PRODUCTION OF SYNGAS FROM PLASTIC WASTE THROUGH FIXED BED GASIFIER, HYDERABAD CITY

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ABSTRACT: *Gasification is a process in which fuel is converted into syngas which can be used as an alternative for natural gas. The main objective is to convert the plastic waste into syngas through a gasifier. Plastic waste is non-degradable waste that leads to accumulation in the earth and causes an environmental burden. The main purpose was to work on the fabrication of a gasifier that can be utilized for the conversion of plastic waste into energy which can be used for many purposes. The temperature required for this process is 700 C-1000C. Plastic was shredded through a shredder was done which exhibits the characteristics of feeding material. The sample analysis in analytical balance device, electric oven, muffle furnace, fixed bed gasifier, gas chromatography. In this study, three types of different plastic waste samples taken, and each sample took two samples and the equal total weight of sample on 750g and 900g, on different temperatures. The samples run in a gasifier through different scenarios. Scenario two is producing good quality syngas 431g to 465g average according to rising in temperature 300C. The efficiency of scenario two is 52.14% which should be more to make it environmentally sustainable. The composition of gas which had produced has 4.9-6.1% CO, 8-10.4% H_2, 22-23% CO_2, 1.1-1.6% CH_4 and 57-63% other gases were present such as nitrogen, NOx, Sox and water vapors.*

Keywords: Plastic Waste material, NTDC, Activating Agent, Bio-martial.

I. INTRODUCTION

Due to the rapid increase in industrialization and urban development, the social and economic growth has been observed. At the same time, such development has become the source of various environmental issues which have affected the ecosystem. Many scientists and research experts are working on various environmental issues which disturbed the ecosystem. Nowadays, the disposal of plastic waste (PW) has been considered as one of the serious problems or threats to the environment that is why the thermal process is being used to convert it into some useful energy. These processes avoid landfilling of PW which can cause the accumulation of non-biodegradable PW. Gasification is a process that is operated at a high temperature (800-900°C) in a partial oxygen environment to degrade any municipal waste to energy. Oil and Gas (fossil fuel) is about 64.2 percent of demand in Pakistan. Pakistan imported a large amount of oil and gas from the Northern Area and Saudi Arabia because of the increasing demand for energy. Pakistan has the potential to meet the scarcity of energy through hydropower and produce cheaper energy than other sources of energy. Hydropower energy demand is being increased because of zero-emission and larger production [1]. A Gasifier is a processing unit or reactor that is used to heat and decompose biomass into synthetic gas, which is a blend of Hydrogen, Carbon monoxide, and Carbon dioxide, in a partial oxygen environment. All four stages of gasification are being operated in that unit with incomplete combustion. Gasification can operate on any carbon-containing feedstock such as coal, biomass, municipal and plastic waste. It is a synthetic material made of a variety of organic materials such as polyethylene, PVC nylon, etc., and composed of various types of elements such as carbon, hydrogen, nitrogen, chlorine, and Sulphur. Plastic has generally higher molecular mass and prevailed over traditional materials such as wood, stone, horn and bone, leather, metal, glass, and ceramics [2,3].

Plastic remains on the earth because it is non-biodegradable material and causes degradation of soil along with the fatality of inhabitants in soil and water. During the recycling of plastic, some problems are faced such as inhalation of toxic fumes, especially hydrocarbons, and whenever we burn the plastic it creates problems of breathing because some toxic elements are released as like vehicle emissions can be the cause of global warming. Some of the major compounds of plastic such as Vinyl chloride, dioxins, and plasticizers are causative factors of hormone disruption, reproductive dysfunctions, breast growth, and testicular cancer [4,5].

Plastic waste is considered more contaminated due to non-degradable property. Therefore, gasification technology was introduced to degrade a limited portion of plastic waste. The one advantage was the considered mixing of nitrogen gas with a product which reduced the heating value of the product. Although in the steam gasification process H_2 rich syngas was produced [6]. The waste which contained fuel had produced less content of H_2, CO, CO_2, and high hydrocarbons than the fuels which contained biomass. The lower heating value (LHV) was continuously increasing from 5.1 to 7.9 MJ/Nm^3 range and plastic waste fractions have been moved from 0% to 100%. Fuel was concerned with a high amount of carbonaceous production having a high fraction of coal (60%), was producing 87.5g/kg fuel as compared to 1.0 g/kg fuel [7,8]. To get optimum, plastic waste was added to the steam of pyrolysis/gasification of wood sawdust with and without Ni /Al_2O_3 catalyst has been investigated. To analyze the effect of blended biomass and plastic, a mixture of different components such as biomass 80% and 20% of polypropylene, polystyrene, and high-density polyethylene (HDPE) were added into the reactor [9,10].

An experimental examination in the production of synthetic gas using fluidized bed gasifier on a lab-scale in which different waste plastic types were used. Initially, plastic waste was shredded into smaller particles which are then dried in the reactor at 150-200°C. At temperature 800-950°C, with a feed rate of 2kg/h waste is decomposed into very useful syngas [11,12]. Different experiments were performed on temperature between (550 to 850 °C) and results were obtained at a different temperature. According to the literature, different plastics such as (PP, PET, and PS) is degraded at a different temperature which affects the amount of product and different amount of by-products such as tar is generated from these plastics [13].

II. MATERIALS AND METHODS

Collection of Samples

In this study, the plastic waste material was collected from Hyderabad city on 26th November- 15th December 2020. The plastic waste material was shredded into small pieces and washed to remove dirt and other impurities at an initial stage. Furthermore, the shredded washed plastic waste material and dehydrated for 24 hours in an oven at a temperature of 105 °C. The Characteristics of plastic waste were determined in the laboratory by Proximately Analysis. The Proximately Analysis included the determination of Moisture Content (MC),), Volatile Matter (VM), Total Solid (TC), Fixed Carbon (FC), and Ash Char (AC).

Protocol for Feeding to Gasifier

This present study divided into three scenarios for putting the samples into a gasifier. In the first scenario took an equal quantity of all three types of soft plastic, semi-soft plastic, and hard plastic to check the quantity and quality of production of syngas. In my second scenario optimize 50 % of the sample from soft plastic and 25 % each from semi-soft plastic and hard plastic. Similarly, in the third scenario to optimize the sample by 50 % of soft plastic and a different ratio of others like 30 % of semi-plastic and 20 % of the hard plastic sample to optimize the production of syngas. Initially, given enough heat to the reactor be setting the thermocouple up to the required gasification temperature. After achieving 100 °C, fed the shredded plastic waste into the main chamber.

Research Methodology

Protocol for Synthetic Gas Production

Set the required gasification temperature by adjusting the thermocouple. After achieving 100°C. feed the material into the reactor. At 120°C, the drying process occurred and the material content of plastic vanished. Up to the 550 °C, the pyrolysis process occurred, and volatile solids have been removed. Then the air is supplied to the reactor for the combustion process occurred at 600 °C, and oxygen in the air helped the combustion process. It was checked required temperature is reaching or not by thermocouple probe. The pressure was checked inside the reactor by the pressure gauge. At 700 °C it was checked either synthetic gas is formed or not by gas chromatography device or through flue gas analyzer. After the process of gasification, synthetic gas had produced which had a composition of H_2, CO_2, CO, and CH_4. Check the gas which had produced by syngas chromatography of flue gas analyzer.

III. RESULTS AND DISCUSSION

The present study was carried out to produce syngas from plastic waste material. In this study, three types (soft plastic, semi-soft plastic, and hard plastic) of plastic waste Samples were selected from Hyderabad city. Initially, samples were shredding in the Crushing machine at the Industrial site area of Hyderabad city. The present study divided into three scenarios according to the composition of plastic waste material and also determined characterization of plastic waste material through proximate analysis method. The proximate analysis was carried out of all samples.

Table 1. Results obtained of different Parameters

S.No	Sample	MC(%)	Ash(Char %)	TS(%)	VC(%)	FC (%)
1	Soft Plastic	5.6	3.4	94.34	96.55	4.9
2	Semi-Soft Plastic	0.455	7.38	99.54	92.61	4.5
3	Hard Plastic	0.59	7	99.4	96	3.9

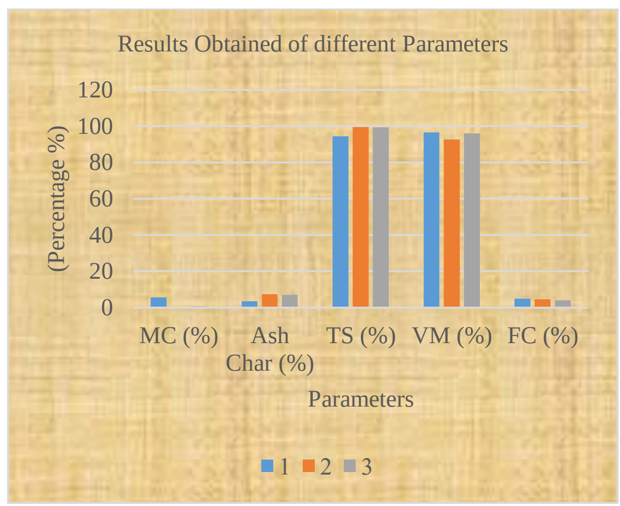

Figure 1. Results obtained of different Parameters

Scenario one is that ratio of 33.33 % soft plastic, semi-soft plastic and hard plastic each at the temperature 300°C.The results are shows given in Table 2.

Table 2. shows the Results of Scenario 1

S. No	Feed Stock (gram)	Quantity of gas (gram)	Characteristics of Gas									
			CO		H_2			CO_2	CH_4			Other Gases (NOx, Sox)
			(%)	(g)	(%)	(g)	(%)	(g)	(%)	(%)	(%)	(g)
1	750 g	296 g	5.5 %	16.28g	8.0 %	23.68g	23.2%	68.6g	1.5%	4.4g	61.8%	182.9g
2	900 g	333 g	5.6 %	18.64g	8.1%	26.9 g	23.5%	78.2g	1.7%	5.6g	61.1%	203.4g
Avg	825 g	314.5 g	5.55%	17.4 g	8.05%	25.35g	23.3%	73.4g	1.6%	5.03g	61.45%	193.2g

The above table shows the results of scenario one, in which the average feedstock of the sample shows 825g, and the quantity of gas is produced 314 g. The other five-column show the characteristics of different gases produced during the production of syngas CO 5.55%, H_2 8.05%, CO_2 23.3%, CH_4 1.6%, and other gases 61.4%. The previous research conducted by Ramesh Kumar et.al 2013 which results shows the H_2 10.1%, CO 6.2%, CH_4 7.1%.

The mass balance equation is described as under for result scenario one.

INPUT ⟹ OUTPUT

750 g + 900 g ⟹ 296 g + 333 g + Leakage Losses

1650 g ⟹ 629 g + Leakage Losses

Efficiency of our gasifier reactor is = $\frac{Output}{Input} \times 100$

$$E = \frac{629}{1650} \times 100$$

E = 38.12 %

plastic waste which is produced 431 g of syngas. The remaining columns show the different gas values during the production of syngas. The values are CO 6%, H_2 10.4%, CH_4 1.2%, CO_2 22.65% and other gases 59.7%. The previous study shows the results is CO 9.4%, CO_2 20.8%, H_2 11.4%, CH_4 6.9%.

The mass balance equation is described as under for result scenario two.

INPUT ⟹ OUTPUT

750 g + 900 g ⟹ 418 g + 444 g + Leakage Losses

1650 g ⟹ 862 g + Leakage Losses

Efficiency of our gasifier reactor is = $\frac{Output}{Input} \times 100$

$$E = \frac{862}{1650} \times 100$$

E = 52.24 %

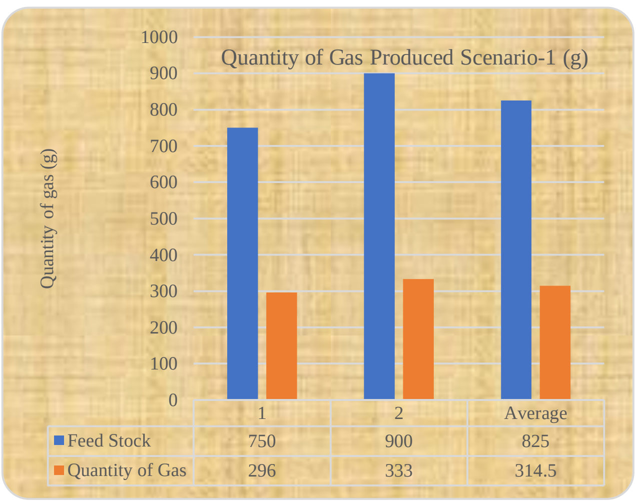

Figure 2. Results obtained of Scenario 1.

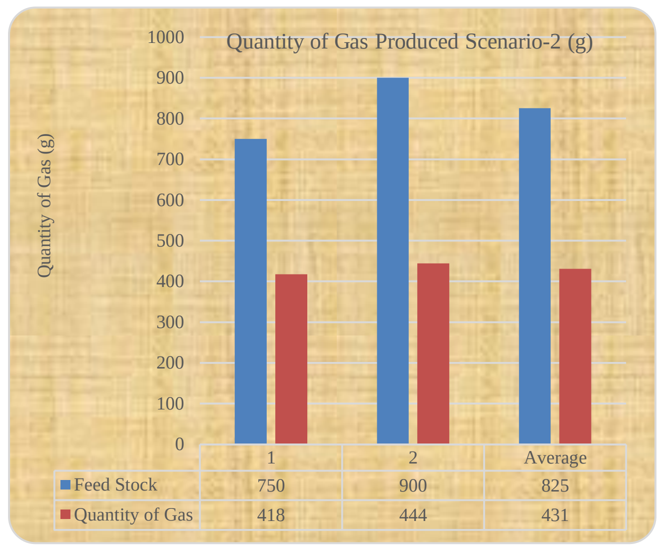

Figure 3. Results obtained of Scenario 2.

Scenario two is the ratio of 50 % soft plastic, 25 % of semi-soft plastic, and 25 % of hard plastic each at the temperature of 300°C. The results show as in Table 3.

The table shows the results of scenario two which is the same feeding stock of sample are 825 g on the different ratio of

Scenario three is the ratio of 50 % soft plastic, 30 % semi-soft plastic and 20 % hard plastic at the temperature of 300 °C. The results are given below table 4.

Table 3. shows the Results of Scenario 2

S.NO	Feed Stock (gram)	Quantity of gas (gram)	Characteristics of Gas									
			CO %		H_2 %		CO_2 %		CH_4 %		Other Gases (NOx, Sox)	
1	750 g	418 g	5.9%	24.6 g	10.3%	43.054 g	22.5%	94.05 g	1.1%	4.6g	60.2 %	251.6g
2	900 g	444 g	6.1%	27.08 g	10.5%	46.6g	22.8%	101.232 g	1.3%	5.7g	59.3%	263.3g
Avg	825 g	431 g	6%	25.8g	10.4%	44.8 g	22.65%	97.6 g	1.2%	5.2 g	59.75%	257.5 g

Table 4. Shows the Results of Scenario 3

S. No	Feed Stock (gram)	Quantity of Gas (gram)	Characteristics of Gas									
			CO %		H_2 %		CO_2 %		CH_4 %		Other Gases (NOx, Sox)	
			(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)
1	750 g	352 g	4.9%	17.2 g	7.6%	26.7g	22.4%	78.8g	1.5%	5.28 g	63.6%	223.8 g
2	900 g	384 g	5.1%	19.5 g	7.8%	29.9g	22.5%	86.4g	1.6%	6.2 g	63.00%	241.9g
Avg	825 g	368 g	5%	18.4 g	7.7%	28.3 g	22.45%	82.6 g	1.55%	5.7 g	63.3%	232.9g

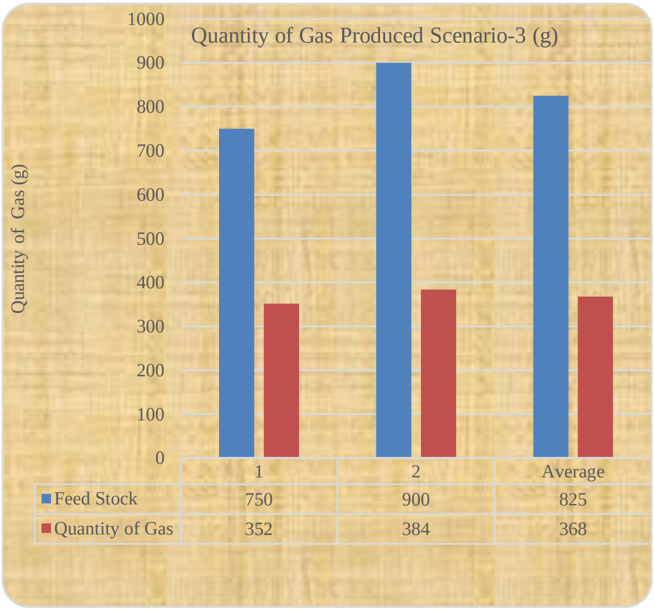

Figure 4. Results obtained of Scenario 3

The table showing the results of scenario three which is 825 g of feedstock sample and producing the average 368 g quantity of syngas. The table showing the results of scenario three which is 825 g feedstock of sample and producing the average 368g quantity of syngas. The remaining columns show the results of CO 5%, H_2 7.7%, CO_2 28.3%, CH_4 1.55%, NOx, Sox 63.3%. The mass balance equation is described as under for result scenario one.

INPUT ⟹ OUTPUT

750 gm + 900 gm ⟹ 352 gm + 384 gm + Leakage Losses

1650 gm ⟹ 736 gm + Leakage Losses

Efficiency of our gasifier reactor is $= \frac{Output}{Input} \times 100$

$$E = \frac{736}{1650} \times 100$$

$$E = 44.60\ \%$$

The optimizing results were obtained from Scenario 2 at temperature 300 °C. The results are shown in Table 5. The table shows the optimizing the results of syngas quantity production at temperature 300 °C. Due to the increase in temperature, the quantity of syngas also increased. At the temperature of 300 °C, the syngas quantity is 431 g. The remaining columns of the table show the characteristics of gas on 300 °C temperature. The previous study shows the result of 3.45g by researcher Ahmed Al Nous et.al 2020.

Table 5. Optimizing Results from Scenario 2 at a temperature 300°C

S. No	Temperature	Feed Stock (gram)	Quantity of Gas (gram)	Characteristics of Gas									
	Av A	Avg	CO			H_2		CO_2		CH_4		Other Gases (NOx, Sox)	
			(%)			(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)
1	300°C	825 g	431 g	6%	5.16 g	10.4%	8.9 g	22.65%	19.4 g	1.2%	1.032 g	59.75%	51.385 g

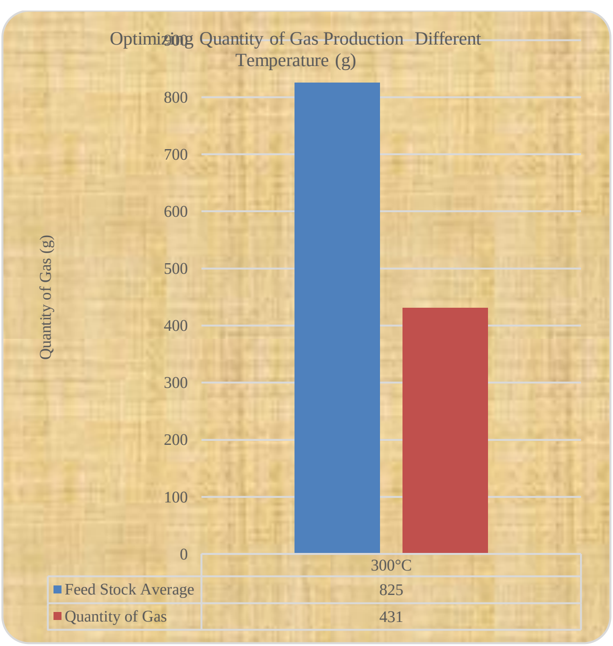

Figure 5. Quantity of Gas (g) Produced at different Temperature 300°C

IV. CONCLUSION AND RECOMMENDATION

1. It is concluded from results that the procedure of gas purely depends upon the amount of the feedstock into the system.
2. The present study was carried out at a constant temperature of 300°C.
3. The results obtained from the present study show the average size of the sample of plastic waste to feed in the gasifier is 825 g and produced 314.5 g of the quantity of syngas.
4. Therefore, it recommended that The electric heater should be replaced with a gas heater to improve the quality and quantity of syngas. Shredder should be mandatorily installed when using at in commercial level.
5.

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