A Review on Application of Different Biofuels in IC Engine

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Abstract- *In India, research and development on biofuels began in the late 1990s. Since then, its commercialization has progressed slowly and with many unknowns. As of not long ago, it has acquired a lot of consideration and ubiquity in India as well asin many regions of the planet, mostly established in certain benefits it has over fossilenergizes. First-generation biofuels, second-generation biofuels, and third-generation biofuels are at least three distinct generations of biofuels. The current paper discusses about different generation of biofuels, their application as internal combustion engine fuels and recent advancements.*

Keywords- Alternative Fuels; Biofuels; Biodiesel; Ethanol; Combustion

I. INTRODUCTION

Since plant biomass contains very little sulfur, biofuels that do not originate from hydrocarbon resources do not result in the emission of sulphur dioxide (SO_2), but they do result in the generation of carbon dioxide (CO_2) credits[1]. Additionally, biofuels exhibit an appealing and appropriate correlation with a variety of viable agricultural production methods worldwide. When burned, they produce significantly fewer emissions than petroleum-based fuels, for example hydrocarbon (HC), carbon monoxide (CO) emissions etc. Even though it has advantages, there is growing concern about how biofuels could compete with other natural resources like land, food, and water. Additionally, because its production depends on the type of biomass and land and the techniques used, the balance of CO is not always positive, which makes it less sustainable[2].

Today, an extraordinary number of organizations have been dealing withfinding an ideal answer for substitution of oil-based fillswith sustainable ones. However, it is evident that each developed technology fits an available raw material, so there is no single technology that could accomplish this general objective.Aviation is one transportation industry sector that has reported a strong growth rate and a strong commitment to the development of alternative fuels. This is primarily due to the fact that decreasing crude oil availability reduces its quality and production yields (the US Energy Information Administration claims that from one barrel of oil, 4 gallons of jet fuel are produced) as well as the associated high CO_2 emissions. The International Air Transport Association (IATA) predicts that by 2030, there will be 7 billion passengers, representing an average annual growth rate of 38% compared to the baseline year of 2014. Although prices are still higher than those of conventional fuels, jet biofuel's commercial spread is limited. In 2015, over 2000 flights on 22 airlines utilized it. Many studies have been done on the fuel derived from waste material [3].

With 1.27 billion people, India is on track to become the world's most populous country[4]. The economy has been expanding at a rate of roughly 8% per year, and energy consumption has also been rising at 8.5% per year. India depends intensely on petroleum derivatives for fulfilling its energy need. As depicted in Fig.1, in 2021, coal, oil, gas, nuclear, hydro, biomass/waste, and other renewables made up 45%, 23%, 6%, 1%, 24%, and less than 0.5% of the total primary energy demand, respectively[5]. India must import oil, coal, and gas because it has very few fossils fuel reserves. The dependence on imports is especially high for oil. 75% of India's demand for oil in 2012 came from imports.

The purpose of this paper is to provide a comprehensive overview of biofuels in India, including their history, current status, and utilized feedstocks, as well as issues pertaining to national policy, technology, and the environment.

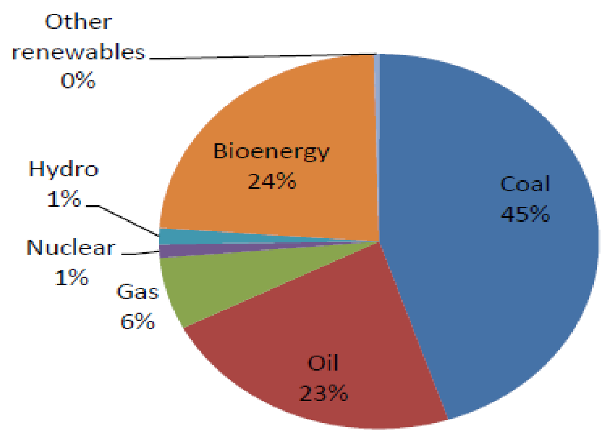

Fig. 1. Energy demand of India [6]

II. BIOFUEL

First-generation biofuels are biodiesel and/or bioethanol made with conventional technology from biore sources like sugar, starch, corn, vegetable oil, or animal fats (mainly using food products as feedstock)[7].As a result, there is a debate about fuel versus food, and issues like food scarcity and rising food prices must be addressed.Non-food biomass and non-food crops typically serve as the feedstock for second-generation biofuels. The feedstock and technologies used can also be used to define second-generation biofuels[8].

Algae and microbes make up the majority of the feedstock for third-generation biofuels (advanced biofuels)[9]. The various generations of biofuels, which can take many different forms, are briefly discussed in next section [10].More than a decade ago, India launched its biofuel program and several policy initiatives to promote biofuels[11]. India introduced its "Ethanol Blending Programme" in 2002 and mandated that ethanol (E5) be blended with gasoline at a rate of 5% beginning in January 2003 in nine States and four Union Territories. In July 2002, the Indian Planning Commission established a Committee on the Development of Biofuels. In its 2003 report, the Committee urged India to gradually increase its goals for the blending of biofuels, including strengthening the ethanol blending program[12].

Fig.2 Different Generation of Biofuels[13]

III. USE OF BIOFUEL AS ENGINE FUEL

A study was carried out when second generation biofuel was used as substitute of diesel fuel[14].The use of renewable fuels to partially or completely replace fossil fuels is the most recent global trend.A single-cylinder, four-stroke, air-cooled, direct injection (DI) engine containing Jatropha methyl ester (JME) and tire pyrolysis oil (TPO) was used in this study to test its performance and emissions characteristics. The engine was fueled by four JMETPO blends: JMETPO5, JMETPO10, JMETPO15, and JMETPO20. Compared to diesel operation, the performance and emission results were analyzed. The investigation reveals that the engine can operate with JMETPO blends without requiring any engine modifications. When compared to diesel, the engine powered by the blends had a slight decrease in the thermal efficiency of the brakes. When compared to diesel, the JMETPO blends produced lower CO, HC, and smoke emissions. The JMETPO blends led to an increase in NO emission. In continuation of the work, the authors carried out rigorous experiment to optimize the engine parameters[15][16].

Using diesel 25% rubber seed biodiesel mixture (B25) blended with 25 ppm and 50 ppm of alumina nanoparticle under various operating conditions, the purpose of this study is to evaluate the performance, combustion, and exhaust emissions of a variable compression ratio diesel engine[17]. Alumina (Al) nanoparticles were uniformly dispersed in the diesel–biodiesel mixture using an ultrasonicate. Biodiesel combination mixed with nanoparticles hasphysico chemical attributes that are tantamount to ASTM (American Culture for Testing and Materials) D6751 limits. The results showed that the B25 had lower HRR (heat release rate) and cylinder peak pressure than diesel at maximum power. BTE (brake thermal efficiency) of B25 is 2.2% lower than that of diesel, but B25's BSFC is 6% higher than diesel's. For B25, smoke, HC (hydrocarbon), and CO (carbon monoxide) emissions were lower at maximum power, while NOx (nitrogen oxide) emissions were higher. Additionally, the addition of alumina nanoparticles to biodiesel blends improved diesel engine performance and combustion. The BTE of the B25 with 50% alumina nanoparticles (B25Al50) mixture increased by 4.8% in comparison to B25, the BSFC decreased by 8.5%, and smoke, HC, and CO also decreased by 36%, 20%, and 44%, respectively. With 50% alumina nanoparticles in a biodiesel blend (B25Al50), the maximum cylinder pressure and HRR of B25 improved by 4.2% and 6.7%, respectively, at peak load.

Many attempts have been done when biofuels are used using different techniques [18]. Sometimes additives were used to enhance the properties of fuel. In recent time fuel derived from waste is more preferred [19][20].

IV. CONCLUSION

Although first-generation biofuels may come with some restrictions, such as energy consumption and the use of arable land, as well as the fuel versus food debate, they are widely used worldwide.

Nonetheless, they continue to be a reliable and financially attainable strategy for reducing fossil fuel consumption and ensuring sustainability. In countries like Brazil, one of the most significant producers of ethanol and sugar in the world, the production of biofuels decreases as a result of the tight competition between the sugar market and the ethanol market. Ethanol from corn is restricted by a comparable Catch 22 with the rising worth of food on the world's market. The same is true for the market for biodiesel, which is constrained by the cost of vegetable oils. Second-generation biofuels are gaining popularity as feedstock prices continue to rise in all cases. The latter is made from biomass that typically costs less, like waste from farms, animals, forests, and cities. For the production of second-generation biofuels, numerous methods are being investigated worldwide, but they all rely on two distinct pathways: either "bio" or "thermo." The "thermo" method involves treating biomass with heat at low or no concentrations of oxidizing agents (CO2, H2O, water, air, or O2). The lower spectrum will primarily result in the production of biochar, a solid biofuel, between 300 and 1,000 °C. Pyrolytic oil is the most common product in the middle spectrum, followed by syngas at high temperatures.

Syngas and pyrolytic oil could be thought of as intermediaries in the process of producing biofuels (like ethanol, diesel, and gasoline) later on. Biomass is transformed into biofuels through the use of microorganisms, typically yeasts, in the "bio" pathway. In order to separate cellulose from the other macromolecules in the biomass, the procedure calls for pre-treatment. Even though the process has been shown to be effective, the "bio" approach needs to use all of the carbon in the lignocellulosic biomass to save money. This makes the biomass into a "biorefinery" that can produce a wide range of biofuels and bio commodities. The majority of third-generation biofuels are related to algae.

As a result, the feedstock is the primary distinction between the second and third generations. A researcher from Sandia National Laboratories sees an algae sample as part of a project to cultivate green algae as a new source of biofuel. Algae are known to produce biomass more quickly and on demand compared with lignocellulose biomass, increased land surface.

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