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Study on Potential of Gasification Technology for Municipal Solid Waste (MSW) in Pune City

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Abstract

Solid waste disposal problem is a growing concern of today's world. It creates serious health hazards and environmental issues need to be tackled on urgent basis. Developing economy like India is facing the waste disposal problem due to the rapid industrialization, population growth and changing lifestyle. Like other parts of the country, we have noticed that in Pune City also, per capita waste generation is growing steadily mainly due to the changed lifestyle. The increased volume of waste generation in last 10 years has created stress on the natural resources. If this waste be suitably utilized for energy production instead of incineration or just dumping in the ground, simultaneous reduction in environmental pollution along with proper utilization of waste will be done. Gasification Technology is an efficient one as most of the solid wastes, irrespective of the sources and materials present can be gasified directly to obtain synthesis gas or producer gas having sufficient calorific value. The gas obtained can be used as fuel or can be utilized to generate electricity, even it can produce plethora of various petrochemical products. We have conducted a mathematical modeling and simulation study on a downdraft gasifier to highlight its potential in waste disposal problem for Pune city.

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Keywords: Municipal solid waste; Gasification; Waste to energy; Sustainability; Downdraft gasifier

1. Introduction

Energy crisis is an ever increasing concern across the globe as most of the countries face severe problem of rising energy demands and finding alternatives to meet the same. The conventional energy sources are being exploited on a

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very large scale and it may lead to serious energy crisis in coming fifty years [1]. Hence, there is a dire need of harnessing the potential of renewable energy sources like solar, wind, tidal, geothermal etc. These energy sources are clean, non-depleting and hence termed renewable. Biomass gasification can serve as a feasible alternative of reducing the environmental pollution as well as reducing the gap of the rising energy demands. Biomass being abundantly available in nature as well as being produced by human activities can easily be obtained at sufficiently low cost, even sometimes some initiatives can be received in turn for processing the wastes. A self-sustaining gasification technology for waste material can be devised in conjunction with power generating devices. The quantum of pollution in gasification is much less compared to incineration technique which is generally utilized for speedy waste disposal. The energy produced in gasification process can reduce the dependence on conventional energy sources and hence it can be termed as dual green and environment friendly technology. The municipal solid waste (MSW) produced in urban areas can be utilized as a low-cost or zero cost biomass for gasification. The gasification utilizes thermochemical conversion and hence much faster compared to the microbial process of biogas generation. Biogas digesters are unable to handle solid wastes containing polymeric material, paper, plastic etc. which causes blockage of pores and sometimes toxic to the microbes and hence the rate of digestion of organic fraction is reduced, even can completely be stopped for the extreme conditions. Gasification technology is independent of microbial culture and its sensitive operating parameters. Gas obtained from gasifier have much higher calorific value compared to the biogas plant [2]. Researchers have carried out experimentation to study gasification process [2,3] and also conducted mathematical modeling and simulation studies for better understanding the gasification technique [3,4]. Gasification process was modeled in various ways, namely single stage modeling, sub-zone modeling, kinetic modeling, even artificial neural network [4] was also been used. Due to the complexities of reactions occurring in a gasifier, the exact prediction of all the reactions often difficult and hence modeling of all the zones encompassing all reactions together is still remains a challenge [4].

Nomenclature

$C_{p,x}$	*specific heat capacity*
H	*Enthalpy*
K_{eq}	*Equilibrium constants*
P	*Pressure*
R	*Gas constant*
R_x	*Rate of formation of x species*
T	*Temperature*
h	*mole of hydrogen per mol of carbon*
o	*mole of oxygen per mol of carbon*
$n_{p,x}$	*no. of moles of species x in pyrolysis*
$n_{ox,x}$	*no. of moles of species x in oxidation*
n_x	*concentration of species x*
r_i	*rate of i^{th} reaction*
y_x	*mole fraction of species x*
v	*gas velocity*
n	*total molar concentration*
z	*length of reduction zone*
ρ_g	*gas density*
w	*amount of water*
α	*amount of air*

The gasification of MSW will be an effective technique to reduce waste due to following:

- Comparatively fast reduction of waste: Gasification is relatively faster process than conventional processes. Hence, more amount of waste can be treated in minimum time.