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Nanoparticles Added Biodiesel to Enhance the Performance of Diesel Engine

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Abstract: Crude oil depletion plays a main role in search of alternative fuel. In this present study jatropha oil is used as an alternative fuel. Jatropha oil cannot be used directly in a diesel engine due to its high viscosity. In order to reduce viscosity transesterification process is carried out. Together with jatropha oil nanoparticles such as cerium oxide, titanium dioxide and cupric oxide are added to reduce the emission levels. Nanoparticles are added in the proportion levels of 0.02% wt, 0.03% wt and 0.04% wt. From the literature survey it can be concluded that B20 blend (20% Jatropha biodiesel + 80% diesel) gives the best performance. Nanoparticles are added to B20 blend. The performance and emission test is carried out in a single cylinder four stroke diesel engine with data acquisition system. The load is varied in the range of 0%, 25%, 50%, 75% and 100% and the speed is kept constant. The performance and emission is carried out for an each combinations in order to get the maximum performance and minimum emission levels.
Keywords: Crude oil depletion, Jatropha oil, transesterification, nanoparticles, diesel engine, load, performance and emission.

I. INTRODUCTION

Researchers are widely growing in the area of an alternative fuels. Many alternative fuels are available such as Jatropha oil, Karanja oil, Pongamia oil; neem oil etc., Of all the above oils jatropha oil is having the properties closer to diesel. Jatropha oil cannot be used directly in a diesel engine due to its high viscosity. In order to reduce the viscosity transesterification process is carried out. After the transesterification process the viscosity is reduced to the value closer to the diesel. Jatropha oil is obtained from the jatrophacurcas fruit.

Jatropha plant is a drought resistant plant and it is growing in many parts of the country. The jatropha oil is having the higher viscosity which produces the engine problems at lower temperature. The jatropha biodiesel should be used in its pure form and it is blended with diesel at different proportions. The jatropha biodiesel can be used in a diesel engine without any engine modifications.

Suresh et al (2012) used jatropha biodiesel as an alternative fuel and concluded that B20 (Jatropha oil 20% + Diesel 80%) shows good brake thermal efficiency. Vijittra et al (2011) show that blends (Jatropha) upto 20% shows the thermal efficiency similar to the efficiency of diesel. Sadhikbasha et al (2011) used alumina nanoparticles with diesel in the mass fractions of 25, 50 and 100 ppm. They concluded that the 100 ppm of alumina nanoparticles with Jattropha biodiesel shoes high thermal efficiency and also the lower emissions of NO and smoke. Sajith et al (2010) used cerium oxide nanoparticles in the range of 20 – 80 ppm. The result is that the nanoparticles of 80 ppm with biodiesel showed an increase of 1.5% in brake thermal efficiency and emission of NO is reduced around 30% for the same dosing level.

Prajwaltewari et al (2013) had used a biodiesel derived from honje oil methyl ester (HOME) blended with multiwalled carbon nanotubes in the mass fractions of 25 and 50 ppm. The conclusion is that the brake thermal efficiency of multiwalled carbon nanotubes with 50 ppm dosing level is higher when compared with other levels. The emission levels of HC is 58 ppm and CO emission is 0.21% for 50 ppm of carbon nanotubes. Saptarshi Mandal et al (2012) used ceria nanoparticles with diesel in order to reduce the emissions. The ceria nanoparticles are varied in the range of 0.02%, 0.04%, 0.06%, 0.08% and 0.10% wt in diesel. For the maximum engine performance and minimum emission levels the optimum condition is 75% of load and 0.06% wt of CeO_2 with diesel. With the above optimum condition brake thermal and mechanical efficiency was increased by 10% and 7% respectively and SFC, NO and CO was decreased by 10%, 50% and 40% respectively.

Ganesh et al (2011) studied the effect of two nanoparticles such as magnalium and cobalt oxide on biodiesel. They noticed that the 60% reduction in unburnt hydrocarbon and 50% reduction in carbon monoxide and 45% reduction in NO at 75% load for cobalt oxide nanoparticles. For magnallium nanoparticles the result is 70% reduction in HC, 41% reduction in CO and 30% reduction in NO. Arul mohziselvan et al (2009) investigated the effect of cerium oxide nanoparticle addition to diesel and biodiesel ethanol blends. In this study the composition used is 70% diesel, 10% biodiesel, 20% ethanol and 25 pm of ceria. The brake thermal efficiency is 23.63% for the biodiesel combination and 25.66% for the diesel. Emissions such as CO, HC and NO are also reduced as the addition of cerium oxide nanoparticles.

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II. METHODOLOGY

The methodology used for the production of biodiesel is transesterification. Transesterification may be defined as the process in which biodiesel is produced from Jatrophaoil. The catalyst used for the transesterification is potassium hydroxide (KOH). The main objective of transesterification process is used to reduce the viscosity of jatropha oil. The primary input for the process is Jatropha oil which is extracted from the jatropha fruit. To accomplish the process the jatropha oil, methanol and KOH are mixed together and heated at a temperature of 55 - 60° C. The temperature of the mixture should not exceed 65° C, since the boiling point of methanol is 65° C. The mixture is also stirred with the help of stirrer at a speed of 600 rpm. The product of the above process is jatropha methyl ester and glycerol.

In order to remove the water content, an etherification process is carried out to reduce the water content in the oil. For this process an oil is stirred at 100° C for 1 hour. Then concentrated hydrochloric acid 20 ml and KOH (41g) is added to the dehydrated oil of 500 ml and again the mixture is stirred for 25 minutes. After the mixture is stirred in a transesterification process, it is kept under gravity in separating funnel for 24 hrs. The settled glycerol is removed and it is followed by washing with 100 ml of distilled water for 7 times. By using this process the free fatty acid of biodiesel is reduced to nearly 2%. If the free fatty acids of the crude jatropha oil are less than 5% then the esterification process can be eliminated. The catalyst potassium hydroxide (KOH) is used to initiate the process. The stirring process is used to speed up the removal of glycerol.

Fig. 1.Jatropha methyl ester

III. BLENDING

Blending may be defined as the process of mixing the jatropha biodiesel with diesel using magnetic stirrer. For a 2 liter of diesel – biodiesel sample, 1600 ml of diesel is taken and 400 ml of jatropha biodiesel is taken and it is mixed in beaker. After mixing it is stirred at a speed of 1100 rpm for 1 hour.

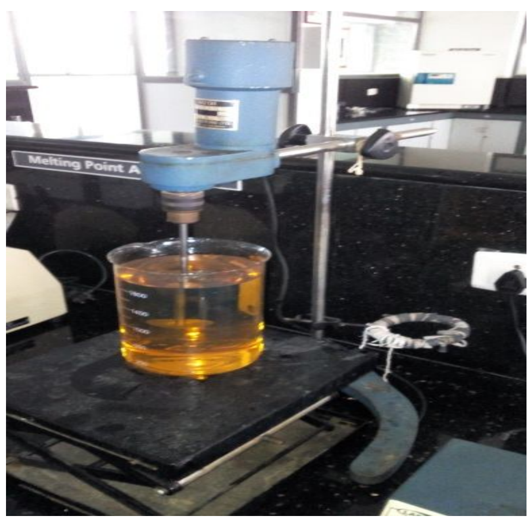

Fig.2. Blending process of jatropha methyl ester to diesel

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IV. SONICATION

The nanoparticles such as cerium oxide, titanium dioxide and cupric oxide are blended with biodiesel using sonicator. The sonication process is carried out for the duration of 1 hour. In order to avoid the deaggloromation in the vessel, surfactants are added. The surfactants used are sodium dodecyl sulphate for cerium oxide and cupric oxide and polyethylene glycol for titanium dioxide.

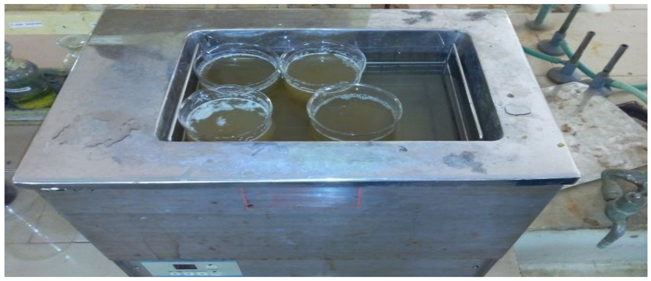

Fig.3. Sonication of nanoparticles to B20 blend

V. PERFORMANCE AND EMISSION TEST

The performance and emission test is carried out in a single cylinder four stroke computerized diesel engine integerated with an gas analyser. The parameters measured are brake

power (BP), specific fuel consumption (SFC) and brake thermal efficiency (BTE) and indicated thermal efficiency (ITE). For emissions the parameters involved are carbon monoxide (CO), Hydrocarbon (HC), carbon dioxide (CO_2) and nitric oxide (NO). The diesel engine is coupled with an electrical dynamometer and the load is given manually by varying the control. The speed of the diesel engine is maintained at 1500 rpm. The load is varied in the range of 0%, 25%, 50%, 75% and 100%. For an each load the brake power, Specific fuel consumption and exhaust gas compositions are measured.

Fig.4. IC engine test rig

The exhaust gas analyser used is AVL Di 444 gas analyzer. To measure the exhaust gas composition the probe is kept at the outlet of diesel engine. Before taking an each measurement the HC residue test is carried out in order to remove the gases present inside the equipment. To carry the test, the exhaust gas probe of AVL gas analyser is closed and it is opened after the test is carried out.

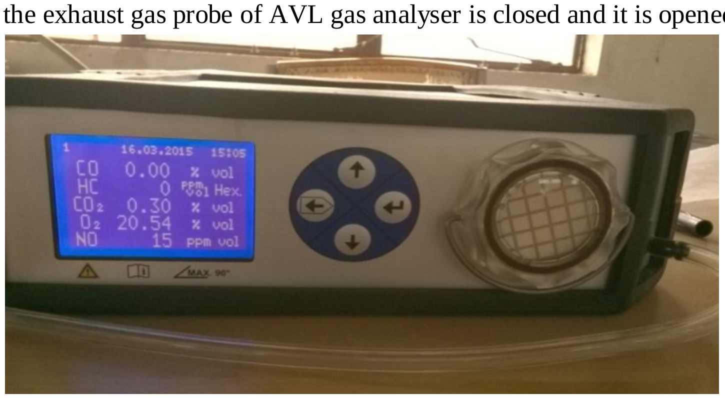

Fig.5. Exhaust gas analyzer

VI. SAMPLE DESCRIPTION

The number of samples used for testing is 9. Its description is shown in the table below.

Table.1. Sample description

Sample no	Description
1	D80 + B20 + 0.02% wt TiO_2 + 0.02% wt CeO_2
2	D80 + B20 + 0.03% wt TiO_2 + 0.03% wt CeO_2
3	D80 + B20 + 0.04% wt TiO_2 + 0.04% wt CeO_2
4	D80 + B20 + 0.02% wt CeO_2 + 0.02% wtCuO
5	D80 + B20 + 0.03% wt CeO_2 + 0.03% wtCuO
6	D80 + B20 + 0.04% wt CeO_2 + 0.04% wtCuO
7	D80 + B20 + 0.02% wt TiO_2 + 0.02% wtCuO
8	D80 + B20 + 0.03% wt TiO_2 + 0.03% wtCuO
9	D80 + B20 + 0.04% wt TiO_2 + 0.04% wtCuO

VII. RESULTS AND DISCUSSIONS

A. Brake Thermal Efficiency

When comparing all the results, sample 6 (D80 + B20+ 0.04% wt CeO_2+ 0.04% wtCuO) is having the highest brake thermal efficiency of 42% at 100% load and least emissions. This sample is best when compared with other samples.

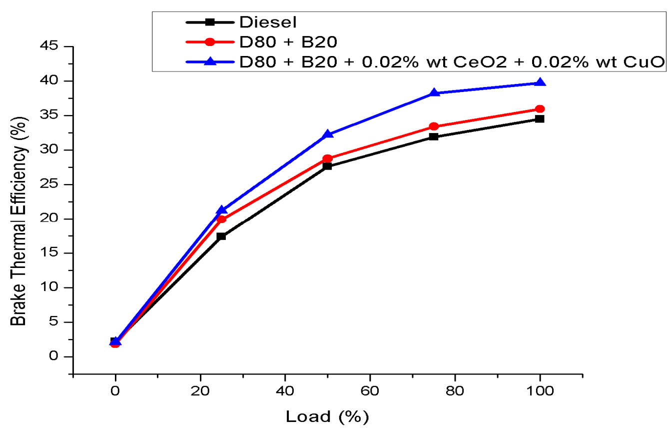

Fig.6. BTE vs. load

Fig. 6 is plotted for Diesel, BD20 and BD20 with 0.04% wt CeO_2+ 0.04% wtCuO. When the load increases the Brake thermal efficiency also increases. Out of all the samples, B20 added with 0.04% wt CeO_2+ 0.04% wtCuO gives the maximum brake thermal efficiency at all the loads. The maximum brake thermal efficiency observed for nanoparticles added biodiesel is 43% at 100% load.

B. Specific Fuel Consumption

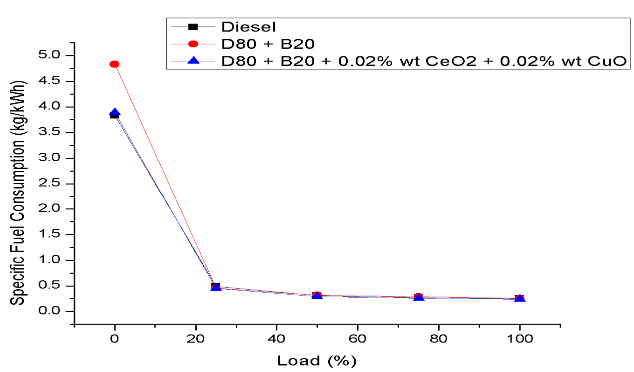

Fig.7. SFC vs load

The specific fuel consumption vs load is shown in the above graph. It is plotted for diesel, Jatropha biodiesel added with diesel and nanoparticles added biodiesel. It is found that the specific fuel consumption is lesser for theblend D80 + B20 + 0.02% wt CeO_2 + 0.02% wtCuO. This is due to the nanoparticles added biodiesel produce more power when compared with diesel .

C. Carbon monoxide

In the below graph the emission levels of CO are plotted for diesel, BD20 and BD20+0.04% wt CeO_2+ 0.04% wtCuO.When comparing all the emission levels the emission values are minimum for 0.04% wt CeO_2+ 0.04% wtCuO nanoparticles and the emission values are maximum for diesel. When the load increases the emission value of CO decreases for nanoparticles added biodiesel.

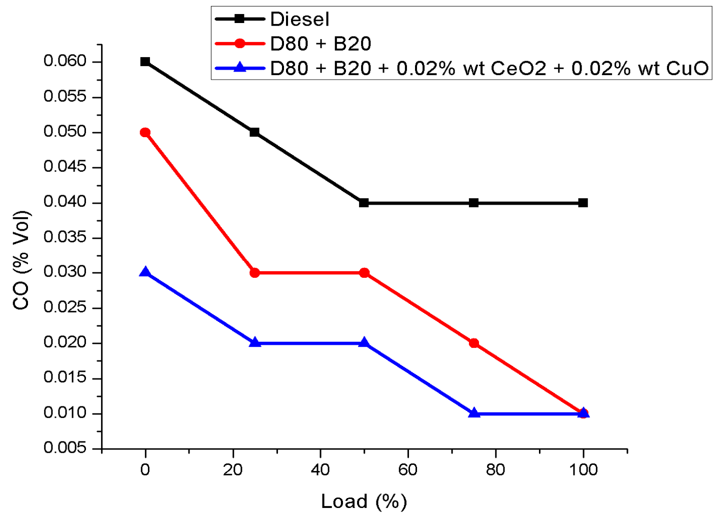

Fig.8. CO emission vs Load

D. Hydrocarbon

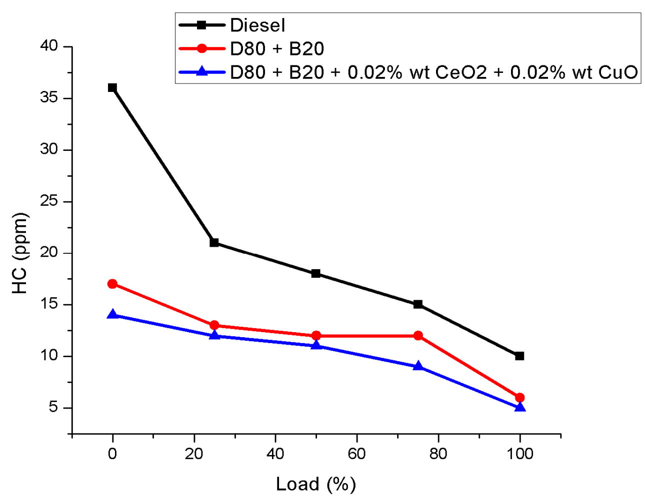

Fig.9. HC emission vs. load

In the above graph the emission levels of HC are plotted for diesel, BD20 and BD20+0.04% wt CeO_2+ 0.04% wtCuO. When comparing all the emission levels the emission values are minimum for 0.04% wt CeO_2+ 0.04% wtCuO nanoparticles and the emission values are maximum for diesel. When the load increases the emission value of HC decreases and then increases for nanoparticles added biodiesel. The HC emission is reduced due to the catalytic activity of nanoparticles.

E. Oxides of nitroge

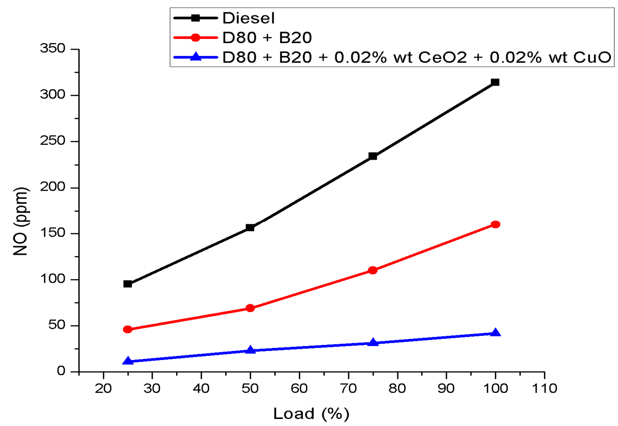

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Fig.10. NO emission vs load

In the above graph the emission levels of NO are plotted for diesel, BD20 and BD20+0.04% wt CeO_2+ 0.04% wtCuO. When comparing all the emission levels the emission values are minimum for 0.04% wt CeO_2+ 0.04% wtCuO nanoparticles and the emission values are maximum for diesel. When the load increases the emission value of NO increases with increase in load for nanoparticles added biodiesel.

VIII. CONCLUSIONS

A. Thus among all the 9 samples prepared, it is been inferred that, the sample that contains D80+ B20+0.04% wt CeO_2+ 0.04% wtCuO produces better results.

B. It is also observed that, higher BTE efficiency is found to be 41.37% when sample D80 + B20+0.04% wt CeO_2+ 0.04% wtCuO is used at 100% loading condition. At same loading condition the BTE for Diesel and BD20 is found to be 32% and 28.68 % respectively.

C. It is found that CO emissions of D80 + B20 and B20+0.04% wt CeO_2+ 0.04% wtCuO samples increases from 0% to 25% then decreases upon increase in load. The CO emission decreases upon increase in load. The B20+0.04% wt CeO_2+ 0.04% wtCuO sample produces least CO emission results compared to diesel and BD20 at all loads.

D. The NO emission of Diesel and B20 decreases from 75% to 100% load. The B20+0.04% wt CeO_2+ 0.04% wtCuO sample produces least NO emissions compared to diesel and BD20 at all loads. The least value of NO emission is found to be 29ppm (at 0% load), 11ppm (at 0% load) and 8ppm (at 0% load) for Diesel, B20 and B20+0.04% wt CeO_2+ 0.04% wtCuO respectively.

E. The B20+0.04% wt CeO_2+ 0.04% wtCuO sample produces better mechanical efficiency compared to B20 at all loads and it is better than diesel at 0%, 25% and 100% loads. The highest value of mechanical efficiency is found to be 86.91% (at 100% load), 83.20% (at 100% load) and 86.48% (at 100% load) for Diesel, B20 and B20+0.04% wt CeO_2+ 0.04% wtCuO respectively.

F. The least value of specific fuel consumption is found to be 0.25kg/kWhr (at 100% load), 0.28kg/kWhr (at 100% load) and 0.27kg/kWhr (at 100% load) for Diesel, B20 and B20+0.04% wt CeO_2+ 0.04% wtCuO respectively. Thus it is found from the above results that the blend B20 with 0.04% CeO_2+ 0.04% wtCuOcan be used in diesel engine to obtain better performance with reduced emissions.

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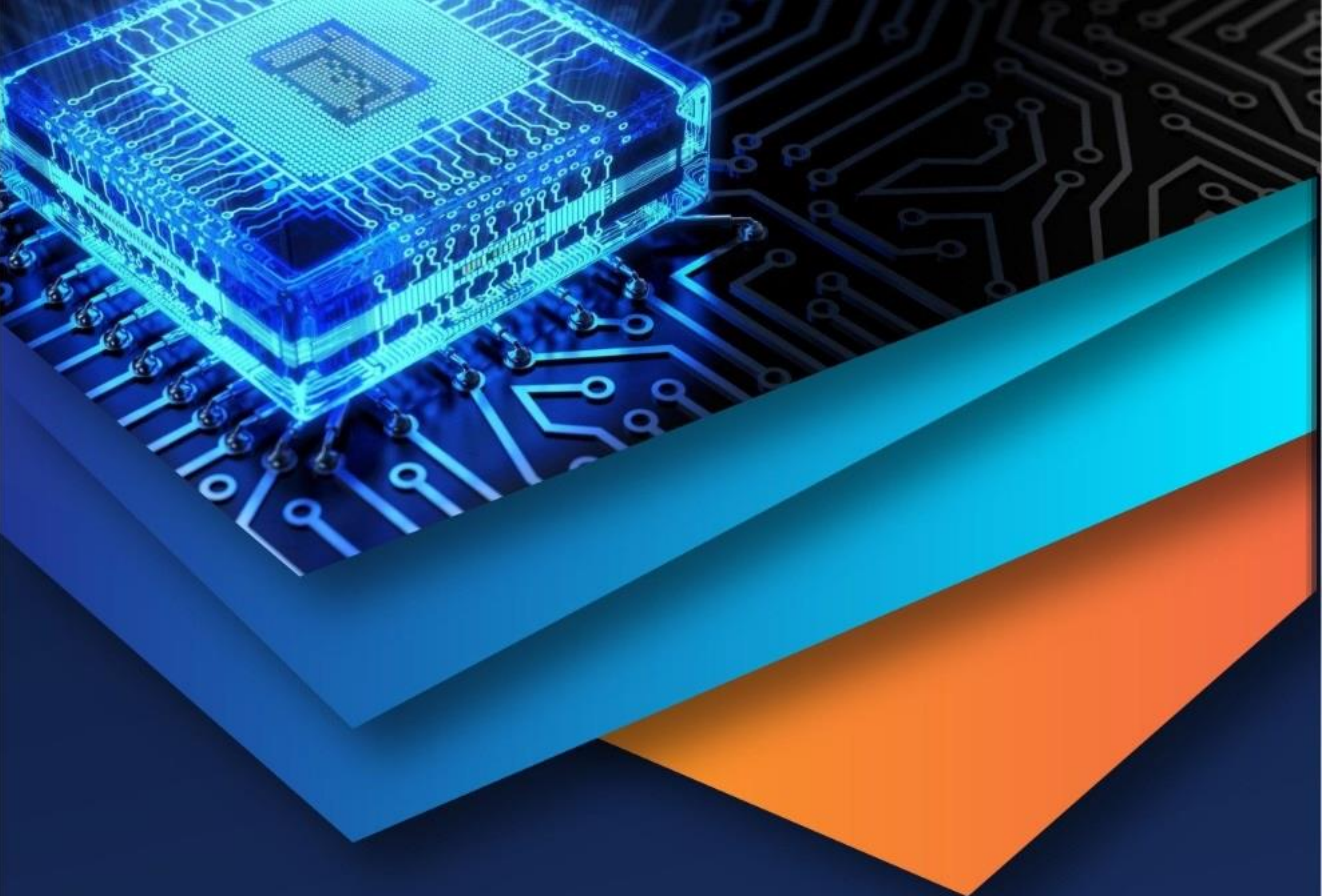

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