A Review on Waste to Energy Progress in India

Ram Avtar Muhal, Yash Verma, Prayagraj Singh, Priya, Chandramani Goswami
Department of Mechanical Engineering, ACEIT, Jaipur, India

Abstract: India is one of the fastest developing country in the world. As everyone know that developing countries generate a huge amount of waste so these developing countries need a good quality technique of waste management. India and such developing countries need power, but waste to energy generation process is a process that can help any country to overcome from both of problem, waste management and power generation. Dumping of waste is not a permanent solution this method has various problem like environmental problem and health diseases. India is a large country and India has different states and all states require different type of WtE generation technology. This paper gives a brief review on previously used technology in different states of India. Also, we studied about the different process of energy absorption techniques. Concentration level & to minimize deformation and finding natural frequency. It is founded that Fatigue life of designed of shaft is safe at a drive range of stress and stability frequency of design shaft is 0 Hz up to 1325.2 Hz. And principal stress drive up to 62% and displacement up to 35% by these result shaft and shape are safe.

I. INTRODUCTION

India is on 11th position in terms of GDP in the world and 3rd position in purchasing power parity, and is the fastest developing nation of the world [1]. The development causes increment in the waste produced due to construction works, urbanization, and increased population. All these factors are responsible for causing economically and environmental problems [1]. India is the second largest population with 136.6 crores, it contains 17.7% of total world's population. India generates 147,613 MT Municipal solid waste (MSW) per day in January 2020 [2]. India's current energy demand is increasing rapidly and required about 17 billion tonnes of oil annually by 2035. The carbon emission also increasing rapidly as per the report by International Energy Agency (IEA). [3]. both these ways are harmful for human race and therefore alternates to reduce these affects are considered, Waste-to-Energy generation method is become prominent option to eliminate all these problems. In this review paper we discuss about process of waste to energy production for India, and also we had discussed about world's status of waste to energy and progress of different countries in the way to control their municipal solid waste and their technologies in the field of energy abstraction from the waste. We had discussed about the different ways to abstract energy from the waste according to the phenomenon of India and plants installed in different states of India their drawbacks, capacity and amount of power generation.

II. WASTE-TO-ENERGY GENERATION SCENARIO AT GLOBAL SCALE

The management of waste in proper manner is primary concern of a country. The method should be sustainable and hygienic, generally open dumping, landfill, recycling, etc. methods are used to handle municipal waste [4]. Recently many currents are looking forward to reuse the waste to generate energy to fulfil their current needs. Since 1990, USA is producing energy from waste. Several energy generation plants based on waste as feed were in working to produce energy in Germany from early 90's. A report by Royal Commission on Environmental Pollution, UK explained the importance of waste to energy generation with the help of modern technologies [5]. Due to such awareness in early years, todays WtE techniques are so advanced to produce energy.

Poland produces gas using agriculture wastes and in 2012, Poland installed 29 biogas plants with total production capacity of 1MW. [6]. Malaysia uses traditional methods of landfill for management of waste, in 2010, the methane emissions from the landfill is costed approximately USD 220 million. Now, Malaysia is also working on utilization of this waste to produce energy [7,8]. In Italy, many co-digestion plants of capacity 50kW to 1MW were installed based on anaerobic decomposition of waste [9].

Ghana, an African country depends upon agricultural residue to produce electricity. People produce electricity and supply it by their own to the community. There is no proper developed electricity supply system, so they are focused to produce energy from waste due to lack of resources and financial [10]. Thessaloniki city of Greece using bio-cells to better utilization of the biogas produced by integrated solid waste management methods [11]. Singapore is also working on utilization of food waste to generate energy and the government is promoting several policies so that involvement of citizens can be increased [12]. Canada is also looking forward to produce energy using municipal waste. Canada has developed several systems and the annual output of WtE is around 135 MWh [13]. Thus, the whole world is working on developing WtE techniques for utilization of waste and generation of energy using solid or municipal waste.

III. PRE-EMINENT MUNICIPAL SOLID WASTE MANAGEMENT USING WTE TECHNOLOGIES

Municipal solid waste can be utilized by using to methods of decomposition, either by thermochemical decomposition or by biological decomposition. Several processes involved in these to methods for utilization of solid waste [14]. The major arises is that no city claims complete segregation of total waste produced [15]. Good part is that the major section of waste is collected but the remaining part is harmful and pollute the environment. Only small part of the collected waste is processed and remaining is dumped at land sites [16]. Some technologies for WtE utilization are now established in some parts of India [17]. The work is done on small scale because the technology is new to India and people are not so aware of it. The WtE technologies are further classified into two groups: one is direct processing and another is indirect processing.

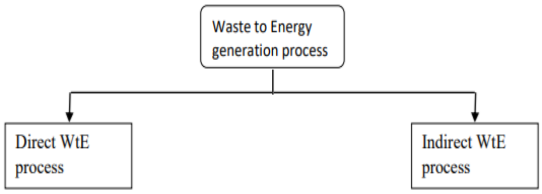

Figure 1: Processes for waste to Energy generation

A. Direct WtE process

This process is used to produce energy from non-recyclable waste using mechanical methods or biological treatment. This solid waste is converted in fuel generally called as Refuse-Derived Fuel. RDF is considered as good quality renewable source for energy generation and is used to replace coal from energy generation plants. Using of RDF in plants reduce the problem of ash handling, air pollution and gas emission that are generally occurs while working with coal as fuel in power plants [18]. The steps involved in direct processing includes size screening, preliminary liberation, shredding, magnetic separation and pelletising [19]. RDF products have calorific values around 1912 to 3346 kcal/kg [20].

B. Indirect WtE processes

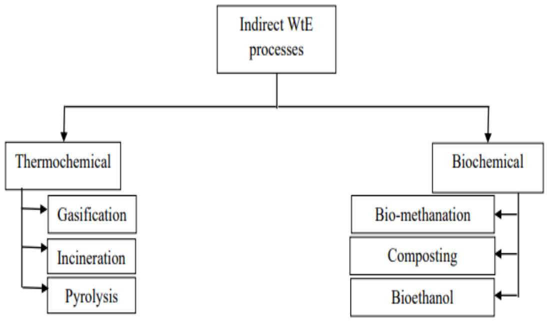

Figure 2: Indirect waste to Energy Generation

a. Gasification

Gasification is the most commonly used methods for the utilization of waste and convert it into useful fuel form. The use of gasification as a WtE technique was increased rapidly has been widely to produce energy from MSW [21]. The main output of waste using gasification is syn-gas also known as synthesis gas such as CO, CH_4, H_2 and some non-combustible gases like CO_2 and N_2. In India, the plants for gasification are only few and the main feedstock or waste used to run these gasifiers includes agro-waste, forest waste and wood-mill dust.

b. Incineration

This process uses thermal treatment of combustible material of waste. In this process the combustible material is converted into CO_2 and H_2O and remaining non-combustible waste in form of ash at the bottom of system. Incineration process is not so popular in India and hence does not practice at large scale due to presence of high organic materials (40-60%) and high moisture content in waste material about 40-60% [22]. This process involve 3 steps includes incineration process, energy recovery and pollution control [23].

c. Pyrolysis

Pyrolysis is a thermochemical process that convert solid waste into useful by-products by thermal degradation at high temperature between 300 degrees to 800 degrees Celsius [24]. The output product obtained are methane, CO_2, H_2O, CO. There are two methods of pyrolysis are widely used depend on heat transfer, they are fast pyrolysis and slow pyrolysis [25].

d. Anaerobic digestion

Anaerobic digestion method is used to utilize energy from farm slurry and food waste which are biodegradable in nature. This process worked under monitored condition, in which microorganism work to convert waste into methane and CO_2 gas. This process also generates waste in form of sludge digestate [26]. Feedstock used for this process includes livestock slurry, manure, crop remains.

e. Bio methanation

This method is used to process municipal solid waste and convert the waste into methane and manure. This conversion occurs by the help of microbials action and without oxygen. The bio methanation is commonly practiced all across India because it consumes agricultural waste to generate electricity and other useful by products like manure and methane.

f. Production of biogas from landfills (landfill gas)

Landfill sites are available outside every major city, the main purpose of these sites is to dump the municipal waste. The waste dumped in landfill sites degrades and decomposed due to warm and humid climate condition of India. This decomposition causes release of biogas called as Landfill Gas (LFG) [27]. Some steps involved in this process are: Decomposition of waste at landfills, LFG extraction, Primary processing of LFG, treatment for quality enhancement and uses as source of energy.

g. Bioethanol production

The crisis of the energy is due to the growth in industrialization and population of human, in turn, the fuel cost and demand has increased. So that, development of Bioethanol is necessity as alternative renewable fuels [28]. Fermentation and distillation are two commonly used methods for bioethanol production from waste. The output also provides us hydrogen as by-product which is effectively used as energy source [29].

IV. WASTE MANAGEMENT CHALLENGES IN INDIA

India is the second largest population of the world it holds around 17.8% (1.35 billion) population of the world. About 40 million tonnes of municipal waste is produced every year in India, then the waste in dumped into open dumping sites and landfills [30,31] There are 53 cities in India having total population over 10 lakh peoples and annual waste production of these cities is around 32 million tonnes. The total waste of municipal generated in India is about 69 million tonnes per annum [32] About 80% pf which is collected and dumped to land sites where as remaining 20% is littered. Out of 80%, only 20% of the waste is recycled and reused [33,34] India’s current annual growth rate is about 3.5% in urban areas [35] India has to work on better collection of waste and set up for waste to energy generation plants to fulfil the increasing need of energy with increase in population.

V. WASTE-TO-ENERGY GENERATION TECHNOLOGIES IN INDIA

As a developing nation, demand of energy growth increases day by day and also required more land for deposition of waste. MSW management is most prominent way to neglected issue of waste in urban development [36]. India cannot handle the waste due to lack of policies, good framework and technological advancements and lack of funding [37]. Some projects of waste to energy generation operating in India are:

In Andhra Pradesh, an installation of RDF plants at Hyderabad, Vijayawada and Guntur. It produces 700 TPD but has a capacity of 1000 TPD of waste. It produced approx 210 TPD of pellets, fluff. The Vijayawada's plant handled 500 TPD of municipal waste to generate 6 MW of power but now these plants are non-operational [38]. Chandigarh has installation of RDF plant having capacity of 500 TPD of municipal waste to produce pellets. But now the plant is rarely operated and lies dormant. Government is working on retrofitted the plant with MSW drying systems to reduce moisture in the final RDF [32]. In Timarpur, New Delhi, the first large scale waste incineration plant was setup in 1987, by Miljotecknik volunteer, Denmark. It has a capacity of 300 tonnes per day and installation cost is about INR 250 million. The plant was out of operation within few months due to lack of supply which forced Municipal Corporation of Delhi to shut it down [39]. A new plant is setup at Okhla landfill site, New Delhi, which has recently begun its operations. It is capable to generate 16 MW of electricity per day by combusting 1350 tonnes of waste. Also, a gasification unit was installed by The Energy Research Institute (TERI) at Gaul Pahari campus, New Delhi, [40].

Gujarat is using renewable sources of energy at large scale in India. M/S Kanoria chemicals Ltd., Ankleshwar produces 2 MW of energy by Anaerobic digestion. Similarly, 4800 nm^3 of biogas per day is manufactured by M/S Anil Starch Products Ltd., with the help of aerobic digestion process. In Surat, a 0.5 MW capacity power plant at sewage treatment plant is installed. Apart from bio methanation, RDF is also practiced in Gujarat, with Rajkot leading the progress. A public private partnership of Rajkot Municipal Corporation and Hanjer Biotech Pvt Ltd. have setup a novel waste management process, which enables them to produce green coal and Bio-bricks from dry organic waste and inert waste [41,42]. In Bangalore, 50 TPD of garbage is converted into 5 tonnes of fuel pellets for domestic as well as industrial uses. Apart from RDF plants, Bangalore boasts of good research work on bio methanation projects. Several bio methanation plants are in operation and are in working to increase the scalability of the bio methanation plants [37]. A Biotech, company based in Thiruvananthapuram, had installed 20,000 biogas units for household use, which consume 2.5% of organic waste from landfill. These units also aid in avoiding 7000 tonnes of CO_2 per year [32]. Som Distilleries, Bhopal commissioned industrial waste treatment plant based on the principle of waste to energy on June 5, 1999. It produces biogas with the help of bio methanation digester. The plant capacity is 2.7 MW and was expected to generate a minimum of 16^{10} kWh per annum [43].

Maharashtra is taking the initiative to convert waste to energy. Maharashtra Energy Development Agency (MEDA) is inviting potential investors to invest in implementing many plants and projects in Mumbai, Pune, Nashik, etc. [44]. Pune Municipal Corporation has taken a step forward to develop a municipal waste management bio-methanation plant that resulting into the generation of 375 kW/day of electricity, serves in managing the waste as well as generates power. The plant has been operational since November 2009 [45]. In early 90's RDF plant at Deonar, Mumbai owned by Excel India is to process garbage into pellets. The plant is not in operation since a few years now [46]. In Chennai, a 15 MW waste to energy project has been established by an Australian company Energy Development Ltd., in financial partnership with State bank of India and Canara Bank [47]. In the field of waste to energy, Uttar Pradesh has been the one of the pioneering states. Lucknow is the first largest scale anaerobic digestion plants to generate 6 MW of electricity, but due to lack of source separation it failed [48].

Waste to energy does not appear to be feasible as a waste reduction process, at either large scale or small scale. Thus, currently waste to energy process is not considered as a municipal solid waste management and reduction process [49]. The major problem in municipal solid waste management at West Bengal is due to lack of waste segregation source, low percentage of waste collection, low operational efficiency of waste transport system and inefficient informal recycling system. Though, the state of west Bengal has witnessed the above- mentioned challenge, it has never shut its doors to the initiatives to ensure improvements.

REFERENCES

1. Malinauskaite, J., Jouhara, H., Czajczy_nska, D., Stanchev, P., Katsou, E., Rostkowski, P., Thorne, R.J., Colon, J., Pons_a, S., Al-Mansour, F., Anguilano, L., Krzy_zy_nska, R., Lopez, I.C., Vlasopoulos, A., Spencer, N., 2017. Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe. Energy 141, 2013e2044.

2. World Bank. data. https://data.worldbank.org/indicator/SP.POP.TOTL?locations¼IN. (Accessed 1 July 2020).

3. Chu, S., Majumdar, A., 2012. Opportunities and challenges for a sustainable energy future. Nature 488, 294e303.

4. https://doi.org/10.1016/j.jclepro.2020.123227

5. Wolpert, Vladimir M. Incineration of municipal solid waste combined with energy production–Latest developments. Renew Energy 1994; 5:782–5.

6. Justyna CM, Szymanska D. Agricultural biogas plants-a chamce for diversification of agriculture in Poland. Renew Sustain Energy Rev 2013;20:514–8.

7. Zainura NZ, Rafiu YO, Ahmad AH, Mohd HA, Mohd FM. An overview for energy recovery from municipal solid waste (MSW) in Malaysia scenario. Renew Sustain Energy Rev 2013;20:378–84.

8. Anwar J, Ahmed SI, Haslenda H, Habib A, Ramli M. Economic and environ-mental benefits of land fill gas from municipal solid waste in Malaysia. Renew Sustain Energy Rev 2012;16:2907–12.

9. Pantaleo A, Gennaro BD, Shah N. Assessment of optimal size of an aerobic co-digestion plants: an application to cattle farms in the province of Bari (Italy). Renew Sustain Energy Rev 2013;20:57–70.

10. Mohammed YS, Mokhtar AS, Bashir N, Saidur R. An overview of agricultural biomass for decentralized rural energy in Ghana. Renew Sustain Energy Rev 2013;20:15–22.

11. Christopher J, Koroneos, Nanaki EA. Integrated solid waste management and energy production a life cycle assessment approach: the case study of the city of Thessaloniki. J Clean Prod 2012;27:141–50.

12. Hsien KH, Teik LZ, Reginald TB. Food waste conversion options in Singapore: environmenta limpacts based on an LCA perspective. Sci Total Env 2010;408:1367– 73.

13. Curry N, Pillay P. Biogas prediction and design of a food waste to energy system for the urban environment. Renew Energy 2012;41:200–9.

14. Tozlu, A., €Ozahi, E., Abus¸ o_glu, A., 2016. Waste to energy technologies for municipal solid waste management in Gaziantep. Renew. Sustain. Energy Rev. 54, 809e815.

15. Kamble, S.K., Kekan, R., Godbole, P., 2019. Challenges in municipal solid waste management in India. Int. J. Sci. Eng. Res. 10, 345e350.

16. MoHUA, 2016-17. Annual report. Ministry of housing and urban Affairs, government of India. http://mohua.gov.in/upload/uploadfiles/files/annual%20report%20English%20-%20print.pdf.

17. Gupta, N., Yadav, K.K., Kumar, V., 2015. A review on current status of municipal solid waste management in India. J. Environ. Sci. 37, 206e217.

18. Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C., 2008. Municipal solid waste management in Indian citieseA review. Waste Manag. 28, 459e467.

19. Ganesh, T., Vignesh, P., Kumar, G.A., 2013. Refuse derived fuel to electricity. Int. J. Eng. Res. Technol. 2, 2278e2281.

20. Govani, J., Patel, H.T., Chabhadiya, K., Jadeja, U., Pathak, P., 2019. Transformation of industrial waste into alternate resource: a critical review. In: National Environmental Conference (NEC-2019). IIT Bombay, India.

21. Thakare, S., Nandi, S., 2016. Study on potential of gasification technology for municipal solid waste (MSW) in Pune city. Energy Procedia.

90, 509e517.

22. Joshi, R., Ahmed, S., 2016. Status and challenges of municipal solid waste management in India: a review. Cogent Environ. Sci. 2, 1139434.

23. Kalyani, K.A., Pandey, K.K., 2014. Waste to energy status in India: a short review. Renew. Sustain. Energy Rev. 31, 113e120.

24. Gupta, N., Yadav, K.K., Kumar, V., 2015. A review on current status of municipal solid waste management in India. J. Environ. Sci. 37, 206e217.

25. Jahirul, M.I., Rasul, M.G., Chowdhury, A.A., Ashwath, N., 2012. Biofuels production through biomass pyrolysis- A technological review. Energies 5, 4952e5001.

26. Whiting, K., Wood, S., Fanning, M., reportWaste Technologies: Waste to Energy Facilities. A Report for the Strategic Waste Infrastructure Planning, Working Group Complied by WSP Environmental Ltd for the Government of Western Australia, Department of Environment and Conservation of Western Australia.

27. Kerr, T., Dargaville, R., 2008. Turning a Liability into an Asset: Landfill Methane Utilisation Potential in India. Int. Energy Agency, pp. 1e24.

28. Akponah, E., Akpomie, O., 2011. Analysis of the suitability of yam, potato and cassava root peels for bioethanol production using Saccharomyces cerevisiae. Int. Res. J. Microbiol. 2, 393e398.

29. Karakashev, D.B., Angelidaki, I., 2011. Emerging biological technologies: biofuels and biochemicals. In: Christensen, T.H. (Ed.), Solid Waste Technology and Management. Wiley.

30. Hoornweg D, Bhada-Tata P. What a Waste: A Global Review of Solid Waste Management. Washington, DC: World Bank; 2012.

31. Wolfe JM, Mahadevia D. Solid waste management in indian cities: status and emerging practices. Concept Publishing Company; 2008.

32. Annepu RK. Sustainable Solid Waste Management in India. New York: Columbia University in the city of New York, Department of Earth and Environmental Engineering; 2012.

33. CPCB Central Pollution Control Board, 2013. Status Report on Municipal SolidWaste Management. Ministry of Environment & Forests) Parivesh Bhawan, East Arjun Nagar, Delhi e 110 032.

34. MNRE Ministry of New and Renewable Energy, 2016. Power Generation from Municipal Solid Waste, 20th Report, Standing Committee on Energy Report. http://164.100.47.193/lsscommittee/Energy/16_Energy_20.pdf.

35. Census, 2011. Census of India. Ministry of Home Affairs, Government of India, New Delhi, India. http://censusindia.gov.in/. (Accessed 10 July 2018).

36. Mourad, M., 2016. Recycling, recovering and preventing “food waste”: competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461e477.

37. Sharholy M, Ahmad K, Mahmood Gauhar, Trivedi R. Municipal solid waste management in Indian cities – a review. Waste Manage 2008;28:459–67.

38. Reddy, S, Galab, S. An Integrated Economic and Environmental Assessment of Solid Waste Management in India: the case of Hyderabad, India. (n.d.).

39. Lal A. Environmental status of Delhi. Indian J Env Prot 1996;16(1):1–11.

40. Ahsan N. Solid waste management plan for Indian megacities. Indian J Env Prot 1999;19(2):90–5.

41. Kalyani K. Alternative Energy Supple Option from House hold Waste Gasification Process A Feasibility Analysis on Rajkot City. Dehradun: University of Petroleum & Energy Studies, College of Management & Economic Studies.

42. Waste processing plant through public private partnership; 2003.

43. Singh RP, Tyagi VV, Allen T, Ibrahim MH, Kothari R. An over view for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. Renew Sustain Energy Rev 2011;15(9):4797–808.

44. Ramachandra T. Management of Municipal Solid Waste. New Delhi: Capital Publishimg Company; 2006.

45. Tayde P. Creating wealth from organic waste. Akshay Urja 2012;5(6):38–40.

46. Yelda S, Kansal S. Economic insight into MSWM in Mumbai: acritical analysis. Int J Env Pollut 2003;19(5):516–27.

47. Ramachandra T, Varghese S. Exploring

possibilities of achieving sustainability in solid waste management. Indian J Env Health 2003;45(4):255–64.
48. Ramachandra T. Management of Municipal Solid Waste. New Delhi: Capital Publishimg Company; 2006.
49. Chattopadhyay S, Dutta A, Ray S. Municipal solid waste management in Kolkata, India - a review. Waste Manage 2009;29:1449–58.