Catalytic Waste Plastic Cracking for Co-Production of Fuel Oil

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Abstract: In India the grown of population and industries are very fast in urban area and therefore plastic waste problem is more generated. The characteristic of plastic waste depends on different factors like lifestyle, climate, tradition, food, habits etc. The problem of waste plastic is that it cannot be disposed which is harmful for environment .The other problem of plastic waste is that when it is being manufactured toxic gases are generate released which then create problem such as global warming & pollution. Present study aims at some sort of new technology develop which can waste plastic cracking for co production of fuel oil. This technology will bring employment opportunities and it may generate big amount of income.

***Keywords* – Waste plastic, Catalyst, Toxic gas**

1. INTRODUCTION

Plastic plays a vital role in improving the human living standard for more than half of century since its birth, due to its unique advantages including lightweight, convenient, low cost and durability. Several representative plastics such as polyethylene (PE), polyethylene terephthalate (PET), polystyrene (PS), polypropylene (PP) and polyvinyl chloride (PVC) have been widely used in various fields such as packaging, building and construction, light-weight vehicles, electronics, medical and health, and energy . In 2017, 348 million metric tons of plastic were produced globally and this demand is expected to quadruple by 2050 . After the large-scale production of plastics in the 1950s, the global plastic waste was estimated to be as high as 6.3 billion metric tons, of which about 79% was accumulated in landfills or discarded into the environment .A series of environmental problems, including water pollution, air pollution and the destruction of terrestrial habitats, have been being caused by an improper disposal of plastic waste (such as burying, discarding and incineration), due to its nature of non-biodegradability and possible toxicity . Furthermore, it is reported that microplastics may easily enter the food chain through the ingestion of fish or marine organisms, which even directly remain in tap water and ordinary salt that undoubtedly poses a serious threat to human life . Additionally, the vast application of plastic products has also accelerated the depletion of fossil fuels since the plastics are made of the petroleum-based materials. Therefore, it is a good strategy to convert plastic waste into fuel through Pyrolysis because it not only solves the problem of plastic waste disposal, but also realizes the resource recycling and energy recovery .

Plastic pyrolysis oil mainly contains many alkanes, alkenes and aromatic compounds, which are close to petroleum-based fuels because plastic waste is primarily composed of carbon and hydrogen elements. Tulashie et al. performed the pyrolysis of the mixture of different plastic wastes for developing an efficient conversion method for heterogeneous plastic waste streams. FTIR analysis showed that plastic pyrolysis oil was rich in aliphatic and aromatic groups of compounds. In addition, GC–MS analysis showed that the substances in the plastic pyrolysis oil were in the range of diesel fuel (C12-C24), which indicates that the plastic pyrolysis oil had a potential to be an alternative to diesel. Although there is no strict unified standard for the relationship between the carbon number range and petroleum fractions so far, the commonly used standards can be obtained from literatures. The carbon number range for petroleum gas (PG), light oil (LO, close to gasoline fraction), medium oil (MO, close to diesel fraction) and heavy oil (HO, close to wax) were defined as C1-C5, C6-C10, C11-C22 and ≥C23, respectively.

However, the major shortcomings including high viscosity, high TAN value, relatively high oxygenated compounds, thermal instability and chemical instability limit its wide applications.

Waste plastic catalyst Pyrolysis in liquid fuel (gasoline, diesel oil, etc.) or chemical raw materials not only can effectively solve the problem of white pollution, but also can alleviate the energy shortage to a certain extent. Recycling of waste plastics is expected to become the most effective way. Waste plastics' recycling, regenerating, and utilizing have become a hot spot of research at home and abroad and gradually formed a new industry.

The decomposition of polymeric materials is also relevant and of interest to industries since plastic is used in many of today's . The wide use of polymeric materials or plastics resulted in the accumulations of untraditional wastes not native to the mother earth life cycle. Therefore, wastes of modern materials are accumulated without effective decomposition and recycling routes in the landfills. The increase of petroleum and petrochemical prices opened the ways for industries to invest in decomposition of plastic wastes to petrochemicals. .

The plastics include polystyrene , poly (vinyl chloride) ,polypropylene ;polystyrene terephthalate, acrylonitrile-butadiene-styrene and polystyrene . In some cases, plastics were co-pyrolyzed with other materials such as waste motor oil. With regard to fast Pyrolysis of polystyrene, Pyrolysis of low density polyethylene, high density polyethylene and various mixtures was reported. In all polystyrene studies, the properties of the resulting bio-oil were not reported, nor were the upgrading to fuel-grade hydrocarbons and subsequent fuel property determination.

The present study aims at some sort of new technology which can control toxic gases and convert plastic waste into a useful energy resource. This technology will bring employment opportunities and it may generate a big amount of income.

2. METHODOLOGY

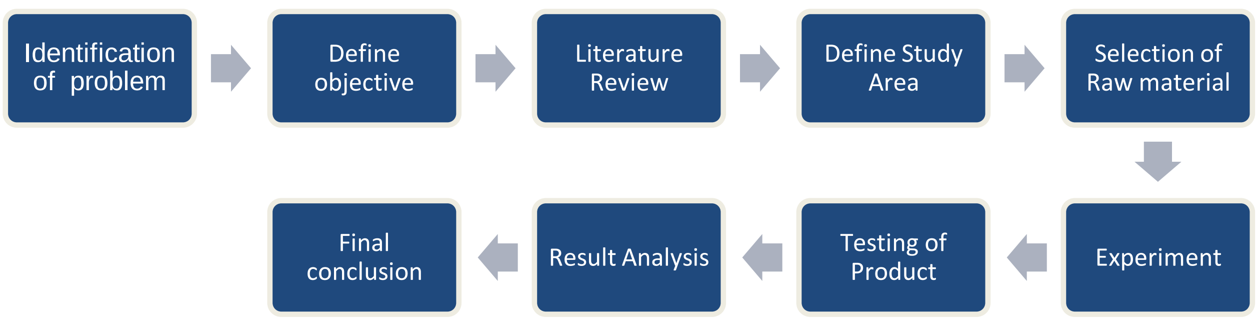


FIGURE 1 FLOW CHART OF METHODOLOGY

3. Material and Process Description

The plastic used in this study was used waste plastic polythene (LDPE), for domestic purposes, used waste plastic sample bottle (HDPE) for water sample collection in laboratories, used waste plastics water bottles (PP) like were cleaned with Isopropyl Alcohol and water to remove contained materials such as dust and Marker ink Washed out waste plastics were dried and cut into small pieces.

4. Experimental work

A laboratory Scale catalyst process batch reactor was used for production of fuel oil from waste plastic like sample bottle, water bottle and polythene bag. The diagram of plastic catalyst process setup is shown in figure2.catalyst process are different unit of the reactor chamber, temperature controller ,condenser, heating coil(Heating mantle) ,collection glass ware ,valve and gas release point. The glass wares three neck round bottom flask as reactor. The reactor with mixed waste plastic was heated electrically up to 210°C to 260°C Ni-Cr wire electric heater. Then the catalyst process by using catalyst typically an alumina balls and zeolite balls gases produced from heating of waste plastic are passed toward catalyst unit condenser, where condensation of these gases occur and get oil from the plastic.

There was no output at low temperature range and the process was carried out between the temperature range 290°C to 345°C in the reactor for about 3hours .the Vapor product of catalyst process were carried out through condenser .The condenser was with Normal water and condensed bio oil was collected into glass ware collector. The non-condensed gas was release to the atmosphere.

TABLE 1 OUTPUTS OF CATALYTIC DEPOLYMERISATION PROCESS

Output	**Gross output**	**Net output**
Residues	5 to 10% wt	5 to 10% wt
Liquid	80 to 90% wt	70 to 80% wt
Gas	5 to 10% wt	0% wt

FIGURE 2 EXPERIMENTAL SETUP

FIGURE 3 FINAL PRODUCT LIQUID FUEL

5. RESULTS

TABLE 2 FINAL PRODUCT TESTING RESULTS

SR NO.	TEST DESCRIPTION	RESULT
1	Redwood viscosity (25^0 C)	22 sec
2	Density	0.67 gm/cc
3	Flash point	20c°
4	Fire point	25c°
5	Sulphur	0.02
6	Calorific value	9080 Kcal/kg

6. ANALYSIS OF RESULTS

TABLE 3 COMPARISION OF DIFFERNT LIQUID FUEL

SR.NO.	PARAMETER	DIESEL	KEROSENE	PYROLYSIS OIL	CATALYST OIL
1	Kinetic viscosity (Centistokes)	11.75	2.71	11.6	1.4
2	Density (Gm/cc)	0.83	0.81	0.77	0.67
3	Flash point c°	55	38	38	20
4	Fire point c°	43	72	40	25
5	Sulphur %	0.25	0.3	0.246	0.02
6	Calorific value (Kcal/kg)	10470	10560	10120	9080

Effect of Temperature on Product Yield

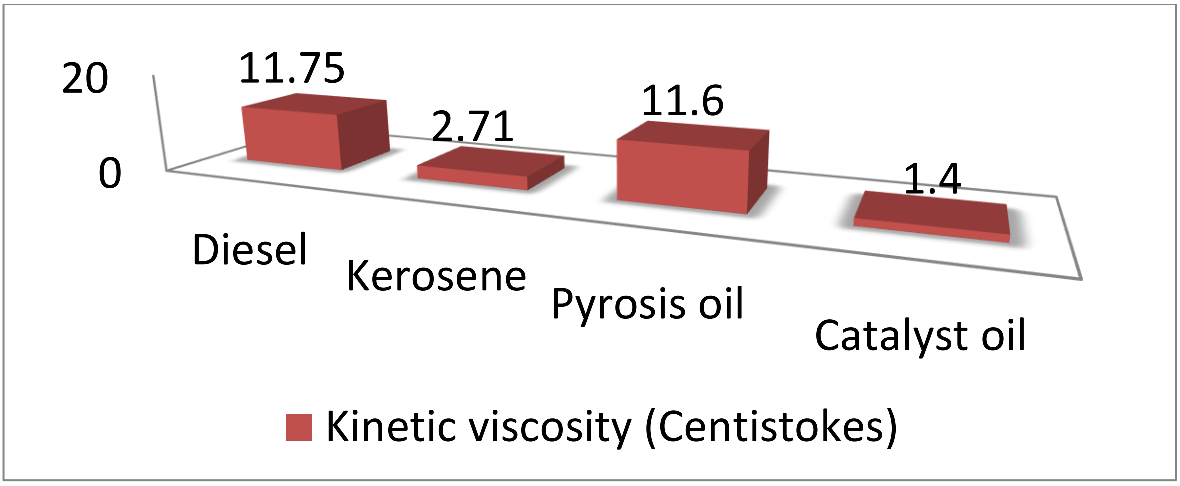
The products are separated into gas, oil, and residue by catalyst of waste plastic. About 38.5% of WPPO was obtained at temperature 288°C as presented in the oil percentage increased constantly to 80.0% at 345°C. The gases produced through plastic catalyst process consist principally of hydrogen (H_2), carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), ethane (C_2H_4), and butadiene (C_4H_6), with trace amounts of propane ($CH_3CH_2CH_3$), propene ($CH_3CH{=}CH_2$), n-butane ($CH_3(CH_2)_2CH_3$), and other miscellaneous hydrocarbons.

Effect of Distillation Temperature on Crude WPPO

Distillation is carried out to separate the lighter and heavier fraction of hydrocarbon present in waste plastic catalyst oil. The distillation is operated between 295°C and 350°C; 78.5% of WPPO is distilled out. At the temperature of 200°C only about 10.0% of distilled WPPO was achieved. However, percentage of WPPO increased constantly to 78.5% at a temperature of 342°C from 10% at the temperature 200°C.

1. Viscosity

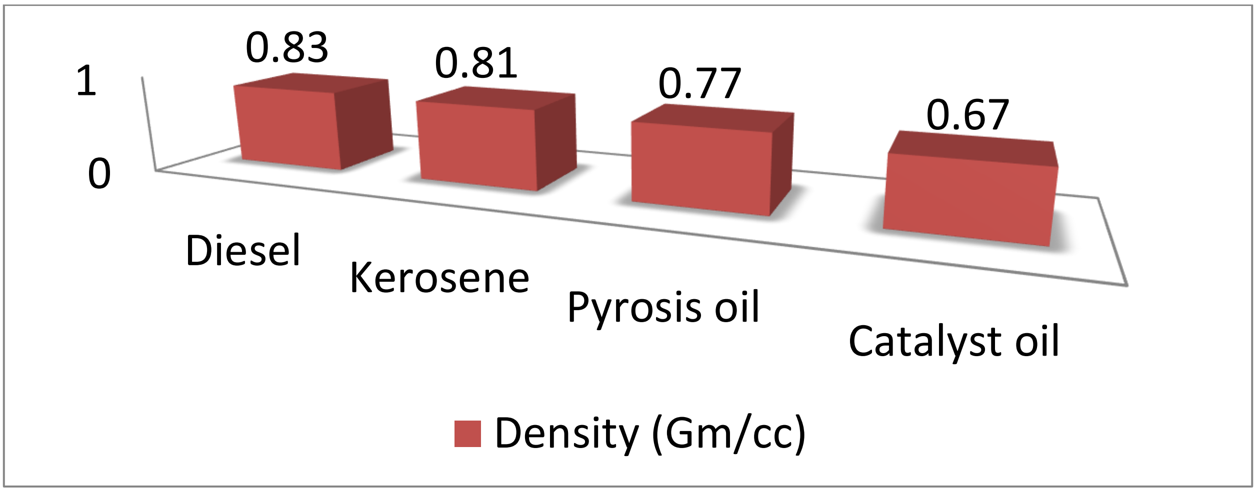
Viscosity varies with feedstock, pyrolysis conditions, temperature, and other variables. The higher the viscosity, the higher the fuel consumption, engine temperature, and load on the engine. On the other hand, if the viscosity of oil is too high, excessive friction may take place. The viscosity was measured by the IP-50 methodology at a temperature of 25°C. It is observed that the viscosity of waste plastic catalyst pyrolysis oil obtained at 342°C temperature which was comparably higher than kerosene, petrol, diesel, and lower than Pyrolysis Following graph 1 represents the comparison of viscosity for various fuels.



GRAPH:1 REPRESENT THE COMPARISION OF VISCOSITY VARIOUS FUEL

2. Density

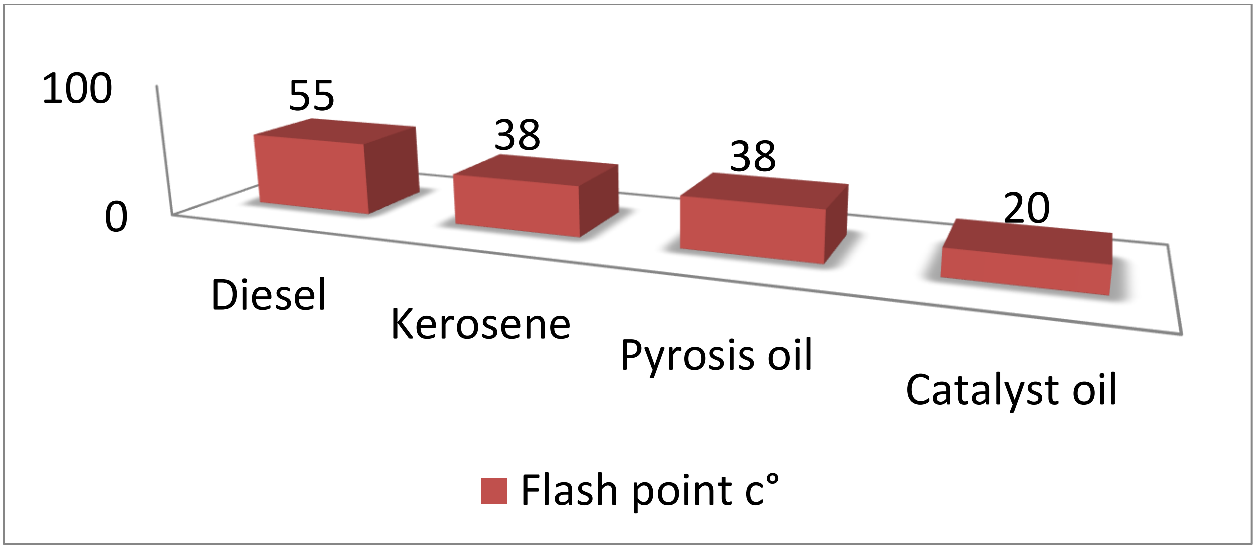
Density is an important property of a fuel oil. If the density of fuel is high; the fuel consumption will be less. On the other hand, the oil with low density will consume more fuel which may cause damage to the engine. Therefore, too low or too high density of fuel oil is not desirable. It is clear from Figure 9 that the densities of WPPO and WPPO50 were found to be 0.77g/cc,0.83g/cc 0.77g/cc,0.81 respectively, which is close to the density of pyrolysis oil, diesel, petrol and Kerosene. So the fuel such as pyrolysis oil, diesel, Petrol, Kerosene may be replaced by plastic Catalytic pyrolysis oil. Following graph 2 represents the comparison of density for various fuels.



GRAPH: 2 REPRESENT THE COMPARISION OF DENSITY VARIOUS FUEL

3. Flash point

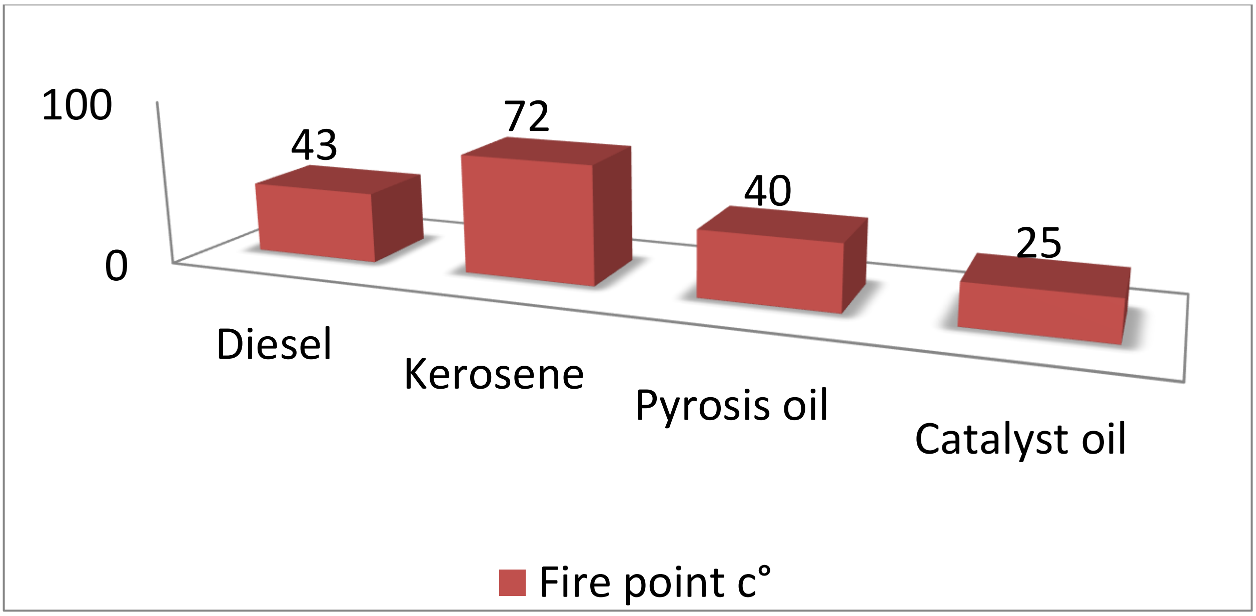
Flash point is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Flash point is used to characterize the fire hazards of fuels. The flash point of WPPO was measured according to ASTM D 93-62 method. The flash point of WPPO was about 15°C. A low flash point indicates the presence of highly volatile materials in the fuel that is a serious safety concern in handling and transporting. The flash point of furnace oil, diesel, and kerosene is higher than WPPO which indicates that these are easy to handle. By removing lighter components (such as naphtha/gasoline) the flash point of WPPO will be increased. It has been observed that the resulted catalyst pyrolysis oil contains 20^{0}C flash point.



GRAPH: 3 REPRESENT THE COMPARISION OF FLASH POINT VARIOUS FUEL

4. Fire point

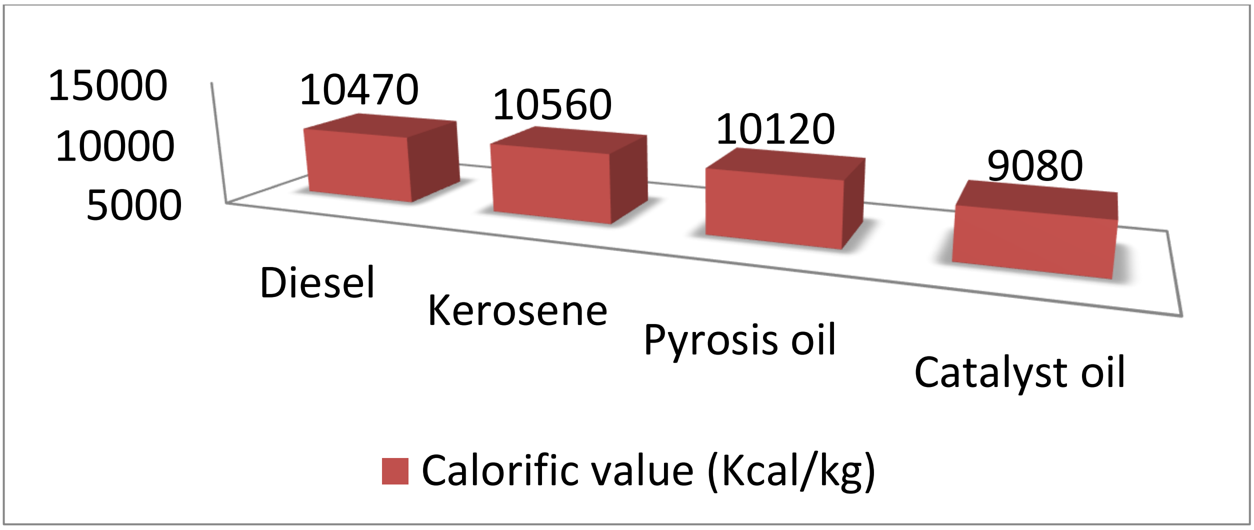
The fire point of a fuel is the temperature at which it will continue to burn for at least 5 seconds after ignition by an open flame. The fire point is used to assess the risk of the materials ability to support combustion. Generally, the fire point of any liquid oil is considered to be about (5–10) °C higher than the flash point. The fire point of waste plastic catalyst pyrolysis oil was 24°C. Following graph 4 represents the comparison of fire point for various fuels.



GRAPH: 4 REPRESENT THE COMPARISION OF FIRE POINT VARIOUS FUEL

5. Calorific value

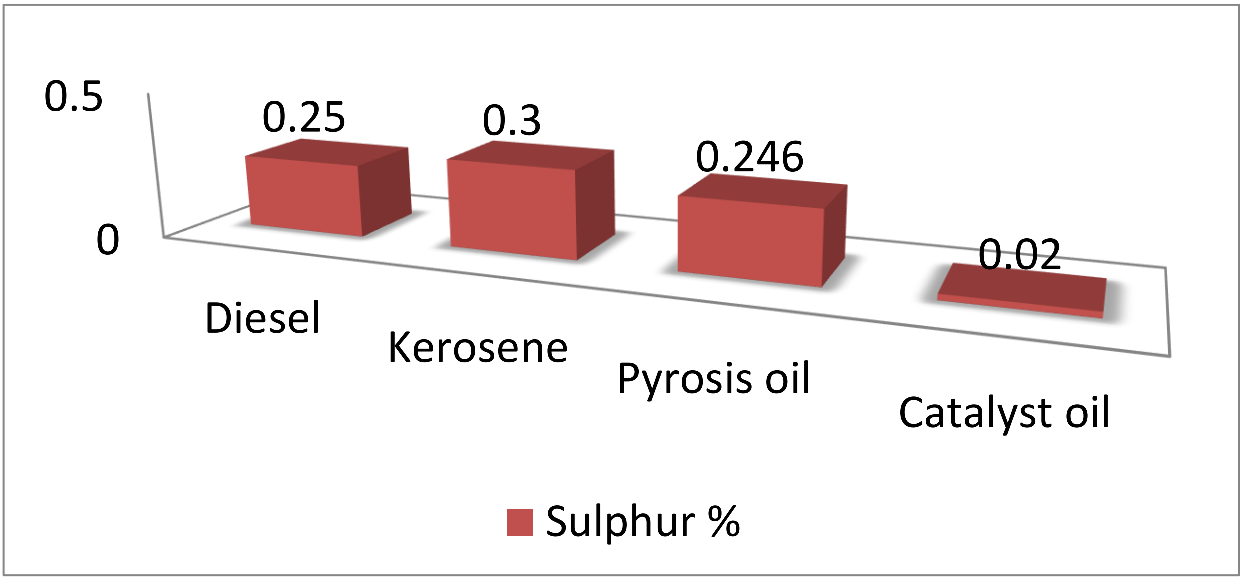
One of the important properties of a fuel on which its efficiency is judged is its calorific value. The calorific value is defined as the energy given out when unit mass of fuel is burned completely in sufficient air. The calorific value of WPPO was estimated according to IP 12/58 method. The calorific value of WPPO was 9829.3515 kcal/kg.The comparison of calorific value of WPPO with other kinds of oil. Following graph 5 represents the comparison of calorific value for various fuels.



GRAPH: 5 REPRESENT THE COMPARISION OF CALORIFIC VALUE VARIOUS FUEL

6. Sulphur

The presence of sulphur in vehicle fuels causes emissions that are an environmental issue. High sulphur content decreases the catalytic conversion capacity of a system, thus increasing the emissions of nitrous oxides , carbon monoxide (CO), hydrocarbons, and volatile organic compounds (VOCs). The sulphur content of WPPO was measured by using ASTM D 129-00 methodology.The sulphur content of waste plastic catalyst pyrolysis oil was 0.02%. Sulphur content of WPPO is lower than, Pyrolysis oil(0.246%), kerosene (0.04-0.3%), diesel (0.25%), and other types of fuel oil because waste plastic contains some contamination. Following table 8 represents the comparison sulphur contents for various fuels



GRAPH: 6 REPRESENT THE COMPARISION OF SULPHUR VARIOUS FUEL

7. CONCLUSION

The catalystic process of mixed waste plastic leads to the production of fuel oil which is a valuable resource energy recovery. It also reduces the problem of disposal of waste plastic .In this work, catalytic process of waste plastic is carried out use of two catalyst Alumina ball and zeolite ball.the benefit of the use of alumina ball as catalyst is absorb the moisture content and the use of zeolite as catalyst is low temperature and increasing the yield of fuel. Mixed plastic catalystic yields a mixture of oil and gas produce very small amount of residues. Higher temperature and longer reaction times increase gas yield and decrease residues production. highly volatile product are obtained at low temperature .liquid yield increase as the holding time increase from 1:30 hr to 2hr but as the holding time in2 hr to 2:30hr ,the liquid yield decrease the liquid yield decreases. The maximum oil yield was 82.05% to 87% at 2 hour. The liquid obtained in this process is relatively greater volume and boiling range. Distillation of fuel like liquid show more light fraction at higher Temperature and longer time .physiochemical properties of obtained fuel oil can be exploited to make highly efficient fuel or furnace oil after blending with other petroleum product.

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