The Result of Nano-Additives in Diesel Engine using Diesel-E Waste Plastics Pyrolysis Oil Fuel Blends: A Review

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Abstract. Primary pollutants IC engines are nitrogen oxide (NOx) and particulate matter (PM). For most recent years, researchers are rigorously working to discover the alternative fuel which will cut emission characteristics without compromising the performance. There are two methods in general to reduce emission in CI Engines. One way is using catalytic converter and another is to get better performance of Diesel engine using nano fuel additive. Adding fuel additive is one of the best ways to improve the performance of CI engines. Many researchers have contributed in this area and this paper consolidates the outcomes of different tests done on the CI engine utilizing nano fuel additives with pyrolysis oil in diesel fuel. It is understood that majority of the researchers report performance enhancement and reduction in emission characteristics with dosing of nano particles additives in diesel and biodiesel. The result of several nano particles on the enrichment in the performance characteristics and drop in emission of CI engine tested with diesel-biodiesel fuel blends are discussed.

1. Introduction

With the huge applications of plastics, the making of plastics is growing worldwide in leaps and bounds. Wood, metals and ceramics have been substituted by plastics as the quality of human improved with the discovery of plastics. From the start of development of plastics, growth of plastic waste gives increase to environmental problems. It may take billions of years for plastic to degrade in nature. Recycling and reuse of plastics is found to be the most favorable solution to administer the plastic waste. Chemical recycling conforms to the principles of sustainable development in future [1] and energy calamity, which has gain huge awareness by researchers. The challenges of E-waste management and increasing fuel energy crisis can be addressed simultaneously with the making of fuel from E-Waste plastics. Several researchers showed that the fuel formed from E-Waste plastics have properties like to that of petroleum fuels [2-9]. This review is to analyze the diesel engine’s performance, emission and combustion characteristics with E-waste plastic oil blends as fuel produced by pyrolysis with nano fuel additive.
1.1 Pyrolysis mechanism

Proximate analysis is typically adopted to measure the chemical properties of E-plastics. The main elements in plastics are carbon, moisture content, volatile matter and ash content as the liquid oil yield depends on the assumed elements [10]. Thermo chemical action and Catalytic conversion are the generally used methods for manufacture of fuel from E-plastics [11]. In thermo chemical treatment, large polymers in E-plastics are split into smaller hydrocarbons in an oxygen free background at high-minded temperatures. Whereas, in catalytic conversion, a catalyst is used to modify the reaction mechanism which reduces the Pyrolysis temperature and selectivity [12,13].

1.2 Thermo chemical treatment

In pyrolysis process, the lighter molecular weight polymers require higher temperatures for degradation [14]. Parameters like degradation time, temperature, type of reactor and residence time govern the residue of plastic pyrolysis procedure. As such, the hydrocarbons having boiling point around 350°C and 1850°C are used as gasoline and that of 1850°C and 2900°C are used as diesel [15, 16]. At the temperature range of 6500°C – 7000°C, the weight % of oil yield and wide supply of hydrocarbon are obtained [17]. In fact, at the temperatures between 3700°C and 4200°C, in the incidence of oxygen, five liquid fraction having hydrocarbons involving C4H8 and C28H58 were obtained [18]. Nitrogen, when used for pyrolysis of mixed plastic E-wastes resulted in privileged concentration of aromatics and alkanes [19]. The Pyrolysis of E-waste electrical and electronic equipment at an elevated temperature of 8000°C has a yield of 30.4 – 45.5% of gas [20].

1.3 Catalytic conversion

In the thermal cracking catalyst helps in growing the reaction rate along with reduction in pyrolysis temperature. This improves the quality of fuel, increase selectivity and residence time [21]. Nano crystalline zeolites like HZSM-5, Hβ and HMOR generally use catalysts [22]. On the outset, more amount of catalyst compact the yield of plastic oil [23]. Hydrocarbon in the plastic oil yield was improved from 52% to 60% by using activated carbon bed containing Fe in the incidence of hydrogen [24]. Catalysts HZSM-5 and SiO2-Al2O3 when used in mixture resulted in the final product with better octane rating [25].

2. Engine Performance and Emission Analysis

In order to balance the energy required and substitute of fossil fuels at least to some extent, the development of alternative energy sources is in evitable. And also, global warming and E-waste management policies have enforced the utilization of alternative fuels on engines.

Experiments were conducted by Ioannis et al [26] on a CI engine fuelled with blends of waste plastic pyrolysis oil in proportions of 25%, 50%, 75%, 90% and 100% (v/v%). The Brake thermal efficiency (BTE) of WPO blends was found to be lesser than diesel. The upper blending ratios of WPO resulted in higher in net heat release rate, cylinder pressure, HC, CO, NOx, and CO2 emissions. Paul Daniel et al [27] used blends of 10%, 20%, 30% and 50% (v/v%) and exhaust gas recirculation of 5%, 10%, 15% and 20%. BSFC increased by 2.3%, 4.6%, 16.3% and 22.6% by EGR of 5%, 10%, 15% and 20% respectively. PPO helped in NOx reduction. However, HC, CO and CO2 emissions were increased with increase in PPO composition and EGR rate.

Plastic oil produced from crude landfills was tested as fuel on diesel engine by Adun et al [28]. The diesel equivalent fraction (LFPL3) was produced at a temperature range between 2500°C and 3500°C. They reported that BSFC by 12.5%, EGT by 11.6%, HC by 12.5%, NOx by 45.4% and CO by 5.4% with LFPL3. Investigation was carried out by Ravi Shankar et al [29] on a CRDI engine with plastic Pyrolysis oil blends in proportions of 10%, 20% and 30% on mass basis. The calorific value of the blend decreased with the increase in quantity of plastic oil. The brake thermal efficiency significantly decreased by 12%, 31% and 48% for plastic oil-diesel fuel blends of 10%, 20% and 30%
respectively. NOx emission was found to be 15%, 22% and 23% higher for 10%, 20% and 30% blends respectively compared to diesel under full load conditions. Sumit and Rohit [30] used semi batch type pyrolysis reactor to produce plastic oil from waste plastics and polyethylene. The Pyrolysis temperature was maintained between 5000C and 7000C. Plastic oil-diesel blends in proportions of 5%, 10%, 15% and 20% were used as fuels on diesel engine. They reported that the catalyst plays an important role in the thermal cracking. As such no catalyst was used in their process of production of plastic oil. Due to low oxidation stability, plastic oil been kept for some hours had gum out.

The addition of oxygenated additive, Di ethyl ether (DEE) reduced the emission levels with plastic oil-diesel blends [31]. Experimental investigations were carried out on VCR engine at compression ratios of 12, 16 and 20 with P2.5, P7.5, P12.5 and P100 blends along with 2.5% volume of DEE by volume. It was found that addition of DEE reduces the viscosity of fuel blends and increases the rate of reaction. Alcohols are highly volatile than DEE and when added to bio-diesels, reduce harmful emissions from diesel engine. Damodharan et al [32] synthesized oil from waste plastics in a laboratory scale batch reactor. Blends of diesel, waste plastic oil and n-Butanol like D50-WPO40-B10, D50-WPO30-B20 and D50-WPO20-B30 were used as fuel on a diesel engine. D50-WPO20-B30 delivered better performance than diesel. Smoke opacity of neat WPO was higher than neat diesel and blends of WPO. With addition of n-Butanol to blends, the smoke emission diminished. This may be due to the improved availability of oxygen and lower carbon content. On the summary, NOx, CO and HC emissions increased with increase in WPO composition.

Devraj et al [33] conducted experiments using diesel, WPPO(100% waste plastic oil), WD05(WPO blended with 5%DEE) and WD10(WPO blended with 10%DEE) on a diesel engine and found that BSFC for diesel was lower than WPPO by 12%. With addition of DEE to blends, HC and NOx emissions were higher than baseline fuel diesel. Under full load conditions, CO emission decreased by 10.5% when compared between WD05 and WD10. This may be due to availability of additional amount of oxygen in DEE. CeylaGungor et al [34] produced oil from waste polyethylene using sodium aluminum silicate catalyst in a thermal reactor. Experimental study was conducted on a 4 cylinder diesel engine with blends of WPE5, WPE10, WPE15 and WPE20 at varying speeds and the results were compared with diesel fuel. Result revolved that Power output was increased by 1.6% and CO emission was decreased by 20.63% for WPE5 blend. Hamzah et al [35] studied the performance of diesel engine using Waste Plastic Disposal Fuel (WPDF) and diesel as fuels at varying speeds and constant load on a single cylinder diesel engine. Reduction in brake power and torque was observed for WPDF at all speeds than diesel. This was attributed to lower cetane number of WPDF which is 5.5% lower than that of diesel. The peak combustion pressure at low speed (1200 rpm) and high speed (2400 rpm) for WPDF is inferior to diesel. Kaimal et al [36-39] synthesized plastic oil in a reactor at a temperature range of 3500C – 4000C with silica catalyst and obtained a yield of 80% by weight of plastic waste. Experiments were conducted with various blends of diesel-plastic oil such as PO, PO05, PO50, PO75 and diesel – plastic – Di ethyl ether like PD5, PD10 and PD15. They reported that the combustion of PO varies from 370CA to 460CA under full load conditions.

Emulsification of waste plastic oil with water was carried out by Senthil and Sankaranarayanan [40]. The emulsions like PW10 (Waste plastic oil 88% + Span 80-1% + Water 10% + Tween 1%), PW20 (Waste plastic oil 78% + Span 80-1% + Water 20% + Tween 1%) and PW30 (Waste plastic oil 68% + Span 80-1% + Water 30% + Tween 1%), PO (WPO 100%) and diesel were used as fuels. They reported that the NOx emissions for emulsions reduced greatly by 32%. Out of which PW30 recorded least NOx emissions under full load conditions. Rajan et al [41] used WPO diesel blends in proportions of 10%, 20% and 30% (v/v%) of WPO. The characterization of plastic oil revealed that the viscosity of WPO 100 is lower than that of diesel.

Plastic oil was produced by Kaoline catalyst from waste polypropylene at a temperature range of 6800C to 34600C which is equivalent to diesel. Blends like, 10% B WPO, 20% B WPO, 30% B WPO, 40% B WPO and 50% B WPO were tested on a diesel engine. Brake thermal efficiency was
greater than diesel for all blends more than 80% load. The exhaust gas temperature and NOx emissions were originate to be higher for blends at all loads. This may be due to the improper penetration of WPO blends deeper into the CI engine combustion chamber. Also, the unsaturated hydrocarbons present in the fuel (WPO) might have lead to higher HC and CO emissions. It was also reported that the vibration of engine had occurred for 50B WPO at full load [42]. Mani et al [43-46] discovered most of the paths of utilizing WPO in neat and blend form. Tests were conducted at advance and retard injection timing using blends like WPO, WPO10, WPO30, WPO50, WPO70 and varying exhaust gas recirculation (EGR) rate as 10%EGR and 20%EGR. Characterization of WPO revealed that 75% of liquid hydrocarbon to be obtained on mass basis from E-plastic wastes. They observed that for WPO without EGR, heat discharge rate increased by 24.5% at max load. Marginal difference in BTE is found with 20% EGR. Also, the exhaust gas temperature, smoke, NOx and CO2 concentration decreased marginally.

Table 1 inclines the summary of previous studies that confirmed the use of waste plastic oil and its mixtures as fuels and Table 2 is the list of properties of E-waste plastic oil and its mixtures from previous studies [48-54].

| Ref No. | Blend | EM | BT E | BSF C | NO x | HC | CO | CO 2 | HR | Smoke | EGT | Cylinder Pressure | Remarks |
|---------|-------|----|------|-------|------|----|----|------|----|-------|-----|------------------|---------|
| [26]    | PPO   | ↓  | ↑    | ↓    | ↑    | =  | ↓  | ↑    | ↑  | ↑    | ↑   | ↑                | A blend between 60% PPO at 80-90% loads optimized |
|         | PPO25 | ↓  | ↑    | ↓    | ↑    | =  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PPO50 | ↓  | ↑    | ↑    | ↑    | =  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PPO75 | ↓  | ↑    | ↑    | ↑    | =  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PPO90 | ↓  | ↑    | ↑    | ↑    | =  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PPO100| ↓  | ↑    | ↑    | ↑    | =  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
| [27]    | PPO 10| ↑  | ↓    | ↑    | ↓    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
|         | PPO 20| ↓  | ↑    | ↓    | ↑    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
|         | PPO 30| ↓  | ↑    | ↓    | ↑    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
|         | PPO 50| ↓  | ↑    | ↓    | ↑    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
| [28]    | LFLP3 | ↑  | ↓    | ↓    | ↓    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
| [29]    | PO 10 | ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PO 20 | ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | PO 30 | ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
| [30]    | WPPO 5| ↑  | ↓    | ↓    | ↓    | ↓  | ↓  | ↓    | ↓  | ↓    | ↓   | ↓                |
|         | WPPO 10| ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | WPPO 15| ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | WPPO 20| ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
| [31]    | P 2.5 | =  | ↑    | ↑    | =    | ↑  | =  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | P 7.5 | =  | ↑    | ↑    | =    | ↑  | =  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | P 12.5 | =  | ↑    | ↑    | =    | ↑  | =  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | P 100 | =  | ↑    | ↑    | =    | ↑  | =  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | CR 12 | =  | ↑    | ↑    | =    | ↑  | =  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | CR 16 | ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |
|         | CR 20 | ↓  | ↑    | ↑    | ↓    | ↑  | ↑  | ↑    | ↑  | ↑    | ↑   | ↑                |

LFLP3 is improved fuel over Diesel.

PO used in pure with Slight modifications to the engine.

20% blend is Optimized.

WPO can be mixed with diesel and DEE used as improver.
| Table | Comparison | Performance | Explanation |
|-------|------------|-------------|-------------|
| [32]  | D50WPO40B 10 = ↑ ↓ ↓ ↑ | D50WPO20B30 is Optimized n-Butanolisgood asimprover |
|       | D50WPO30B 20 ↓ ↑ ↓ ↓ ↑ |
|       | D50WPO20B 30 ↓ ↑ = ↑ ↓ |
|       | WPO ↓ ↑ ↓ ↓ ↑ ↑ |
|       | WPO ↓ ↑ ↓ ↓ ↑ |
| [33]  | WD 05 ↓ ↑ ↑ ↑ ↓ ↑ | Adding of DEE is encouraging |
|       | WD 10 ↑ ↓ ↓ ↓ ↑ ↓ |
|       | WPE 5 ↑ ↑ ↑ ↓ ↑ |
|       | CPE 5 ↑ ↑ ↓ ↓ |
| [34]  | WPPO ↑ ↑ ↓ ↓ | WPE 5 mixture is the good blend |
|       | WPF ↓ ↓ ↓ ↓ |
|       | PO ↑ ↑ ↑ ↑ ↑ Engine to be adept of run using 100% PO |
| [35]  | WPDF ↑ ↓ |
|       | PO 25 ↓ ↑ ↑ ↑ ↑ |
|       | PO 50 ↓ ↑ ↑ ↑ ↑ |
|       | PO 75 ↓ ↑ ↑ ↑ ↑ |
|       | PO 100 ↓ ↑ ↑ ↑ ↑ |
| [36]  | PO 25 ↓ ↑ ↑ ↑ ↑ |
|       | PO 50 ↓ ↑ ↑ ↑ ↑ |
|       | PO 75 ↓ ↑ ↑ ↑ ↑ |
|       | PO 100 ↓ ↑ ↑ ↑ ↑ |
|       | PO 25 ↓ ↑ ↑ ↑ ↑ |
|       | PO 50 ↓ ↑ ↑ ↑ ↑ |
|       | PO 75 ↓ ↑ ↑ ↑ ↑ |
|       | PO 100 ↓ ↑ ↑ ↑ ↑ |
| [37]  | PO 25 ↓ ↑ ↑ ↑ = ↑ |
|       | PO 50 ↓ ↑ ↑ ↑ |
|       | PO 75 ↓ ↑ ↑ ↑ |
| [38]  | PO 25 ↓ ↑ ↑ ↑ |
|       | PO 50 ↓ ↑ ↑ ↑ |
|       | PO 75 ↓ ↑ ↑ ↑ |
|       | PO ↓ ↑ ↑ ↑ |
|       | PD 5 ↑ ↑ ↑ ↑ |
|       | PD 10 ↑ ↑ ↑ ↑ |
|       | PD 15 ↑ ↑ ↑ ↑ |
|       | PO ↓ ↑ ↑ ↑ |
| [39]  | WPO ↓ ↑ ↑ ↑ ↑ |
|       | PW 10 ↓ ↑ ↑ ↑ |
|       | PW 20 ↓ ↑ ↓ ↓ |
|       | PW 30 ↓ ↓ ↓ ↓ |
|       | WPF ↑ ↓ ↓ ↓ ↓ |
|       | WPF10D90 ↑ ↑ ↑ ↓ ↓ |
|       | WPF20D80 ↑ ↑ ↓ ↓ ↓ |
|       | WPF30D70 ↑ ↓ ↓ ↓ ↓ |
| [40]  | WPF10D90 ↑ ↑ ↑ ↓ ↓ |
|       | 10%B WPO ↓ ↑ ↑ ↑ ↑ ↑ |
|       | 20%B WPO ↓ ↑ ↑ ↑ |
|       | 30%B WPO ↓ ↑ ↑ ↑ |
|       | 40%B WPO ↓ ↑ ↑ ↑ |
|       | 50%B WPO ↓ ↑ ↑ |
| [41]  | 10%B WPO ↓ ↑ ↑ ↑ |
|       | 20%B WPO ↓ ↑ ↑ |
|       | 30%B WPO ↓ ↑ ↑ |
|       | 40%B WPO ↓ ↑ |
|       | 50%B WPO ↓ ↑ |
| [42]  | PW 30 has improved performance. |
|       | Performance of WPF10D90 is like to diesel |
|       | Improved performance up to 30% blend. |
|       | BTE of blends is closely same as diesel |
| [43]  | WPO displays upper BTE up to 75% graded power |
|       | Retarded injection timing |
| [44]  | Retardation solid NOx emission by 30% |
| [45]  | NO EGR ↑ ↑ ↓ ↓ ↓ ↓ ↑ ↑ |
|       | 10% EGR ↑ ↑ ↓ ↓ ↓ ↓ ↑ |
|       | EGR reduces NOx emission |
|       | 20% EGR ↑ ↑ ↓ ↓ ↓ ↓ ↑ |
| [46]  | WPO results imnprovedperformancethan blend of WPO anddiesel |

↓ = Decreased; ↑ = Increased
Table II. Properties of E-waste plastic oil and its blends

| Ref No | Blend | Density (kg/L) | Kinematic Viscosity (Cst) | Flash point (°C) | Calorific Value (MJ/kg) | Cetane No. |
|--------|-------|----------------|---------------------------|-----------------|------------------------|------------|
| [26]   | PPO   | 0.9813         | 1.918                     | 13              | 38.3                   | -          |
|        | Diesel| 0.8398         | 2.62                      | 59.5            | 42.9                   | -          |
| [27]   | WPO   | 0.8423         | -                         | 28              | 40.05                  | -          |
|        | Diesel| 0.8377         | -                         | 66              | 44.8                   | -          |
| [28]   | LFLP3 | 0.802          | 2.085                     | 50              | 46                     | 65         |
|        | Diesel| 0.834          | 3.162                     | 75              | 45.5                   | 60         |
| [30]   | WPO   | 0.78           | 3.8                       | 100             | 39.76                  | -          |
|        | Diesel| 0.79           | 1-4.11                    | 52-96           | 44.8                   | -          |
| [31]   | P 2.5 | 0.831          | 1.568                     | 49              | 44.414                 | 42.51      |
|        | P 7.5 | 0.824          | 1.79                      | 48              | 44.091                 | 43.03      |
|        | P 12.5| 0.819          | 1.92                      | 47              | 43.868                 | 43.61      |
|        | P 100 | 0.790          | 2.52                      | 42              | 43.34                  | 51         |
|        | DEE   | 0.714          | 0.23                      | -10             | 33.85                  | 126        |
|        | Diesel| 0.84           | 2.0                       | 50              | 44.8                   | 42         |
|        | Diesel| 0.838          | 3.8                       | 70              | 41.82                  | 54         |
| [32]   | WPO   | 0.813          | 2.16                      | 38              | 40.35                  | 51         |
|        | n-Butanol| 0.810   | 2.2                      | 36              | 34                     | -          |
|        | D50WP040B10| 0.825 | 3.0                      | 36              | 40.45                  | 48.6       |
|        | D50WP030B20| 0.8249   | 3.1                      | 36              | 39.815                 | 44.7       |
|        | D50WP020B30| 0.8246  | 3.2                      | 36              | 39.18                  | 40.8       |
| [33]   | Diesel| 0.84           | -                         | 50              | 46.5                   | 40-45      |
|        | WPPO  | 0.798          | -                         | 42              | 45.216                 | 51         |
|        | DEE   | 0.713          | -                         | 45              | 33.9                   | 126        |
|        | WD05  | 0.794          | -                         | 43              | 44.65                  | -          |
|        | WD10  | 0.754          | -                         | 43.5            | 44.084                 | -          |
| [34]   | Diesel| 0.833          | 2.52                      | 58.5            | 10790 (kcal/kg)        | 54.58      |
|        | WPE 100| 0.788         | 2.326                     | <100            | 10867 (kcal/kg)        | 43.751     |
|        | WPE 5 | 0.831          | 2.49                      | 58.5            | 10800 (kcal/kg)        | 52.58      |
|        | WPE 10 | 0.828       | 2.48                      | 59              | 10807 (kcal/kg)        | 51.63      |
|        | WPE 15 | 0.826       | 2.43                      | 59.5            | 10812 (kcal/kg)        | 50.37      |
|        | WPE 20 | 0.824       | 2.4                       | 61              | 10818 (kcal/kg)        | 49.62      |
| [35]   | Diesel| 0.8416         | 3.05                      | 84              | 42.49                  | 68.2       |
|        | WPDF  | 0.7710         | 2.149                     | 72              | 34.72                  | 64.4       |
| [36]   | Diesel| 0.84           | 2.15                      | 45              | 43.5                   | 54         |
|        | PO    | 0.83           | 2.64                      | 40              | 44.2                   | 50         |
|        | Diesel| 0.84           | 2.15                      | 45              | 43.5                   | 54         |
| [39]   | PO    | 0.83           | 2.64                      | 40              | 44.2                   | 50         |
|        | DEE   | 0.714          | 0.22                      | -45             | 33.87                  | 125        |
|        | PD5   | 0.83           | 2.52                      | 40              | 43.167                 | -          |
|        | PD10  | 0.827          | 2.4                       | 40              | 42.834                 | -          |
|        | PD15  | 0.821          | 2.37                      | 39              | 42.501                 | -          |
| [41]   | WPF10D90| 0.804   | 0.616 (Poise)            | 65              | 44.87                  | 46         |
|        | WPF20D80| 0.832    | 0.052 (Poise)            | 66              | 44.39                  | 46         |
|        | WPF30D70| 0.815    | 0.064 (Poise)            | 69              | 45.58                  | 47         |
|        | WPF100 | 0.78       | 0.0457 (Poise)           | 72              | 42.90                  | 44         |
|        | Diesel| 0.80           | 0.61 (Poise)             | 61              | 45.35                  | 49         |
| [43]   | WPO   | 0.835          | 2.52                      | 42              | 44.34                  | 51         |
3. Conclusions
The necessity for exploration of other alternate has raised because of quicker run-down of diesel fuels and natural consequences. The oil from E-waste plastic has start to become the alternative fuel whereby the controlling of the same is to be spoken mentioning the difficulty in energy management with respect to E-waste. In the research constrained review the combustion, emission and performance characteristics of E-waste plastic oil-diesel blends on internal-combustion engine using diesel as a fuel. But, there are some issues like kinetics of oil from E-waste plastic, improvising properties of combustion and engine alterations which shall be thought-about for exhaustive exploration of IC engine combustion consuming the blend of oil from E-waste plastic with nano fuel additive.

References
1. SL. Wong, N. Ngadi, TAT. Abdullah, IM. Inuwa, Current state and future prospects of plastic waste as source of fuel – a review, Renewable and sustainable energy review, 50, 1167-1180,2015.
2. AK. Panda, RK. Singh, Mishra DK, Thermolysis of waste plastic to liquid fuel – a suitable method for plastic waste management and manufacture of value added products – a world prospective, Renewable and sustainable energy review, 14(1), 233-248,2010.
3. Buekens AG, Huang H, Catalytic plastics cracking for recovery of gasoline range hydrocarbons from municipal plastic wastes, ResourConservRecycl, 1998; 23(3);163-181.
4. Miskolczi N, Bartha L, Deak G, Jover B, Thermal degradation of municipal plastic waste for production of fuel like hydrocarbon, Polymer degrade stab, 2004; 86(2);357-366.
5. Jan MR, Shah J, Gulab H, Catalytic degradation of waste high density polyethylene into fuel products using BaCO3 as a catalyst, Fuel processing technology, 2010; 91;1428-37.
6. Jung SH, Cho MH, Kong BS, Kim JS, Pyrolysis of a fraction of waste poly propylene and polyethylene for the recovery of BTX aromatics using a fluidized bed reactor, Fuel processing technology, 2010; 91;277-84.
7. Miskolczi N, Bartha L, Deak G, Thermal degradation of polyethylene and polystyrene from the packaging industry over different catalysts into fuel like feed stocks, Polymer degrade stab, 2006; 91(3);517-26.
8. Shah J, Jan MR, Mabood F, Jabeen F, Catalytic Pyrolysis of LDPE leads to valuable resource recovery and reduction of waste problems, Energy conversion manag, 2010; 51;2791-801.
9. Akminsky W, Schlesselmann B, Simon CM, Thermal degradation of mixed plastic waste to aromatic and gas, Polm degrade stab, 1996; 53;189-97.
10. Hong SJ, Oh SC, Lee HP, Kim HT, Yoo KO, A study on the pyrolisis characteristics of poly vinyl chloride, J Korean inst chem. Eng, 1999; 37;515-21.
11. Passamonti FJ, Sedran U, Recycling of waste plastics into fuels-LDPE conversion of FCC, Applecatal B environ, 2012; 125;499-506.
12. Al Salem SM, Lettieri P, Baeyens J, Recycling and recovery routes of plastic solid waste – A review, Waste manag, 2009; 29;2625-43.
13. Shah SH, Khan ZM, Raja IA, Low temperature conversion of plastic waste into light hydrocarbons, J hazard matter, 2010; 179;15-20.
14. Gao F, Pyrolysis of waste plastic into fuels, University of Canterbury, 2010.
15. Sharma BK, Moser BR, Vermillion KE, Dell KM, Rajagopalan N, Production characterization and fuel properties of alternative diesel fuel from Pyrolysis of waste plastic
grocery bags, Fuel process technol, 2014; 122;79-90.
16. Encinar JM, Gonzalez JF, Pyrolysis of synthetic polymers and plastic wastes kinetic study, Fuel process technol, 2008; 89(7);678-86.
17. Agvado J, Serrano DP, Escola JM, Fuels from waste plastics by thermal and catalytic processes – a review, Indeng chem. Res, 2008; 47(21);7982-92.
18. Sarker M, Rashid MM, Molla M, Waste plastic converting into hydrocarbon fuel material, J Environ scieng, 2011; 5; 446- 452.
19. Ding F, Xiong L, Luo C, Zhang H, Chen X, Kinetic study of low temperature conversion of plastic mixtures to valueadded products, J anal appl Pyrolysis, 2012; 94;83-90.
20. Alston SM, Clark AD, Arnold JC, Stein BK, Environmental impact of Pyrolysis of mixed WEEE plastics part 1- experimental Pyrolysis data, Environ scitechnol, 2011; 45(21);9380-5.
21. Manos G, garforth A, Dwyer J, catalytic degradation of high density polyethylene over different zeolite structures, Indeng chem. Res, 2000,1198-202.
22. Sharuddin SDA, Faisal A, daud WMAW, Aroua MK, A review on Pyrolysis of plastic wastes, Energy conversion manag, 2016; 115;308-326.
23. Chika M, Jude A, paul TW, Thermal degradation of real world waste plastics and simulated mixed plastics in a two stage Pyrolysis catalysis reactor for fuel production, Energy fuels, 2015; 29(4),2601-2609.
24. Scott DS, Czernik SR, Piskorz J, Radlein DSAG, Fast Pyrolysis of plastic wastes, Energy fuels, 1990; 4(4);407-11.
25. Vemichi Y, Nakamora J, Itoh T, Sugioka M, Conversion of polyethylene into gasoline range fuels by two stage catalytic degradation using silica alumina and HZSM-5 Zeolite, Indengchem Res, 1998; 38(2);385-90.
26. IoannisKalargaris, Guohong Tian, Sai Gu, Combustion performance and emission analysis of a DI engine using plastic Pyrolysis oil, Fuel processing technol, 2017; 15;108-115.
27. Vijay Kumar K, Paul Daniel M, Durga Prasad B, Ravi Kumar P, Performance and emission characteristics of diesel engine operated on plastic Pyrolysis oil with exhaust gas recirculation, International journal of ambient energy, 2017; 38(3); 295- 299.
28. ChumsuntiSantaweesukSompop, AdunJanyalertadun, Fuel production performance and emission of a CI engine using waste plastic oil, World journal of engineering, 2017; 14(2);114-120.
29. Divakar Shetty AS, Ravi Shankar Shukla, Antony AJ, Performance and emission characteristics of CRDI engine working on plastic oil, Indian journal of science and technology, 2016; 9(45),1-6.
30. Sumit Bhat, Rohit Singh Lather, Production of oil form waste plastics and polythene using pyrolysis and its utilization in compression ignition engine, Indian journal of science and technology, 2016, 9(48),1-16.
31. Jayabal S, Thirumal P, Anantha Kumar S, Investigation on performance emission and combustion characteristics of variable compression engine fuelled with diesel waste plastic oil blends, J Brazsocmecheng, 2017; 39(1);19-28.
32. Damodharan D, Sathiyagnanam AP, Rana D, Rajesh Kumar B, Saravanan S, Extraction and characterization of waste plastic oil with the effect of n-Butanol addition on the performance and emissions of a DI diesel engine fueled with WPO diesel blends, Energy conversion and management, 2017; 131;117-126.
33. Devraj J, Robinson Y, Ganapathi P, Experimental investigation of performance emission
and combustion characteristics of waste plastic Pyrolysis oil blended with di ethyl ether used as fuel for diesel engine, Energy, 2015; 85;304-309.
34. Ceyla Gungor, Hasan Serin, Mustafa Ozcanli, Selahattin Serin, Kadir Aydin, Engine performance and emission characteristics of plastic oil produced from waste polyethylene and its blends with diesel fuel, International journal of green energy, 2015; 12(1);98-105.
35. Mohd Herzwan Hamzah, Abdul Adam Abdullah, Agung Sudrajad, Nur Atiqah Ramlan, Nur Fauziah Jaharudin, Performance of diesel engine operating with waste plastic disposal fuel, Applied mechanics and materials, 2014; vols 465- 466,423-427.
36. Kaimal VK, Vijayabalan P, A detailed investigation of the combustion characteristics of a DI diesel engine fuelled with plastic oil and rice bran methyl ester, Journal of the energy institute, 2015; 90(2);324-330
37. Kaimal VK, Vijayabalan P, A detailed study of combustion characteristics of a DI diesel engine using waste plastic oil and its blends, Energy conversion and management, 2015; 105;951-956.
38. Kaimal VK, Vijayabalan P, A study on synthesis of energy fuel from waste plastic and assessment of its potential as an alternative fuel for diesel engines, Waste management, 2016; 51;91-96.
39. Kaimal VK, Vijayabalan P, An investigation on the effects of using DEE additive in a DI diesel engine fuelled with waste plastic oil, Fuel; 2016; 180;90-96.
40. Senthil Kumar P, Sankaranarayanan G, Investigation on environmental factors of waste plastics into oil and its emulsion to control the emission in DI diesel engine, Ecotoxicology and environmental safety, 2016; 134;440-444.
41. Rajankumar, Mishra MK, Singh SK, Arbind Kumar, Experimental evaluation of waste plastic oil and its blend on a single cylinder diesel engine, Journal of mechanical science and technology, 2016; 30(10);4781-4798.
42. Achyut Panda K, Murugan S, Singh RK, Performance and emission characteristics of diesel fuel produced from waste plastic oil obtained by catalytic Pyrolysis of waste polypropylene, Energy sources Part A- recovery utilization and environmental effects, 2016; 38(4);577-585.
43. Mani M, Subash C, Nagarajan G, Performance emission and combustion characteristics of a DI diesel engine using waste plastic oil, Applied thermal engineering, 2009; 29;2738-2744.
44. Mani M, Nagarajan G, Influence of injection timing on performance emission and combustion characteristics of a DI diesel engine running on waste plastic oil, Energy, 2009; 34;1617-1623.
45. Mani M, Nagarajan G, Sampath S, An experimental investigation on a DI diesel engine using waste plastic oil with exhaust gas recirculation, Fuel, 2010; 89;1826-1832.
46. Mani M, Nagarajan G, Sampath S, characterization and effect of using waste plastic oil and diesel fuel blends in compression ignition engine, 2011; 36;212-219.
47. P. Sushma, Waste plastic oil as an alternative fuel for diesel engine – A Review,2018:455; 1-7.
48. S.Deepankumar,B.Saravanan,J.Balaji,R.Gobinath,Experimental Investigation of Performance and Emission Characteristics of Diesel-Bio Diesel (CSOME) - Ethanol-Diethyl Ether Blends in CI Engine” in Journal of Thermal Energy Systems Volume 2 Issue 3. 148-155
49. GovindasamyRajamurugan, Sadhasivam Deepankumar, Anbalagan Ramakrishnan,
PrabuKrishnasamy, Dinesh Dhanabal, Corrosion Characteristics on Friction Stir Welding of Dissimilar AA2014/AA6061 Alloy for Automobile Application, 2019-28-0063

50. S. Deepankumar, M. Boopathi & J Balaji S. Balachandran, R. Gobinath, “Experimental Analysis Of Performance And Emission Characteristics Of Single Cylinder Direct Injection Diesel Engine Using Algae As A Biodiesel And Barium Oxide As A Nano-Fuel”, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) Volume 9 Issue 1.35-42

51. S. Deepankumar, T. Raja, A. Tamilselvan, R. Gobinath, “Enhancing The Four Stroke Ci Engine Performance And Reducing Emission By Preheating And Oxidation Process Using Biodiesel”, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 8 Issue 7.230-240

52. S. Deepankumar, S. Jegadheeswaran & R. Thangavel “Experimental Investigation On Emission Analysis Of Multi-Cylinder Direct Injection Diesel Engine Using Manifold Injection Of Ethanol”, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 8 Issue 7.704-710.

53. S Deepankumar, R Gobinath, S Balachandran, M Boopathi, “Experimental Investigation of Performance and Emission Characteristics of Diesel-Bio Diesel (CSOME) with Nano Additive Blends in CI Engine”, AdvAutomobEng, Volume 7 Issue 176, 2.

54. S Deepankumar, R Gobinath, S Balachandran “Experimental Investigation of Performance and Emission Characteristics Of Diesel-Bio Diesel (CSOME)-Ethanol-Diethyl Ether Blends In CI Engine”, in Journal of Thermal Energy Systems Volume 2 Issue 3. 148-155