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# Effect of Inlet Air Temperature on HCCI Engine Fuelled with Diesel- Eucalyptus Fuel Blends

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***Abstract: In this study, port injection single-cylinder HCCI engines were used to conduct an experimental investigation into the impact of diesel-Eucalyptus fuel blends on HCCI engine performance and exhaust pollutants. In the tests, eucalyptus and diesel were blended in a variety of volume ratios as test fuels, including 20% eucalyptus to 80% diesel (Eu20/D80), 40% eucalyptus to 60% diesel (Eu40/D60), 60% eucalyptus to 40% diesel (Eu60/D40), and 100% diesel. The tests were performed at a 1500 rpm engine speed with a 19-compression ratio at inlet air temperatures between 70° and 130°C. This study observed at the variations in brake thermal efficiency, exhaust gas temperature, and carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NOx) emissions. According to test results, HCCI with diesel-Eucalyptus fuel blends increases brake thermal efficiency, exhaust gas temperature, decreases carbon monoxide, unburned hydrocarbons at inlet temperatures of 130°C, and decreases nitrogen oxides at inlet temperatures of 70°C. It was subsequently found that diesel-Eucalyptus fuel mixtures significantly affected the output and exhaust emissions of HCCI engines.***

***Keywords: HCCI combustion, Eucalyptus, Diesel, Performance, Exhaust emission***

## I. INTRODUCTION

Researchers and manufacturers are looking for other energy sources and studying different ways to burn fuel because oil reserves are running out and prices are going up. When the number of vehicles goes up, especially in the transportation sector, energy use goes up a lot. Furthermore, strict emission regulations like EURO VI have reduced the amount of pollution that comes from motor vehicle exhaust emissions. [1–2]. So, in order to cut down on fuel use and harmful exhaust emissions, researchers, especially those who work in the automotive industry, have focused on ways to improve engines or fuels, such as homogeneous charged compression ignition (HCCI) engines or biofuels that are renewable and can be used over and over again. HCCI engines share great qualities such as spark ignition (SI) and ignition engines (CI) with higher thermal efficiency and lower soot and nitrogen oxides (NOx) emissions [3]. HCCI engines can run on a variety of fuels as long as the temperature is high enough to start the fuel ignition at the end of the compression stroke. As a result, the utilisation of fuel mixtures in HCCI operation is practical and effective [4]. The HCCI engine's combustion phase can be influenced by the following parameters: fuel characteristics, inlet air temperature, fuel injection pressure, and fuel injection timing. Furthermore, the injector spray shape, exhaust gas recirculation, variable value timing, swirl ratio, and compression ratio can all have an effect on engine performance [5]. Creating a homogenous mixture is one of the most difficult aspects of HCCI engines. In HCCI engines, a port fuel injector that injects fuel into the input air stream to build a premixed charge produces a homogeneous charge. Higher UHC emissions are the primary issue with external mixture development. This injector was used to feed gasoline into the intake air for HCCI mode engine operating. The heated intake air and EGR permitted an intake temperature of up to 240 degrees Celsius for fuel vaporisation [6]. The first to use a premixed direct injection system for HCCI operation. The majority of the fuel in this system was injected into the intake manifold to generate a homogenous charge, and a premixed charge was injected with a minor amount of fuel immediately injected into the cylinder. This method can lower NOx and smoke emissions more effectively than a normal diesel engine [7]. One of the governing parameters for controlling and improving HCCI combustion is the inlet air temperature. The inlet air temperature influences the timing and duration of combustion; a high inlet air temperature advances the start of combustion while decreasing the volumetric efficiency of the engine. [8]. The experiments on an acetylene-fueled homogenous charge compression ignition engine. The input air was heated to various temperatures in order to establish the optimal level between 40°C and 110°C. The inlet air temperature was shown to improve brake thermal efficiency, while nitric oxide and smoke levels were lowered [9]. The combustion behaviour of an HCCI engine at varying injection pressures of 400 bar, 500 bar, 600 bar, and 700 bar, where rapeseed methyl ester and diesel were injected earlier directly into the cylinder during engine suction.

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The author concluded from this experiment that increasing the injection pressure lowered NOx and smoke exhaust emissions. At the same time, the increased injection pressure results in a slight reduction in carbon monoxide and HC emissions [10]. According to the literature review, increasing the inlet air temperature is the most effective strategy for HCCI combustion control; however, increasing the fuel injection pressure can enhance power output and may lower exhaust emissions. Today, the usage of vegetable oils as motor fuels may appear modest. Yet, such oils may become as essential in the future as petroleum and coal tar products are now. Vegetable oil has been discovered to be a viable substitute for diesel. Vegetable oil has qualities similar to diesel and can be used in diesel engines with little adjustment [11]. Problems such as gum formation, flow atomization, and significant smoke and particle emissions are conceivable due to the high viscosity of vegetable oil (Alton et al., 2001). Vegetable oil can be used in four ways to solve the issues outlined above: direct use and blending, microemulsions, pyrolysis (thermal breaking), and transesterification [12]. The direct usage and mixing method are used in this investigation. Biomass-derived Eucalyptus oil is selected and blended directly with diesel fuel without any alteration to the oil. Eucalyptus oil has comparable density, viscosity, boiling point, and flash point as diesel fuel. In this experiment, eucalyptus and diesel were mixed in varied proportions by volume, such as 20% eucalyptus and 80% diesel (Eu20/D80), 40% eucalyptus and 60% diesel (Eu40/D60), 60% eucalyptus and 40% diesel (Eu60/D40), and 100% diesel.

## II. EXPERIMENTAL SETUP AND PROCEDURE

A four stroke, direct injected single cylinder diesel engine converted in to HCCI mode using electronic control unit was used for experimentation. Engine torque was measured by eddy current dynamometer. The engine has a conventional fuel injection system. A piezoelectric pressure transducer was mounted with cylinder head surface to measure the in-cylinder pressure. It is also provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperatures. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-Ɵ, P-V, mass fraction burnt and heat release versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built in program in the system calculates indicated power, brake power, thermal efficiency, volumetric efficiency and heat balance. The software package is fully configurable and averaged P-Ɵ diagram, P-V plot and other diagram can be obtained for various operating conditions. Table 1 shows engine specifications fig 1 shows engine set up.

| | |
|---|---|
| Engine manufacturer | Kirloskar oil engines ltd Single cylinder,4stroke, port injection |
| Bore & stroke | 87.5 mm & 110 mm |
| Number of cylinders | 1 |
| Compression ratio | 19 |
| Speed | 1500rpm |
| Cubic capacity | 0.661 litres |
| Method of cooling | water cooled |

Table 1 Engine specifications

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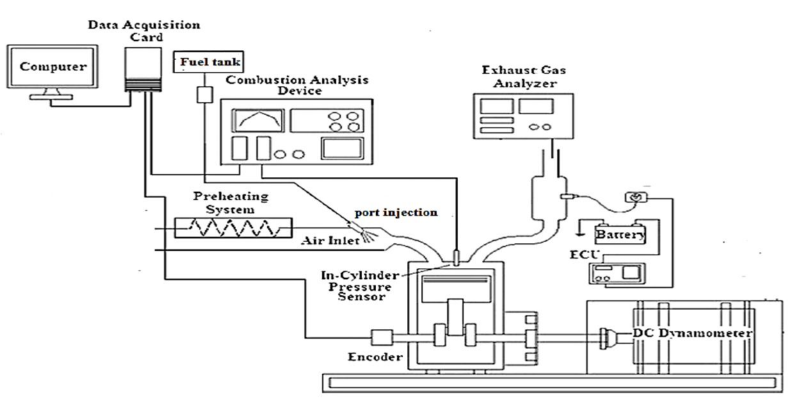


Fig 1 Engine set up

Table.2 Physical and chemical properties of Diesel and Eucalyptus oil

| Properties | Diesel | Eucalyptus oil |
|---|---|---|
| Formula | C8 to C25 | C10H18 O |
| Molecular Weight | 200-240 | 154.25 |
| Composition (% Weight) | C87 H16 | - |
| Density (kg/m3 ) | 830 | 913 |
| Specific Gravity | 0.83 | 0.913 |
| Boiling Point (°C) | 180-340 | 175 |
| Viscosity (cSt) | 3-4 | 2.0 |
| Latent Heat of Vaporization (kJ/kg) | 230 | 305 |
| Lower Heating Value (kJ/kg) | 42700 | 43270 |
| Flash Point (°C) | 74 | 53 |
| Auto Ignition Temperature (°C) | 250 | 300-330 |
| Flammability limit(%Volume) | 1.0 | 0.8 |

## III. RESULTS AND DISCUSSION

### A. *Brake Thermal Efficiency*

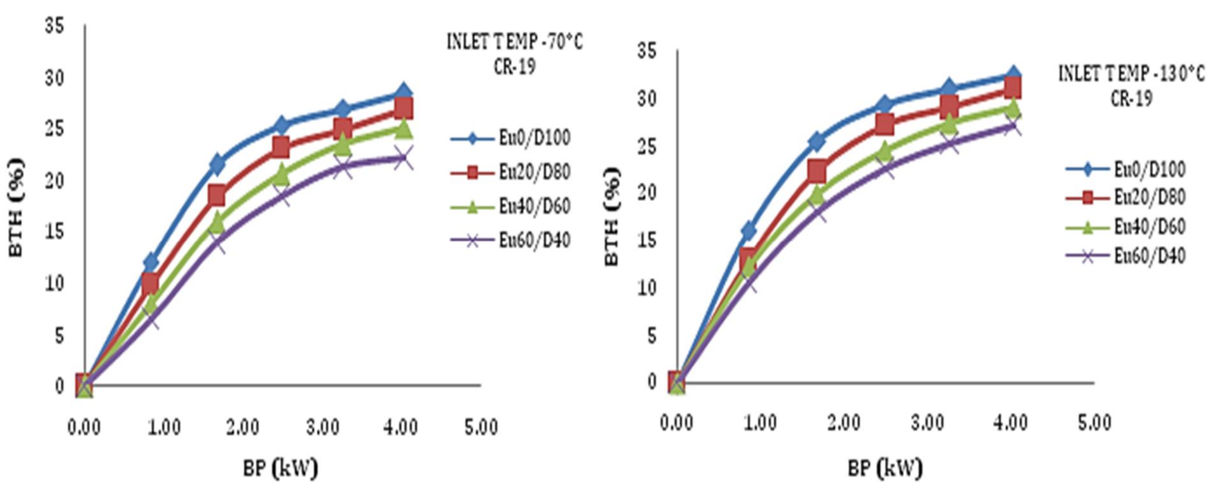


Fig 3.1 Variations of brake thermal efficiency for diesel–Eucalyptus fuel blends at 70°C and 130°C with respect to brake power.

Graph 3.1 depicts the influence of brake thermal efficiency at 70°C and 130°C on braking power for diesel–Eucalyptus fuel blends. Due to the production of a homogenous mixture by port fuel injection, the thermal efficiency of the HCCI engine's brakes approaches that of a typical diesel engine. Observations indicate that brake thermal efficiency increased as incoming air temperature increases. At an inlet air temperature of 130°C, (Eu0/D100) (Eu20/D80), (Eu40/D60), and (Eu60/D40) thermal efficiency increased by 5.49 percent compared to an inlet air temperature of 70°C. Increasing the volume of Eucalyptus oil lowered the thermal efficiency at both 70°C and 130°C inlet temperatures. To increase fuel vaporisation and provide a more homogeneous air/fuel charge, the start of ignition (SOI) timing is slightly retarded by increasing the inlet air temperature. The SOI timing varies based on the temperature of the incoming air. Hence, a higher input air temperature may encourage more complete combustion and raise the cylinder's maximum temperature. This is due to the improved vaporisation and mixture preparation of eucalyptus oil, which results in a rapid rate of heat release.

### *B. Exhaust Gas Temperature*

Figure 3.2 depicts the influence of Exhaust Gas Temperature on Brake Power for Diesel–Eucalyptus Fuel Blends at 70°C and 130°C. Due to the production of a homogenous mixture by port fuel injection, the Exhaust Gas Temperature of the HCCI engine is lower than that of a traditional diesel engine. Observations indicate that Exhaust Gas Temperature increased as inlet air temperature increases at 130°C of intake air temperature (Eu0/D100) (Eu20/D80), (Eu40/D60), and (Eu60/D40), the Exhaust Gas Temperature increased by 15% compared to 70°C of inlet air temperature. By increasing the volume of eucalyptus oil, the inlet temperatures of both 70°C and 130°C exhaust gas temperatures fell. Exhaust Gas Temperature is entirely dependent on the temperature of the incoming air and the combustible mixture. In HCCI Engine, the combustible mixture is homogeneous, allowing combustion to occur at a lower temperature than in conventional diesel engines.

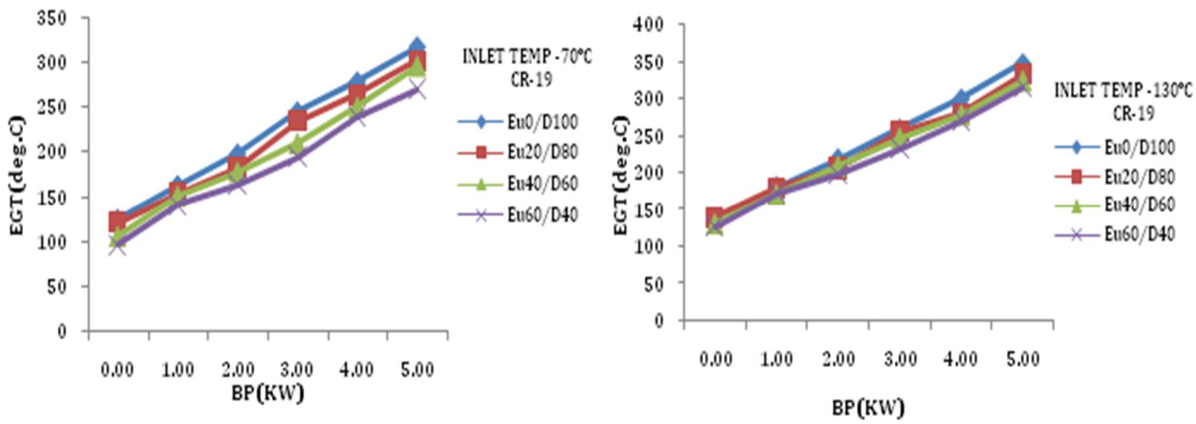


Fig 3.2 Variations of Exhaust gas temperature for diesel–Eucalyptus fuel blends at 70°C and 130°C with respect to brake power.

### *C. Oxides of Nitrogen*

Fig 3.3 shows the effect of oxides of nitrogen for diesel–Eucalyptus fuel blends at 70°C and 130°C with respect to brake power. In this study, analysing the formation of NOx in HCCI engine operates with different inlet air temperatures. The emission mainly depends up on the combustion chamber temperature. The higher inlet temperature increases fuel atomisation and penetration ratios, thereby increasing the homogeneity of the charge. In HCCI combustion one of the best methods to makes the combustion at lower temperature due to auto ignition of homogenous mixture. The oxides of nitrogen of HCCI engine highly decreased compared to the conventional diesel engine. It is observed that $NO_x$ increased with increasing of inlet air temperature. At 130°C of inlet air temperature (Eu0/D100) (Eu20/D80), (Eu40/D60), (Eu60/D40) resulting 35% of $NO_x$ increased compared to inlet temperature of 70°C. Inlet temperature of both 70°C,130°C $NO_x$ decreased by increasing the volume of Eucalyptus oil due to lower combustion temperature.

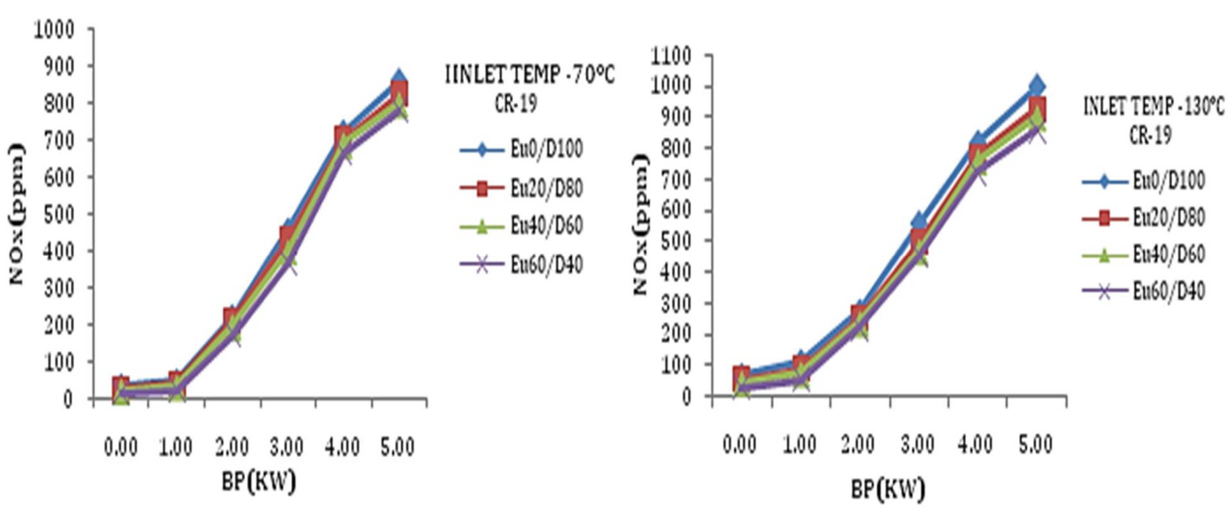


Fig 3.3 Variations of oxides of nitrogen for diesel–Eucalyptus fuel blends at 70°C and 130°C with respect to brake power.

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*D. Carbon Monoxide*

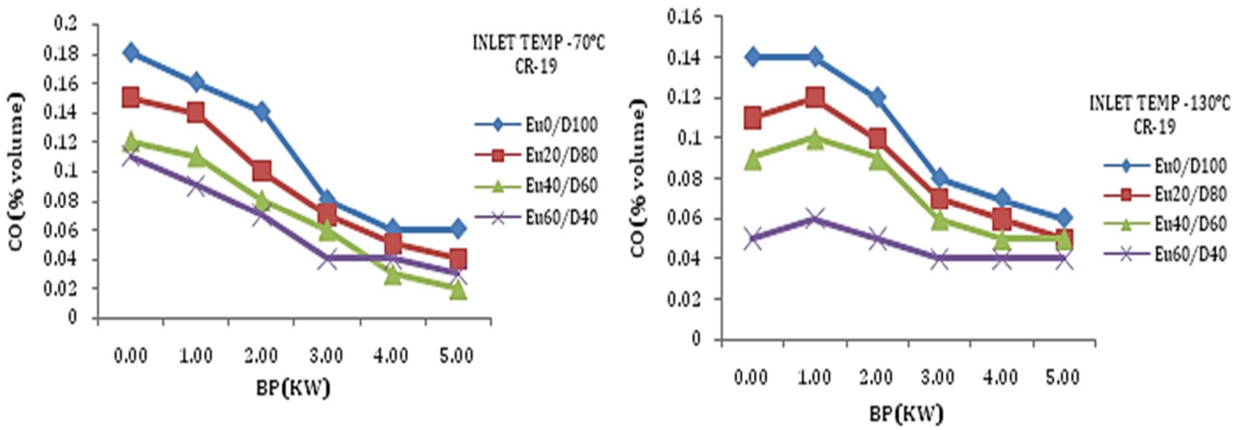


Fig 3.4 Variations of carbon monoxide for diesel–Eucalyptus fuel blends at 70°C and 130°C with respect to brake power.

Figure 3.4 depicts the effect of carbon monoxide on the brake power of diesel–eucalyptus fuel mixes at 70°C and 130°C. The carbon monoxide that mostly results from insufficient oxygen and inefficient combustion. Depending on combustion temperature and mixture homogeneity, carbon monoxide is created throughout the combustion process. Typically, oxygen availability in Eucalyptus is high, therefore carbon readily interacts with oxygen at high temperatures to limit CO emission. Due to the increased inlet air temperature and the production of a homogenous mixture, the HCCI engine produces less carbon monoxide. At 130°C of intake air temperature (Eu0/D100), (Eu20/D80), (Eu40/D60), and (Eu60/D40), CO dropped by 20% compared to 70°C of inlet air temperature. Due to the presence of oxygen, the inlet temperature of both 70°C and 130°C CO dropped as the volume of Eucalyptus oil increased.

*E. Unburned Hydrocarbons*

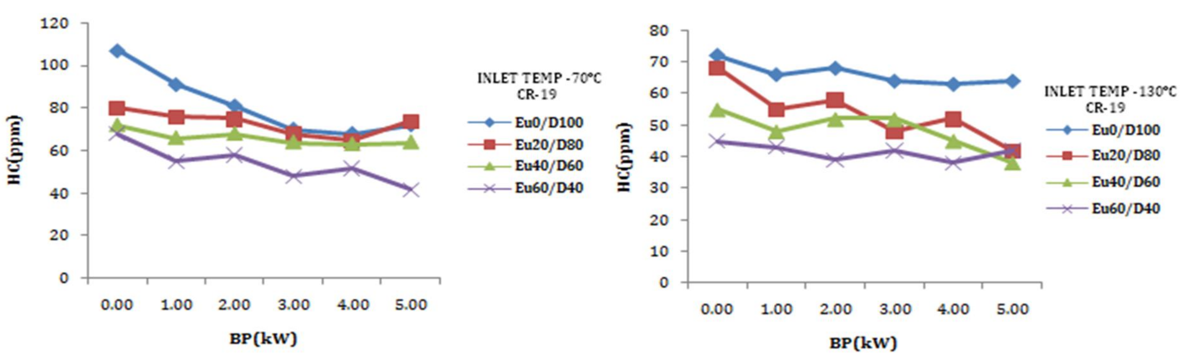


Fig 3.5 Variations of Hydrocarbons for diesel–Eucalyptus fuel blends at 70°C and130°C with respect to brake power.

Figure 3.5 depicts the effect of hydrocarbons on the brake power of diesel–eucalyptus fuel blends at 70°C and 130°C. Hydrocarbons, which are primarily the result of incomplete combustion and oxygen deficiency, are formed during the combustion process in proportion to the combustion temperature and the homogeneity of the mixture. Typically, oxygen availability in eucalyptus is high; therefore, carbon readily interacts with oxygen at high temperatures to limit HC emission. Due to a rise in the inlet air temperature and the production of a homogenous mixture employing port fuel injection, the hydrocarbon emissions of an HCCI engine are reduced. At an inlet air temperature of 130°C (Eu0/D100), Eu20/D80), Eu40/D60), and Eu60/D40), HC is reduced by 18% compared to an inlet air temperature of 70°C. Due to the presence of oxygen, the inlet temperatures of both 70°C and 130°C declined as the content of eucalyptus oil increased. As the temperature of the incoming air rises, full combustion occurs. As a result of the increase in inlet air temperature, the HCCI engine's low HC emissions result in full combustion.

## IV. CONCLUSION

The impacts of inlet air temperature on the performance and emission parameters of a diesel Eucalyptus-fueled HCCI engine were investigated in this research. The results identify the optimal inlet air temperatures required for an effective HCCI engine. The brake thermal efficiency at 130°C of inlet air temperature of several diesel–Eucalyptus blends (Eu0/D100), (Eu20/D80), (Eu40/D60), and (Eu60/D40) increased by 22% compared to 70°C of inlet temperature. Exhaust gas temperature at 130°C of inlet air temperature of various diesel–Eucalyptus blends (Eu0/D100), (Eu20/D80), (Eu40/D60), and (Eu60/D40) increased by 15% compared to 70°C of inlet temperature. NOx emission at 130°C of inlet air temperature of various diesel–Eucalyptus blends (Eu0/D100), (Eu20/D80), (Eu40/D60), and (Eu60/D40) increased by 35% compared to 70°C of inlet air temperature. The CO Emission at an inlet air temperature of 130°C (Eu0/D100) (Eu20/D80), (Eu40/D60), and (Eu60/D40) reduced by 20% compared to an inlet air temperature of 70°C. At 130°C of inlet air temperature, the HC of different diesel–eucalyptus blends (Eu0/D100), (Eu20/D80), (Eu40/D60), and (Eu60/D40) reduced by 18% compared to 70°C.

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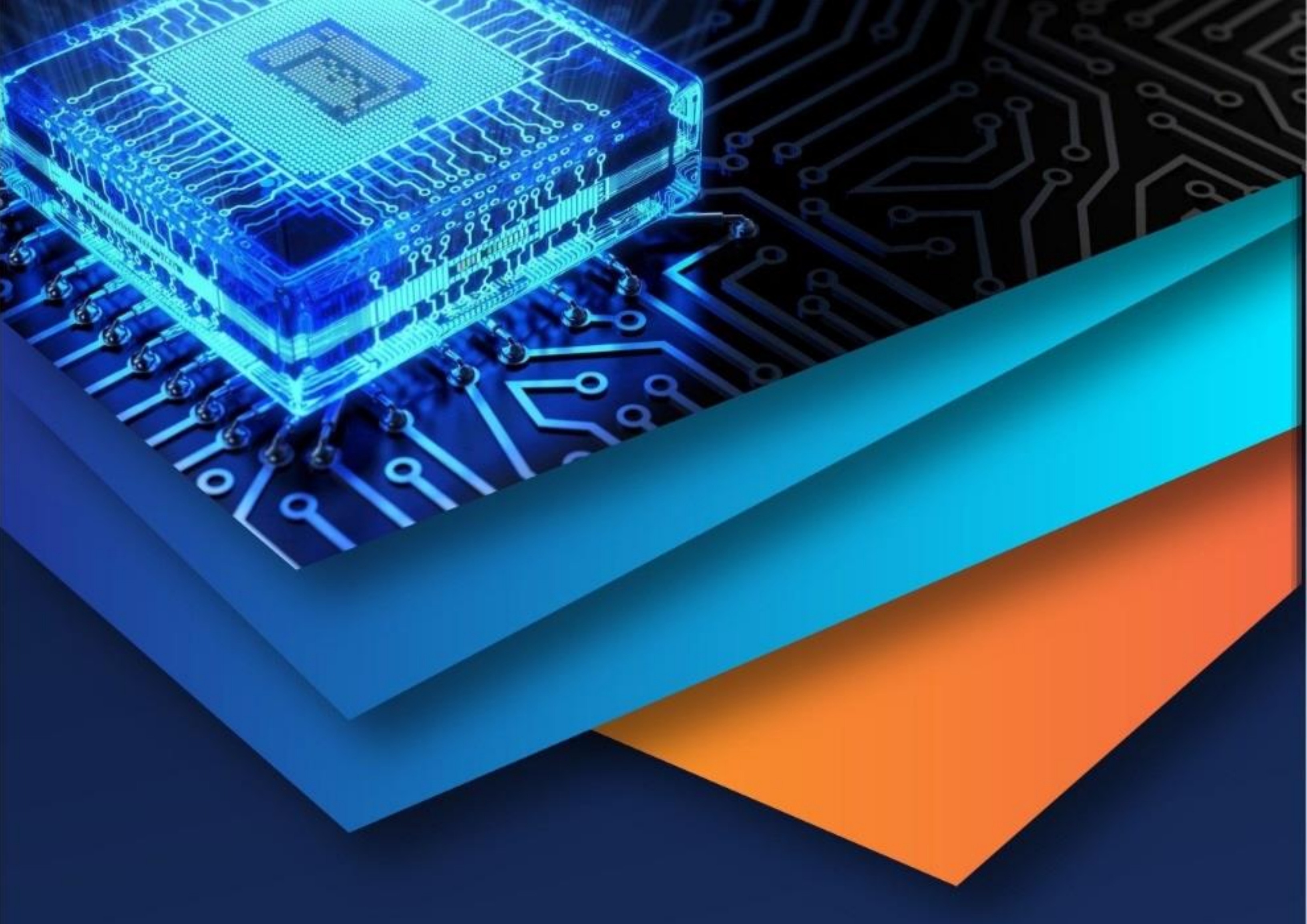

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