

Ethanol based Waste to Energy Conversion System as Distributed Generation for Electric Vehicle Charging

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Abstract: Most of the environmental, health related problems are caused due to waste. From the very ancient times people follow cleanliness as a tradition only to escape from the diseases. To make our society clean and neat, a very place to live happily various engineers and chemical scientists drafted various technologies to conserve waste and process it without affecting either the environment or social lives. Waste comprises of variety of things and mainly it comprises some content of energy. This energy content will be extracted to some useful work by adopting certain kinds of technologies persistent and not confined to those particular areas. This paper intends to present some methodologies involving in waste processing with views and comments related to it. A comprehensive study is made to understand those technologies and their impact is being presented in this paper. This study has been extended on the usage of ethanol as fuel for hybrid electric vehicle and charging of electric vehicles after few electrical and electronic conversions.

Keywords: Biomass, Biogas, Distributed generation, Electronics, Electric vehicle, Ethanol, Waste to energy.

1. Introduction

Latest statics from World Bank show that, in the year 2016, the world generated an amount of 0.74 kgs of waste per capita per day globally which is a significant figure. In the latest statistics it has been shown that the amount of waste generation has already at its peak to about 2.01 billion tones. Though the waste is produced in such huge quantity, not at least 1/3rd of it is processed and handled in an environmental friendly way. An urgent initiative must be taken towards poor handling, unmanaged type of wastes because these type of waste contaminates the environmental properties like rivers, seas, demographic lands. This contamination is the root cause of disease transmission and adverse environmental changes like greenhouse gases, global warming.

Waste- Municipal solid waste, waste from houses, electronic waste, industrial waste are varieties of wastes largely produced in any area or country. Managing of solid waste is vital for any urban or developed area because it is closely linked with

environmental health. It is the Environmental health which has key role in development of any urban area.

After processing the waste from different facilities the next approach will be to use that energy content for some useful work. Waste from domestic utilities particularly from the kitchen waste few pounds of vegetable and fruit peels and other kitchen waste and processed to get ethanol from starch content and by product of ethanol is syngas or synthetic gas will be obtained. Syngas will be utilized to produce electricity and ethanol engines implemented will also produce electricity and this electric energy will be used to charge stand by electric vehicle. This process when implemented at large scale is found to be useful.

Section II of this paper presents comprehensive results for generating electricity from waste and process involved in this journey. Fig. 1 shows the amount waste generated and processed from all states of INDIA according to an article published in July 2018 in Times of India newspaper.

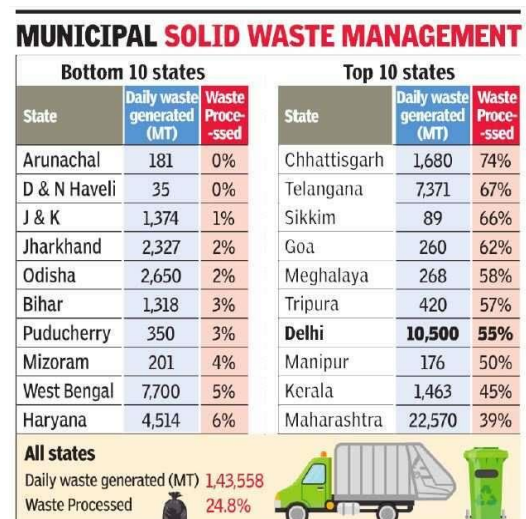


Fig. 1. Amount of waste generated and processed in India in the year 2018
*courtesy: Times of India 2018

2. Problem Formulation

A. Waste generation and poor management of waste

The garbage of Municipal and its management in most of the places of India is quite a key issue since people dump tons of waste in open land and leave it to environment to process. In this process lots of microorganisms decompose it to have adverse effects on health of human life, flora, fauna and environment. To lessen this effect proper processing and management of waste is necessary. Though it is waste for the world, engineers and scientist see that waste as energy source and through engineering process the energy stored in that waste is converted to useful energy for other utility purposes.

B. Charging and discharging of Electric Vehicles

Universal problem hindering the development in electric vehicle and encouragement in market is duration time for battery to charge and its weight. These constraints encouraged hybrid electric vehicle (HEV). In HEV, additional energy source is gasoline fuel which is connected to generator and this generator charges the battery and propulsion motor gets operated. The functional block diagram of Hybrid electric vehicle is shown in fig. 2.

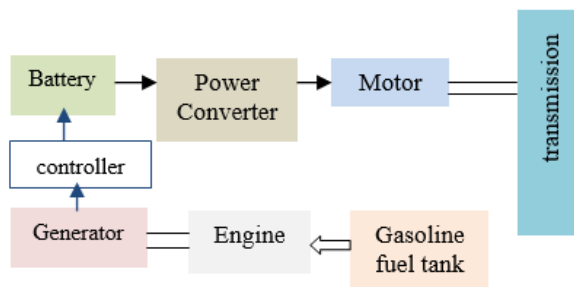


Fig. 2. Functional block diagram of hybrid electric vehicle

Based on the power flow, HEV is categorized as

1. Series HEV
2. Parallel HEV
3. Series-Parallel HEV

Though HEV developed and satisfactory result obtained, environmentalists suggested elimination of gasoline fuel. This led to use of pure electric vehicles with distributed fast charging points and battery swap points in the vicinity. In the course of time, engineers concentrated on the renewable energy sources and concept of local or distributed generation. This viable concept led to a thought of reducing waste in environment and contribution in global climate change and waste used for charging of battery in Electric vehicle in economic budget range. This idea is elaborately presented in the block diagram shown in fig. 6.

3. Waste Processing Methodologies

Though there are various methods to process different types of waste, in this section some of the common methods used by people and authorities is being discussed. Proper processing of

waste is termed to be waste management.

A. Landfills

It is the common method and widely adopted method to dump waste in the open lands. This type of methodology is found in developing countries. Since this method require large open spaces, now-a-days it is becoming less adopted due to unavailable open lands. The severe effects of Landfills are air and water pollution.

B. Incineration

The word Incineration refers to Combustion or burning in presence of oxygen. In this method municipal waste will be burned at high temperatures considering some thermodynamics conditions. The eventual product for this process is residues and gaseous products. The exclusiveness of this method is that it can reduce volume of waste to 20-30% of original volume in less space which makes this method to overcome Landfills method at some countries which has very less open space like US and Japan. Incinerators are used to convert or burn solid waste to ash, gas, residue or steam based on the type of waste input.

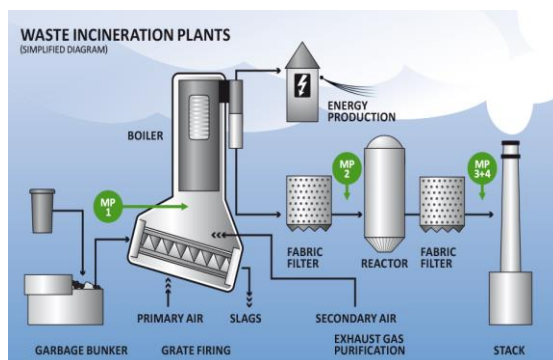


Fig. 3. Incineration process

C. Plasma gasification

Plasma is electrified charged or ionized gas which is produced at around 12500°F. this method uses a container consisting of plasma torches operating at +10000°F with gasification zone limited to 3000°F. in gasification zone solid waste is converted to syngas. Fig. 4 shows the process involved in plasma gasification.

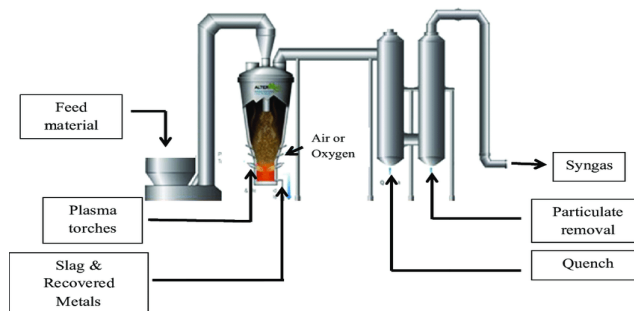
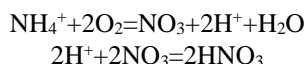


Fig. 4. Plasma Gasification Process

D. Composting

In this method, the organic waste is composted and goes through various phases like mesospheric, thermal, cooling and maturation which will be observed through temperature regime. Out of these phases, concentration of bacteria is high in mesospheric stage and decreases there on from this stage to maturation. The composting method takes place in four steps namely (1) collection and crushing (2) addition of catalysts (3) homogenization (4) Manure formation.

In this course of steps, the reactions and content of manure is given as,



Content percentage in manure

pH	:	7.10
Nitrogen	:	1.13%
Phosphorous compounds	:	0.852%
Magnesium	:	0.476%
Carbon	:	18.30%

4. Proposed Work

In the proposed block diagram, the ethanol as produced from waste processing unit is sent to the generation unit. The generation unit is similar to that of diesel generation system. Since there are various renewable sources available, this ethanol generation unit can be integrated with other renewable sources. A power electronic converter (rectifier and inverter stack) are necessary component in the proposed topology to maintain the electrical standards and quality power. The following mathematical modeled equation describes the process of ethanol formation.

For cell concentration, the logistic model derives as,

$$\frac{dx}{dt} = \mu_m x \left(1 - \frac{x}{x_m}\right) \tag{1}$$

With respect to fermentation conditions and boundary values as t=0, x=x₀ while μ_m is maximum specific growth rate. Further simplifying and integration led to kinetic model of biomass production rate as

$$x = \frac{x_0 x_m e^{\mu_m t}}{x_m - x_0 + x_0 e^{\mu_m t}} \tag{2}$$

Equation 2 represents the relation between fermentation rate and biomass.

Further mathematical calculation leads to final product of rate of ethanol generation from the given biomass as,

$$P = Y_p \left[\frac{x_0 x_m e^{\mu_m (t-\Delta t)}}{x_m - x_0 + x_0 e^{\mu_m (t-\Delta t)}} - \frac{x_0 x_m e^{-\mu_m t}}{x_m - x_0 + x_0 e^{-\mu_m t}} \right] \tag{3}$$

Though the efficiency of ethanol engine is quite lesser than diesel generator, it can be widely adopted due to the fact that ethanol produced here is from organic waste and the cost incurred is only for the installation.

The further step for the proposed work is electricity production from the ethanol engine. A system consisting the couple of converters and storage systems is designed based on the rate of ethanol production. A remote system produces the ethanol fuel and used at the generation unit to produce the electricity from the waste and transmitted to the load end which is the vehicle charging point. The onboard vehicle configuration for electric vehicle is shown in fig. 5.

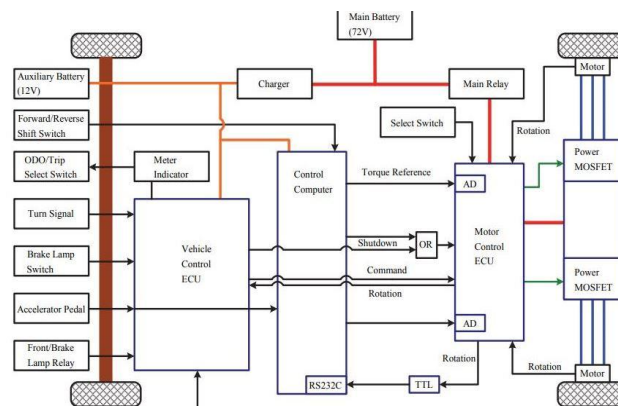


Fig. 5. Vehicle Configuration

The electronic components like microprocessors and microcontrollers are used for controlling the operation of the vehicle.

5. Results

The fuel consumption of vehicle is estimated by simulation of vehicle models and mathematical equations, models when operated by gasoline, ethanol blends E50 and E85 as shown in fig. 7.

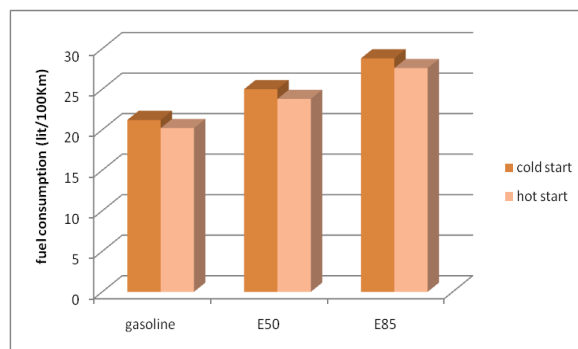


Fig. 7. Fuel consumption of vehicle

The same energy content of ethanol E85 can be converted to electrical equivalent to be utilized by electric vehicle battery for charging.

The saccharification of rice straw, wheat and Baggase is shown in the fig. 8.

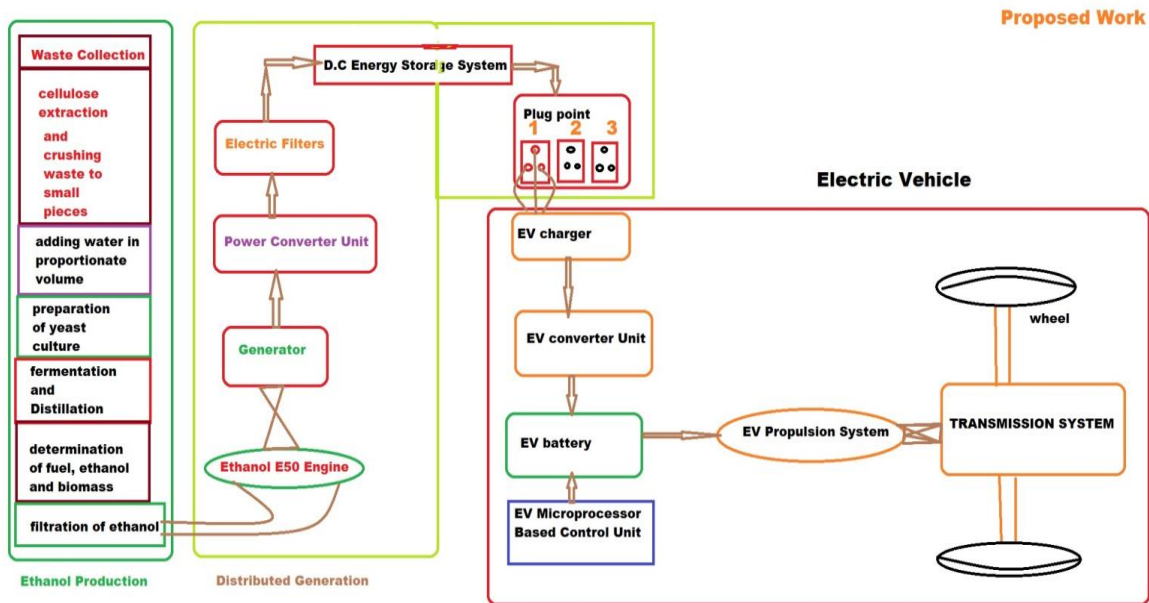


Fig. 6. Proposed block diagram

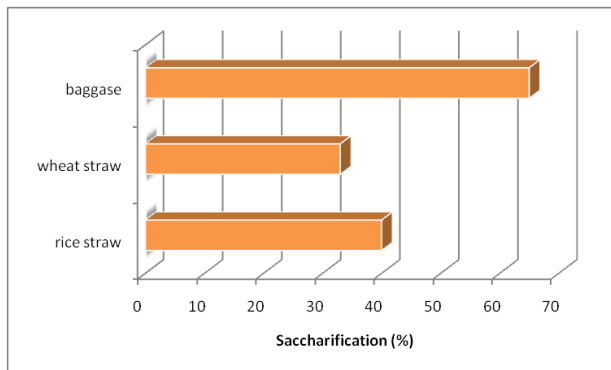


Fig. 8. Saccharification of different organic waste

The fig. 9 shows the ethanol concentration in gram/Litre for different duration of times.

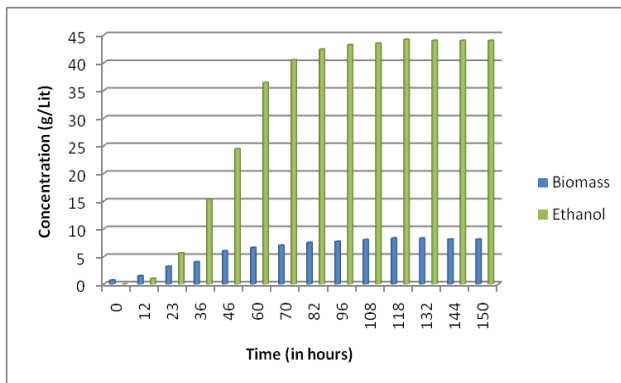


Fig. 9. Ethanol Production in different hours of time

6. Conclusion

The proposed work describes how to convert waste into

useful energy and application is chosen in a way to deal the existing factor hindering the growth and development of electric vehicle. Due to the insufficient charging points, the development of electric vehicle has been a step back in modern transportation. Also the environmental degradation due to waste is addressed in such way that two literature problems can be solved, namely, the environmental pollution due to waste and waste management and charging of electric vehicles which are global problems. Proper waste management can lead to good efficiency for the proposed work. The microprocessor control unit monitors the waste input and rate of ethanol production based on which the generation system can be operated. This microprocessor control unit is situated in distributed generation block of fig. 5. Clean and Green energy concept can be achieved with the work presented in this paper. The specific energy for ethanol is lesser than that of diesel engine and hence efficiency would be less. The specific energy of ethanol can be improved by blending ethanol with gasoline thereby forming Gasohol. Since ethanol generated from waste, efficiency can be compromised and the cost incurred will be installation and minimum maintenance costs. In the long run, the impact of waste on environment will be significantly reduced and problems persisting to the Electric Vehicle can be addressed in well manner.

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