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Experimental Analysis on Environmentally Friendly Fuel Obtained from Waste

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ABSTRACT

The amount of waste produced by human activities is constantly increasing as a result of social development and industrial evolution. The amount of municipal solid waste, (MSW), is expected to rise by 5% annually as the population grows. The MSW has a number of negative effects on the environment, including its contribution to the worsening climate crisis, its effect on wildlife, the natural environment, and humans. Therefore, proper management one that is effective, eco-friendly, and cost-effective is required to address this issue. The Indian government has established numerous regulations for the proper management of MSW. In this regard, the current paper discusses about solution of one of the major components of MSW i.e. waste tyre. In this paper the conversion of waste tyre into fuel, its utilization, management policies, challenges encountered, and prospects for the future are discussed.

Keywords: Economy; Pollution; Population; Waste Management; Waste to Energy

Introduction

The amount of waste produced by human activities is constantly increasing as a result of social development and industrial evolution. Our ecology has been harmed as a result of the non-sustainable disposal of these wastes. Wastes that are not biodegradable, like plastic, tires, fibers, glass, and so on are not being as expected reused and possessing the oceans and landfills. A recent study found that only 9% of the 6.3 billion metric tons of plastic waste in the world was recycled, 12% was burned, and 79% was dumped in landfills. Environmental Protection Agency-provided data that in comparison to 2015, the amount of municipal solid waste (MSW) produced in the United States in 2017 was 267.8 million tonnes, or 5.7 million more. As the world's population grows, so does the amount of waste produced by other nations. India, a nation with a high population density, produces approximately 42 million tons of municipal solid waste annually, or 1.15 lakh metric tons per day (TPD). Overall, the amount of waste produced has a number of negative effects on the environment, including its contribution to the growing climate catastrophe, its effect on wildlife, the natural environment, and people.

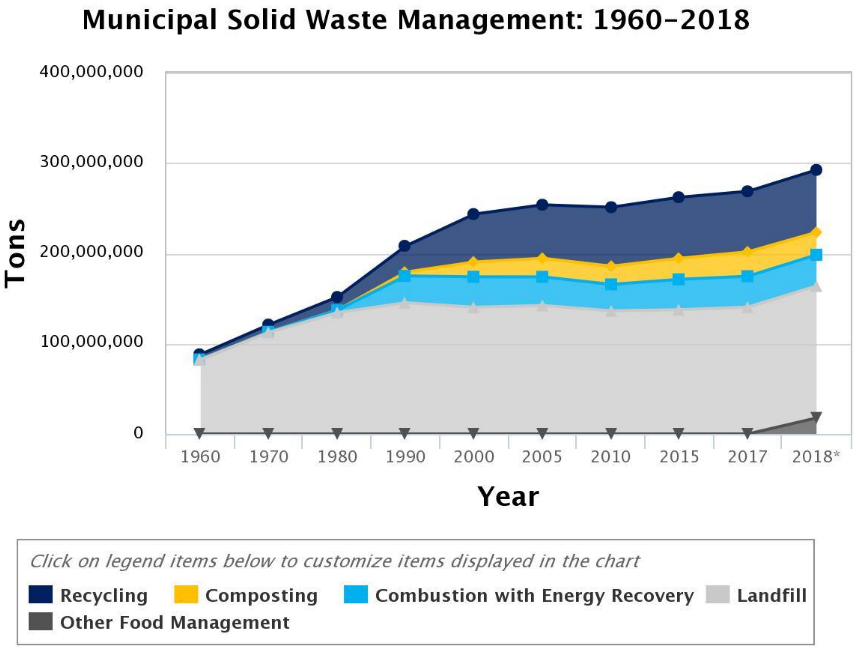

Fig.1 Municipal solid waste management [1]

Fine particulates and harmful gases like carbon monoxide (CO), nitric oxide (NO), and polycyclic aromatic hydrocarbons (PAHs) are produced by the uncontrolled burning of MSW at dumpsites which are major contributors to respiratory problems [2]. Methane (CH_4) has about 21–23 times the potential to cause global warming as carbon dioxide (CO_2) [3]. The fourth largest source of non-CO_2 global emissions is solid waste from municipalities [4]. Each year, MSW is responsible for approximately 550 Tg of global methane emissions. The third-largest human-caused source of CH4 emissions is landfills. By 2020, it is anticipated that MSW landfill emissions will reach 816 MtCO2 equivalent if no action is taken to reduce them. Figure 1 depicts the management of municipal solid waste (SWM) from 1960 to 2018. In this regard, the current paper discusses about solution of one of the major components of MSW i.e. waste tyre. In this paper the conversion of waste tyre into fuel, its utilization, management policies, challenges encountered, and prospects for the future are discussed.

Materials and Methodology

Waste Tyre pyrolysis oil (WTDL) was obtained from a pilot pyrolysis plant for the study. Truck tyres served as the plant's feedstock. Figure 2 displays the pyrolysis process and its yield during the pyrolysis process. The plant has a batch capacity of 5 T. The pyrolysis unit makes use of a horizontal, rotating reactor. Coal and waste wood are used to heat the reactor from the outside. It was discovered that the reactor rose at a rate of 30-40 C/h. The pyrolysis was carried out at 550 degrees Celsius, the temperature at which the greatest oil yield was achieved. The monthly production of 50,000 liters of TPO necessitates approximately Rs. 8000. The evolving vapour from the reactor enters the water-cooled condenser during the pyrolysis process, where it is condensed and transformed into pyrolysis oil. Since some of the vapor was unable to condense, it was utilized as secondary fuel for the purpose of heating the reactor.

The current work is meant to assess the impact of WTDL mixed with jatropha biodiesel (JB) in four unique rates as fills, on the ignition, execution and outflow qualities of an immediate infusion (DI) diesel motor. In order to produce the fuel blends needed for the investigation, TPO and JB were mixed with JB 5-20% with remaining percentage of diesel. Transesterification is the process by which vegetable oils produce their esters [5]. Glycerol and fatty acid esters are produced through the reaction of triglyceride with alcohol in the presence of a catalyst. JME was obtained from a commercial biodiesel plant in Raipur, India, for the current investigation. Table 1 displays the fatty acid compounds found in Jatropha oil.

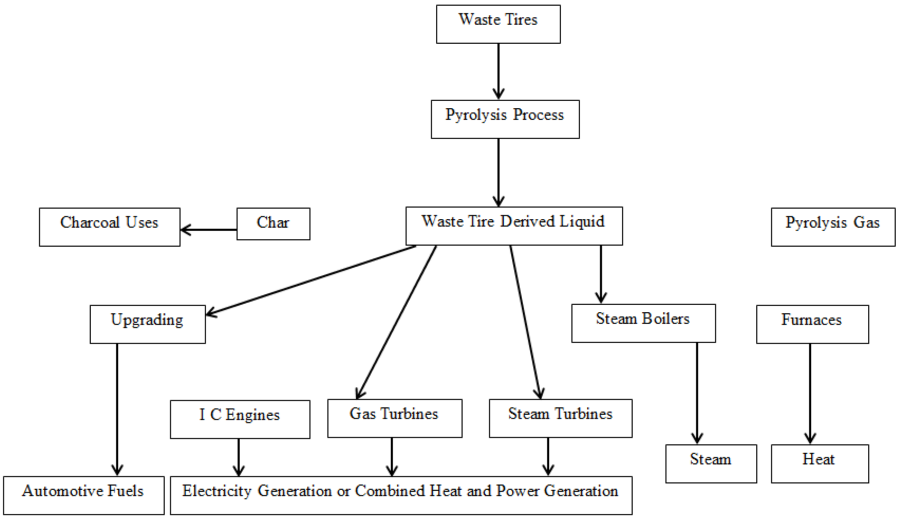

Fig. 2 Pyrolysis process and potential utilizations of end product [6]

A diesel engine with one cylinder, four stroke, air-cooled, direct injection, and a developing power of 4.4 kW at 1500 rpm was used for the experiments. Diesel was used to start the experiments, and once the engine was warm up, it was switched to JB followed by the various test blends. The cylinder pressure history was measured with a data acquisition system, a piezoelectric pressure transducer, and a crank angle encoder. The data acquisition system recorded and processed the pressure–crank angle diagrams in all cases to obtain the combustion parameters. The total amount of fuel consumed was measured with a fuel level indicator. The intake air flow rate was measured with a U-tube manometer connected to an orifice in the suction air box. To measure the temperature of the exhaust gas, a K-type thermocouple was installed. An AVL DiGas444 exhaust gas analyzer was utilized for the measurement of the engine's exhaust emissions. The smoke levels were measured with an AVL437 smoke meter. After all of the tests with the blends, the engine was run again on diesel to make sure the JB/WTDL blends were not in the fuel. This was done to avoid deposits and problems with cold starting.

Results and Discussion

The variation in brake thermal efficiency based on brake power for diesel and blends is depicted in Figure 3. Diesel has the highest brake thermal efficiency of any of the fuels tested, at 29.89% at full load. At full load, it is 28.61 percent for JB, 29.87 percent for B5, 29.88% for B10, 29.88% for B15, and 27.86% for B20. With increasing brake power, diesel, JB and blends improve their thermal efficiency. Thermal efficiency improves when the brake power is increased because more heat is produced in the cylinder. Due to their higher density and low volatility, blends have a lower thermal efficiency than diesel and JB at full load. The thermal efficiency of the blends is significantly lower than that of diesel at low loads [7]. Compared to the other blends, B20 has a higher brake thermal efficiency at full load.

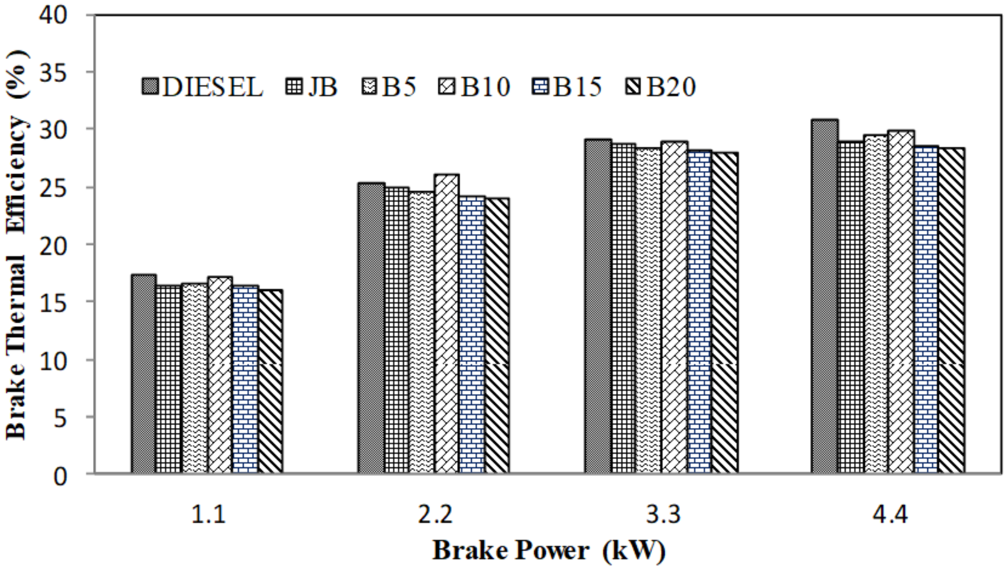

Fig.3 Load vs BTE

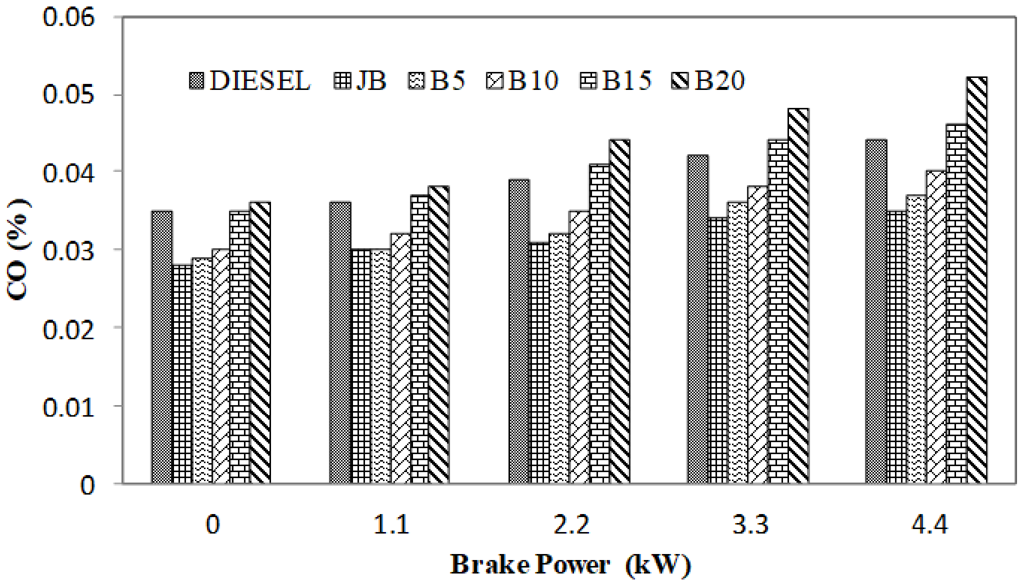

Fig.4 Load vs CO emission

The CO emissions of diesel, JB and blends based on brake power are shown in Figure 4. The operation of a CI engine with a lean mixture results in lower oxygen availability and poor mixture formation, both of which contribute to CO emissions [8]. The graph makes it abundantly clear that diesel emits more CO than blends do. Because the JB too much oxygen, it helps complete combustion, which reduces the amount of CO released [9].

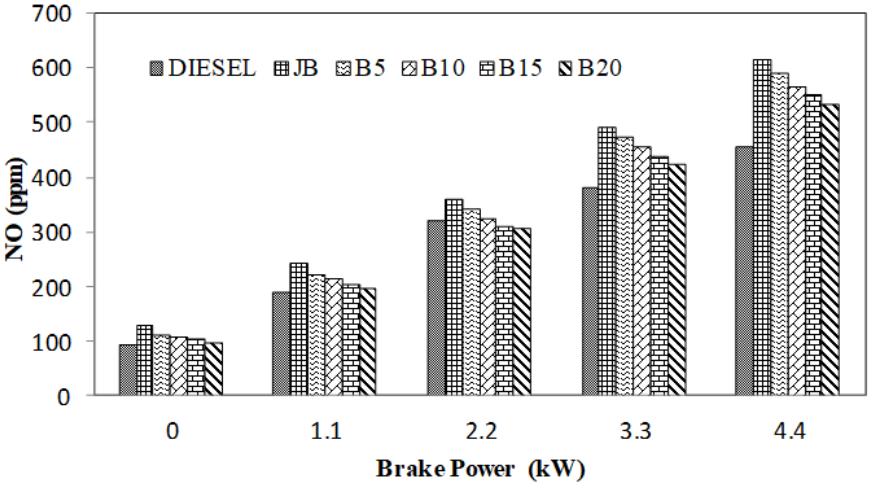

Fig.5 Load vs NO emission

Figure 5 depicts the relationship between brake power and the tested fuels' NO emissions. The NO emanation is exceptionally reliant upon the temperature and accessibility of oxygen inside the chamber [10]. The temperature inside the cylinder rises along with the load Diesel, JB, and test blends have NO_x emissions of 452, 614, 612, 589, 574, and 564 ppm at full load, respectively. The NO discharge is viewed as higher for all the blends contrasted with that of diesel, yet lower than JB. The justification for bring down NO emanation with JMETPO mixes than JME are because of the expansion in sweet-smelling items in the mixes [11].

Conclusion

Experiments with JB-Diesel blends were carried out in a single cylinder, four-stroke, air-cooled, DI diesel engine for the present investigation. When compared to diesel, the engine produces higher NO emissions but lower HC, CO, and smoke emissions and performs similarly with blends. When compared to the other blends, B15 produces the best results.

- At full load, B15 brake thermal efficiency is nearly identical to diesel's.

- At full load, the BSEC for B15 is 11.92 MJ/kWh, while the BSEC for diesel is 11.86 MJ/kWh. With JMETPO15, the BSEC rises by about 0.05%.

- At full load, the B15 EGT is higher than that of diesel.

- At full load, B15 reduces carbon monoxide emissions by about 11.36 percent when compared to diesel.

- At full load, the NO emission for B15 is about 27% higher than that of diesel.

- At full load, the smoke opacity of B15 is about 32% lower than that of diesel.

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