International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 2 Ver. IV || February 2018 || PP. 49-54

Reuse Potential of Municipal Solid Waste by Refuse Derived Fuel (RDF)

Deepika M [1], Susmitha T [2], Shwetha Priya G [3], Ramakrishnan N[4]
[1](*Assistant Professor, Department of Civil Engineering, Sona College of Technology, Salem, Tamil Nadu, India)*
[2,3,4] *(UG Student, Department of Civil Engineering, Sona College of Technology, Salem, Tamil Nadu, India)*
Corresponding Author: Deepika M

ABSTRACT: *Earth's natural resources are being depleted. To compensate this negative aspect, we need to develop a recycling-based society. The main objective of this study is to bring to light the potential energy of solid wastes. The energy efficient Refuse Derived Fuel (RDF) briquettes are produced and it is emerging as a world-wide trend. The solid wastes were collected from the dump site of Sona College of Technology in Salem city. These solid wastes included paper, plastics, teacups, garden waste, and cardboard with the exception of glass, metals, polyvinyl chloride materials and textiles. The collected wastes were comminuted down to a grain size of less than 4 mm using cutting blades. In order to increase the biomass content and to enhance the thermal properties of the Refuse Derived Fuel (RDF), a binding substance was used as an additive to the solid waste. Sago-starch of about 2% weight of the input materials was added so as to increase the combustion stability and also to enhance the duration of combustion for a longer time.*
KEYWORDS - *Solid Waste, Energy Efficient, RDF Briquettes, Sago-starch*

Date of Submission: 09-02-2018 Date of acceptance: 24-02-2018

I. INTRODUCTION

Due to increasing energy demands and changing life style of urban population, the per capita generation of waste is increasing. As per the planning commission report, around 62 million tonnes of MSW were generated annually in urban areas in 2013 and it is estimated to be 165 million tonnes by 2031 and 436 million tonnes by 2050 [1]. The amount of Municipal Solid Wastes (MSW) has continuously increased in the last few years with the development of economy [2].

Improperly disposed MSW harms the environment and human health, and occupies too much land. The traditional solid waste disposal/treatment methods include landfill, incineration and biological treatment, but these methods bring about certain disadvantages [3, 4]. Therefore, safe disposal and treatment of MSW have become a challenging task all over the world [5]. Technologies for conversion of waste to energy have been utilized in developed and developing countries. In India, this technology has been implemented only with very little success [6]. Refuse Derived Fuel (RDF) has been recognized as one of the most appropriate ways to safely dispose MSW [5].

RDF is a fuel produced from various types of wastes such as Municipal Solid Wastes (MSW), industrial wastes or commercial wastes. RDF consists largely of combustible components of plastics (excluding PVC), paper, cardboard, labels, and other materials.

The RDF usage includes advantages such as minimizing CO_2 emission and ash content. They possess high calorific value and low moisture content. For a net carbon offset through the replacement of coal with RDF, water content must be less than 15% and in this case net reduction in emissions is obtained as 0.4 tons CO_2/ton coal [7]. RDF has energy and organic materials that are useable for burning in cement, wood and paper industries, thermal stations, and residue burners [8].

In this study, we produced energy efficient RDF from the solid waste generated in Sona College of Technology, Salem, Tamil Nadu, India. The objective of this research is to suggest a suitable solution for the disposal of solid wastes in Sona College of Technology in a safe and reusable manner in the form of RDF.

II. Materials And Properties

Solid wastes from the dump site include waste generated in the college campus excluding the hazardous waste. The combustible wastes are segregated from the total waste collected. The composition of waste varies from place to place and time to time. The general composition of MSW (taking example of MSW of Rasht) is given in Table 1[9].

Table 1 General composition of MSW

MSW COMPONENTS OF RASHT	**PERCENTAGE OF MUNICIPAL WASTE**
Organics	67.5%
Metals	1.5%
Glasses	3%
Papers	10.6%
Plastics	11.9%
Textiles	2%
Rubbers	2.5%
Wood	1%

The weight percentage of solid waste generated in Sona College of Technology (SCT) is presented in Table 2 and Figure 1.

Table 2 Composition of solid waste in SCT

COMPONENT	**WEIGHT (kg)/month**
Paper	3398
Plastic and rubber	630
Organic	767
Glass and ceramic	36
Metal	50
Wood	60
Textile	30
Garden waste	3313
Others (laboratory waste)	370
TOTAL	**8653**

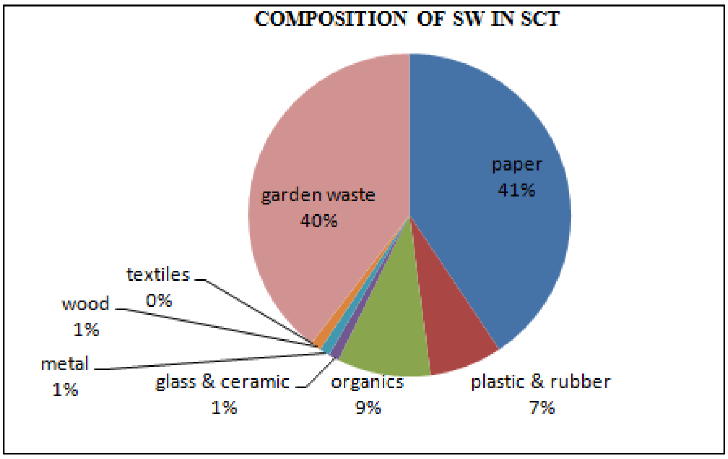

Figure 1 Component Proportions of SW

Data on physical and chemical properties of MSW were collected from literatures and are presented in Table 3.

Table 3 Physical and Chemical Properties of Solid Waste

Sl. No.	**Types of Solid Waste (based on source)**	**Calorific value**	**Ash residue**	**Chlorine Content**	**Sulphur Content**	**Water content**
		MJ/kg	*%wt*	*%wt*	*%wt*	*%wt*
1	Household dry waste	12-16	15-20	0.5-1	---	10-35
2	Household wet waste	13-16	5-10	0.3-1	0.1-0.2	25-35
3	Commercial waste	16-20	5-7	<0.1-0.2	<0.1	10-20
4	Industrial waste	18-21	10-15	0.2-1	----	03-10
5	Demolition waste	14-15	1-5	<0.1	<0.1	15-25

Sources: Data reported for Finland in WRC Ref: CO5087_4 July 2003

III. EXPERIMENTAL METHODS

There are different methods followed in the manufacturing of RDF in large scales. In a small scale, an affordable method for RDF production from solid wastes generated in SCT campus is given below (Figure 2).

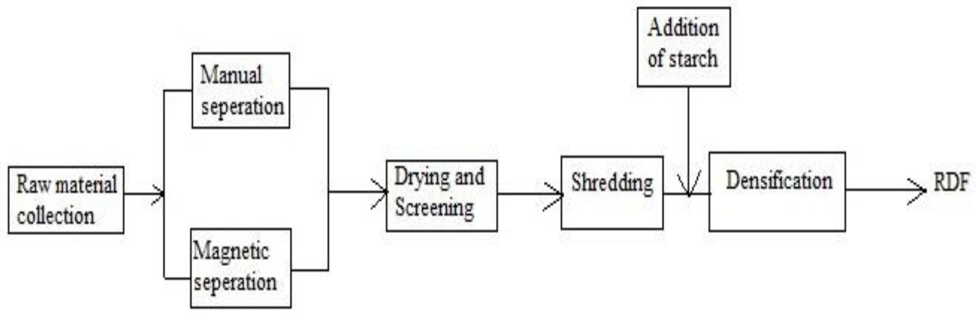

Figure 2 Flow chart outlining the production of RDF

3.1 RDF types

Refuse Derived Fuel has been classified according to ASTME 828-81 into 7 groups (Table 4).

Table 4 Classification of RDF (ASTME 828-81)

RDF TYPES	**SPECIFICATIONS**
RDF 1	Raw waste without processing or with minimal processing
RDF 2 (Coarse RDF or C-RDF)	Waste is processed into coarse particles without separation of metals in such a way that 95% of weight passes through 6-inch square mesh sieve
RDF 3 (fluff RDF)	The fuel is processed from waste by separating the metals, glass and other inorganic materials. The material passes through a 2-inch square mesh.
RDF 4 (Power RDF or dust RDF)	Combustible waste components in the form of powder and 95% of weight passes through 0.035-inch square mesh sieve
RDF 5 (densified RDF or d-RDF)	Flammable wastes were compressed in the form of pellets, cubes, briquettes and similar forms. The advantages of portability, storage and the ability to co-ordinate with a variety of combustion systems are developed.
RDF 6	The combustible waste is processed to give rise liquid fuel.
RDF 7	The combustible waste is processed to give rise to gas fuel.

The RDF prepared in this study belongs to Category 5 of ASTME 828-81 which is d-RDF or densified RDF, since it can take different forms like cubes, briquettes, pellets, and similar forms.

3.2 RDF production

The RDF production process begins with the collection of unsegregated solid waste. The non-combustible wastes are removed in two stages namely manual separation and magnetic separation. The residues are allowed to dry in sunlight by uniformly spreading them on an open paved area for duration of 1 to 2 days. The screening process with trommels ensures that the larger particles are segregated from the residues. The residues are shredded down to a size of < 4 mm. The residues are blended with 2% weight of sago-starch for enhancing the binding property and are compacted/densified as briquettes.

3.3 RDF model mixtures

For the preparation of RDF model mixtures the biogenic and fossil materials are used. Paper and cardboard are considered to be biogenic matter, whereas HDPE, PET and PS represent fossil materials (produced from crude oil). All materials are shredded down to a grain size of < 4mm by a cutting mill. The compositions of the RDF model mixtures are shown in Table 5 [10].

Table 5 Composition of RDF model mixtures

	BIOGENIC MATERIALS		FOSSIL MATERIALS			THEORETICAL BIOGENIC MASS FRACTION IN MIXTURE	
	Paper wf (wt%)	Cardboard wf (wt%)	HD-PE wf (wt%)	PET wf (wt%)	PS wf (wt%)	Wf (wt%)	Waf (wt%)
Mixture I (600 g)	79.4	-	20.6	-	-	79.4	75.5
Mixture II (1200 g)	26.4	34.3	18.8	10.3	10.2	60.7	55.9

Wf = Water free
Waf = water and ash free
Wt% = wt% percentage by weight (ratio of mass to total mass)

In this study the RDF briquettes were prepared with different composition and varying proportions of solid waste materials as shown in Table 6.

Table 6 Mixing proportions for the production of RDF samples of solid waste materials

SOLID WASTE	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
PAPER	30%	30%	20%	20%
CARD BOARD	30%	20%	20%	20%
TEA CUPS	20%	30%	25%	-
SAW DUST	-	20%	5%	30%
PLASTICS	20%	-	30%	-
GRASS	-	-	-	30%

Central Electricity Regulatory Commission (CERC) on 07.10.2015 has fixed generic tariff for Waste-to-Energy as Rs. 7.90 per unit of power for RDF [12]. As compared with CERC the prepared RDF models as in Table 6 yield a good profit and help to produce clean and healthy environment by way of safe disposal of solid waste generated in the SCT campus.

IV. RESULTS AND DISCUSSION

Length and diameter of the RDF briquettes were measured. The briquettes were weighed. The volume and absolute density of the briquettes were calculated. Moisture content of each sample was determined. A known weight of the sample was dried in an electric oven at 103 ± 5°C for one hour, and it was weighed until constant weight was reached [13].

$$Moisture\ content\ in\ \% = \left(\frac{initial\ weight\ of\ sample - weight\ of\ sample\ after\ drying}{initial\ weight\ of\ sample}\right) X\ 100$$

Gross calorific value was experimentally determined using bomb calorimeter [14]. Ash content, pH and chlorine content were determined. These characteristics of the RDF briquette samples are tabulated below.

Table 7 Analysis of RDF characteristics

Parameters	S 1	S 2	S 3	S 4

Density (kg/m^3)	55.42	48.67	54.07	43.26
Calorific value (kJ/kg)	20488	19192	21134	15304
Moisture content (%)	9.09	8.9	7.8	7.7
Ash content (%)	9.7	9	8.8	8.9
pH value	8.43	10.37	9.09	11.20
Chlorine (%)	0.001	0.001	0.001	0.001

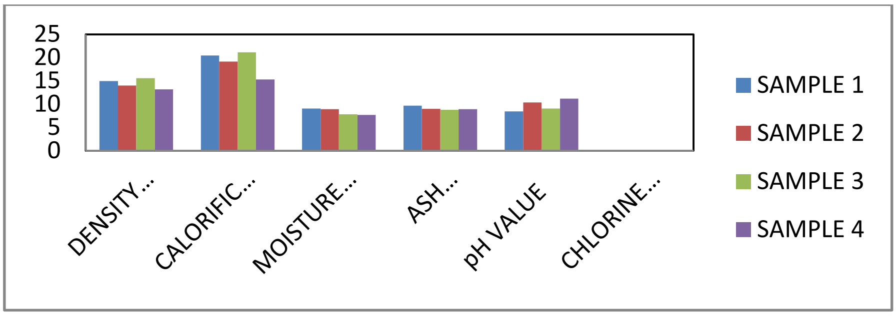

Figure 3 Comparison of analysis results

4.1. Comparison between coal and RDF

The manufactured RDF should meet the calorific value attained by the coal and must prove to be having less moisture content and economical. The RDF possesses better properties than coal, as shown in Table 8 [15].

Table 8: Comparison of properties of RDF and coal

Fuel factors	***Coal***	***RDF***
Calorific value (Kcal/kg)	4000	3500-4000
Equivalent ton in calorific value	1	1.14
Cost per ton in Rs.	6000	2000
Sulphur content (weight %)	0.4	0.2-0.5
Moisture content (weight %)	39	10
Ash content (weight %)	4.2	<15
NO_x content (weight %)	1.2	1-1.5
Carbon (weight %)	31.4	35-40
Oxygen (weight %)	7.4	25-30
Hydrogen (weight %)	4.3	5-8

V. Conclusion

RDF briquettes using solid wastes generated in SCT campus were prepared in four compositions. The tests were performed to determine the characteristics of RDF briquettes. From the four samples prepared, it has been identified that sample 3 briquette with more percentage of plastic and sawdust has higher calorific value and less moisture content. From the test results it is found that the calorific value is inversely proportional to moisture content. As the moisture content value decreases the calorific value increases. Thus the RDF sample 3 yields optimum calorific value of 21134 kJ/kg at moisture content of 7.8%, ash content of 8.8%, pH value of 9.09, and density of 54.07 kg/m^3. This calorific value is almost equal to that of fossil fuels (coal, oil). The burning time of one RDF briquette was about 45 minutes. It is concluded that sample 3 with more plastic waste and sawdust has higher calorific value due to low moisture content and other favourable physical characteristics like improved density. This particular mix proportion of solid wastes can be adopted to prepare energy efficient RDF for fossil fuel replacement to produce heat energy in boilers, cement plants, etc.

Acknowledgements

Authors are thankful to Dr .R. Malathy, Professor and Head of Civil Engineering Department, Sona College of Technology for providing the facilities to do this project at Environmental Engineering Laboratory, Department of Civil Engineering, Sona College of Technology, Salem, Tamil Nadu, India.

References

[1]. Planning Commission, India (2014), report of the task forces on waste to Energy (vol.1), report prepared for Integrated MSW management at New Delhi, India.

[2]. Gupta A K., Thermal destruction of solid waste, *J Energy Resource Technology* 1996; **118:187**-192

[3]. Daskaopoulos. E, Badr. O, Probert. SD, Economic and environmental evaluations of waste treatment and disposal technologies for municipal solid waste, *Applied Energy* 1998; **58(4)**:209-255.
[4]. Robert M. Clark, James I. Gillean, *Resource recovery planning and management*, Ine:Ann Arbor Science Publishers; 1981.
[5]. [Inoue, K Kawamoto K, Control of hydrocarbon content of a reforming gas by using a hydrogenation catalyst, *Chemosphere* 2010;**78**:599-603.
[6]. Asnani. P.U, India Infrastructure Report 2006, Solid Waste Management. Available Online at http://www.iitk.ac.in/3inetwork/html/reports/IIR2006/Solid_Waste.pdf as of 08/09/2011 accessed on August, 28th 2012
[7]. Nakajima Y, Matsuyuki M, Utilization of waste tires as fuel for cement production, *Conserve Recycle* 1981;4:145–51.
[8]. Mokrzycki E, Uliasz- Bochenczyk A, Alternative fuels for the cement industry, *Applied Energy* 2003; 74:95–100.
[9]. Gilan, Waste management master plan in Rasht, The municipal waste management in Rasht, *Science and technology park* 2010.
[10]. Therese Schwarzböck , Philipp Aschenbrenner, Helmut Rechberger, Christian Brandstätter, Johann Fellner, Effects of sample preparation on the accuracy of biomass content and determination for refuse-derived fuels, *Fuel Processing Technology*; 153 (2016) 101–110.
[11]. Standing Committee on Energy, Sixteenth Lok Sabha (2015-16), Power Generation from Municipal Solid Waste, Twentieth Report, Ministry of New and Renewable Energy, Lok Sabha SECRETARIAT New Delhi.
[12]. Browning B. C.,1997, Method of Wood Chemistry, *Interscience Publishers*, New York, USA. *Vol.1 and 2*.
[13]. Phyllis 2, database for biomass and waste, http://www.ecn.nl/phyllis2, *Energy research Centre of the Netherlands*, access date March 2013.
[14]. T. Ganesh, P. Vignesh, Refuse Derived Fuel to electricity (Sep 21, 2014), https://www.researchgate.net/publication/265684610

International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

Deepika M.“ Reuse Potential of Municipal Solid Waste by Refuse Derived Fuel (RDF)” International Journal of Engineering Science Invention (IJESI), vol. 07, no. 02, 2018, pp. 49–54.