Experimental Investigation on A Four-Stroke Ci Engine Using Blends of Various Biodiesels (Moringa Oliefera, Rice Bran, Pongamia)

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Abstract- *The world's fossil fuels are depleting rapidly, according to the survey 75% of fossil fuel production will be decreased in coming years. Developing countries like India, invests heavily on imports of fossil fuels. Diesel fuelled vehicles discharges significant amount of pollutants like CO, HC, NO_X, Lead, Soot etc., which are harmful to the environment as well as human beings. In this present work, different biodiesels (Moringa Oliefera, Rice bran, Pongamia oils) are used in the form of blends at various proportions with diesel. Viscosities of Moringa Oliefera, Rice bran and Pongamia oils are 4.8 m^2/sec, 5.9 m^2/sec, 5.6 m^2/sec respectively. This blended biodiesel is used as an alternate fuel for CI engine and then experimental study is carried out. Experiments are carried out on a diesel engine using blends of various biodiesels together (Moringa Oliefera, Rice bran, Pongamia oils) as an alternative fuel, which is a single cylinder, four- stroke , water cooled and constant speed engine capable of developing a power output of 3.5 kW at 1500 rpm. Performance parameters and emissions of this alternative fuel are compared with diesel fuel. It has been observed that Performance parameters such as Brake Thermal efficiency is increased for alternative fuel at B15 (29.98%) compared to Diesel fuel(26.83%) and Brake Specific Fuel Consumption is decreased for alternative fuel (0.294 Kg/kW-hr) compared to Diesel fuel(0.319 Kg/kW-hr). emissions such as CO is slightly decreased for alternative fuel at B15(0.02% vol) compared to Diesel fuel(0.028) and NO_X is slightly increased for alternative fuel at B15(685 ppm)) compared to Diesel fuel(603 ppm).*

Keywords- Moringa oliefera, Rice bran, Pongamia, Biodiesel, Blend, Transesterification

I. INTRODUCTION

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions. Following the global energy crisis in the 1970s and the increasingly stringent emission norms, the search for alternative renewable fuels has intensified.

Depleting petroleum reserves and increasing cost of the petroleum products demands in the intensive search of new alternatives fuels. Bio-diesels are proved to be very substitute to petro diesels. Bio-diesels derived from vegetable oils present a very promising alternative to diesel fuel since biodiesels have numerous advantages compared to fossil fuels as they are renewable, biodegradable, provide energy security and foreign exchange savings besides addressing environmental concerns and socio-economic issues. Experiments were carried out with jatropha[1],rapeseed oil[2], karanja[3], orange oil[4] bio-diesel on direct injection diesel engine and it was reported that performance was compatible with pure diesel operation on conventional engine.

The quest for developing energy efficient internal combustion engines has been going on from past several decades. Different alternative fuel gives different results, which are compatible with the diesel performance parameters. By using single alternative fuel, the results were observed by so many. But in this present investigation I have used 3 different types of alternative fuels at a time together having different viscosities as blends B05, B10, B15, B20 and with pure Diesel(100% diesel). **Umer Rashid** et. al. [124] tested Moringa oleifera oil for the first time for its potentiality as biodiesel feed stock. Produced biodiesel from Moringa oleifera oil using two step transestrification process. Oil was rich in oleic acid so biodiesel produced had good oxidative stability and high cetane number of nearly 67 said to be one of the highest of available biodiesel fuels. With a concern of high cloud point still it can be well substituted for diesel and other biodiesels. **Hifjur Raheman** et. al. [49] evaluated the engine performance fuelled with blends of biodiesel and high speed diesel including the soot formation on engine components. Biodiesel was mixiture of two mahua and simarouba in equal percentages with blends prepared by mixing of HSD. B10 blend engine performance for 100 hr engine operation was better than other blend and soot formation on engine components reduced by 21% compared to that of HSD. Wear metals presence except manganese in the lubricating oil reduced nearly by 50% in comparison with HSD.

The main aim of this study is to evaluate the performance and emission evaluation of diesel engine fuelled with various blends of bio-diesel (Moringa Oliefera, Rice bran, Pongamia oils). The results showed that enhance in brake thermal efficiency at B15 and emissions such as CO, HC are reduced compared to diesel. CO_2 and NO_X were slightly increased compared to conventional engine fuel.

II. MATERIALS AND METHODS

2.1 Moringa Oleifera Oil:

Moringa oleifera is the most widely cultivated species of the genus Moringa, which is the only genus in the family Moringaceae. English common names include: moringa, drumstick tree (from the appearance of the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish), ben oil tree, or benzoil tree (from the oil which is derived from the seeds). It is a fast-growing, drought-resistant tree, native to the southern foothills of the Himalayas in northwestern India, and widely cultivated in tropical and subtropical areas where its young seed pods and leaves are used as vegetables However, the most effective and commonly used method is Soxhlet extraction which has a 31.3% an oil extraction rate. This method is suitable for oil extraction in laboratories, whereas leaching may be used in large-scale industrial preparations because of its very limited energy consumption. For this paper, extraction of Moringa oleifera oil (MSO) from dried Moringa oleifera seeds using n-hexane in a Soxhlet extraction.

2.1.1 Soxhlet Extraction Method (Moringa oil extraction):

The Soxhlet apparatus used for solvent extraction (SE) where 300ml of normal Hexane was poured into round bottom flask.10 grams of powdered Moringa Oleifera was placed in the thimble and inserted in the centre of the extractor. The Soxhlet was heated at 60^oc. When the solvent was boiling, the vapour rises through the vertical tube into the condenser at the top. The liquid condensate drips into the filter paper thimble in the centre, which contains the oil to be extracted. The extract seeps through the pores of the thimble and fills the siphon tube, where it flows back down into the round bottom flask. This was allowed to continue for 30 minutes. It was then removed from the tube, dried in the oven, cooled in the desiccators and weighed again to determine the amount of oil extracted. The experiment was repeated by placing 5g of the Moringa oleifera into the thimble. The weight of oil extracted was determined at 30 minutes interval. At the end of the extraction, the resulting mixture containing the oil was distilled off using simple distillation to recover solvent from the oil. The oil extracted was stored in a plastic container for further use. [1]

2.2 Rice bran Oil:

Rice is the seed of the grass species Oryza sativa (Asian rice) or Oryza glaberrima (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with the third-highest worldwide production (rice, 741.5 million tonnes in 2014), after sugarcane (1.9 billion tonnes) and maize (1.0 billion tonnes). Rice, a monocot, is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years.[3] Rice cultivation is well-suited to countries and regions with low labor costs and high rainfall, as it is labor-intensive to cultivate and requires ample water. However, rice can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide. Rice bran is a byproduct of the rice milling process (the conversion of brown rice to white rice), and it contains various antioxidants. Rice bran oil is extracted from the germ and the inner husk of rice. Rice bran oil manufacturing processes mainly includes rice bran oil expelling, extraction and refining.

2.2.1 Extraction of Rice Bran Oil:

Rice bran oil expelling relies on high quality rice bran oil expellers. After the well prepared rice bran is put into the feeder of the expeller, a screw worm will transport the rice bran advance. As the screw worm moves, the space becomes smaller and smaller, thus squeezing rice bran oil out. Then the fresh rice bran oil seeps out through the small openings in the bottom of the squeezing barrel where the rice bran oil cake cannot pass through, and thus separating rice bran oil from oil cake. After collecting rice bran oil cake, rice bran oil extraction comes with the help of food grade solvent, usually hexane. Rice bran oil extraction works on the principle of counter current and moving bed with variable bed height and different speed mechanism to ensure the permit of excellent penetration and percolation of solvent for absolute extraction. Then the distillation begins in the vacuum, and the extracted rice bran oil is collected by vaporizing solvent out for later recovery. Then the rice bran oil is pumped into the refining machinery to produce different grades of rice bran oil. The refining process usually includes: filtering, neutralization, degumming, decolorization, deodorization, and dewax, etc. After all these manufacturing processes, fresh rice bran oil would be ready.

2.3 Pongamia Oil:

Pongamia oil is derived from the seeds of the Millettia pinnata tree, which is native to tropical and temperate Asia. Millettia pinnata, also known as Pongamia pinnata or Pongamia glabra, is common throughout Asia and thus has many different names in different languages, many of which have come to be used in English to describe the seed oil derived from M. pinnata; Pongamia is often used as the generic name for the tree and is derived from the genus the tree was originally placed in. Other English names for this oil include Honge oil (from Kannada), Kanuga oil (from Telugu), Karanja oil (from Hindi), and Pungai oil (from Tamil).

2.3.1 Extraction of Pongamia Oil:

Pongamia oil is extracted from the seeds by expeller pressing, cold pressing, or solvent extraction. Locally collected Karanja seeds were dehusked manually and the kernels thus obtained were crushed with a hammer mill and dried in the oven at a temperature of 1050^{o}C to about 4-6% moisture. The moisture content in the fresh kernel was determined by IUPAC (international union of pure and applied chemistry) method. The oil was then extracted with hexane in a Soxhlet apparatus for about 12 hours. The solvent was then removed using a rotary vacuum evaporator at reduced pressure and the percentage of oil was determined by AOCS (American oil chemist's society) methods.[9]

2.4 Production of Biodiesel:

It is the reaction of a crude oil with an alcohol to form esters and glycerol. 20 g of Moringa Oliefera oil was weighed and poured into a 250 ml round bottom flask. The oil was made to react with the mixture of catalyst potassium hydroxide (K0H) and methanol. The flask was kept with a magnetic stirrer for 4–5 hours at a temperature of 60 ^{0}C. The mixture was allowed to settle in two layers, the lower layer is a methanol–glycerol mixture and the top layer is a biodiesel layer. The two layers were separated with the help of a separating funnel. The bottom layer was separated and distilled to recover the methanol. The top layer was washed with water to remove the traces of methanol and glycerol and the biodiesel is dried in the hot air oven and stored. The same procedure is repeated for rice bran oil and pongamia oil.

A catalyst is usually used to improve the reaction rate and yield. Excess alcohol is used to shift the equilibrium to the products side since the reaction is reversible. Transesterification as an industrial process is usually carried out by heating an excess of the alcohol with vegetable oils under different reaction conditions in the presence of an inorganic catalyst. The reaction is reversible and therefore excess alcohol is used to shift the equilibrium to the products side. The alcohols that can be used in the Transesterification process are methanol, ethanol and amyl alcohol.

➢ **Basic Process Flow Chart**

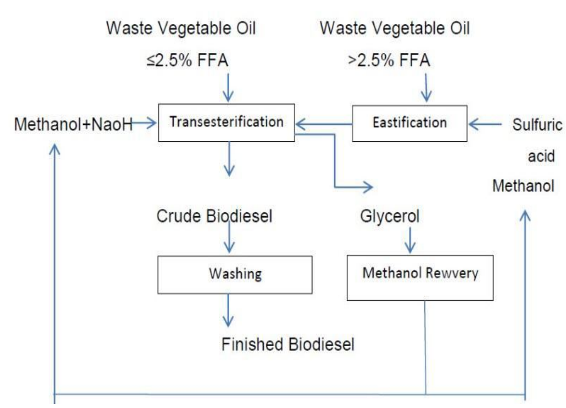

Fig. 1 Process Flow of Biodiesel

III. EXPERIMENTAL SETUP

Experiment is carried out in diesel engine with the following engine specifications as follow:

3.1 Engine specifications:

TABLE I .ENGINE SPECIFICATIONS

Model	AV1
Make	KIRLOSKAR
Type	Single cylinder, four stroke, water cooled
Bore	80mm
Stroke	110mm
Speed	1500rpm
Rated power	5hp

3.2 Procedure:

Initially experiment is done on conventional engine fuelled with Diesel from no load to full load and the following readings are noted,

a. Engine speed

b. Time taken for 5cc of fuel consumption.
c. Voltmeter and ammeter readings.
d. Temperatures at different locations.
e. exhaust emissions such as CO2,CO,HC and NOx by using exhaust gas analyzer.

Then the experiment is carried out on conventional engine fuelled with blends of biodiesels (Moringa oliefera, Rice bran, Pongamia) from no load to full load and the same procedure was repeated to evaluate the performance and emission characteristics. And the performance parameters and emission characteristics of Diesel and Biodiesel is compared.

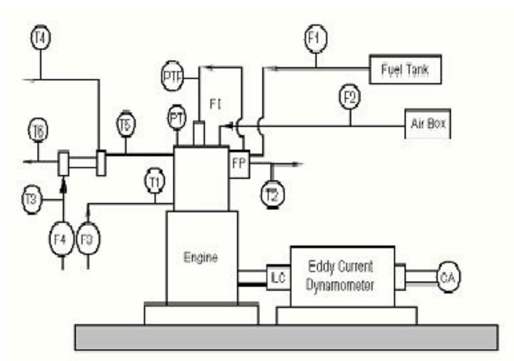

Fig. 2 Engine setup

Fig. 3 conducting experiment

PT: Combustion Chamber Pressure Sensor
PTF: Fuel Injection Pressure Sensor
FI: Fuel Injector
FP: Fuel Pump
T1: Jacket Water Inlet Temperature
T2: Jacket Water Outlet Temperature
T3: Inlet Water Temperature at Calorimeter
T4: Outlet Water Temperature at Calorimeter
T5: Exhaust Gas Temperature before Calorimeter
T6: Exhaust Gas Temperature after Calorimeter
F1: Liquid fuel flow rate
F2: Air Flow Rate
F3: Jacket water flow rate
F4: Calorimeter water flow rate
LC: Load Cell
EGC: Exhaust Gas Calorimeter

3.3 Properties of biodiesels (Moringa Oliefera, Rice bran, Pongamia):

TABLE II. PROPERTIES OF DIESEL AND BIO-DIESEL (MORINGA OLIEFERA, RICE BRAN, PONGAMIA)

PROPERTY	Moringa Oliefera oil	Rice bran oil	Pongamia oil	DIESEL
Density(Kg/m^3)	875	885	885	812
Calorific value(KJ/Kg)	43280	40535	36120	42000
Kinematic viscosity *10^{-6}(m^2/s)	4.8	5.9	5.6	3.8
Flash point °C	162	167	217	56
Fire point °C	168	171	223	63

3.4 Blends Used:

1. B05 = (5% Moringa oil + 5% Rice bran oil + 5% Pongamia oil) + 85% Diesel
2. B10 = (10% Moringa oil + 10% Rice bran oil + 10% Pongamia oil) + 70% Diesel
3. B15 = (15% Moringa oil + 15% Rice bran oil + 15% Pongamia oil) + 55% Diesel
4. B20 = (20% Moringa oil + 20% Rice bran oil + 20% Pongamia oil) + 40% Diesel

IV. RESULTS AND DISCUSSIONS

4.1 Brake Specific Fuel Consumption:

The BSFC value at full load is 0.319 Kg/kW-hr for diesel (standard engine). It can be observed that the engine fuelled with biodiesel blends B05, B10, B15, B20 gives BSFC of 0.294 Kg/kW-hr, 0.362 Kg/kW-hr, 0.297 Kg/kW-hr, 0.304 Kg/kW-hr respectively at 2500W load. At blends B05, B15, B20 the BSFC is decreased comparatively to diesel. Because of less BSFC the Brake thermal efficiency is increased.

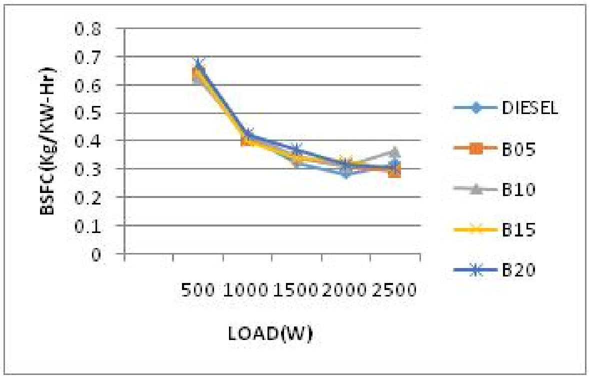

Fig. 4 Load VS Brake Specific Fuel Consumption

4.2 Brake thermal Efficiency:

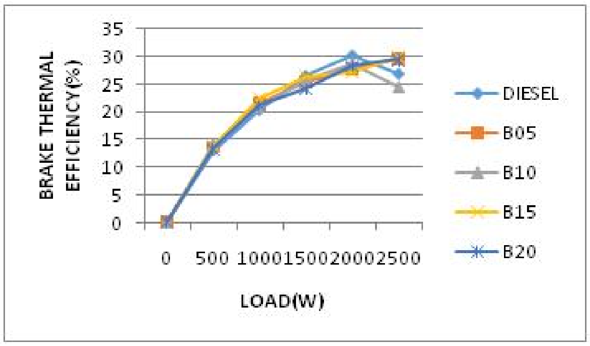

Fig. 5 Load VS Brake Thermal Efficiency

The Brake thermal efficiency of the engine by different blends B05, B10, B15, B20 and diesel is observed as 29.68%, 24.50%, 29.98%, 29.47% and 26.83% respectively. The enhancement of Brake thermal efficiency is observed at all blends except at blend B10 compared to diesel fuel. The B15 gives more brake thermal efficiency than the other fuels. As the engine produces higher power output, the frictional losses are changed and hence change in the brake thermal efficiency.

4.3 Exhaust Gas Emissions of Carbon monoxide(CO):

From the fig.6 it is clear that CO is decreased due to the complete combustion. CO emission from diesel engine is related to the fuel properties as well as combustion characteristics. It is well known that better fuel combustion usually resulted in lower CO emission. The CO which arises mainly due to incomplete combustion is a measure of combustion efficiency. Generally, oxygen availability in diesel fuel and biodiesel blends is high, so at high temperatures carbon easily combines with oxygen and reduces the CO emission. It is clear that emission concentrations are lower than Bharath Stage III.

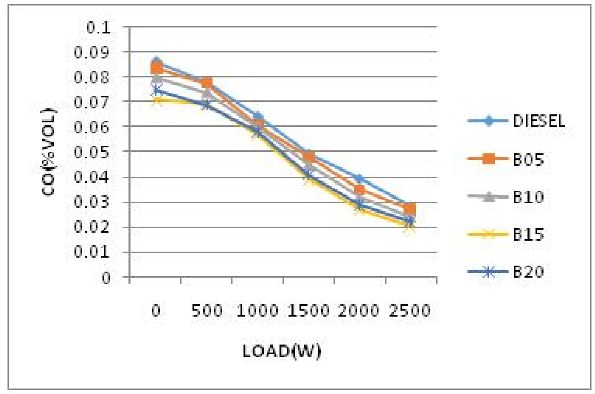

Fig. 6 Load VS CO Emissions

4.4 Exhaust Gas Emissions of Hydro Carbons(HC):

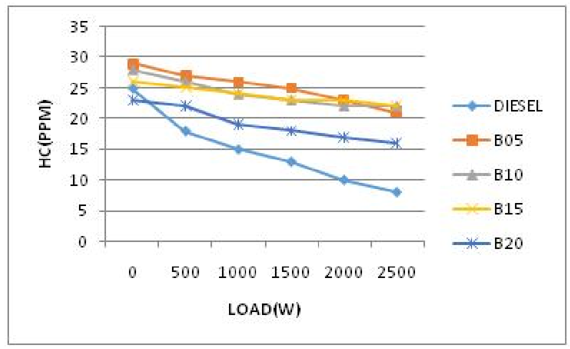

Fig. 7 Load VS HC Emissions

From the results it is clear that, the concentration of HC emissions are decreased from no load to full load. But here the HC emissions for diesel fuel s comparatively low compared to other blends. It is clear that emission concentrations are lower than Bharath Stage III.

4.5 Exhaust Gas Emissions of Carbon dioxide(CO_2)

From the results, it is observed that the amount of CO_2 produced while using blends of biodiesel are higher than diesel at full load condition, that indicates the complete combustion of the fuel except at B20 blend. As a general rule, the higher the CO_2 reading, the more efficient the engine is operating.

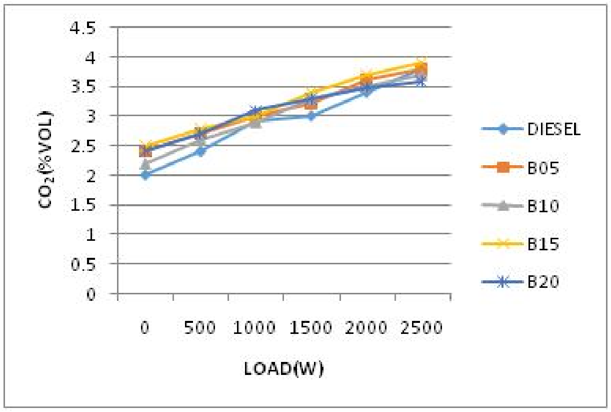

Fig. 8 Load VS CO2 Emissions

4.6 Exhaust Gas Emissions of Nitrogen Oxides(NO_x) :

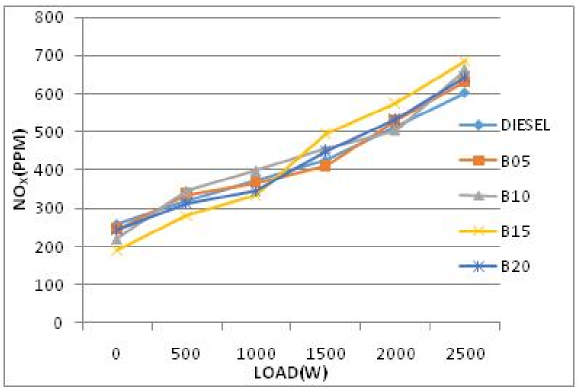

Fig. 9 Load VS NOx Emission

The formation of nitrogen oxide emissions depends on the heat transfer rate and evaporation rate of the fuel. This increases further, with the availability of oxygen and the higher prevailing temperatures in the chamber. From the results, it is noticed that NO_x is slightly increased for biodiesel blends compared to diesel fuel (standard engine).

V. CONCLUSION

In this study, the performance and emission characteristics of a diesel engine operated on diesel fuel and blends of biodiesel (Moringa Oliefera, Rice bran, Pongamia) such as B05, B10, B15, B20 were experimentally investigated.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency and Mechanical efficiency. The emission characteristics of the engine were studied in terms of concentration of CO, CO_2, HC, NO_x. The results obtained for biodiesel fuel (Moringa Oliefera, Rice bran, Pongamia) blends are compared with the diesel fuel.

Following are the conclusions based on the experimental results obtained while operating single cylinder water cooled diesel engine fuelled with (Moringa Oliefera, Rice bran, Pongamia) oils and its diesel blends.

- The blend B05 of biodiesel shows lower brake specific fuel consumption (BSFC) than the diesel at full load (2500W). The BSFC of diesel fuel is 0.319 Kg/kW-hr and for blend B05 is 0.294 Kg/kW-hr. The BSFC is found to be reduced by 0.025 Kg/kW-hr.
- Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled biodiesel blend B15. The Brake Thermal efficiency of diesel fuel is 26.83% and for blend B15 is 29.98% at full load (2500). The Brake thermal efficiency to found to be increased by 3.15%.
- Mechanical efficiency of the tested diesel engine is improved when it is fuelled with biodiesel blend B15. The Mechanical efficiency of diesel fuel is 60.46% and for blend B15 is 69.45%. Mechanical efficiency is increased by 8.99%.
- CO emissions slightly decreased with increase in percentage of biodiesel blend in the diesel fuel. The CO emissions are found to be reduced by 0.08% vol.
- CO_2 emissions are slightly decreased with increase in percentage of biodiesel blend in the diesel fuel. The CO_2 emissions are found to be reduced by 0.2 %vol at B20.
- NO_x emissions of biodiesel blends are slightly higher than that of diesel. The NO_x emissions are found to be increased by 0.8%.

From the above analysis we found that the biodiesel (Moringa Oliefera, Rice bran, Pongamia) and its diesel blends are suitable substitute for diesel as they produce lesser emissions and have satisfactory performance and emission characteristics.

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