Municipal Solid Waste Management by Waste to Energy: A Review

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***Abstract*— The Municipal Solid Waste (MSW) is a problem if the proper management is not performed. The waste to energy is good solution for the MSW management. In this paper we review the MSW management by waste to energy, the combustion of waste incinerators. The combustion control technologies reviewed and the combustion performance of various control strategies reviewed.**

***Index Terms*— Incineration, Municipal Solid Waste, Waste management, Waste to Energy, Waste combustion, Moving grate incinerator.**

I. INTRODUCTION

The municipal solid waste (MSW) is increasing with the developments. The MSW is a problem as the most of the waste is going to landfills. Landfills are not the solutions as the land resources are limited. Processing of MSW can be solution, if processed in controlled manners with the norms set by the authorities.

The concept of energy generation from MSW i.e. Waste to Energy (WTE), either heat or electricity is much better solution than the landfills. In incineration the volume is significantly reduced and the ash generated after incineration can also be recycled. By recycling of the ash other materials can also be recovered.

In India it is projected that the waste volume increase up to 125 million tonnes by 2031[1]. Action plan proposed is storage at source, segregation, primary collection of waste and local bodies accountability for implementation of the plan.[2]. In Indian context integrated framework required which be strict and strategic for waste management also educating the people for the waste management is necessary[3].

Plastic waste disposal has very harmful effect on environment so logical methods required for the maximum energy recovery and disposal for it[4].

In India MSW rate of generation is 400g per capita. MSW generated is dispose off by unorganised way although many of the technologies available for scientific disposal[5].

In India as of 2018 more than 68 million metric tonnes (MTs) of waste generated yearly. Expected increase in waste generation is 165 million MTs by 2031 and 436 million MTs respectively. The land requirement for dumping of 62 million MTs untreated waste is around 1260 hectares per year. The WTE potential in India is about 2.554 GW from MSW and about 1.683 GW from urban and industrial waste[6].

The citizens and the policy makers are being attentive for municipal solid waste management (MSWM). The bodies are taking the environmental issues seriously. The waste to energy concept is gaining acceptance from policy makers[7].

When considering the WTE as the solution of MSWM then it important to analyse the energy content of waste i.e. Low Calorific Value (LCV) of the waste used for the incineration[8].

II. MUNICIPAL SOLID WASTE

In metropolitan cities the MSWM is prime concern and necessary that the action plan in advance. The artificial intelligence techniques can be used for forecasting the waste generation trends so that the proper action plan can be prepare[9].

Waste collection in India is not well organized the local bodies are not doing well due to lack of awareness and also the financial problems. The public awareness in small cities is also less[10]. Solid waste generation prediction plays very important role for the planning. Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) predictive models

verified for prediction of mean Seasonal Municipal Solid Waste Generation (SMSWG) rate[11].

"As per Solid Waste Management Rules 2016, "Bulk Waste Generator" means and includes buildings occupied by the Central Government Departments or Undertakings, State Government Departments or Undertakings, Local Bodies, Public Sector Undertakings or Private Companies, Hospitals, Nursing Homes, Schools, Colleges, Universities, other Educational Institutions, Hostels, Hotels, Commercial Establishments, Markets, Places of Worship, Stadia and Sports Complexes etc having an average waste generation rate exceeding 100kg per day (of all waste streams put together)"[12].

There are different waste categorisations e.g. wet waste, dry waste, e-waste, industrial waste, biodegradable waste[3].

Table I: Waste Classification[12]

Biodegradable/ Wet Waste	Non Biodegradable	Domestic Hazardous
Kitchen Waste. Leafs. Bones. Dung. Flowers. Ashes. House dust.	News Paper. Paper Books & Magazines. Leather. Rags. Wood.	Aerosol Cans. Batteries. Paints. Oils. Lubricants. Thermometer. Medicines.

Incineration is the process in which various volatiles components present in the waste in burn in presence of oxygen in the burning chamber of the incinerator by which steam generated and the use of stem for generating electricity[13].

The elements which are in majority components of solid waste are given in table 2. The components in starting and after the incineration are tabulated. The volatile materials burn inside the furnace and the byproducts produces[13].

Table II: Solid Waste Elements

Initial Components		Final (Gases)
Carbon (C)		Carbon Dioxide (CO_2)
Hydrogen (H)	Combustion Process	Water (H_2O)
Oxygen (O)		Nitrogen (N_2)
Nitrogen (N)		
Sulphur (S)		SO_2 other Gases and ash

III. MSW MANAGEMENT AND WASTE TO ENERGY

The combustion control design on the basis of fire position observation by the control room operator by the furnace cameras installed in the field and visual in the control room[14]. In modern waste management energy recovery from waste is essential and integrated part of waste management. The energy recovery from waste reduce the dependency on fossil fuels for energy generation[15].

The main problem of waste incineration is waste uncertainty. The base-layer control assessment by IPCOS provide stable operation[16]. Incineration usually combustion of unprepared MSW in presence of high oxygen[17]. Zero emission of carbon dioxide can be achieved by oxy-fuel technology in waste incinerators[18].

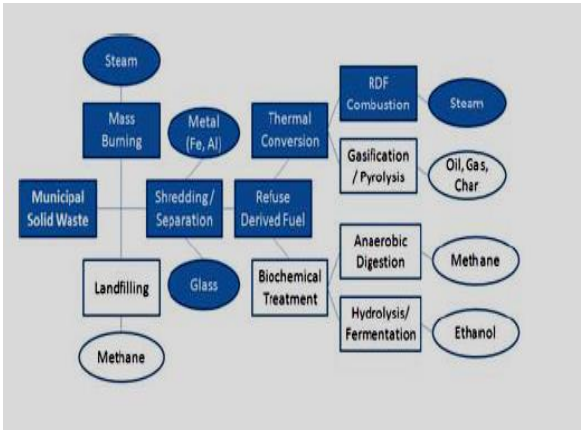

Fig.1 Energy From MSW[19]

Fig. 1 shows the energy from MSW. WTE is more costly than the coal fired plant as per comparison. WTE by refused derived fuel (RDF) is technological advancement of mass burn MSW WTE plant. Fig.2 shows RDF process flow[19].

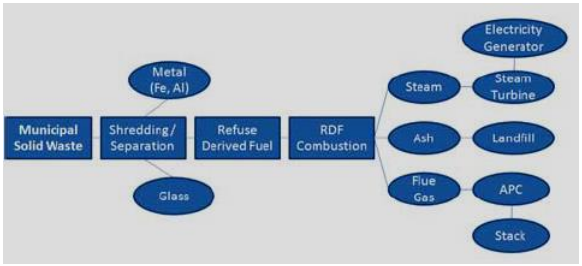

Fig.2 RDF Process Flow Diagram[19]

Current time demand is sustainable energy. It is gaining importance as the low carbon emission. The switching from fossil fuel to renewable energy is better solution for air pollution, resource management, climate change and various other things related to the environment[20]. Survey of U.S. MSW WTE facilities

conducted and found the operating conditions, furnace temperature more than 1160ºC, gas residence time 2 sec and exit gas concentration is 10% oxygen on dry basis[21].

MSW incineration is fluctuating as the batch feeding and the uncertainty of the MSW. A fuzzy rule based designed for counter this problem and improving the generation of steam and reduction of the waste volume[22]. In developed and developing countries MSW has the high energy potential but the technology transfer between these countries should be easy so that more efficient way can be adopted[23].

Combustion control system with inclusion of grate movement, primary air and secondary air developed in DCS[24]. For characterization of heterogeneous behavior of particles on moving grate, MSW particle mixing within a WTE combustion bed a 2-dimensional stochastic model developed[25]. In standard linear control for the WTE there is problem in the boiler. The non linear control and observer design simulated for better performance analysis an stability of the incinerator[26]. Simulation analyzed for fuzzy model predictive control for small scale biomass furnace for better performance than the traditional control strategies[27]. A regulator control strategy is tested for improving the combustion control as compare to the Proportional-Integral-Derivative (PID) controller[28]. The multivariate analysis of plant in Spain conducted which implies the parameters which more impact on the performance of incinerator[29].

Online steam generation prediction of MSW incinerator by fully tuned Radial Basis Functional Network performed[30]. The MSW incinerator in Tibet Pleatu analyzed and the optimum furnace temperature and the air level, furnace temperature and oxygen percentage analyzed for the combustion of MSW in incinerator[31]. Multi-Criteria Decision Analysis (MCDA) is power full aspect for taking the decision for MSW management by WTE facility[32].

Incineration flow chart is shown in fig. 3.

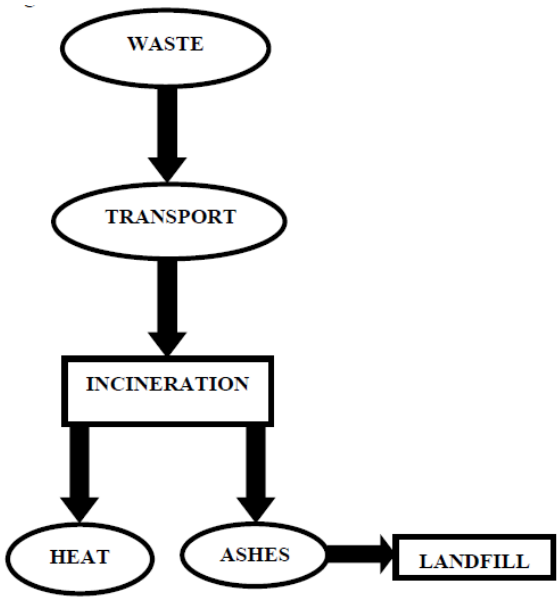

Fig. 3 Incineration Flow Chart[33]

Oxygen-Enriched combustion in commercial running plant indicates that the less emission of toxic gases and also the efficiency improvement[34]. Comparison of grate movement and fluidized bed combustion sowed that moving grate is better than the fluidized bed technology[35]. Bench scale reactor qualification for the WTE[36].Air pre-hating effect on moving grate furnace in China plant performance improved[37].

IV. CONCLUSION

The waste to energy is very good solution for the MSW management. The incineration is better than the other technologies for combustion of waste. The decision making for the policy makers consideration must be in all aspects such as environmental, economical and also the financial. The combustion of MSW is not very smooth as the heterogeneous nature of waste so the better combustion control requirement for good combustion and efficient operation of the MSW incinerator. The better combustion control can reduce the volume of the ash and also the steam generation improvement. The toxic emission must be taken into account at the WTE plant design. The furnace temperature and the oxygen percentage as such that the toxic gas emission will not occur.

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