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Some Aspects of Compression Ignition Engine Performances Using n-Butanol-Diesel Mixtures

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Abstract*: The biofuels are playing identical prominent activities in solving the green house issues and providing an effective alternatives green energy origin. Alcohol is one of the promising and significant biofuel source used in internal combustion engines in general and in diesel engines in particular. The famous ethanol and methanol has solubility difficulties problem with net diesel when mixture is formed. Butanol C4H10O or C4H9OH is an alcoholic compound has a good soluble in diesel and has bio source. In this work, performances of compression ignition engine using bio n-butanol-diesel mixtures as a fuel is implemented. The 5%, 10%, 20%, and 30% of n-butanol-diesel mixtures by volume are examined as supplementary fuel for diesel engine. The results are showed a stable solubility of n-butanol-diesel mixture. Also, the mixture has 20% n-butanol is optimum blend. It is observed that at 20% n-butanol and 80% diesel, the engine efficiency increased by 6.6% at full load. The carbon dioxide is reduced by 28% and nitrogen oxides are increased by 3% unfortunately.
***Keywords:* Biofuel energy, butanol-diesel mixtures, thermal performance, exhaust emissions, net diesel fuel.**

I. INTRODUCTION

Nowadays, the sources of traditional fossil fuels are limited. There is a critical need to find alternatives fuels origins. Biofuels are excellent and promising substitution fuel for diesel engine. As a result to power factor, diesel engine is remarkable high power efficiency engines and widely using in sector of life. Butanol has good specifications represented by stable dissolved in net diesel and contents oxygen. Generally, oxygenation fuel significantly reduces particular matter and exhaust toxic gases such as carbon monoxide (CO), sulfur oxides (SO*x*), and, NO*x* [1].

Many researchers are tested ethanol, methanol, and butanol. However, the main drawback with mixtures of ethanol-diesel or methanol-diesel researches is the stability of blends whereas ethanol and methanol are separated from net diesel after some time of mixture formation [2,3]. Investigations on different mixtures of ethanol, methanol, and butanol are conducted. Stability, solubility, and physico-chemical properties for different mixtures compositions are investigated [4]. The main factors affect alcohols the dissolved of alcohol in diesel are length of alcohol carbon chain, water content in alcohol, temperature of mixture, and hydrocarbon composition of net diesel fuel [4]. Experimental results emphasize that bio butane has best characteristics as a compare with rest bio alcohol types [4]. A revision to more than 80 critical works is achieved by Rakopoulos at el. [5] up to the date of publishing his paper. Researchers focused on ethanol and normal butanol (n-butanol) as promising and active alcohol that might be used with diesel as a mixture. The emission constituents that exhausted due to use of methanol and n- butanol are fully investigated. Particular matter (PM) and smoke is highly reduction when alcohol was used with diesel [5]. The reduction in (NOx) emissions and (PM) for partially premixed combustion for n-butanol-diesel mixture is remarked significantly in compare with carbon exhaust emissions [6]. The timing of injection, variations of n-butanol, iso-butanal blends with diesel, and exhaust gas circulation rates are investigated in multi cylinder and direct injection chamber [7]. Results were so compatible with critical literature outcome. Different blends ratio of n-butanol to diesel are tested up to 100% n- butanol on base of volume percentage of engine fuel. Different types of compression ignition engines chamber design are used to test the mixture of n-butanol and diesel [8-13]. Some other efforts are excerted to blends more than one alcohol type with diesel and biodiesel whereas the n-butanol is mixed with biodiesel and gasoline-diesel is mixed with n- butanal and iso methanol respectively and investigated [14,16].

In this paper, 5%, 10%, 20%, and 30% (by vol%) of bio n-butanol-diesel mixtures are prepared. The stability of soluble of n-butanol-diesel mixtures is examined. Then, the mixtures are tested by run the compression ignition engine. The performance parameters represented by combustion efficiency and exhaust emission constituents are investigated.

II. EXPERIMENTAL LAY-OUT

Full computerized multi cylinder engine test rig is used to carry out the experiments. This rig contains two mainly parts: the compression ignition engine used the n-butanol-diesel mixtures as a fuel and the measuring units. Table I provides the compression ignition technical description. Electric eddy current are coupled with engine. This dynamometer is measured the engine output power and to loaded the engine. Variation of engine load is controlled by electric current controller fixed on eddy current dynamometer. Engine and dynamometer are fixed on bed with suitable water cooling system. Fig. 1 schemes the experiment rig. The weighting of diesel and n-butan-diesel mixture before and after the experiment gives fuel consumption where the difference in weight divided by the experiment time duration.

TABLE I
COMPRESSION IGNITION ENGINE TECHNICAL DESCREPTION

General details	4 cylinder, 4 stroke, compression ignition, direct injection chamber, vertical.
Bore	72.80 mm
Stroke	89.00 mm
Clearance volume	17.00 cm^3
Compression ratio	23:1
Max. power	37hp @ 4000 rpm
Max. torque	83.4 Nm @2250 rpm
Capacity	1490 cm^3
Lubricating oil	SAE 30/SAE 40
Cooling media	Water

The speed of engine is calculated by counter the number of times that white dot point crosses line on the main axis of the engine. Digital anemometer is used to measure the engine intake air quantity. K- type thermometer is utilized to engine outlet gasses temperature. A DAC is run on system to convert all sensors analog signals to digital. Hence, all measuring instruments are connected to computer. Portable gas analyzer is used to analyze exhaust emission. The basic power formulas are used to calculate compression ignition engine performance [17].

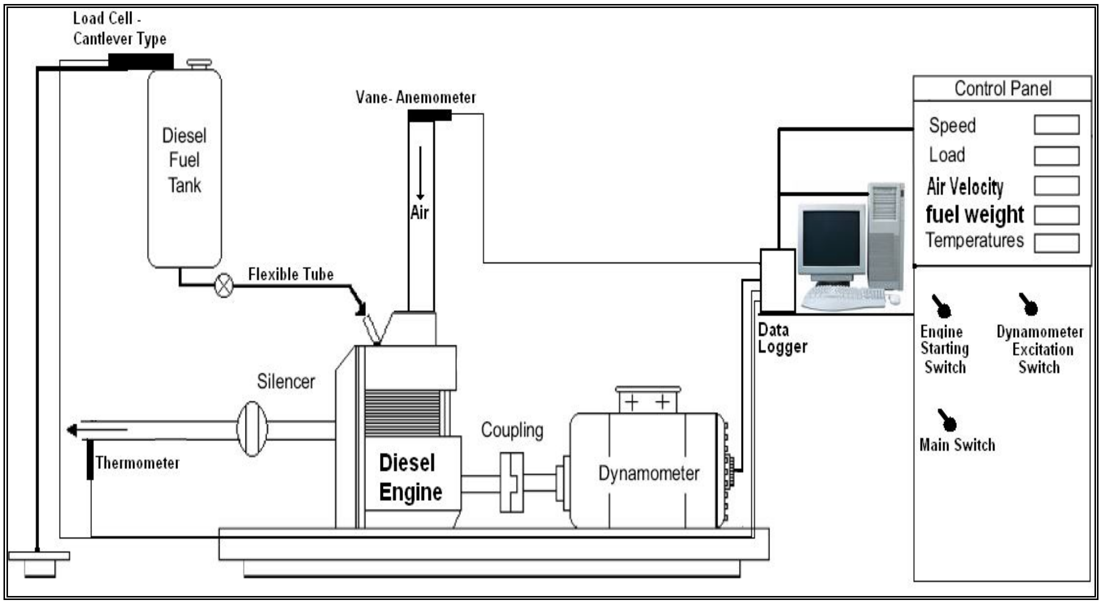

Fig. 1 Schematic of engine and its measuring parameters

III. DESCREPTION OF EXPERIMENTAL TEST

The following experimental steps are followed in this work: In transparent glass tubes, the bio n-butanol and net diesel at 5%, 10%, 20%, and 30% with 95%, 90%, 80%, and 70% by volume % respectively. Those four tubes are put in laboratory ambient temperature to test the solubility of mixtures for 84 hours. After this time period, the mixture was still stabile and n-butanol kept soluble in net diesel. After this test, the compression ignition engine performance is investigated. This investigation is represented by engine thermal combustion calculated and engine gas emission constituents analyzed whereas the diesel engine is run to attain steady state. The stable of outlet temperature reading is an indicator to start gathering the reading of sensors by acquiring system. The data of engine for torque, diesel and n-butanol mixture consuming, intake air amount, load, speed, exhaust temperature, and emission components. These data are gathered at fuel vol.% are 0%, 5%, 10%, 20%, and 30% of n-butanol-diesel. Load of engine are no load (0 ampere), 1/4 load (0.5 ampere), 1/2 load (1.0 ampere), 3/4 load (1.5 ampere), and full load (2.0 ampere). The speed of engine is constant at 1500 rpm. Table II gives the index of fuel for bio n-butanol and net diesel that used in this work. Experiments are repeated to verify that acquisition system readings and experiment design are reliable. A high attention is followed during the experiment tests to keep the variation in: environment temperature, humidity, atmospheric pressure, diesel properties from refinery and bio n- butanol from source are mostly fixed to avoid observations variance.

Table II
THE INDEX OF FUEL FOR n-BUTANOL AND NET DIESEL

Property	n-butanol	Net diesel [7]
Density (kg/m^3)	810	840
Calorific value (MJ/kg)	33.0	43.0
Kinematic viscosity (mm^2/sec) @ 40 ^oC	3.6	2.6
Flash point (^oC)	35	53
Cetane number	26	47
Cloud point (^oC)	-7.5	7
Pour point (^oC)	N/A	-8
Boiling temperature (^oC)	117.5	282-338
Oxygen contain (%)	21.6	0

IV. RESULTS AND DISCUSION

Most of critical papers that search the n-butanol- diesel mixtures are focused on the combustion parameters analysis and the emission gas constituent analysis. This scenario is followed in this work.

A. The Combustion Parameters Analysis

Fig. 2 represents the the relation of brake thermal efficiency with load for different n-butanol-diesel mixtures. Margin enhancement in thermal efficiency can be noticed. At mixture 20% and 30%, the effect of oxygenated fuel on combustion is indicated. At 2 Ampere load, the gain in brake thermal efficiency is 6.6% at 20% n-butanol mixture when compare with engine efficiency at net diesel fuel only. In meanwhile, the brake thermal efficiency is increase by 6.0% at same load and 30% n-butanol mixture as a compare with brake thermal efficiency at 2 Ampere load and net diesel is used. The difference in net caloric value between net diesel and n- butanol has limited effect on the combustion.

Fig. 3 demonstrates the relation of specific fuel consumption with engine load at different n-butanol-diesel mixtures. Its easily observed that specific consumption of fuel in terms of ne and mixtures is increased with engine load increment. The increment of n-butanol in fuel mixture led to increasing in consumption of fuel. The decreasing of caloric value of n- butanol is substituted by consume more fuel. At full load and other loads the average increasing in fuel consumption is 10%.

Fig. 4 gives the relation of volumetric efficiency with engine load at different n-butanol-diesel mixtures. Volumetric efficiency is the indicator to the amount of air that sucks by engine during the combustion stroke. Normally the volumetric efficiency of diesel engine is decreased with increased of engine loads. The time period of intake value is decreased with engine speed. At constant speed engine, the increment of load means more consumption of fuel inside the combustion chamber which led to decrease the amount of air in combustion chamber where the volume of chamber is constant. The effect of oxygenated fuel or existence oxygen yields to a margin decreasing in volumetric efficiency. Logically, this behavior is appearance more with increasing of n-butanol in mixture.

Fig. 5 presents the relation of exhaust temperature with engine load at different n-butanol-diesel mixtures. Exhaust temperature is varied linearly with engine load. Generally, the oxygenated fuel such alcohol leads to increase the temperature of exhaust of diesel engine. This behavior is evident in trends of mixtures curves in figure 5. Increasing of n-butanol in fuel mixture caused a sequent increasing in temperature of exhaust gases.

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B. The Emission Gas Constituent Analysis

Fig. 6 shows the relation of carbon monoxide percentage with engine load at different n-butanol-diesel mixtures. Normally, the carbon monoxide decreased with increasing of engine load. The increment of engine load has shorten the time period of carbon monoxide formation i.e carbon monoxide has not enough time for formation. The adding of oxygenated fuel like n-butanol with low carbon to the traditional diesel caused a high reduction in carbon monoxide. at full load the contraction in carbon monoxide is around 50% when the mixture contains 30% of n-butanol which represented the maximum reduction.

Fig. 7 gives the relation of unburned hydrocarbons with engine load at different n-butanol-diesel mixtures. Unburned hydrocarbon is increased with engine load increment. The increasing in fuel amount leads to increase the unburned hydrocarbon. As a result to use n-butanol as a mixture with net diesel the percentage of unburned hydrocarbons is decreased unstable chemical compound such as the monoide of carbon. The adding of 30% from n-butanol by volume to net diesel caused 10% decreasing in HC.

Fig. 8 gives the relation of carbon dioxide percentage with engine load at different n-butanol-diesel mixtures. the carbon dioxide is increasing with the increment of engine load. The formation of dioxide carbon is opposite the formation of monoxide carbon. Its observed from figure 7. that as the n-butanol volume ration increasing, the dioxide percentage is decreased. 30% of n-butanol reduced 50% of CO_2 emission in gas exhaust.

Figure 9. gives the relation of nitrogen oxides with engine load at different n-butanol-diesel mixtures. The NOx forming is depending on the amount of air in combustion chamber and combustion chamber temperature. Traditional, the increasing in engine loads leads to increasing in NO_x due to increasing in the combustion chamber temperature. The adding of n-butanol to the diesel cause margin increasing in NOx of exhaust emission. At full, the adding of 30% of n- butanol by volume led to increase the NO_x by 4%.

V. CONCLOUSION

A. Bio n-Butanol have a good solubility with diesel to form a homogenous mixture at 5%, 10%, 20%, and 30% by vol.
B. The mixture has 20% of n-butanol and 80% of diesel is the optimum mixture.
C. Bio n-Butanol mixtures are decreased the CO%, HC%, and CO_2%. Almost 21% the reduction in CO2.
D. Bio n- butanol mixtures are increased marginally the NOx by 3%.

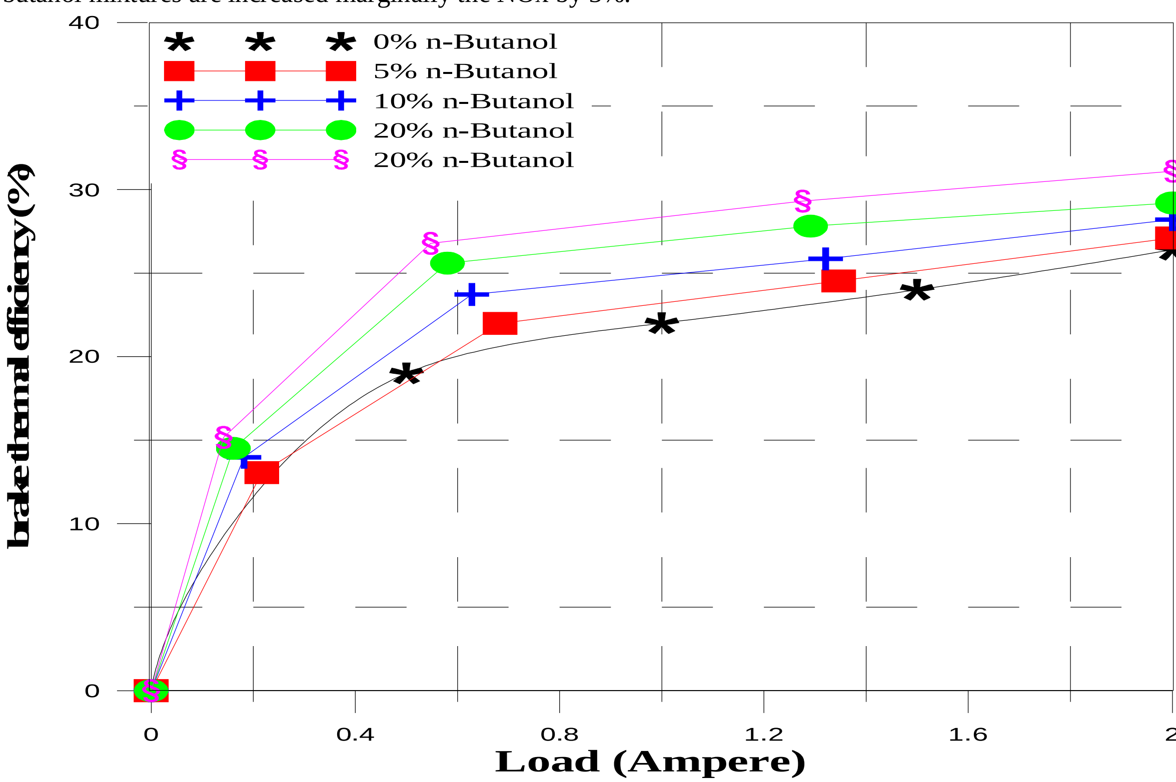

Fig. 2 Relation of brake thermal efficiency with engine load at different n-butanol-diesel mixtures.

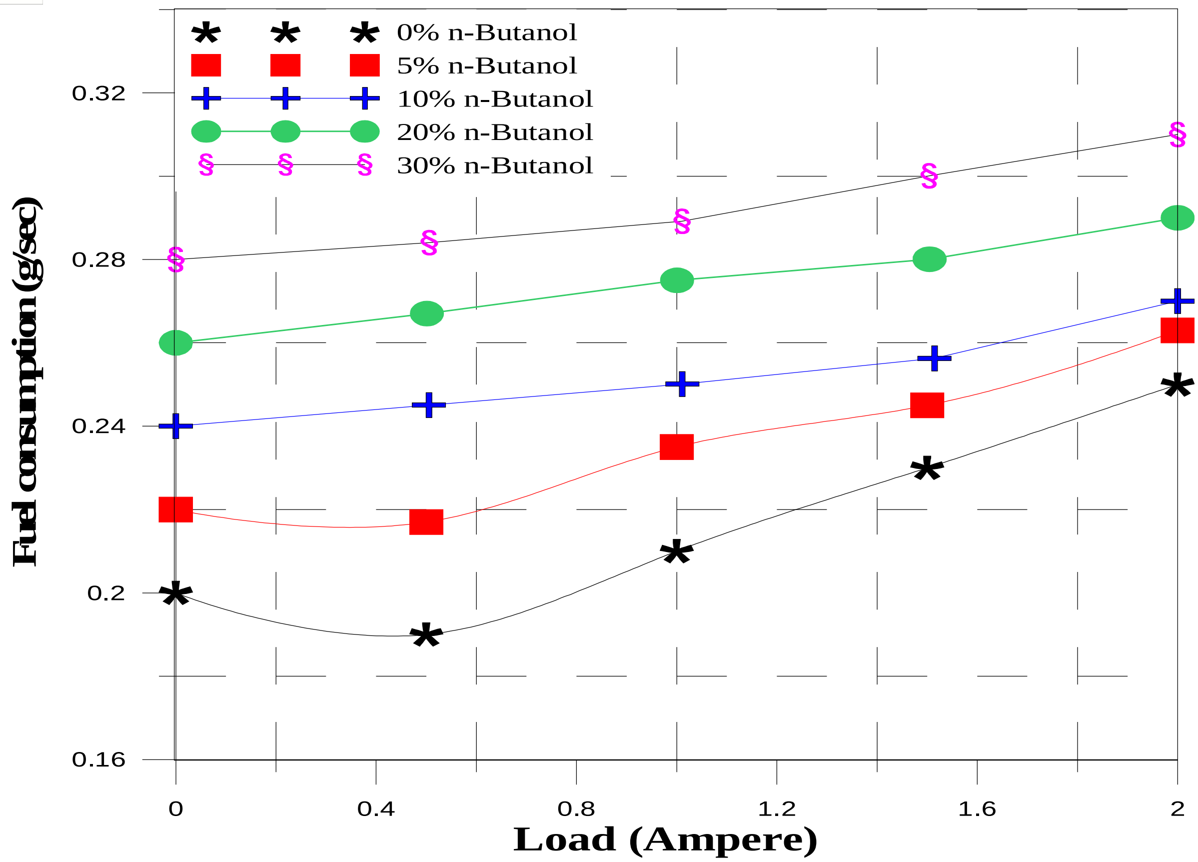

Fig. 3 Relation of fuel consumption with engine load at different n-butanol-diesel mixtures.

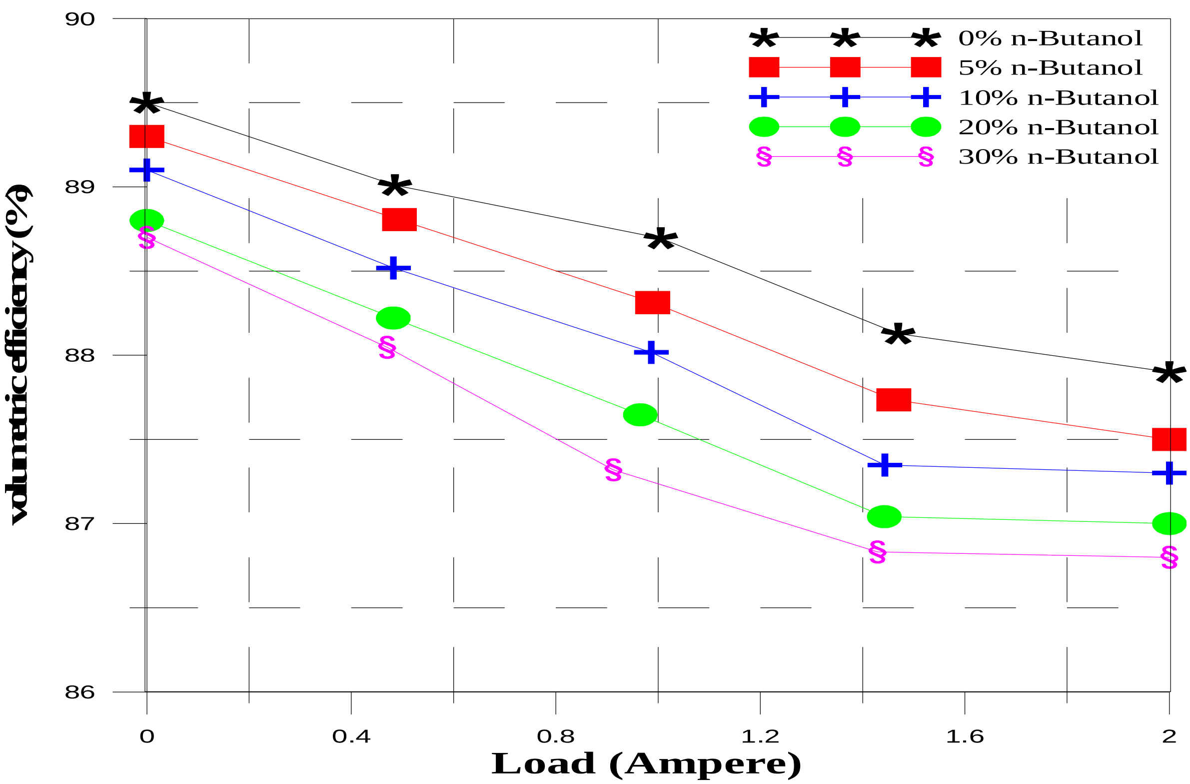

Fig. 4 Relation of volumetric efficiency with engine load at different n-butanol-diesel mixtures.

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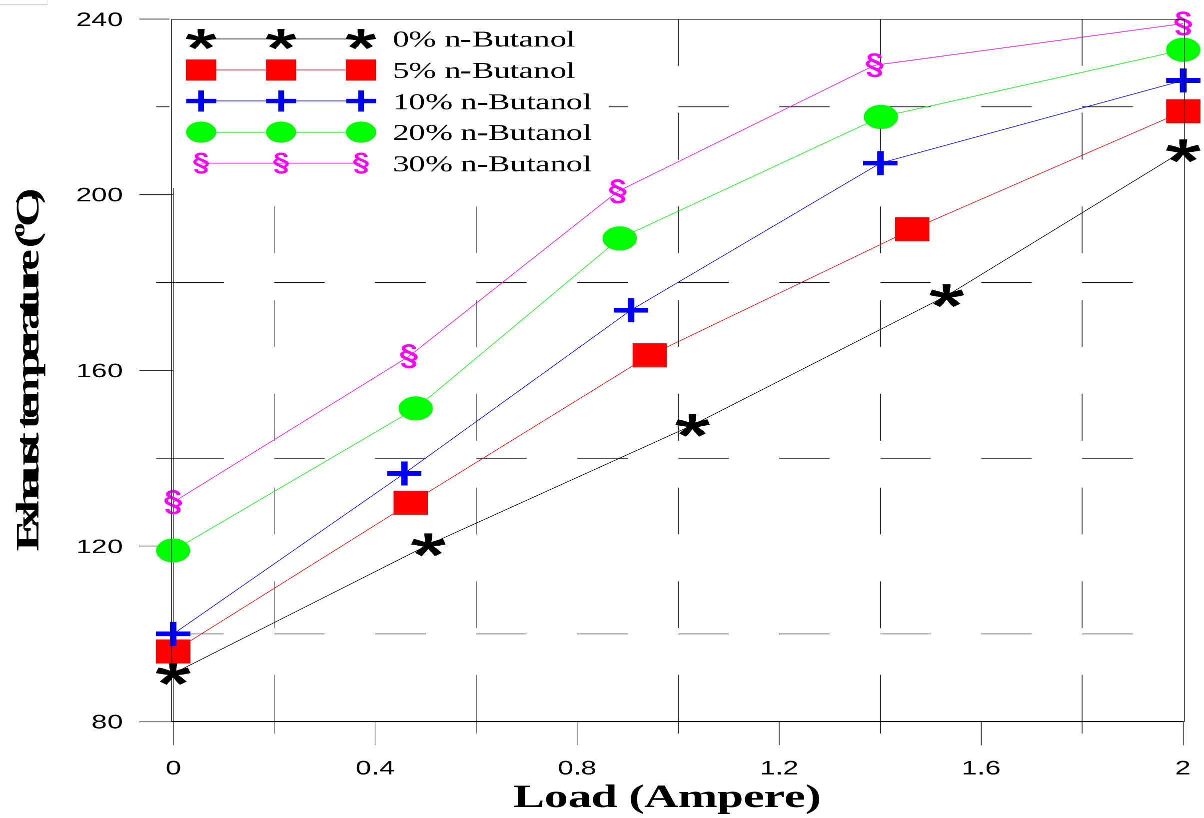

Fig. 5 Relation of exhaust temperature with engine load at different n-butanol-diesel mixtures.

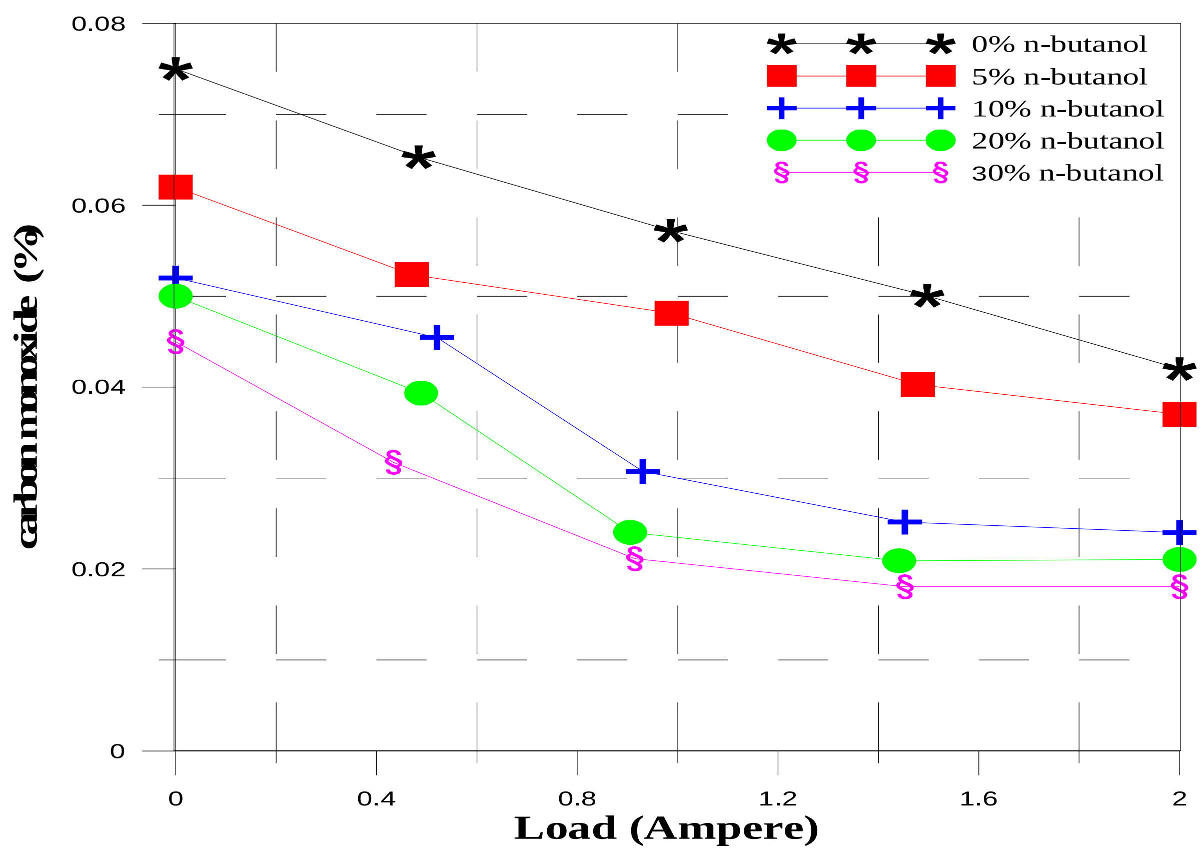

Fig. 6 Relation of carbon monoxide with engine load at different n-butanol-diesel mixtures.

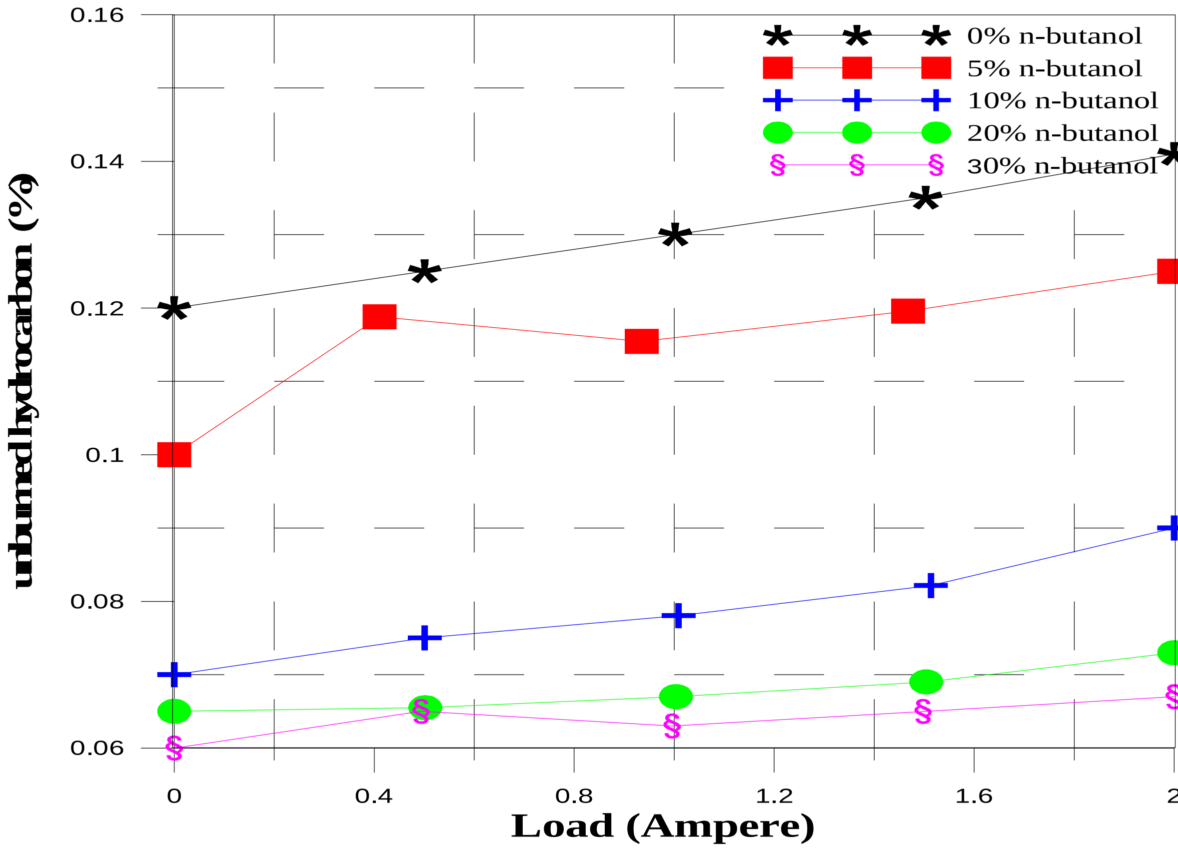

Fig. 7 Relation unburned hydrocarbons with engine load at different n-butanol-diesel mixture

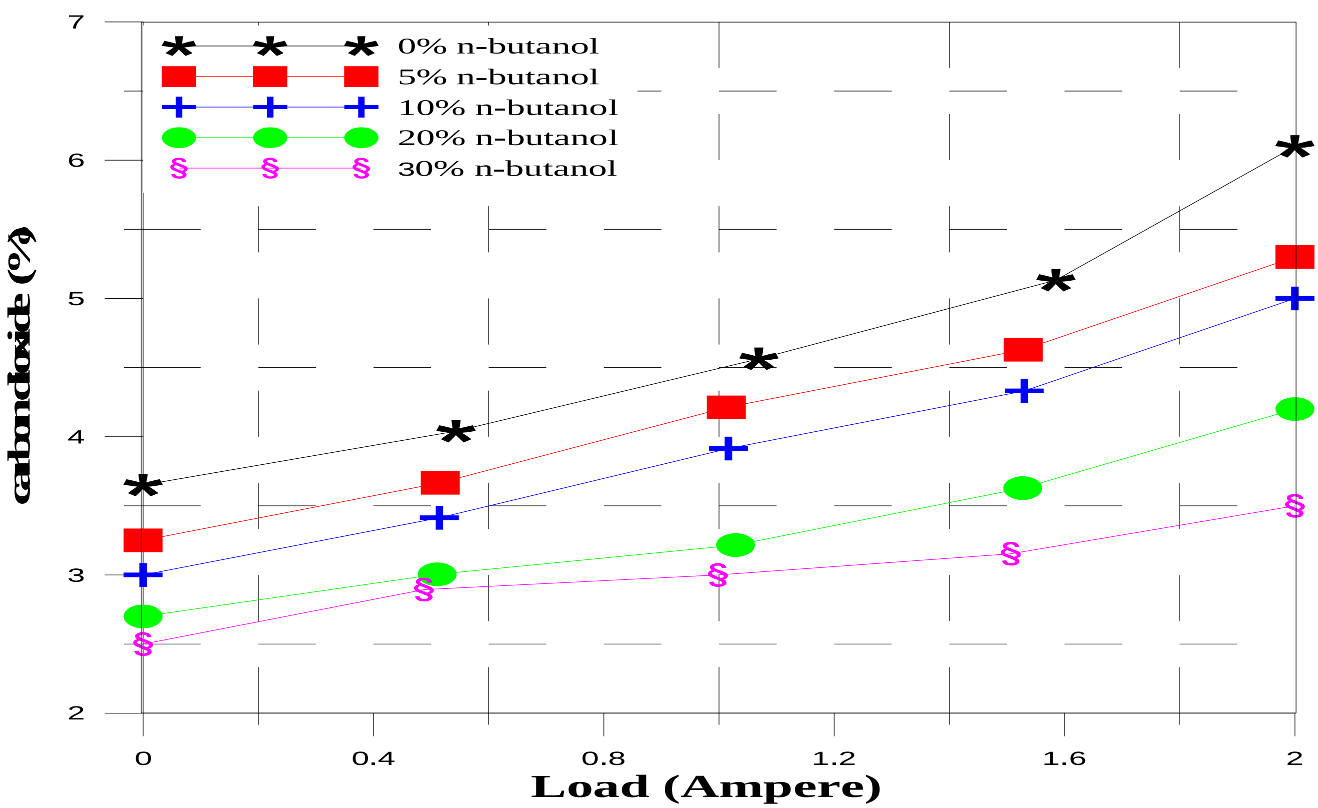

Fig. 8 Relation of dioxide of carbon with engine load at different n-butanol-diesel mixtures.

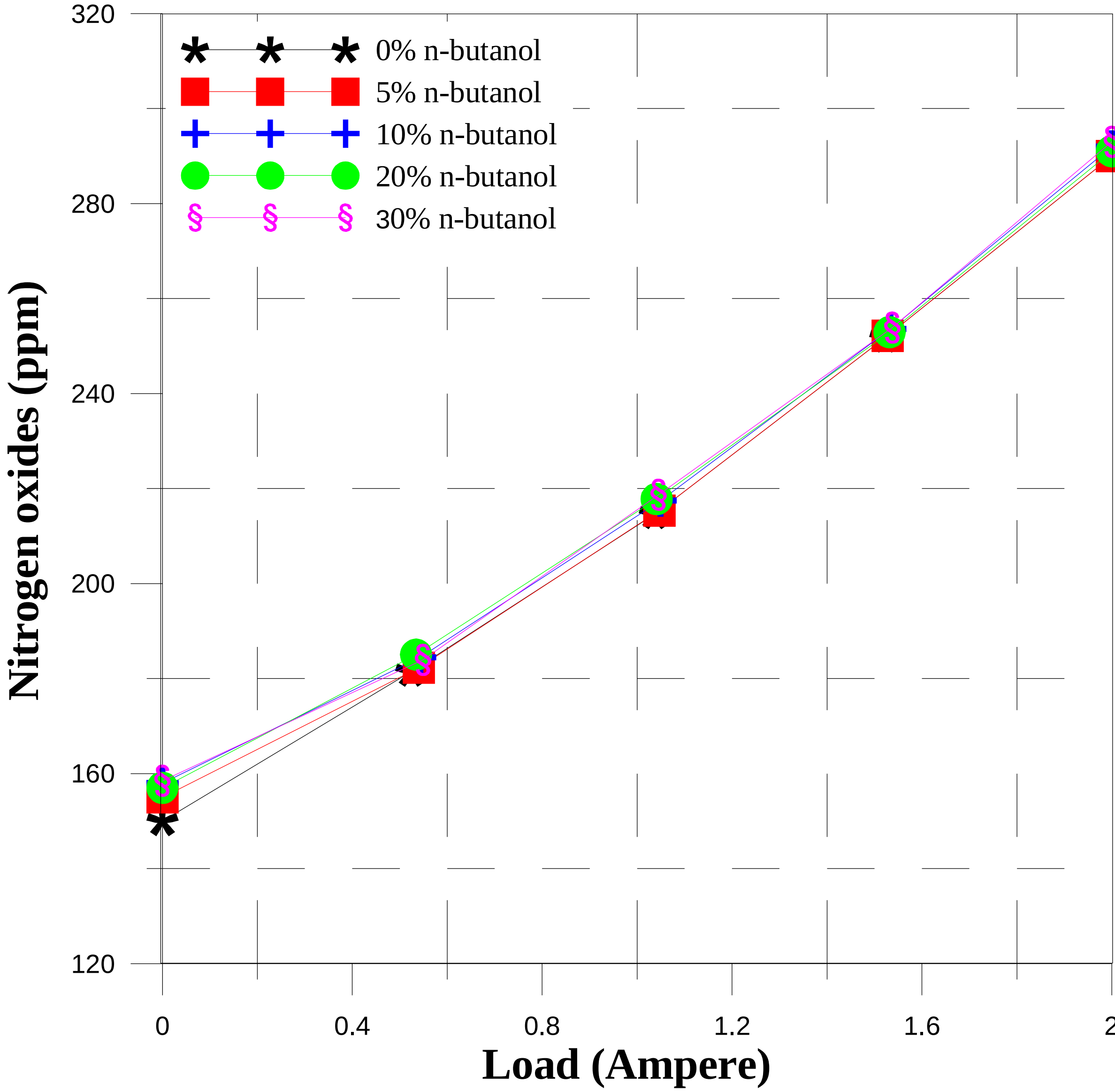

Fig. 9 Relation of nitrogen oxides with engine load at different n-butanol-diesel mixtures.

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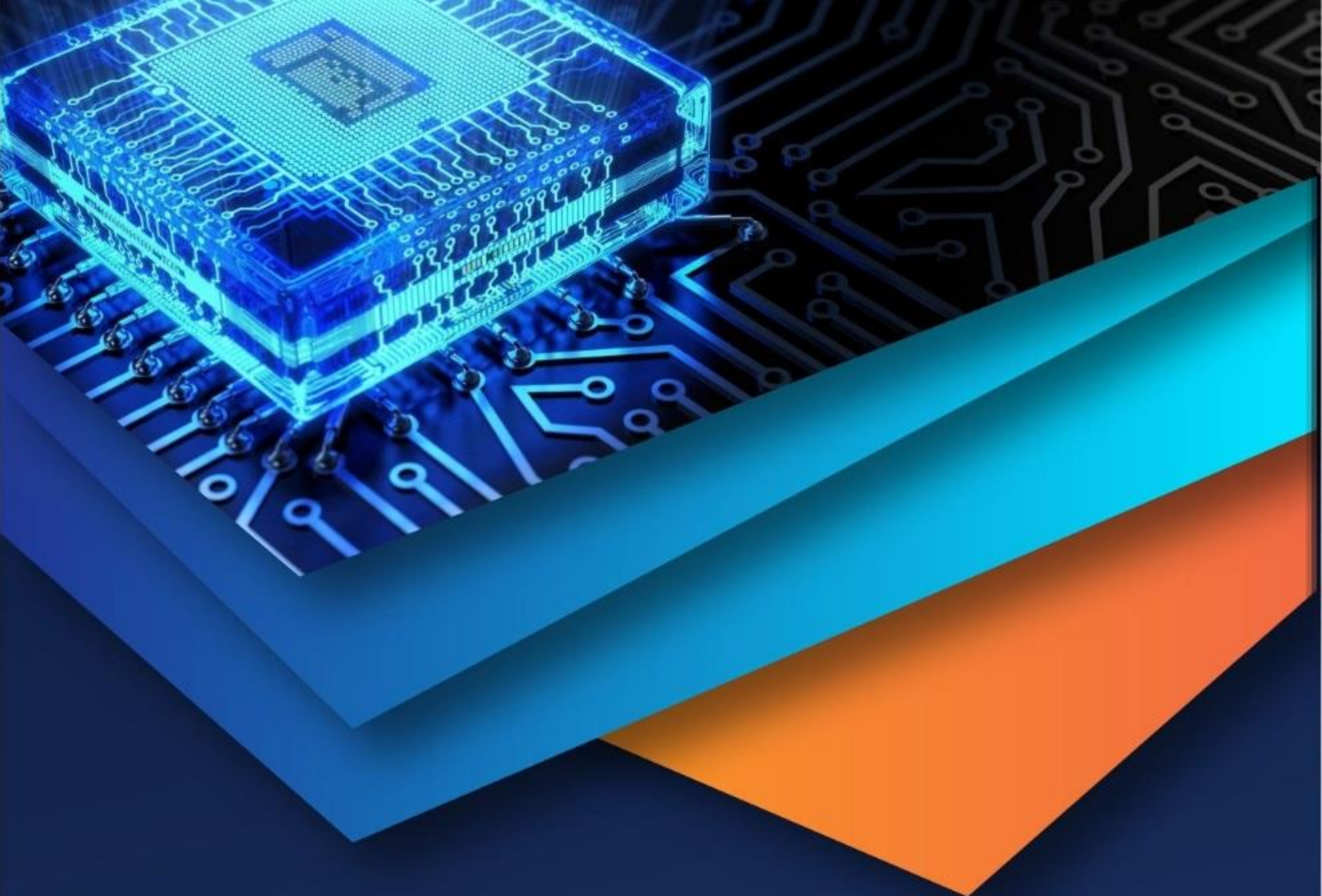

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