Study of performance and emission characteristics of CI engine fuelled with refined Neem Oil blended diesel fuel.

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ABSTRACT

This paper study the performance and emission characteristics of compression engine fuelled with neem oil blended diesel fuel. The experiment was carried out in the four stroke single cylinder water cooled naturally aspirated Compression ignition engine coupled with eddy current dynamometer. Performance and emission test was conducted at constant speed by varying the loading conditions. Result was found that Brake thermal efficiency for B10NO was found closer to diesel fuel. Increasing the blending ratio of the neem oil decrease the Brake thermal efficiency. B20NO was found closer to Diesel fuel. Brake specific fuel consumption was found higher for B20NO and B30NO because of the lower calorific value of the fuel. B10NO fuel has very closer value diesel fuel. B20NO fuel has good combustion characteristics because of the increase oxygen content of the fuel. All loading condition B20NO average ignition delay period than B10NO and B30NO fuel. Because of well balanced between parameters like calorific value, moderate viscosity value and more Oxygen content. HC emission was found lesser than diesel for blended diesel fuel. This is because of the high oxygen content of the Neem oil. Co emission was found lesser at lower load and increase for higher loading conditions. At higher loading conditions leads shorter duration for combustion and higher viscosity of the fuel leads to poor atomization of the fuel. Nox emission was found higher for Diesel because of high heating value. Nox emissions were found lower for biodiesel for because of lower heating value. Increase in blending ratio of the fuel leads increase in NOx emissions because of the increase in Oxygen content of the fuel.

KEY WORDS: biofuel, neem oil, diesel engine, Performance, Emission, Combustion.

1. INTRODUCTION

Scarcity and Rapid depletion of fossil fuels leads to intensive search of alternate fuels. Increase in energy demand and decrease in conventional energy resources need an alternate fuel which can be effective substitute. Alternate fuels should have scope of ecofriendly and fulfill the demand. Economy of the country depends on the energy resource and most of the countries depend on foreign resources. World cultivation scenario having different bio-fuels which can utilize efficiently to decrease dependency on other countries. Utilization of monopoly fuel leads to more concentrations of similar pollutant. More constraint in emissions norms need an alternate fuels which should have less impact on environment. Urbanization and industrialization mainly depends on energy resources. Transport sector of the country plays major role in developing the country status. Current scenario of country mainly depends on the fossil fuels and mostly on diesel engine. Diesel engine mainly uses the diesel as fuel. It has the good fuel properties such that high cetane number, high heating value, less viscosity etc. But it suffers from the depletion of its resources. Biodiesel was produced from the different oil such that cotton seed oil, Honge oil, Neem oil, Rice Bran oil, palm oil, almond oil coconut oil, microalgae oil, karanja oil, polanga oil, madhua oil, rubber seed oil, jojoba oil, tobacco seed oil, linseed oil etc.. (Nurun Nabi, 2009; Banapurmath, 2009; Nidal, 2015; Mohan kumar Chinnamma, 2015; Gokhan Tuccar, 2013; Ashraful, 2014), used as the fuel for CI engine. Since biodiesel has few drawbacks of higher viscosity which leads to poor atomization of fuel and result in poor combustion. By blending the biodiesel with diesel fuel was reason for the reduction in viscosity. Oil derived from plants can also be used as the fuel for the diesel engine even though it has the high viscosity and lower calorific value then diesel fuel. Using plant oil as straight fuel result in slow burning and high Smoke pollution and contaminate the lubricating oil. But plant oil can be used in CI engine by blending with Diesel fuel. Because of higher viscosity of the plant oils, blending ratio is limited to 20%. Much plant oil are available in enormous Quantity with promising fuel properties. Plant oil such that mustard oil, palm oil peanut oil, cotton seed oil etc having good cetane number which favors these oil as CI engine alternate fuel. Neem oil extracted from seeds of Neem tree which is available more in number. The potential of neem oil resources is high and it can be easily used. Higher viscosity of neem oil fuel increase the ignition delay period due to poor atomization on the hot air particle inside the combustion chamber. Higher viscosity of the fuel can be reduced by blending the oil with diesel fuel. Properties which supports for biodiesel as alternate fuel were good oxygen content, high cetane number. Cetane number defines ignition quality of the fuel i.e defines degree of auto ignition. Because higher cetane of the neem oil can be auto ignited by compression in diesel engine. High oxygen content of the fuel leads to good oxidation properties enhances the high combustion efficiency. Basavaraj, Shrigiri (2016) studied the performance and emission characteristics of CI fuelled with neem oil methyl ester and cotton seed oil methyl ester. He found reduction in brake thermal efficiency and higher SFC for blended fuel. Nox was found to be higher than diesel fuel. Mohammed Takase, (Mohammed Takase, 2015) did review on the biodiesel of neem oil, karanja oil, jatropha oil and rubber seed oil. He found that slight reduction brake thermal efficiency. Biodiesel is suffering from High viscosity, lower calorific value. Because of that brake thermal efficiency was found lesser than diesel fuel. Higher oxygen content of the fuel leads more No_x emission. Md. Hasan Ali, (Hasan Ali Md, 2013) studied the feasibility of biodiesel production from Neem oil. He found that at molar ratio of 1:3, reaction temperature of 55°C having viable biodiesel production. Soo-Young No (2011), found that inedible have drawbacks of high viscosity and low volatility. He stated that it has advantage of the renewability, lower sulpur content and higher heating value. Venkatraman (2015), It is found that the combined compression ratio of 19:1, injection pressure of 240 bar and injection timing of 27°bTDC increases the brake thermal efficiency and reduces the brake specific energy consumption with lower emissions.

2. EXPERIMENTAL SET UP

Experimental set up consist of four stroke single cylinder water cooled naturally aspirated diesel engine coupled with eddy current dynamometer whose schematic diagram was shown in the figure 1. Fuel to the engine was supplied from the fuel tank engaged with burette for measuring the fuel flow rate. Air was supplied to engine through the air chamber provided with orifice plate coupled with u tube manometer to measure the volume flow rate of the air. Exhaust gas temperature was measured with thermocouple type K provided in the exhaust gas pipe line. Speed of the engine was measured with speed sensor (photoelectric sensor) with speed indicator. Load was measured by the load indicator provided with load sensor (load cell). Emission parameter of HC, CO, CO_2, Nox was recorded using the AVL gas Digas analyzer. Engine specification was showed in the Table 1. Accuracy of the measuring instruments of is given in the Table no 2.Biofuel was prepared on the volume basics. The fuel which is used in study are 90% diesel 10% neem oil B10NO,80% diesel 20% neem oil B20NO, 70% diesel 30% neem oil B30NO. Fatty acid composition was given Table 3. Fuel properties were shown in the Table 4.

Properties of fuel: Increasing the Neem oil in the fuel increase the Cetane number and reduce the Calorific value of the fuel. And also increase in Blending ratio of the fuel increase the viscosity of the fuel. Higher viscosity of fuels leads to poor atomization of the fuel. The ignition quality of the fuel depends on the cetane number of the fuel. B30 NO oil high cetane number which make the Neem oil as CI engine fuel. Density of the fuel is increasing with increase in blending ratio of neem oil to fuel on volume basis. B30NO fuel has higher density than remaining fuel. Fuel consumption is function of density. Higher density fuel has higher fuel consumption. Spray Characteristics and Atomization fuel depends on the viscosity of the fuel. Higher viscosity fuel have poor atomization and leads to poor combustion. B30 has higher viscosity than B20NO, B10NO and diesel fuel. B30NO oil viscosity 2.5 times greater than diesel fuel.

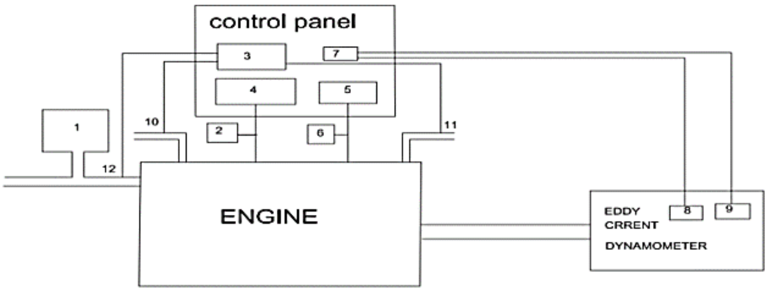

Figure.1.Engine setup

1	AVL gas analyzer	7	load indicator and speed indicator
2	burette	8	speed sensor
3	temperature indicator	9	loading sensor
4	fuel tank	10	cooling water inlet temperature
5	air tank	11	cooling water outlet temperature
6	u-tube manometer	12	EGT thermocouple

Table.1. Specifications of engine

Description	Specification	Description	Specification
Make	Kirloskar	Type of Dynamometer	Type Eddy current
Type	TV1	Type of cooling	Water cooling
No of cylinder	Single cylinder	bore	87.5 mm
No of stroke	Four stroke	stroke	110 mm
Rated power	5.2 kW (7 BHP) at 1500 rpm	capacity	661 CC

Table.2. Specifications of measuring instruments

Instrumentation	component	Measuring range	Accuracy	Resolution
AVL gas Digas 444 Analyser	HC (PPM)	0-20000	± 10PPM	1ppm
	Co (% by vol)	0-10%by vol	±0.5%	0.01%vol
	Co_2(%by vol)	0-20%by vol	±0.5%	0.1%by Vol
	O_2 (%by vol)	0-22% by vol	±0.1%	0.01% by vol
	Nox (ppm)	0-5000ppm	±50 ppm	1PPM

Table.3. fatty acid composition

Fatty acid	(%)
Palmitic acid $C_{16:0}$	18
Stearic acid $C_{18:0}$	15
Oleic acid $C_{18:1}$	50
Linoleic acid $C_{18:2}$	13
Arachidic acid $C_{20:0}$	2

Table.4.Properties of Fuels

Properties	Diesel	Neem oil	B10	B20	B30
Density (kg/m^3)	840	920	848	856	864
Viscosity at 40°C cST	5.6	35	8.50	11	14
Cetane Number	45	53	45	46	47
net calorific value MJ/kg	44	39	43.5	43	42

3. RESULT AND DISCUSSION

Brake thermal efficiency: Brake thermal efficiency is the function of load applied on the engine, fuel consumed by the engine and calorific value of the fuel (Alpaslan Atmanlı, 2013). Figure 2 shows the variation of Brake thermal efficiency with respect to different loading conditions of the engine. Brake thermal efficiency was directly proportional to load and inversely proportional to total fuel consumption. That's why Brake thermal efficiency was increasing with increase in load applied to the engine.

Total fuel consumption was increasing with increase in load because of that also leads to increase in brake thermal efficiency at higher loading conditions. B10NO was found higher brake thermal efficiency in all loading conditions because of low viscosity than B20NO and B30NO and high oxygen content of the fuel than diesel. B10NO has closer property to diesel fuel with slight reduction in calorific value that leads to higher brake thermal efficiency. B20NO and B30NO have poor atomization of the fuel due to high viscosity. At higher load, all the blended fuel reduced because high viscosity of the fuel leads to poor combustion (Bajpai, 2009).

Brake specific fuel consumption

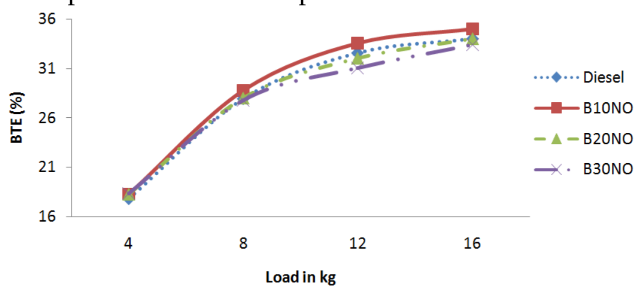

Figure.2. variation of the Brake thermal efficiency with respect to load

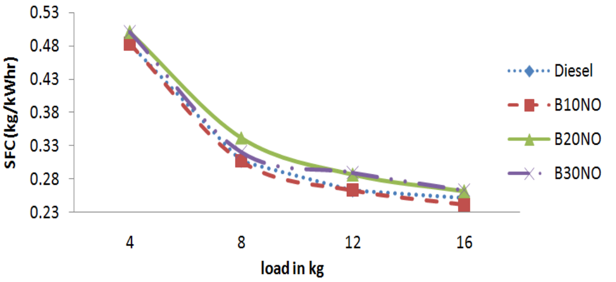

Figure.3.Variation of the Brake Specific fuel consumption with respect to load

Figure 3 show the variation of BSFC with respect to loading conditions of the engine. Brake specific fuel consumption inversely proportional to power available at the shaft the engine and result in reduction of lower BSFC for higher load operating conditions of the fuel. B10NOhas lower BSFC because of the high oxygen content of the fuel than diesel and high heating value than B20NO and B30NO. B20NO and B30NO fuel has higher BSFC value because of lower heating value of the fuel and high density of the fuel (Bajpai, 2009; Devan, 2009). Combined effect of closer calorific value and increased oxygen content of B10NO oil has very close BSFC value compare to diesel fuel. High oxygen content of the B30NO did not have impact on the lower loading conditions because of the high air fuel ratio.

Combustion Characteristics: Combustion characteristics of the engine are depends on different loading condition of the engine. In CI engine air fuel ratio is predetermined on the basics of loading conditions. Figure4, 5, 6 &7 shows the variation of in cylinder pressure for Diesel, B10, B20 and B30. It was found that in cylinder pressure was increasing with load. Maximum in cylinder pressure was found for full load conditions. This is because of higher turbulence for higher loading conditions. Ignition delay period was decreasing with increase in load conditions. This leads to attaining the peak pressure far from the TDC with increase in load. Combined effect of high viscosity and high cetane number leads to having peak pressure just far from TDC for higher loading condition then lower loading conditions. At lower load conditions because of less amount of leads to less peak pressure than higher loading conditions.

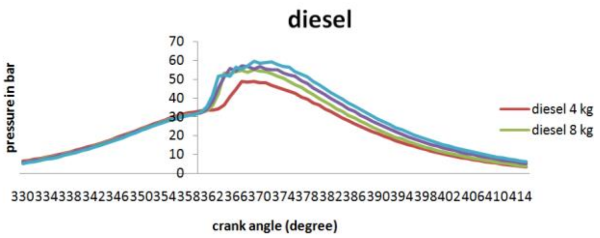

Figure.4.Pressure vs crank angle for different loading condition of Diesel

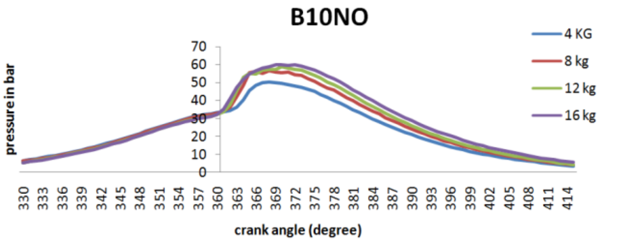

Figure.5.Pressure vs. crank angle for different loading condition of B10NO

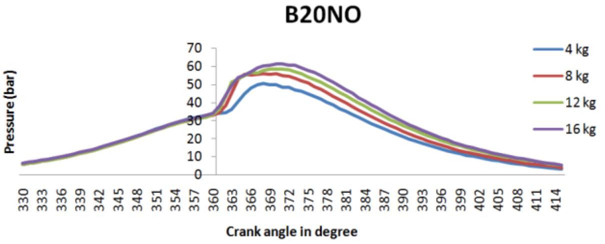

Figure.6.Pressure vs. crank angle for different loading condition of B20NO

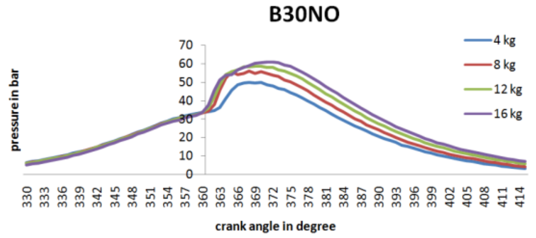

Figure.7.Pressure vs. crank angle for different loading condition of B30NO

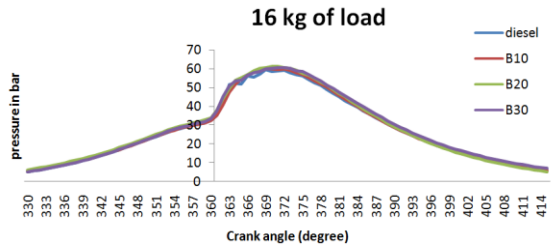

Figure.8.Pressure vs. crank angle for different Blending ratio for 16kg loading condition

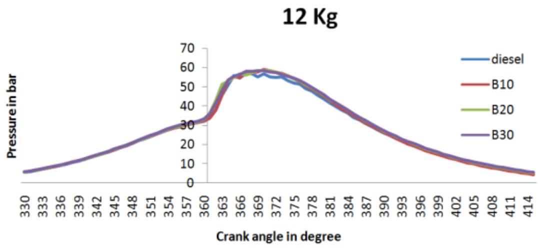

Figure.9.Pressure vs. crank angle for different Blending ratio for 12 kg loading condition

Figures 8, 9, 10 &11 shows the variation of diesel and blended fuels in cylinder pressure variation with respect to Crank angle. In loading conditions Diesel has lowest peak pressure than blended fuel. High oxygen content and higher cetane number of the fuel leads to achieve higher peak pressure for blended diesel fuel with little bit compensation of calorific value. Increasing the blending ratio of fuel in the fuel increase the peak pressure because of high oxygen content and high cetane number of the fuel. Comparison of B10NO, B20NO and B30NO, B10NO is not competitive with B20NO and B30NO. B20NO fuel has high viscosity than B10NO and less than B30NO and also having high oxygen content than B10NO and Lower than B30NO have the better combustion leads to good peak pressure lower ignition delay compare to B30NO. Increasing the blending ratio of the fuel increase the ignition delay period because of higher viscosity of the fuel. But fuel having longer ignition delay leads more fuel to burn in controlled combustion zone. This is reason for higher peak pressure for blended fuel.

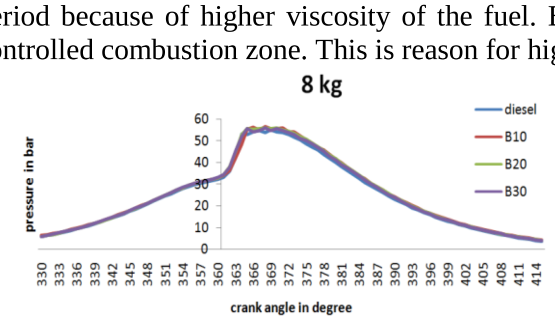

Figure.10.Pressure vs crank angle for different Blending ratio for 8kg loading condition

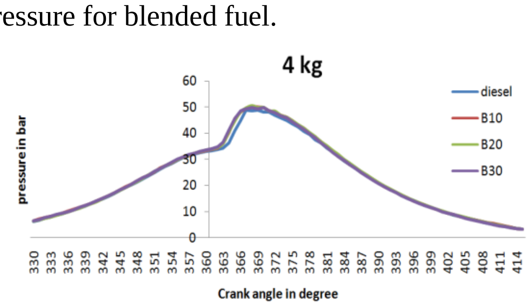

Figure.11. Pressure vs crank angle for different Blending ratio for 8kg loading condition

Carbon monoxide: Carbon monoxide was decreasing with increase in load. This is because of the increase in fuel air ratio. Highest CO emission was found to diesel as low loading condition when compare to blended fuel. Blended fuels content more oxygen content then diesel fuel leads lower CO emission. But in higher loading conditions CO emission was found higher for blended fuel because of higher viscosity of the blended fuel then diesel fuel (Devan, 2009). Increase in blend of the fuel increase the CO emission of the fuel.

Carbon di oxide: CO_2 emission was increasing with increase in load because of the increase in air fuel ratio which leads more oxygen available for oxidation. CO_2 emission was found lower than diesel fuel because of the lower carbon content of fuel (Devan, 2009). High viscosity of the fuel is reason for poor atomization of the fuel and leads to incomplete combustion of the fuel (Devan, 2009). Increase in blending ratio of the fuel leads lower CO_2 emission because of higher viscosity and lower calorific value. In blended fuel, Temperature rise in unburnt mixture caused by the burnt mixture is less compare to high calorific value fuel. B30NO has lower CO_2 emission because of its higher viscosity of the fuel.

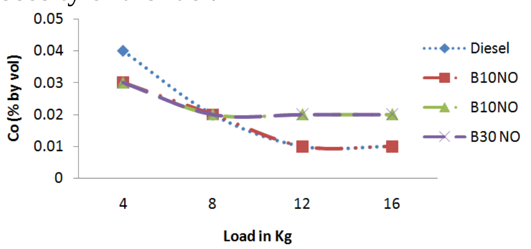

Figure.12. Co emission vs load

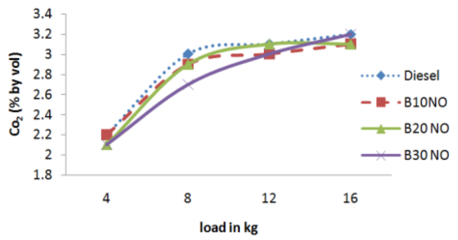

Figure.13.Co_2 emission vs. load

Unburnt Hydrocarbon: Hydrocarbon emission was mainly of crevices volume deposit of fuel, incomplete combustion, Quenching of the flame and formation of lean mixtures at local region (Viswanath, 2016). Hydro carbon emission was found reducing with increase in load because of increase in fuel air ratio. B10NO has lower HC because of lower viscosity of the fuel compare to B20NO and B30NO and high cetane number than diesel fuel. B20NO and B30NO have emission between B20NO and Diesel. This is combined effect of higher viscosity and higher cetane number. Increasing the load of the engine leads to higher turbulence and reduce in HC emissions. Moderate calorific value, cetane number and viscosity of B20NO have the moderate HC emissions.

Oxides of Nitrogen: Nox emission was increasing with increasing in load because of increase in air fuel ratio. Generally increase in oxygen content of the fuel and high heating value supports for Nox emission. Suitable conditions for Nox emission are higher temperature of the combustion which will enable surrounding oxygen for chemical reaction. Nox was found for higher for diesel fuel than blended fuel this because of high heating value of the fuel (Corsini, 2015). Poor atomization of blended fuel leads low rate heat release and leads to less Nox compared to diesel fuel.

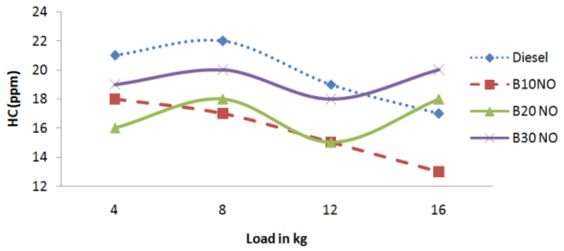

Figure.14. HC emission vs. load

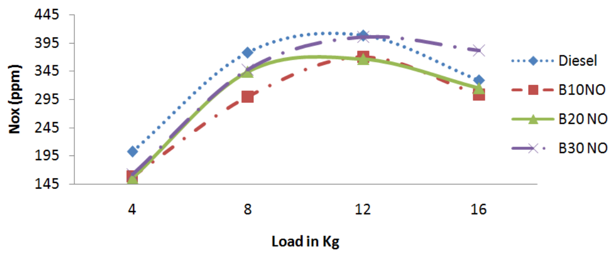

Figure.15. NOx emission vs load

4. CONCLUSION

Experimental results shows the following points: Brake thermal efficiency for B10NO was found closer to diesel fuel. Increasing the blending ratio decrease the Brake thermal efficiency. B20NO was found closer to Diesel fuel. Brake specific fuel consumption was found higher for B20NO and B30NO because of the lower calorific value of the fuel. B10NO fuel has very closer value diesel fuel. B20NO fuel has good combustion characteristics because of the increase oxygen content of the fuel. All loading condition B20NO average ignition delay period than B10NO and B30NO fuel. Because of well-balanced calorific value, moderate viscosity value and more Oxygen content. HC emission was found lesser than diesel for blended diesel fuel. This is because of the high oxygen content of the Neem oil. Co emission was found lesser at lower load and increase for higher loading conditions. At higher loading conditions leads shorter duration for combustion and higher viscosity of the fuel leads to poor atomization of the fuel. Nox emission was found higher for Diesel because of high heating value. Nox emissions were found lower for biodiesel for because of lower heating value. Increase in blending ratio of the fuel leads increase in NOx emissions because of the increase in Oxygen content of the fuel. B20NO fuel has Brake thermal efficiency very closer value to diesel fuel. BSFC also found higher than Diesel fuel. Emission HC, CO and NOx was found lower than Diesel fuel. Co2 was found lower than diesel fuel and have closer value to diesel fuel. B20NO fuel can best among the B10NO and B30NO

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