i.e., Span 80, Tween 80, and Atlox 4914) and the bio-oils produced from the fast pyrolysis of wood wastes were employed. The results suggest that Atlox 4914 provides the best performance compared to Span 80 and Tween 80. The correlation of optimum HLB and HHV provides the best result. The developed correlations are conducive to reducing operation cost. [1]

In this, the enriched blends for testing were prepared by add methyl oleate (MO) to palm oil methyl ester (PME) at specified volumetric ratio. The results reveal that enriched blends yielded a lower brake torque with increase brake specific fuel consumption than the petroleum diesel because of low calorific value. In addition, enriched blends showed a noticeable improvement in BSFC, with a slight higher in carbon monoxide, hydrocarbon , exhaust gas temperature, and NO_x emission over individual PME as result. a of lower ignition quality and lower oxygen content. Consequently, biodiesel that possesses excessive oxygen content produce lower EGT, as well as reduce CO, HC, and NO_x emissions. However, as a consequence, BSFC is increased.[2]

In this study the diesel engine fueled with diesel -biodiesel blends .The results showed that, effective power increases constantly, effective efficiency more than a specified value and then starts to reduce with greater engine load at constant biodiesel percentage and compression ratio. However, effective efficiency is more, effective power reduced to a certain value and then begins to increase with higher biodiesel percentage at constant equivalence ratio and compression ratio.[3]

[3]

Biodiesel fuels obtained from two types of waste cooking oils were mixied with No. 2 diesel fuel. And their effects on the engine performance and emissions were observed. His result showed, the ignition delay was decreased with the biodiesel addition for all loads with the earlier combustion timings due to higher cetane number of biodiesel fuel. For the time being, the in-cylinder pressure rise rate and the maximum heat release rate were slightly decreased and the combustion duration was generally increased with addition biodiesel. While there were no significant changes on CO emissions at the low-medium engine loads, some reductions were detected at the full load. CO_2 emissions were slightly increased for all loads. [4]

In this study at 2500 rpm, engine power decreased 4.97% with the use of B7 fuel and 14.39% with the use of B100 fuel compared to diesel fuel because of the lower heating value of the fuel., with the use of diesel fuel engine torque was measured as 185 Nm at 2000 rpm . Engine torque was measured as 175 Nm with the use of B7 fuel and 158 Nm with the use of B100 fuel. With the use of B100 fuel the Specific fuel consumption is increased 56.25% and 12.21% with the use of B7 fuel and compared to diesel fuel. CO_2, NO_X emissions were higher for B7 and B100 fuels compare to diesel. And HC emissions were lower because of the oxygen content of biodiesel maintains adequate oxidation. Mass fraction burned (MFB) at 2500 rpm and with B7 blend this value was found as 100% after 30^0 (ATDC), at 4000 rpm as 100% after 34^0(ATDC). [5]

Though encouraging performance in short term operations, biodiesel contribute to several operating issues such as carbon deposition, injector coking, engine oil dilution and its degradation, fuel filter plugging and wear related concern, especially corrosive wear in long term tests. The network has yielded R2(fraction of variance) values of 0.99 and the mean %errors are smaller than 4.2 for the training data, while the R2 values are about 0.99 and the mean %errors are smaller than 5.5 for the test data. The performance and exhaust emissions from using biodiesel blends on a diesel engine, with No. 2 diesel fuel up to 20%, have been predicted using the ANN model. [6]

Combustion and emission characteristics of rapeseed plant oil and its blends with diesel fuel observed using a multi-cylinder direct injection diesel engine. . In this study, the soot emissions from combustion of rapeseeds oil were decreased by changing injection parameters such as injection timing and injection pressure .Decreases the NO_x emissions from the combustion of 30% blend of RSO in diesel fuel . [7]

Combined effect of modification and B40 (40% jatropha biodiesel + 60% diesel) on wear after 512 h engine operation . In the comparison of engine components observe that relatively thin carbon deposits were formed on the surfaces with modified biodiesel engine compared with diesel operated engine. Decrease wear for piston and cylinder for B40. Modification of engine parameters of diesel engine to suit and successfully operated with B40. [8]

The biodiesel is produced by different methods using transesterification, Reducing or eliminating mass transfer effects, Heterogeneous catalysts, Direct contact between feedstock and alcohol, Microwave irradiation..etc and properties of biodiesel least influenced by minor components can be determined. The properties discussed here are those that are to a significant extent determined by the fatty ester composition of the diesel fuel. These are kinematic viscosity, cetane number and other combustion related properties, cold flow, oxidative stability and density. The Biodiesel feed stocks also discussed. [9]

Analyzed the performance and emissions of a four stroke, direct injection, naturally aspirated single cylinder diesel engine fueled with rubber seed oil methyl ester(RSOME) and reported that the maximum BTE obtained was about 3% higher than that of diesel fuel for B10 at the rated speed of 1500 rpm at maximum load.The lower biodiesel blends increased the brake thermal efficiency and diminished the fuel consumption and exhaust emissions were decreased with rise in biodiesel concentration. [10]

According to the results, the density, viscosity, and acid value of the blended fuel increase with the rise of biodiesel concentrations in fuel blend and meet the blended fuel standard ASTM D7464 for up to 30% biodiesel. Increasing biodiesel ratio in the blend, with a lower heating value for palm oil biodiesel, which is about 14% lower than mineral diesel .Engine tests revealed that improve biodiesel ratios up to 30% in the blended fuel reduced the engine brake power by 2.6% and increased the brake specific fuel consumption by 3%.However, there was no changes in the engine brake thermal efficiency with the blended fuels compared to the mineral diesel. However, the energy content reduces by about 1.42% for each 10% increment of biodiesel and the lowest engine cyclic variation was achieved with blended fuel B30. [11]

Experimental fuels were obtained in the forms of D_{100}, $B_{2.5}M_{2.5}D_{95}$, $B_5M_5D_{90}$, $B_5M_{2.5}D_{92.5}$ and $B_{2.5}M_5D_{92.5}$ by mixing diesel fuel with the biodiesel fuel obtained from safflower and adding bio-ethanol at the rates of 2.5% and 5%, and volumetrically in inverse ratio. The maximum engine power was measured to be 10.64 kW in the D_{100} fuel at 2100 min_1. Compared with the D100 fuel, and no variation in the fuel mixtures of , $B_{2.5}M_{2.5}D_{95}$, $B_5M_5D_{90}$, $B_5M_{2.5}D_{92.5}$ and $B_{2.5}M_5D_{92.5}$.The maximum engine torque was measured to be 56.2 Nm in the $B_5M_{2.5}D_{92.5}$ fuel at 1100 min^{-1}. Compared with the D_{100} fuel no changes in the other kinds of mixtures. Minimum specific fuel consumption was measured to be 299.76 g/kWh in the D100 at 1400 $min^{-1.}$ Compared with the D_{100} fuel, increases of 1.14%, 0.66%, 2.87% and 7.74% were observed in the $B_{2.5}M_{2.5}D_{95}$,$B_5M_5D_{90}$, $B_5M_{2.5}D_{92.5}$ and $B_{2.5}M_5D_{92.5}$.fuel mixtures. According to emissions optimum mixture of engine fuel was $B_{2.5}M_5D_{92.5}$ eacuse it was high cetane number. It makes the engine run silently, affects the increase of combustion efficiency. [12]

In this study, the emulsification technology has been considered to reduce the NOx emission level of fuel. The surfactants (span80 and tween80)add for proper mixing of w/o and o/w/o emulsions. The effects of the emulsification variables such as hydrophilic lipophilic balance (HLB), and water content on the fuel properties and emulsion characteristics of W/O and O/W/O emulsions were investigated. The experimental results show that the surfactant mixture with HLB = 13 produced the highest emulsification stability while HLB = 6 produced the lowest emulsification stability. [13]

Six solid catalysts (ZrO_2, ZnO, $SO4^{2-}$/SnO2, SO_4^{2-}/ZrO2, KNO_3/KL zeolite and KNO_3/ZrO_2) were tested for the transesterification of crude palm kernel oil and crude coconut oil.The experiments were performed at a methanol:oil molar ratio of 6:1, using a 3 wt.% of the catalyst (based on the weight of the vegetable oil), pressure at 50 bars under nitrogen atmosphere, temperature at 200 ◦C, and the 350 rpm stirrer. Among the investigated solid catalysts, SO42−/SnO2 andSO42−/ZrO2 provide the highest yield of methyl esters at 90.3 wt.% based on crude palm kernel oil. [14]

In this paper the fuel used as animal fat residues bio diesel .The use of AFRBD on diesel engine decrease s a 9% power drop at 1500 rpm because of its lower heating value . And engine brake thermal efficiency dropped by 1.5 points at low loads and increased by 1 point at high loads. The NOx emissions were increased at low loads by 20%, the difference between NOx emissions diminished with load until disappearing at 2.4 bars of BMEP and finally it decreased by 4% at full load. The use of AFRBD in the engine resulted in similar performance with slight brake thermal efficiency decrease at low loads and a slight increase at high loads. In pollutant emissions the reduction of unburned hydrocarbons between 32% and 45% was obtained with AFRBD . The PME were also reduced at low and medium load ranges, but no differences were detected at high loads. [15]

in this paper an increasing of brake specific fuel consumption , especially at lower engines' loads, with maximum 32.4%, reducing engine brake thermal efficiency with maximum 21.7%. The brake specific fuel consumption is greater for the blends, because their heating value is smaller. . CO emissions decrease, especially at high loads with maximum 59%, On the basis of CO2 increased emissions due to high level of oxygen content in biodiesel and ethanol, which support the oxidation process during the exhaust process as well. NO_x emissions slightly increased the fuel combustion temperature, due to the oxygen content of biodiesel and ethanol, which feasible more complete combustion and thus an increased combustion temperature, which facilitates the generation of NO_x, especially at partial and high loads, meanwhile HC and smoke emissions decrease in all engines loads. The fuel properties are viscosity, density flash point, CFPP ,cetane number are discussed. [16]

The main objective of the present study was to evaluate suitability of biodiesel production from Jatropha bio diesel oil as a fuel for Diesel engine, to evaluate the performance, combustion and emission characteristics of the engine. Fuel The brake thermal efficiency of Jatropha methyl ester and its blends with diesel were lower than diesel because of lower calorific value and increase in fuel consumption of JME and its blends as compared to diesel fuel. brake specific energy consumption was found to be higher. This is mainly due to the combined effects of the viscosity, relative fuel density and heating value of the blends. The higher density of Jatropha biodiesel has led to more discharge of fuel for the same displacement of the plunger in the fuel injection pump, thereby increasing the SFC. While running the engine with biodiesel and its blends, emissions such as CO, smoke density and HC were reduced as compared to diesel. Biodiesel is oxygenated fuel and contains oxygen which helps for complete combustion. [17]

In this study the properties and specifications of ethanol blended with diesel fuel are discussed. The properties of ethanol–diesel blends have a significant effect on safety, engine performance and durability, and emissions. It is accepted that the add ethanol to diesel fuel will have effect in reducing the PM emissions at least. The addition of ethanol to diesel naturally reduces the content of sulfur in the fuel in proportion to the amount added, including any sulfur-free additive. [18]

Fuel properties such as heating values, cetane number ,viscosity, and corrosivity were characterized. The heating value of centrifuged bio-oil was about one third of that of No.2 diesel ,reducing the heating values of emulsions accordingly. A cetane number of pyrolytic bio oil was 5.6. The viscosity of emulsion fuels was best described by Einstein's equation for dilute solid disprsions. The corrosivity of emulsion fuels defined by the weight loss of steel is about half of the bio-oil alone. [19]

It is observed that the thermal efficiencies of Z2JOE15 and ATJOE15 emulsions are higher by 11.3% and 8.2% than that of diesel and 11.6% and 8.5% higher than that of the JME operation. The increase in brake thermal efficiency is due to the improvement of the combustion process on account of increased oxygen content in the fuels and the faster combustion process of emulsions at full load, exhaust gas temperature is the highest for the JME and the lowest for diesel. The exhaust gas temperatures of Z2JOE15 and ATJOE15 are lower than that of JME operation. Because water content present in the WPO gets vaporized during the combustion process and absorbs the heat energy which lowers the local adiabatic flame temperature. The BSHC emissions are reduced by about 14.2%, 37.9% and 35.7% for JME, Z2JOE15 and ATJOE15, respectively, at full load compared to that of diesel. The BSCO emissions of Z2JOE15 and ATJOE15 are found to be higher by about 17.5%, and 46% than that diesel at full load.The percentage decrease in the smoke opacity of 19.6% is observed with the JME at full load when compared to that of diesel. When fuelled with the Z2JOE15, the smoke opacity is found to be lower by 27.8% and with the ATJOE15 the smoke opacity increases by about 8% compared to that of diesel operation. [20]

In the present study, the results of DI diesel engine using water–diesel emulsions (2%, 5%, 8% and 10% water by volume) are examined. The engine was run at different engine speeds(1600-1900 rpm) at different engine load conditions (25%, 50%, 75% and 100%) were taken. The kinematic viscosity, dynamic viscosity and density of the blends increased with increasing water percentage in emulsions, The 2% water–diesel blend showed the highest engine power and torque. There are not significant changes between noise emissions of neat diesel and E2. Lower peak HRR at higher engine speed led to weaker and more silent combustion for

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emulsions than neat diesel. Thermal efficiency increase from 25% to 75% engine load may lead to more powerful and louder combustion. Engine noise reduction from 75% to 100% load may be due to the effect of ignition delay decrement. [21]
In this study the production of biodiesel by using different methods and fuel properties of vegetable oil, methyl esters and ethyl esters of bio-diesel can be grouped conveniently into physical, chemical, and thermal properties. The vegetable oil usually contains free fatty acids, water, high viscosity and poor volatility .Some methods to overcome these difficulties are Preheating, Blending, Micro-emulsion, Pyrolysis (Thermal cracking), transesterification. The section describes the performance parameter BTE and BSFC of bio diesel derived from several vegetable oils. Also emission parameters like carbon monoxide (CO,) hydro carbon(HC), nitrogen oxide(NOx), and smoke density of various bio-diesel blends have been observed. [22]

In this study, the addition rates of water are 2,4 and 6% water into B5(diesel- bio diesel blend) resulted in around similar brake power and brake specific fuel consumption. the emissions of CO2, HC, and NOx were decreased by over 8.5%, 28%, and 24%, respectively, at maximum speed of 2500 rpm and this reduction because of increasing the amount of water. Generally the calorific value of the water-containing fuels were decreased but here, B5Wt 4% is highest bte value of 28.25% amongst all the investigated fuel blends. These improvements caused by the micro-explosion phenomenon in response to the presence of water. Moreover, the results showed that water addition into B5 increased the ignition delay due to water resistance against the flame spread. In addition to that, water decreases the in-cylinder pressure due to the low calorific value of water. [23]
In this research, with low water concentrations produce engine power and torque values that are same to B5 and reduce NOx emissions, soot opacity was decreased and co, co_2 emissions high water concentration in bio diesel fuel. [24]
The combustion starts for bio diesel than for micro-emulsions. Compared with biodiesel, the micro-emulsions show higher peak pressure rise rate and identical peak cylinder pressure and peak heat release rate at high and medium engine loads, but lower for low engine loads. The micro-emulsions increase the combustion and hence have lower brake specific energy consumption under all range of engine load and exhibit just higher brake specific fuel consumption due to the low heating value, as compared with biodiesel. CO and HC, emissions of the micro-emulsions are just higher than those of biodiesel at all engine loads, all fuels show almost the same HC and CO emissions. NOx emissions decrease small for the micro emulsions under all engine load conditions. [25]

III. CONCLUSION

From this review following observations are noteworthy,Blends of bio-diesel as fuel in diesel engine would develop engine efficiency that is comparable with diesel as fuel. Use of biodiesel emulsions is alternative method in reducing harmful emissions as such 40-50 % reduction in NO_x from diesel engine.There are number of methods for emulsification but using surfactant method would lead to minor or no modifications in the engine.Bio diesel obtained from crop produces favorable effects on the environment, such as decrease in acid rain, reduction in greenhouse effect caused by pollution.

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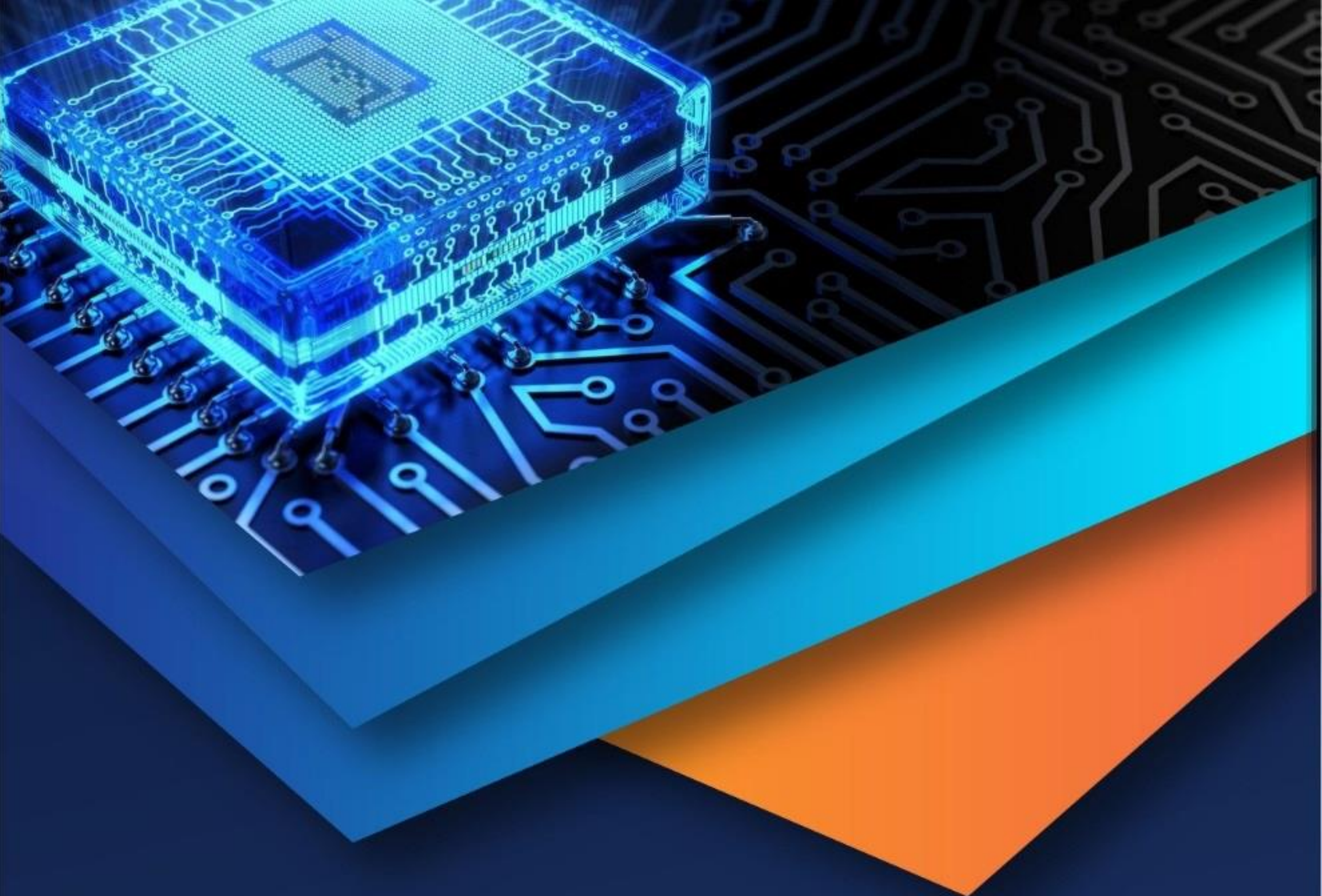

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