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Wear Analysis of Compression Ignition Engine using Mesua ferea linn Methyl Eseter

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Abstract: ***As the standard of living is increasing day by day, the demand for energy consumption is also increasing due to the increasing population and expanding urbanization.At the same time,the whole world is aware about the depletion of petroleum reserves and its impact on environment pollution through exhaust emissions which has become a major threat to the whole world, so to deal with this there is an urgent need of suitable alternative fuels for use in diesel engine. Biodiesel is a suitable alternative fuel which is generally produced from renewable biological resources like vegetable oil and animal fats. It is biodegradable , non toxic, has lower emissions profile and at the same time environment friendly. In this study, biodiesel is prepared using mesua ferea linn(MFL)seed oil by transterification process. Two similar engines were operated for long turm endurance test using optimum biodiesel blend and petroleum-diesel oil, respectively. Atomic absorption spectroscopy (AAS) was used to check the wear debris concentration in lubricating oil samples which were drawn from both the engines after a fixed interval of time. Biodiesel operated engine showed lower wear debris concentration as compared to diesel operated engine. Scanning electron microscopy(SEM) showed lower damage of small disk of piston ring when operated with 20% biodiesel fuel, which revealed the better lubricity of biodiesel fuel. Also, carbon deposition of various parts like fuel injector, piston head were found to be lower in biodiesel used engine than that of diesel used engine.***

Keywords: ***Biodiesel, Transterification, CI engine, Wear, Endurance test, Lubricating oil.***

I. INTRODUCTION

Now a days, fossil fuels are the one of most demanded energy sources all over the world. It fulfills the energy needs in the sectors like transportation, industry, agricultural equipments etc. The continuous increase in worldwide demand and also the increasing the price of these fuels day by day is a great concern in the present days because of limited resources and limited reserves of these fuels. Due to lack of fossil fuel reserves ,country like India is heavily dependent on other countries to import large amount of fuels to meet their day to day needs. Also, the combustion of fossil fuels emits harmful emissions like carbon di oxide (CO2), carbon monoxide (CO), nitrogen oxide (NOx) ,hydrocarbo (HC) from internal combustion engine which have a bad impact on environment [1]. To minimize the above difficulties there is a great demand of alternative fossil fuels. Because of the environmental benefits and the fact that it is a renewable resource biodiesel is focused as one of the most suitable alternative fuel for diesel engine.

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The American Society for Testing and Materials (ASTM) defines biodiesel fuel as mono alkyl esters of long chain fatty acids derived from renewable sources, such as vegetable oil or animal fat.

In general transestarification process is used to produce biodiesel from vegetable oil and animal fats. Esterification vegetable oil has better fuel properties than neat vegetable oil. Transterification process is suitable because it reduces the viscosity, increases the volatility and loses the polyunsaturated character from vegetable oil. one mole of triglyceride for three moles of glycerol is required for overall transterifcation reaction. Transesterification reaction breaks the triglycerides from vegetable oils into two components,i,e fatty acid esters, and glycerol. Glycerol can be easily separated from the product and it can be used in pharmaceuticals, cosmetics, toothpaste, and other commercial products[2][3]. Due to high production cost biodiesel is generally blended with petroleum diesel. Neat biodiesel can be used in diesel engine with little or no modification of the engine, but sometimes it shows corrosive nature on various parts on the engine. For example , Karanja biodiesel oil shows no corrosion on piston metal and piston liner whereas *Jatropha curcas* biodiesel oil has slight corrosive effect on piston liner[3].As an alternative fuel, biodiesel can be used in Internal Combustion engine in the neat form or mixed with petroleum-based diesel[4]. Blending with diesel helps to bring down the values of properties of biodiesel such as specific gravity, viscosity, and carbonresidue to acceptable ranges and would improve the atomization process during combustion [5].

Though India is well equipped with non edible oil resources like *Madhuka indica, Mesua Ferea L, Linum usitatissimum, Pongmia pinnata, Orzya sativa, Shorea robusta, Jatropha Circus, Callophylum inophyllum, Gossypium herbaceum, Azaderachta indica* etc. Hence, India has potential to produce biodiesel from non edible resources which are available in various region [6].

Wear occurs when surface contact takes place between different engine parts like piston, piston ring, cylinder head etc. This normally occurring wear can predict the life cycle, performance rating, maintenance schedule etc. of the engine. Direct mixing of engine fuel and lubricant takes place through fuel dilution and indirect mixing takes place through the formation of combustion products and gases which may later get dissolved in the oil. The process of fuel dilution occurs by the fuel impingement on the cylinder walls which gets mixed with the lubricant, and slowly accumulates in the oil sump thus resulting in poor lubrication and increased wear of the engine parts[7].

When engine temperature highly increases, it may lead to overheating, burning of cylinder head gaskets and cylinder liner which decreases the lubricating oil viscosity.

Low lubrication oil viscosity results in friction, overheating etc. while high viscosity of lubricating oil results in choking of filters, oil starvation and engine seizure. On the other hand, lower engine temperature results in higher fuel consumption and incomplete combustion [8].Monitoring of oil is a way to identify the wear rate of rubbing parts and help in diagnosing the faults in engine parts[1].Its a method of predicting the performance of the engine in advance by proper monitoring of the wear particles as well as wear rate.

Also, biodiesel corrosive nature are greatly influenced by factors like moisture absorption, presence of oxygen moieties, fatty acid produced from auto oxidation, increased total acid number, increase in viscosity and density etc [9]. The different parameters which indicates the tribological behavior of oil consumption in diesel engine are moisture content, density,viscosity, ash content, Total base Number (TBN), Pentane and Benzene and Ferrography. Ash content denotes metallic wear debris in the lubricating oil, soot, fuel and non metallic parts of decomposition. Moisture aids in rusting and corroding the metallic surfaces which increases the wear. The presence of water in lubricating oil will lead to excessive fuel dilution, coolant leakage and short trip driving conditions. The corrosive effects of oxidation can be countered by measuring the alkaniity of the lubricating oil given by TBN[7].

In this study, wear and tear of engine parts using both diesel and biodiesel in two similar 4 stroke single cylinder diesel engines were analyzed. *Mesua ferrea linn* seed was selected as a feedstock for biodiesel production. *Mesua ferrea linn* (MFL),is a timber plant. The wood of this tree is very heavy, hard and strong. The tree is generally found in northeastern region of Himalaya in India and in Srilanka. The seed contains 55-57% w of oil. It is a reddish-brown colored oil, which had been traditionally used as fuels. It is also used in medicine for the treatment of fever, dyspepsia and renal diseases[10] .

II. MATERIALS AND METHODS

MFL seeds were collected from Sivasagar and Sonitpur district, Assam,India. The oil extraction from the seeds was done mechanically using a screw press in the mechanical expeller and then, settled the oil until impurities were precipitated .In the present work ,MFL methyl ester(MFLME) was prepared using methanol in the presence of catalyst NaOH. Glycerol is the byproduct of the reaction which can be easily separated from the product. The fuel properties of the MFLME were determined in the laboratory of Numoligarh Refinery Limited, Assam and most of them were found to be within standard limits as defined by ASTM. Some fuel properties are shown in the table 1.

Table1: Properties of fuel

Properties	Unit	Diesel	Biodiesel
Density@15°C	gm/cc	0.852	0.874
S- Content	% wt	0.0165	0.0033
Viscosity@40°C	cst	2.781	5.7
Flash Point	°C	49	>110
Pour Point	°C	0	3
Calorific value	kJ/g	45.01	40.11
Cetane number		46	54
Carbon residue	% wt	0.011	0.088
Cloud Point	°C	-18	5
Ash content	% wt	0.0185	0.0141

Performance and emissions characteristics were carried out using different biodiesel blends in a standard test rig. The purpose of this test was to find out the suitable biodiesel blend which can be used in wear –tear analysis. Different blends like B10, B20, B30, B40 and B50 (Percentage of biodiesel with diesel) were prepared with diesel fuel. All the blends were then subjected to performance and emission test on the engine. Performance and emissions data were analyzed from the graphs recording power output, efficiency, specific fuel consumption, CO, CO_2, NO_X and HC for all the blends of biodiesel. From the test, B20 blend was found to be optimum blend based on power, efficiency and emissions point of view.

For wear analysis two similar engines were subjected to a long term endurance test for 512 hours. The selected engine was a vertical type,single cylinder ,4 stroke diesel engine. The cooling system of the engine was water cooled type having a bore and stroke lengths are of 80 mm 110 mm respectively. The engine develops 3.7 kW power out put at a rated speed of 1500 rpm. The compression ratio is 16.5:1. As per IS10000, part viii ,1980, each engine was running for 32 cycles, each of 16 hours continuous running at rated speed[11]. For both the test SAE Grade 20W40 was used as a lubricating oil. The first engine operated on 20% biodiesel blend (B20) and the second engine operated on neat diesel oil. The metallic wear debris and corrosive wear debris generated during engine operation by wear of vital moving components were carried away by the lubricating oil and accumulated in the lubricating oil sump. After an interval of every 128 hours, the lubricating oil samples were collected from the engine to check the wear debris in the lubricating oil. The condition of the engine can be predict by measuring the wear particles present in the lubricating oil. Atomic Absorption Spectroscopy (AAS) was performed to estimate engine conditions indirectly through oil analysis. The same procedure was also done by other researcher[12].Scanning Electron Microscopy (SEM) was performed on two small disks of piston rings to check the roughness of the surface after 512 hours of engine run. The another method was the dismantled the engine parts and physically measured the dimensions and compared with the initial state (IS 10000).

III. RESULT AND DISCUSSION

A. Atomic Absorption Spectroscopy(AAS)

Atomic absorption spectroscopy(AAS) is a spectroanalytical method for quantitative determination of chemical elements using the absorption of optical radiation by free metallic ions. AAS was used to detect the quantity of various wear elements present in the lubricating oil sample which were collected at different time interval. Since ,many moving and sliding components were involved in the engine, hence wear debris in lubricating oil originated from different metallic parts inside the engine. Various elements such as Fe, Cu, Zn ,Pb, Mg and Cr were analyzed.

Table2:Possible source of wear debris in Engine

Metals	Components
Fe	Piston, cylinder liner, block corrosion,Valves, gear sets, bearings etc.
Cu	Main and rod bearings, bushing, some cylinder inserts, valve guide etc.
Zn	Bushing, bearing, gear set etc.
Pb	Bearings, sealing component etc.
Mg	Engine block, housing etc.
Cr	Shafts, bearings, piston rings, valve guide etc.

AAS results of various wear metals debris in lubricating oil were shown in the figure1 to 6. It seems that the lubricating oil drawn from the biodiesel operated engine has lower amount of wear debris as compared to the diesel operated engine. These results indicate that 20% amount of biodiesel present in significantly reduces wear of moving components except Cr concentration. Cr concentration was found to be higher at the initial stage of engine run (at 128 and 256 hours). Fe and Cu concentrations were seemed to be lower at the initial hours of engine run. It may be due to the hardness of the new engine cylinder parts. Zn concentration was found to be higher for both the engine. It may be due to thermal stress in the lubricating oil, Zn gets added to the lubricating oil. Also, Mg and Pb concentration were found to be lower in lubricating oil which was run by biodiesel fuel. It may be due to improved combustion and lower soot formation in biodiesel fueled engine.

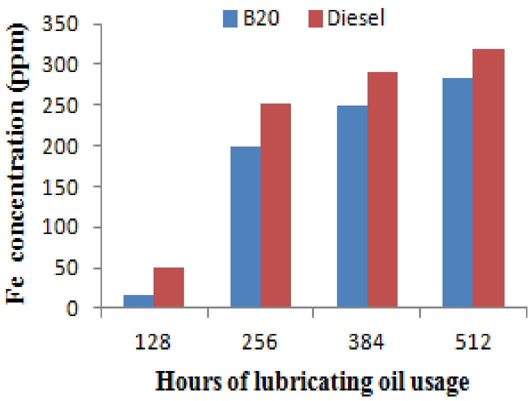

Fig.1. Fe concentration in lubricating oil

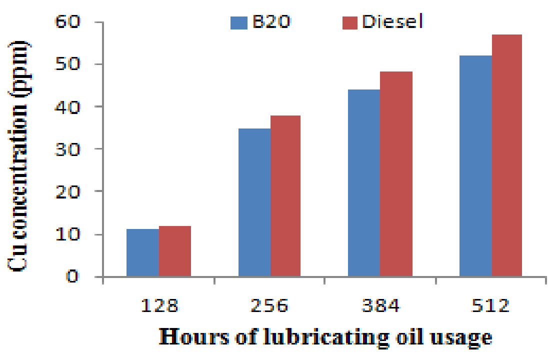

Fig.2. Cu concentration in lubricating oil

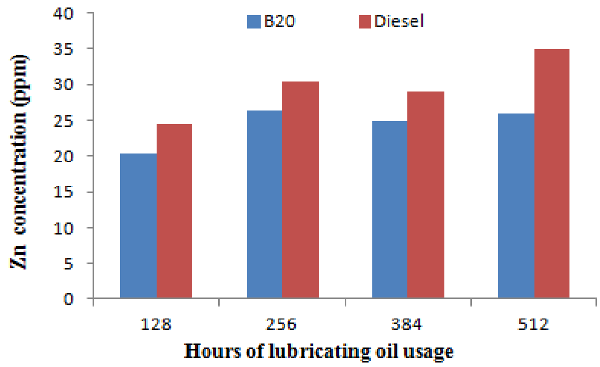

Fig.3. Zn concentration in lubricating oil

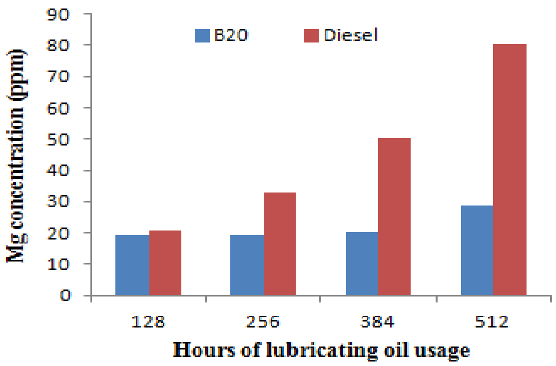

Fig.4. Mg concentration in lubricating oil

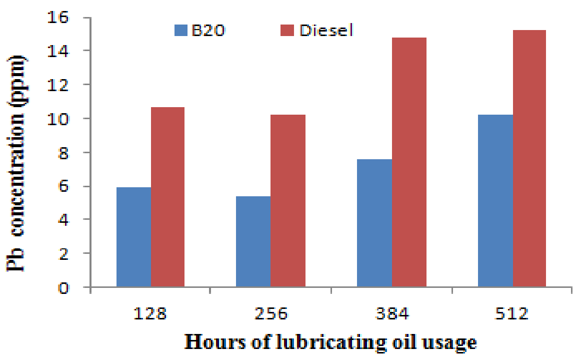

Fig.5. Pb concentration in lubricating oil

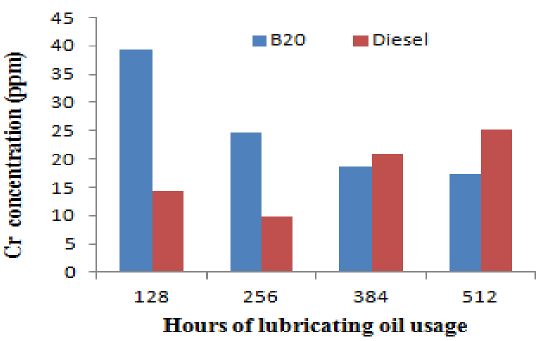

Fig.6. Cr concentration in lubricating oil

B. Scanning Electron Microscopy (SEM)

SEM was conducted on two disks of piston rings, one subjected to neat diesel oil and the second one subjected to 20% biodiesel blend. The micrographs for the two disks with different magnifications are shown in Fig. 7 to 12 . In all the cases, the disk subjected to 20% biodiesel blend, the overall surface appeared to be significantly smoother than the disk subjected to diesel indicating the reduction in wear. This also supports the fact that biodiesel is a better lubricant since it reduces the wear of the disk. A very high extent of grooving can be seen in the case of diesel-disk, which is due to body abrasive wear.

The initial wear debris from the sliding surfaces get trapped in the contact zone and keep on abrading the surface till it is thrown out of the contact zone. In all the figures with same magnifications, disk subjected to diesel showed higher surface roughness than disk subjected to 20% biodiesel. It is evident from the study that the lubricity property of biodiesel results in reduced wear of engine parts.

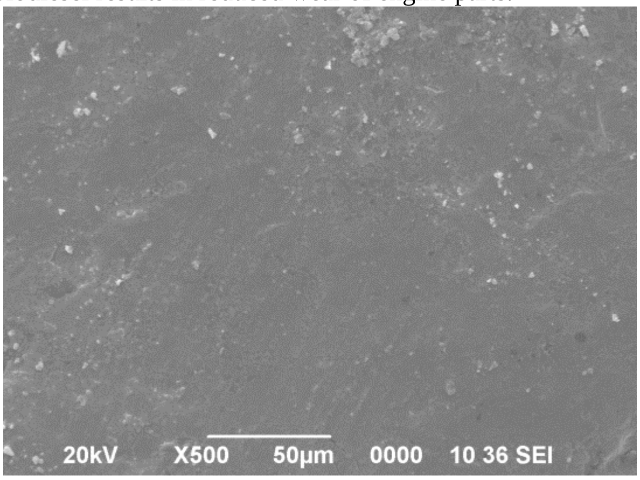

Fig.7.Micrograph of disk subjected to B20 Blend

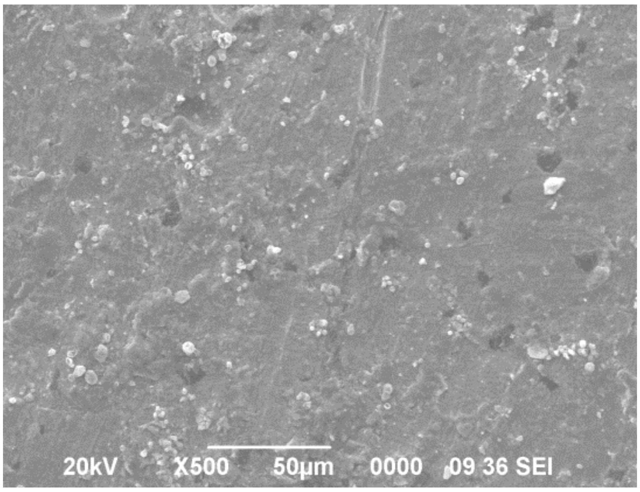

Fig.8.Micrograph of disk subjcted to diesel

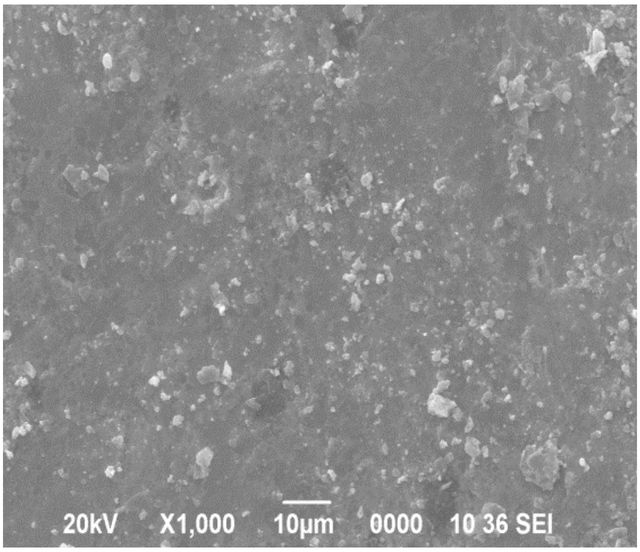

Fig.9.Micrograph of disk subjected to B20 Blend

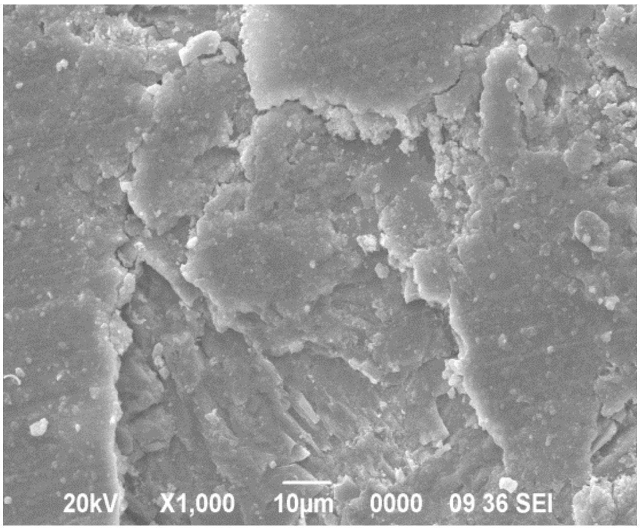

Fig.10.Micrograph of disk subjected to diesel

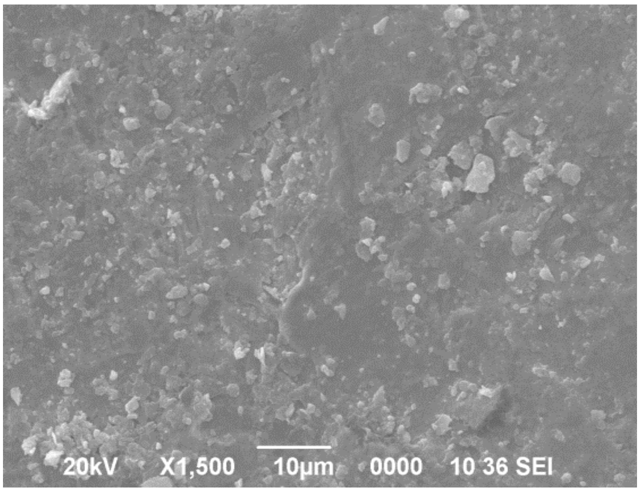

Fig.11.Micrograph of disk subjected to B20 Blend

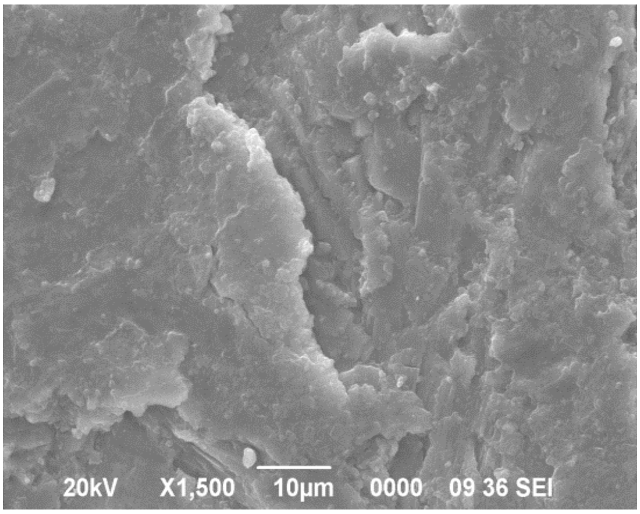

Fig.12.Micrograph of disk subjected to diesel

C. Carbon deposited in engine parts

The photographs presented in the Fig. 13 to 16, it was evident that carbon deposition was found to be more in diesel used engine. On the other hand carbon deposition was partially removed from the engine components running on biodiesel. This was due to physical and chemical properties of biodiesel, which have excellent solvent action and could able to lose old deposits[13].

Fig.13.Injector using B20 Blend

Fig.14.Injector using diesel fuel

Fig.15.Piston head using B20 Blend

Fig.16.Piston head using disel fuel

IV. CONCLUSION

Based on the above studies, it can be concluded that biodiesel from MFL seed oil is superior in wear performance to conventional diesel.It is biodegradable and enviroment friendly.Hence ,it can be readily adopted as a partial substitute fuel for the existing diesel engine. Transterification process found to be most suitable process for production of biodiesel from vegitable oil.

Atomic absorpstion spectrometry test was conducted on lubricating oil samples drawn from biodiesel-operated engine and diesel-operated engine. From the test low concentration of wear particles found in biodiesel operated engine.The scanning electron microscopy conducted on a small disk of piston ring. The test results showed biodiesel fuel produced less wear to the moving parts of the engine. The result establishes the self lubricating property of MFLME. Carbon deposition of various engine parts like fuel injector, piston head were found to be lower in biodiesel used engine than that of diesel used engine.

This evident the good burning quality of the biodiesel.
Thus from the above investigation 20% MFLME can be used as an alternative fuel of conventional diesel for long duration run of the engine without any engine modification.

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