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Municipal Solid Waste Recycle - An Economic Proposition for a Developing Nation

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Attenuation of the world's reserves of conventional and nonrenewable energy has affected the industrial scene of the developing countries in a big way **and stimulated the hunt for renewable and unconventional energy sources. In addition, treatment and disposal of huge tonnages of municipal solid waste (MSW) generated from the cities (as a result of rapid urbanisation) has emerged as a new environmental problem in the afore - said countries. Recycle of MSW as a technique to create renewable source of energy and to solve the disposal problem in an environmentally acceptable manner is, DO doubt, an economic proposition. This article gives a comparative picture of the conventional methods with those of the recent ones, namely the incineration and pyrolysis (recycling techniques) for the treatment of the MSW in general and the salient features of the pyrolysis process in particular. Suitability of the waste recycle techniques in the context of a developing nation has also been discussed.**

INTRODUCTION

Energy crisis and the environmental pollution have hit the economic and the social fronts of the third world countries in a big way, which unless otherwise taken care of may lead to some total catastrophe in the near future. These two problems are not so pressing for the advanced countries. They have already become conscious of a clear environment. To tackle the energy crisis, not only do they have greater buying power, but they have alternative sources already at hand also. The quest for renewable energy sources in these countries is therefore a marginal one, which is evident by almost a wholesale abandonment of renewable energy projects in the U.S. and Western Europe in the face of the decline in oil prices that occured in 1982 and 1983. But for oil - importing developing countries this quest for alternate and renewable sources of energy is **a** matter of life and death. The developing countries are at the thresh - hold of a second energy crisis often called the real energy crisis - a challenge which they must meet at their own.

This challenge of impending energy crisis can be tackled at the two main fronts, which are efficient energy management, and exploitation of alteranate renewable sources of energy. As regards the first aspect, attampts are being made for the identification of inefficient pockets and suitable remedial measures for their complete/partial elimination with a view to attenuate the energy needs. The second factor can contribute in a big way for the solution of energy crisis in the developing countries. However new alternates for energy must be technically viable, economically feasible, socially acceptable, and environmentally sound.

In addition to energy problem rapid urbanisation coupled with increased population have brought in **a** new environmental problem in these developing countries. Huge tonnages of solid refuse are being produced in the urban areas, which need to be disposed off in a manner, that should be economically viable and environmentally acceptable. Inspite of the fact that the per - capita generation of this refuse is comparatively low (400 - 425 gm in India as against 2400 gm in the U.S.), the financial involvement in the collection and disposal of the refuse as per the traditional methods has been quite high especially for the big metropolis of the country. To quote an example, for solid waste management of greater Bombay the corporation spends 9% of its annual budget which is around 17 crore of rupees per year (tnat is Rs 20 per head for a population of 8.6 million). 675 vehicles with 20000 staff collect 3000 tonne/day of garbage from 4136 points and the total cost averages to around Rs 150 / tonne. This refuse is a potential source of low and medium calorific value fuel gas, tar (a liquid fuel) and char (a solid which can be briquetted). In addition, large quantities of glass and metal can also be recovered from this. The city refuse produced at the rate of 2.4 kg/ day/ head in U.S. has been found to be a rich source of metal and glass from which around 12 million tonne of each of the materials could be recovered annually. Municipal solid waste being a potential source of valuable materials and renewable energy, recycle of city waste is an economic proposition. This, when effectively implemented, will also lessen the associated environmental problems encountered by its traditional methods of disposal.

MUNICIPAL SOLID WASTE

The source for the Municipal solid waste (MSW) are : (a) Residential Colonies - LIG, MIG, HIG, Slums, (b) Commercial Units - Markets, Shops, Hotels, Offices, (c) Institutional Units - Schools, Colleges, University, and (d) Common Municipal Areas - Street and lane sweepings, trees, Banks, Dead bodies of animals, Construction materials (left - overs). MSW compositions are related primarily to the standard of living and dietary habits of the population. The compositions of refuse from Indian cities and those of European and north American cities vary widely (Table 1). The composition also changes with time and depends on the population of the cities as are evidenced from Tables 2 and 3, respectively. The paper and plastic contents increase with increase in population of the city. High ash and fines in Indian city refuse is due to the mixing of the street sweepings to the municipal waste.

Table 1. *Comparative picture of city refuse compositions (Standard of living effect)*

Item	Composition, Weight %		
	European city	North American city	Indian city
Mixed paper	20 - 35	40 - 50	3 - 8
Wood and Textile	4 - 7	2 - 6	—
Plastic and Rubber	3 - 7	4 - 7	1 - 2
Putrescibles	20 - 23	20 - 25	33 - 42
Fines and ash	15 - 20	5 - 8	32 - 47
Metal	3 - 6	5 - 7	0.5 - 1.0
Glass	5 - 9	5 - 9	1.0
Heating Value	1500 - 2300	2300 - 2800	800 - 1100

Table 2. *Composition of MSW of greater Bombay (1978 and 1982) (time effect)*

Item	Composition, weight %	
	1972	1982
Papcr	7.07	8.01
Plastics	0.86	0.60
Metal	1.04	—
Glass	0.76	0.31
Ash and fines	31.74	26.55
Putrescibles	41.69	34.60
Other misc. materials	16.85	29.93

Table 3. *Characteristics of solid waste from Indian cities, (population effect)*

Population range, in million	Constituents, weight %					Heating value, kcal/kg
	Paper	Metals	Glass	Ash and fine	Putrescible	
< 0.2	3.09	0.51	0.29	46.6	33.4	801
0.2 - 0.5	4.76	0.39	0.34	40.0	39.8	874
0.5 - 2.0	3.80	0.64	0.44	41.8	40.2	867
> 2.0	7.07	1.03	0.76	31.7	41.7	1140

TRADITIONAL METHODS OF MUNICIPAL WASTE DISPOSAL

The cheapest method is 'open dump' where unprocessed refuse is dedosited in low - lying area on the city out - skirt with little regard to public health and/or aesthetics. The obvious evil consequences are serious problems of ground water pollution through leaching, loss of land value, fire dangers and rodent infestation. A more acceptable sanitary land fill method which reduces the above threats to the environment is by 'composting' and covering the garbage with dirt. However, this practice is also losing ground, at acceptable sites, if available at all, have to be located far from habitation centres. Other biodegradation approaches, like aerobic digestion and biochemical conversion require lengthy residence time and are susceptible to stability problems.

INCINERATION

This is a method of burning garbage in a controlled manner. This comprises of a lined furnace, fire grate, air blowers and range in capacities from 50 kg - 20 tonne/hr. Incineration takes places between 750 - 1000 °C and can be coupled with steam and electricity generation. A volume reduction of 80 - 90 % is possible by this. But air pollution standard cannot be ensured without costly stack gas leaching system. Further the residue obtained is not biologically inactive and land fill is required.

PYROLYSIS

Of the disposal methods, pyrolysis or carbonisation of wastes, a thermal method of treatment requiring the heating of wastes in an oxygen free atmosphere is of interest. Various advantages claimed of the process are : (a) Substantial volume reduction of the waste < 50 - 90%), (b) production of solid, liquid and gaseous fuels from waste, (c) Storable/transportable fuel or chemical feed stock is obtained, (d) Minimal environmental problem, (e) Desirable process as energy is obtained from renewoble sources like municipal solid waste or sewage sludge, (f) The system lends itself to diversification in burning, (g) The capital cost is comparatively less than that of incineration process, and (h) Once started, the process is self - sustaining.

PROCESS

The process is classified on the basis of reactors used as shaft furnace (vertical/horizontal), rotary kiln, and fluidized bed. For shaft furnace, residue discharge and gas take off systems are important accessories for the main unit. Although a better mixing is achieved by the second method compared to the first, sealing of the rotating cylinder from stationary feed and discharge ports is a problem. In view of waste conversion and heat transfer fluidized bed process is the most ideal one in spite of certain miner problems like the erosion of the confining vessel and carrying over of the solids.

FLUIDIZED BED PYROLYSIS

On the basis of the laboratory investigations conducted by the Chemical Engineering department of the West Virginia University, some pilot plant scale and commercial models have been developed. In this case two fluidized bed reactors are combined to form a pyrolysing section (temperature of 830 °C) and combustion section (950 °C). Refuse is fed to the base of the former which consists of a bed of hot sand, fluidized by recirculating product gas which is stripped of char by means of cyclones (Figure 1). The carboneceous char (cyclone underflow) is fed into the second bed which is air - fluidized, thus providing a combustion unit to burn the char and heat the sand, the products being passed through another cyclone. The two beds are crosslinked, so that heated sand flows into the pyrolysis reactor, whereas cooler sand is displaced back to the heating stage.

For the pyrolysis of 400 tonne/day of refuse, 6 m high reactors with diameters of 2 m and 1 m, respectively for the pyrolysis and combustion purposes have been found to be suitable. A sand rate of about 7 kg/sec and a fluidizing velocity of three times the minimum are generally maintained. One - third of the pyrolysis gas is recycled to supply the requisite process heat. Fluidized bed pyrolysis process can be applied to MSW, rubber plastics and allied materials. The products generally include solid char (which can be briquetted), liquid tar (which can be a substitute for furnace

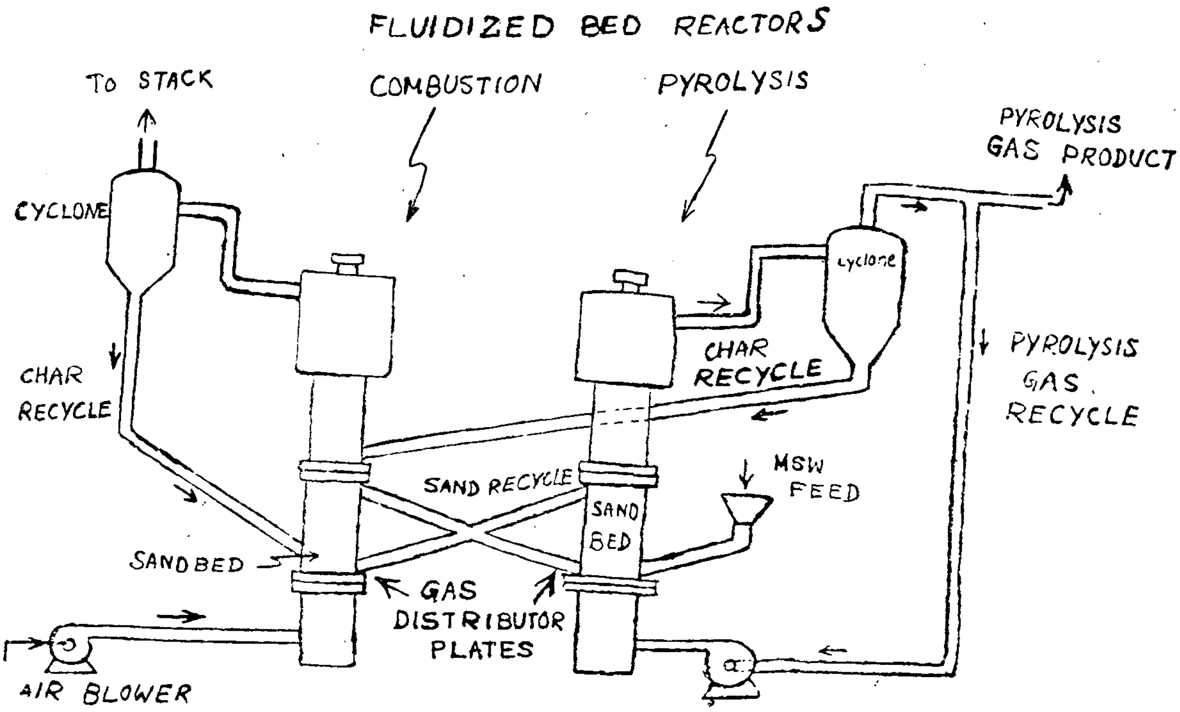

Figure 1. *Fluidized bed pyrolysis of municipal solid waste*

oil) and a low calorific value gas. A typical composition of pyrolysis gas is given below (Table 4).

Table 4. *Composition of pyrolysis gas from MSW*

Constituent	Amount, vo! %
CO	35.5
CO_2	16.4
CH_4	11.0
H_2	37.1
Calorific value, kcal/Nm^3	3430

Uses of pyrolysis gas

Potential uses of the pyrolysis gas are as under :

(i) Firing of the kilns

(ii) Separation of H_2 for ammonia synthesis :

$$CO + H_2O \xrightarrow[\text{(Fe/CR)}]{} CO_2 + H_2 \text{ (shift reaction)}$$

(iii) Synthesis of methanol :

$$Co + 2H_2 \xrightarrow[\text{(Cu/Cr)}]{(250-400\ ^oC)} CH_3\ CH$$

(iv) Production of high - Btu SNG (substitute natural gas) by methanation :

$$CO + 3H_2 \xrightarrow[\text{(Ni)}]{260-370\ ^oC} CH_4 + H_2O$$

(v) For the synthesis of liquid fuel by the F - T (Fischer Tropsch) process :

$$CO + 2H_2 \xrightarrow[\text{(Fe/CO)}]{} (-CH_2-) + H_2O$$

INDIAN CONTEXT

The failure of composting has made city authorities in India turn to other alternatives, like incineration and pyrolysis of MSW. Two such projects are likely to be completed in the near future. The first one based on incineration is to come up in Delhi. This 300 tonne/day incineration plant of rotary kiln type wiht turbo generator to burn NSW and generate electricity is to be supplied by a Danish Company. With a refuse of 1642. 5 kcal/kg, calorific value, about 6 Mw of electricity can be generated per day. The cost of the plant with 1983 March price is about Rs 15 crore. Annual income from the sale of electricity (at the rate of Rs 0.45 per unit) will be around Rs. 1 crore.

Some inherent problems which renders the refuse from Indian cities at times unsuitable to the incineration system are inadequacy of combustible materials, and prepondence of moisture in the refuse. Further the plants are capital - intensive to be taken up independently by the municipal corporations. However incineration method is used on a small scale at places such as hospitals (for the incineration of pathological wastes) in greater Bombay. Pyrolysis of city refuse is a better method whereby fuels of renewable nature aswell as chemical feedstocks are obtained. The second project on the recycle of MSW, which is likely to be set up soon will be a 100 tonne/hr pyrolysis plant at R.C.F. premises, Chembur to convert MSW to methanol. The total cost of the plant with 2400 tonne/day refuse will be around Rs. 140 crore and the return on capital has been worked out to be 27.4%.

CONCLUSION

Pyrolysis of waste is pertinent in the context of energy crisis. Development work has been done in USA and Europe and commercialized in USA with a 100 tonne/day plant. The process is self - suflicient and regenerative. A valuable byproduct is tar oil, which is a substitute for furnace oil. Coke can be used as domestic fuel. In the backdrop of energy crisis and investigations conducted, it is worthwhile to further the investigations relating to the pyrolysis of MSW and industrial waste on pilot and semicommercial scale, at least in the metropolitan cities of the developing nations. The proposition is no doubt, an economic one, since it not only converts garbage to solid, liquid and gaseous fuels but produces valuable chemical and other feed stocks for downstream processing also. To quote an example 2000 tonne/day of city garbage of Delhi, when subjected to pyrolysis will yield 600 tonne of char, 30 tonne each of glass and metal and 80000 litre of oil. Therefore, recycle of municipal solid waste by the pyrolysis route is not only an answer to the disposal problem in order to maintain a clear habitate but can transform 'waste to energy and wealth' also.

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