Potential of India for Ethanol as a Transportation Fuel

Vivek Pandey[1], Vatsal Garg[2], Niraj Singh[3], Deepak Bhasker[4], Partha Pratim Dutta[5]

[1, 2, 3,4]*Department of Mechanical Engineering, Maharaja Agarsain Institute of technology Pilukhuva, Ghaziabad, Uttar Pradesh*

[5]*Department of Mechanical Engineering, Tezpur University, Tezpur, Assam*

ABSTRACT

Ethanol being an oxygenate fuel proved to be a good substitute for petrol and diesel engine with little or no modification into the engine make up. At present, ethanol is the most widely produced biofuels in India. it is mainly produced using sugarcane as feedstock. For successful implementation of the EBP (Ethanol Blending Programme) in the country, a steady supply of sugarcane (or sugarcane juice) as feedstock is required. Sugarcane and molasses which are suitable feedstock for ethanol production are not able to fulfill the government mandation of ethanol blending in the future. On the other hand cellulosic biomasses which are available in abundant amount in India have potential to replace 20% petroleum based fossil fuels by 2017. The present paper discusses first and second generation ethanol fuel. Ethanol as an IC engine fuel posses little or no problem with petrol engine but with diesel engine it poses some problem which require further research. Presently India uses only 5% blending of ethanol. However, for achieving higher ethanol blending programme which was established by government of India, a continuous supply of this fuel is needed which can be fulfill by second generation ethanol due to abundance of biomasses in India. This paper also focuses on some experimental studies which were conducted in the past by using ethanol blend in diesel and petrol engine.

Keywords: Ethanol, Biofuels, Ethanol blending programme, Sugarcane, Molasses, Biomass.

1. INTRODUCTION

According to worlds coal Institute, India is producing 2.4% of the world's total annual energy. Whereas it is consuming 3.7% of the world total energy consumption [1]. This is how India is the fifth largest consumer of energy in the world, and is likely to surpass Japan and Russia to become worlds third biggest energy consumer by 2030[2]. Biofuels are going to play an extremely important role in meeting India's energy needs. The country energy demand is expected to grow at an annual rate of 4.8% over the next couple of decades. Biofuels are renewable liquid fuels coming from biological raw materials and have been proved to be good substitutes for oil in transportation sector. Biofuels such as ethanol is gaining momentum over the whole world as a solution to

environmental problem, energy security, reducing imports, rural employment, and improving agricultural economy and also to achieve prescribed emission norms [3].

2. ETHANOL POTENTIAL OF INDIA

First and second generation ethanol. India mainly uses first generation feedstocks such as sugarcane molasses for ethanol production. The availability of surplus ethanol from molasses is very limited. The other option for first generation ethanol is starchy biomass like grains and tubers. However, in a country like India with the world's second largest population to feed, and with more than 238 million people living below the poverty line sparing food crops for ethanol production is not an option[4]. Whereas Second generation ethanol which is made from cellulosic biomass such as corn Stover, switch grass, crop residues. India produces 440 MT of crop residues annually; this translates to about 130 MT of ethanol per annum. Cellulosic ethanol is in new stage in India. It is in R&D stage only and few pilot projects are running on this. The following table presents the key differences between first (conventional) and second (cellulosic) generation ethanol.

. Table. 1 Conventional and Cellulosic Ethanol – Comparison

Aspect	Conventional Ethanol	Cellulosic Ethanol
Choice of Feedstock	Feedstock's are agriculture plants like corn wheat, soybeans, sugarcane etc	Feedstocks are agricultural plant wastes like corn stover, cereal straws, and sugarcane bagasse, plant wastes from industrial processes like sawdust, paper pulp as well as switchgrass.
Food vs Fuel	Ethanol production carries the risk that food cropping will turn into more lucrative fuel-cropping	Cellulosic ethanol production prevents the danger
Feedstock Availability	The supply of raw material is scarce	The supply of raw material is much higher than that for first generation ethanol
Fertilizer and Water Use	High amounts of fertilizers and water essential for ethanol production	The quantities of fertilizers and waters required are not as high as those for feedstocks for first generation ethanol
Production Process	Corn ethanol extraction from feedstock is simple and economic.	Cellulosic ethanol extraction from feedstock is complex and less economic.

The only disadvantage of cellulosic ethanol lies in the difficulty with which it is presently extracted. India is still lacking in mature technologies for ethanol production from biomasses which is by far the most abundant energy source.

Ethanol supply and demand in India. India is the fourth largest producer of ethanol in the world. India uses sugar, cereals, sugar beet to molasses as a raw material ethanol production. The average sugar cane productivity in India is about 70MT per hectare and ethanol produced from one MT of sugar cane is 70 litres. According to Indian Sugar Mills Association (ISMA), annual sugarcane production in 2011-12 is estimated to be around 380 million tones. In a recent report, the US Department of Agriculture (USDA) has pegged India's ethanol production at 2,170 million litres in 2012, against 1,681 million litres last year. On the total sugarcane production in India, 60% is utilized for sugar production by sugar mills. At present condition also, 25-30% of sugarcane produced is processed for production of unrefined sugar [5]. In the year 2003, the Report of the Committee on Development of Biofuels published by the Planning Commission of India gave projections of demand and supply of ethanol for India for the end of each five-year plan (shown in Table 2)[6].

Table 2: Projected Demand and Supply of Ethanol (million litres)

Year	Ethanol production			Ethanol utilisation			Ethanol Blending Requirement for Transport Sector		Petrol Demand
	Molasses	*Cane*	*Total*	*Industry*	*Potable*	*Balance*			
2001–02	1775	0	1775	600	648	527	5%	448.03	8,960.52
							10%	896.05	
							20%	1,792.10	
2006–07	2300	1485	3785	711	765	2309	5%	638.14	12,762.72
							10%	1,276.27	
							20%	2,552.54	
2011–12	2300	1485	3785	844	887	2054	5%	814.30	16,286.09
							10%	1,628.61	
							20%	3,257.22	
2016–17	2300	1485	3785	1003	1028	1754	5%	1,039.27	20,785.36
							10%	2,078.54	
							20%	4,157.07	

This report shows the break-up of production and consumption of ethanol in terms of molasses and cane.

Ethanol as a motor fuel - Advantages and Disadvantages. The total registered motor vehicles in India in fiscal year 2005/06 numbered approximately 90 million [7]. Increased motorization and tight emission norms has accelerated ethanol blending programme in India in last few years. Presently bioethanol consumption is restricted to transportation sector only. The Indian biofuels consumption market had total revenue of $277 million in 2010, representing an annual growth rate (CAGR) of 18.6% for the period 2006-2010 [8]. By 2017, the government of India (GOI) mandates replacing 20% of petroleum based motor fuel with biofuels.

The advantages of using ethanol as automobile fuel is that they are oxygenate containing 35% oxygen and are renewable. They reduce hydrocarbon emissions such as CO and eliminate emission of lead, benzene; butadiene etc. The calorific value of ethanol is lower than that of gasoline by 40%. It makes up a part by increased efficiency. Blends below 10% of ethanol do not present problems. However, blends above 20% pose certain difficulties such as (i) higher aldehyde emission(ii) corrosiveness, affecting metallic parts, but 10% ethanol blend no compatibility problem have been found (iii)higher latent heat of vaporization causing start ability problem, but blends upto 25% ethanol in gasoline poses no problem. (iv) higher evaporation losses due to higher vapour pressure and(v) requiring large fuel tank due to lower calorific value. Table 3 presents properties of ethanol as compared to conventional fuel [9].

Table 3: Energy value and properties of various fuels

Parameter	Petrol	Diesel	Ethanol
Energy content(MJ/Kg	43.65	45.15	29.73
Liquid density (Kg/I)	0.735	0.843-o.848	0.77843
Energy density (MJ/I)	32.1	38.16	23.32
Normal b.p.(0 c)	37-205	140-360	79
Octane#	91-97	25	111
Cetane#	0-5	45-55	5

Recent trends of ethanol in diesel and petrol engines. In diesel engines ethanol blend poses some problem. A 15% ethanol blend reduce particulate emission, however the blend provides certain technical problems. Ethanol reduces the flash point of blend to 13°C. it reduces the lubricity of fuel and causes wear of piston rings and injector. Ethanol and diesel does not mix properly, Effective emulsifier is required. The cetane no of ethanol is just 8 and so reduces the cetane no of diesel on blending.

The greatest scale fleet trials is being conducted in the state of Karnataka in India, where the largest ethanol-diesel fleet in the world comprises about 5,200 buses using O2-diesel(Enerdiesel), a diesel containing 7.7% ethanol and 0.5% biomass based additives[10]. In the past it was reported that ethanol diesel blend up to 20% can be used in constant speed engines without any hardware modifications and leads to significant reductions in CO and NOx emission[11].

Engine performance, combustion and exhaust emission characteristics of a single cylinder four stroke diesel engine using different blends of ethanol such as E0-neat diesel,E10, E20,E30,E40 and E50 was tested. To satisfy homogeneity and prevent phase separation, 3% of ethyl acetate was added to ethanol-diesel blend. This study shows that BTE is improved by 8% for 10% ethanol addition and only 2% increases on further ethanol addition with added advantages of reduced specific fuel consumption. Ignition retards and combustion duration shorten, which results in rapid combustion and NOx emission is reduced by 8% with 10% of ethanol blend [12]. Experiment on hexanol as an additive to prevent phase separation was also observed. Five kinds of fuel were prepared: diesel (D0) as base line fuel, 20% ethanol blending with 105 hexanol and 705 diesel(denoted as D20E) similarly D25E, D35E and D45E. Among these blends D20E shows higher BTE and D35E shows better smoke reduction, D25E shows maximum heat release rate. Finally, all the blends slightly increase the NOx emission beyond 75% load than that of diesel [13].

Ethanol is a high performance biomass fuel. It is most suited alcohol for SI engine. The most attractive property of ethanol is its ability to be produced from renewable energy sources, its high octane no, and its high laminar flame speed [14].

In gasoline engine different blends of ethanol has been tested. A 4-stroke, four cylinder, varying RPM, petrol(MPFI) engine was tested on blends containing 5%, 10%, 15%, 20% ethanol and it was found that exhaust gas emission such as HC,O2, CO,CO2, decreases and BTE increases. Result shows that 10% ethanol blend is most attractive and we can utilize it for further use in SI engine with little constraint on material used to sustain little increase in pressure [15]. It was observed that ethanol blends (up to 30% by volume), when used as a fuel in spark ignition engines, reduce NOx emissions [16]. Other experiment has reported that emission of NOx is same for E10 and gasoline

[17]. As for as emission is concerned, ethanol blending with gasoline decreases many toxics, such as aldehydes in presence of ethanol which acts as a ozone precursor and increases the smog-formation potential [18].

Catalytic converters have been used to reduce pollutants in SI engine reduction of pollutants depends upon mass of catalyst, amount of air injected in catalytic chamber [19]. Engine modification with copper coatings on piston crown and inner side of cylinder head improves engine performance as copper is a good conductor of heat and combustion is improved with copper coating. In a experiment of 2-stroke, single cylinder SI engine, with alcohol blended gasoline(80% gasoline, 10% methanol, 10% ethanol by volume) having copper coated combustion chamber provided with catalytic converter with sponge iron as catalyst. The result shows that thermal efficiency increased by 9%, 8% and exhaust gas temperature decreased by 19%, 5% with gasoline operation and alcohol blended gasoline operation respectively[20].

3. CONCLUSION

In India the ethanol industry is mature, but with efficiency improvements, the use of alternate crops and the deployment of new technologies like enzymatic fermentation of cellulosic material, it can easily supply the ethanol requirements for 5 per cent or even 10 per cent ethanol blending. It is technically feasible to design and run automobiles on 100% ethanol; but for the reason of availability and compatibility with vehicles presently in use, blending of ethanol with motor spirit needs to make a very modest beginning. Second Generation Biofuels Can Provide a Solution to India's Transport Fuel Woes, But Only If Government and Industry Take Proactive Measures and Make Significant Investments. Being oxygenate fuel ethanol offers less emission in IC engines. In diesel engine, ethanol does not mix with diesel, hence effective emulsifiers are required and to prevent phase separation certain additives are required. Catalytic converters are used in petrol engine to reduce pollutants. Ethanol has less calorific value which is compensated by improved thermal efficiency.

REFERENCES

[1] The Brookings Foreign Policy Studies Energy Security Series India, November 2006. www.brookings.edu/~/media/research/files/reports/.../india/2006india.pdf.

[2] Report of the committee on the development of biofuels. Planing commission government of India New Delhi. April 16, 2003.

[3] National Sample Survey Reports, National Sample Survey Organization. Ministry of Statistics and Program Implementation, Government of India.2007 http://www.mospi.gov.in/mospi_nsso_rept_pubn.htm.

[4] Sharma Y.C, B. Singh and S.N. Upadhyay. 2008. Advancements in development and characterization of biodiesel: A review. Fuel. 87: 2355-2373.

[5] Ray S, Miglai S, Goldar A. ICRIER Policy Series, ethanol blending policy in india: demand and supply issues. December 2011.

[6] Mustard A, Biofuels Annual. India, 2012. gain.fas.usda.gov/.../Biofuels%20 Annual_New%20Delhi_India_6-20-20.

[7] Biofuel Consumption In India.Market Research Report Portal. nebulodi.com/ko/Biofuel_Consumption_in_India.htm.

[8] Srivastava A, Srivastava S , Nigam A.C. Alternative Fuel for Transportation. International Journal of Environmental Sciences 2010; 1(2): 191-197.

[9] ENVIS (Environmental Information System), MoEF (Ministry of Environment and Forests), Government of India, Web site, "Pollution control technology." http://www.terienvis.nic.in, accessed 2007.

[10] Agarwal, Avinash Kumar. 2007. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines, Progress in Energy and Combustion Science, 33, pp.233-71.

[11] Gnanamoorthi V, Devaradjane G. Effect of Diesel-Ethanol Blends on Performance, Combustion and Exhaust Emission of a Diesel Engine. International Journal of Current Engineering and Technology 2013; 3(1): 36-42.

[12] Sathiyagnanam A.P, Saravanan C.G, Gopalakrishnan M. Hexanol-Ethanol Diesel Blends on DI-Diesel Engine to Study the Combustion and Emission. Proceedings of the World Congress on Engineering 2010; 2: ISBN: 978-988-18210-7-2.

[13] Bayraktar, H., 2005, "Experimental and Theoretical Investigation of Using Gasoline-Ethanol Blends in Spark-Ignition Engines," Renewable Energy, 30, pp. 1733-1747.

[14] Kumar J, Ansari N.A, Verma V, Kumar S. Exhaust Gas Analysis and Parametric Study of Ethanol Blended Gasoline Fuel in Spark Ignition Engine. American Journal of Engineering Research (AJER) 2013; 2(7): 191-201.

[15] Baghdadi-Al, M., 2008, "Measurement and Prediction Study of the Effect of Ethanol Blending on the Performance and Pollutants Emission of a Four-Stroke Spark Ignition Engine," IMechE, 222(D), pp. 859-873.

[16] Karman, D., 2003, "Ethanol Fuelled Motor Vehicle Emissions: A Literature Review," Health Canada, Carleton University.

[17] Sahu R. Overview- Impacts of Mid-Level Ethanol On- Road and non road engines and equipment, 2009. nmma.org/.../Exhibit%20A-1%20ALLSAFE%20e-15%20Waiver%20Co.

[18] Murali Krishna M.V.S, Kishor K. Control of pollutants from copper coated spark ignition engine with methanol blended gasoline, Indian Journal of Environmental Projection 2005; 25 (8):732-738.

[19] Murali Krishna M.V.S, Kishor K, Prasad P.R.K, Swathy G.V.V. Parametric studies of pollutants from copper coated spark ignition engine with catalytic converter with gasoline blended methanol, Journal of Current Sciences 2006; 9 (2):529-534.

[20] Kishor K, Murali Krishna M.V.S, Murthy P.V.K. Comparative Studies on PerformanceParameters and Exhaust Emissions from Four Stroke Copper Coated Spark Ignition Engine with Alcohol Blended Gasoline with Catalytic Converter. International Journal of Innovative Research in Science, Engineering and Technology 2013;2(12):7343-7352.