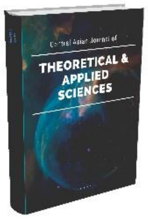

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Experimental Analysis of Municipal Solid Waste

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Abstract: *As the quantity of municipal solid waste (MSW) increases with economic growth, problems arise in regard to sustainable management solutions. Thermal treatment presents a valid option for reducing the amounts of post-recycling waste to be landfilled. Incineration technology, besides reducing the total volume of waste and making use of the chemical energy in MSW for power generation, has negative environmental impact from high emission of pollutants. Recent policy to tackle climate change and resources conservation stimulated the development of renewable energy and landfill diversion technology, thereby giving gasification technology development renewed importance. In this work a two-dimensional CFD model for MSW gasification was developed and an Eulerian–Eulerian approach was used to describe the transport of mass, momentum and energy for the solid and gas phases. This model is validated using experimental data from the literature. The numerical results obtained are in good agreement with the reported experimental results.*

Keywords: *MSW, incineration, gasification, pollutants, experimental, solid, model, data.*

Introduction

A work explores the use of advanced thermal technologies for the conversion of refuse derived fuel prepared from MSW into clean syngas suitable for catalytic transformation into light hydrocarbon products. In particular, the possibilities for the specific production of C1–C4 hydrocarbons utilising a good quality syngas produced by two-stage plasma assisted gasification method are investigated. A number of catalytic tests were prepared with modified chemistry to evaluate the preliminary component activities on real waste-derived syngas. C1–C4 paraffins formed in all cases as a main products, with different product distribution for different conditions examined (up to 95% bioSNG on hydrocarbon product for supported nickel, 40% bioLPG for Cu–Zn/ZSM-5 catalysts mix).[1,2] CO_2 was the main byproduct with outlet concentrations ranging from 10 to 50% in volume. When increasing H_2:CO in the syngas by external addition of hydrogen, CO conversion increases, as well as paraffin selectivity and hydrocarbons yield. Projections on a 65 MW thermal input bioSNG plant show that if 40 MW of electrical output from renewable sources are used to power a PEM stack during high power availability, the production of bioSNG could be increased by more than 33%, with a simultaneous reduction in CO_2 emissions of more than 43%.

In last few years, municipal waste generation and regulating are common problems forall over worldcountries. Conversions of waste to energy technologies arecreating manyend-products like electricity, thermal energy, fertilizer and biogas etc. Due to this, compression of solid waste has become compulsory to save the space in garbage carrying tuck, which is also known as hydraulic compactor machine. Hydraulic compactor machine is a garbage carrying compact truck after Compressing the garbage up to 50 to 60 percent more than the capacity of truck of municipal solid waste (MSW). Solid waste contains different component, high compressibilityfactor, and more water content. This study has been carried out with the municipal solid waste. The unpredictable compression mechanical characteristic varies with the simulation of solid waste compression process. The process shows the compression and shear characteristic analysisfor compressing garbage. Experimental analysis of the mechanical properties of solid waste, animportant test instrumentfor shear test and compression test was designed. Total fourteen tests on solid waste wereconducted as pe the designed test instrument and themodel parameters by analyzing testing data [3,4]. At last, the defined characteristicstests were simulated ontested model and designed model factors werejustified. This paper gives us information for the mechanical behavior of garbage compression in hydraulic compactor for energy generation process.

Solid waste management and energy generation have been of major concern in Niger Republic. Municipal solid waste samples were collected during the months of February, March and April and during the rainy season in August for three years in Diffa, Dosso, Maradi, Niamey and Zinder in Niger Republic. The refuse physical characteristics were then evaluated by sifting through the waste and separated into wood, grass, metal, plastic, paper and sand. The refuse samples were analyzed by proximate and ultimate analyses using ASTM standards. Proximate and ultimate analyses results of refuse in the area of study showed refuse characteristics as moisture: volatile matter: fixed carbon: ash content, as 19.693: 26.877: 19.310 and 34.120 for Niamey and 17.539: 25.950: 19.111: 37.40 for Zinder. The standard deviation and the mean deviation of the lower calorific value were found to be 7.35% and 1.60 % respectively for the five cities in the study area. The lower calorific values of the refuse were low and found to fall below the limit for the production of steam in electricity generation, therefore would not to be able to sustain an industrial incineration process. There is need to provide a supplementary fuel in the form of bagasse, any herbaceous biomass at up to 50% of the total fuel to be loaded in the incinerator. It was found that population density and geographical locations are not real determining factors as whether refuse quality may change or not but rather the life style of the population and its awareness towards waste management techniques like recycling, re-use and composting.[5,6]

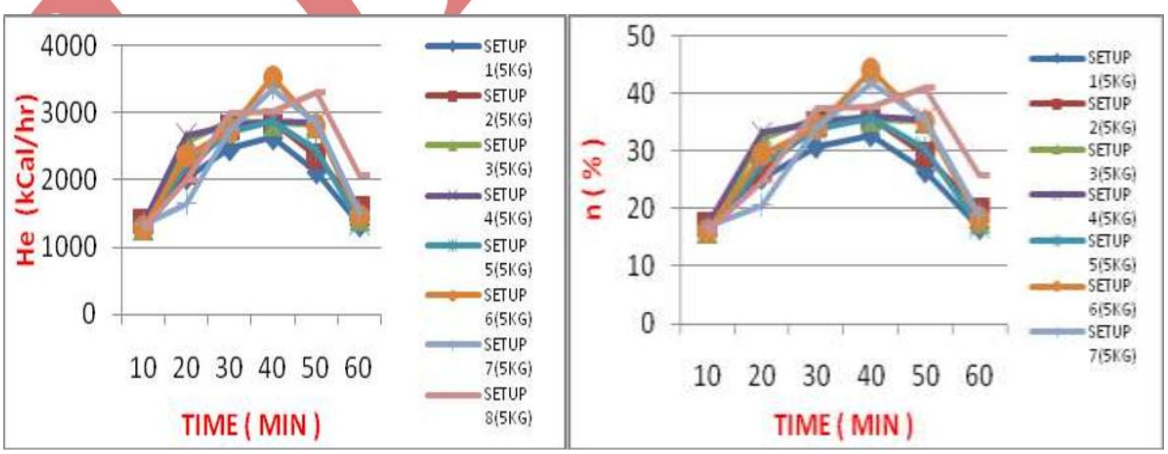
The innovation of the technology and its development are highly emphasised for converting waste into energy through gasification. The designed and fabricated gasifier (100 kg/h capacity) is a downdraft gasifier that is square in shape and operates slightly above atmospheric pressure to generate tar-free producer gas. The design operates with pellets and fluffy MSW. The generated producer gas was tested for both thermal applications. This designed gasifier can be scaled up and implemented to suit the requirements of industrial energy demand, which has wide-ranging applications. For optimum performance, a 25 kg amount of char is needed to gasify MSW completely. The energy output from the mass and energy balance is 92.5% optimal for effective gas generation. Energy generation from the designed gasifier and process optimisation for thermal energy from gas with enhanced efficiency abets in drastically reducing the cost of factory’s energy consumption. This also helps achieve reduced environmental emissions with good returns on investments.

Discussion

As the quantity of municipal solid waste (MSW) increases with economic growth, problems arise in regard to sustainable management solutions. Thermal treatment presents a valid option for reducing the amounts of post-recycling waste to be landfilled. Incineration technology, besides reducing the total volume of waste and making use of the chemical energy in MSW for power generation, has negative environmental impact from high emission of pollutants. Recent policy to tackle climate change and resources conservation stimulated the development of renewable energy and landfill diversion technology, thereby giving gasification technology development renewed importance. In this work a two-dimensional CFD model for MSW gasification was developed and an Eulerian–Eulerian approach was used to describe the transport of mass, momentum and energy for the solid and gas phases. This model is validated using experimental data from the literature. The numerical results obtained are in good agreement with the reported experimental results.[7,8]

In last few years, municipal waste generation and regulating are common problems forall over worldcountries. Conversions of waste to energy technologies arecreating manyend-products like electricity, thermal energy, fertilizer and biogas etc. Due to this, compression of solid waste has become compulsory to save the space in garbage carrying tuck, which is also known as hydraulic compactor machine. Hydraulic compactor machine is a garbage carrying compact truck after Compressing the garbage up to 50 to 60 percent more than the capacity of truck of municipal solid waste (MSW). Solid waste contains different component, high compressibilityfactor, and more water content. This study has been carried out with the municipal solid waste. The unpredictable compression mechanical characteristic varies with the simulation of solid waste compression process. The process shows the compression and shear characteristic analysisfor compressing garbage. Experimental analysis of the mechanical properties of solid waste, animportant test instrumentfor shear test and compression test was designed. Total fourteen tests on solid waste wereconducted as pe the designed test instrument and themodel parameters by analyzing testing data. At last, the defined characteristicstests were simulated ontested model and designed model factors werejustified.

Indian per capita waste generation is 0.2 – 0.6 kg/day, which is estimated to increase at 1.33% annually. As per estimates,1,27,486 TPD (Tons per day) municipal solid waste is generated in the Country during 2011-12.

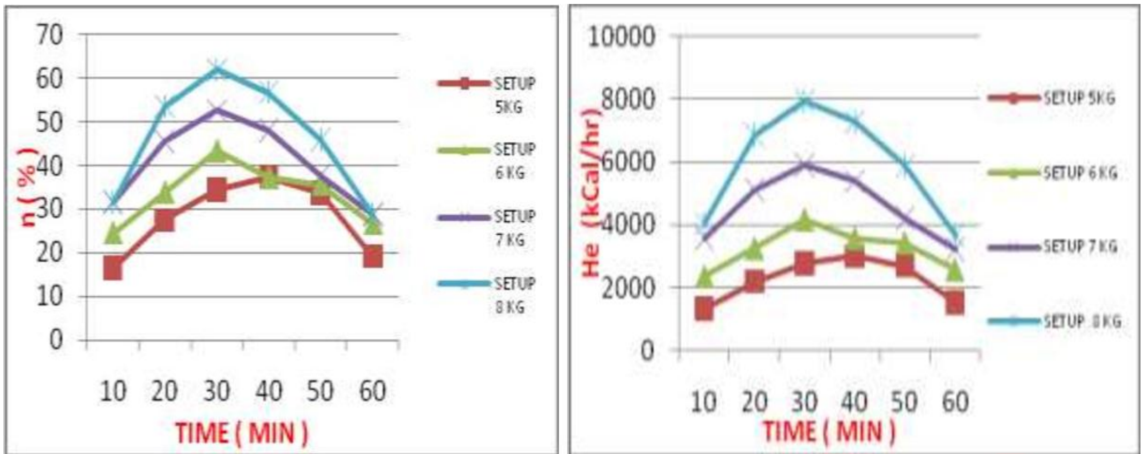


Heat in flue gas of furnace with respect to Time for each set of 5 Kg fuel

Out of which, 89,334 TPD (70%) of MSW is collected and 15,881 TPD (12.45%) is processed or treated. Municipality used the landfill as the main solution to deal with the MSW, however the rapid growth of MSW volume leads to that the new high efficient MSW treatment method are needed to replace the landfill. One of these methods is waste incineration with energy recovery which has an aim to minimize waste volumes as well as generate power.

This evaluating the thermal efficiency of incinerator. The prototype incinerator, designed gives the maximum efficiency of 61% having fuel MSW calorific value 1601.29 Kcal/Kg. Incineration, if properly designed, is an efficient way to reduce the volume of waste and demand for landfill space. Incineration reduces the need for landfill space to 5%, while the ash can also provide an inexpensive for environment-friendly fertilizers and aggregate for construction.[9,10]

Efficiency of furnace with respect to Time and Heat in flue gas of furnace with respect to Time for 5 Kg, 6 Kg, 7 Kg and 8 Kg fuel MSW



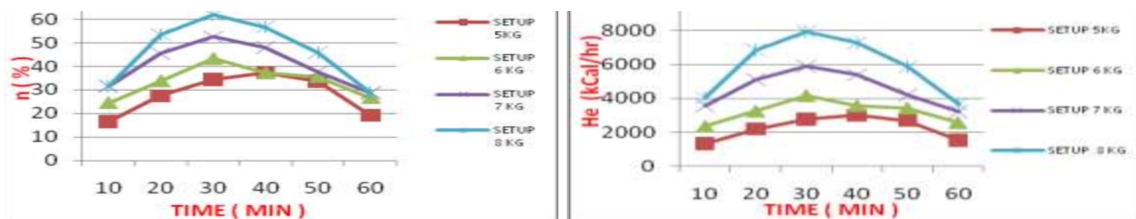


Fig. 4 a) Efficiency of furnace with respect to Time and b) Heat in flue gas of furnace with respect to Time for 5 Kg, 6 Kg, 7 Kg and 8 Kg fuel MSW

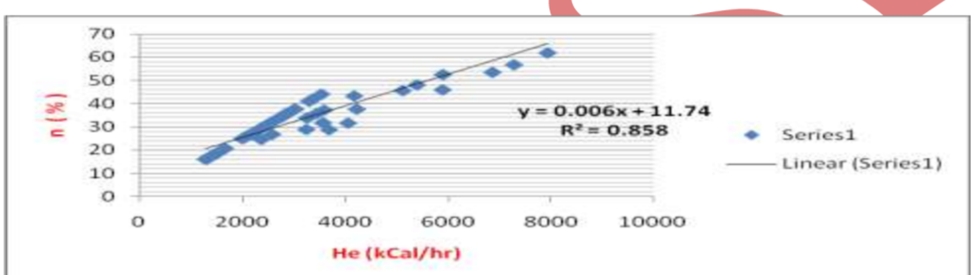
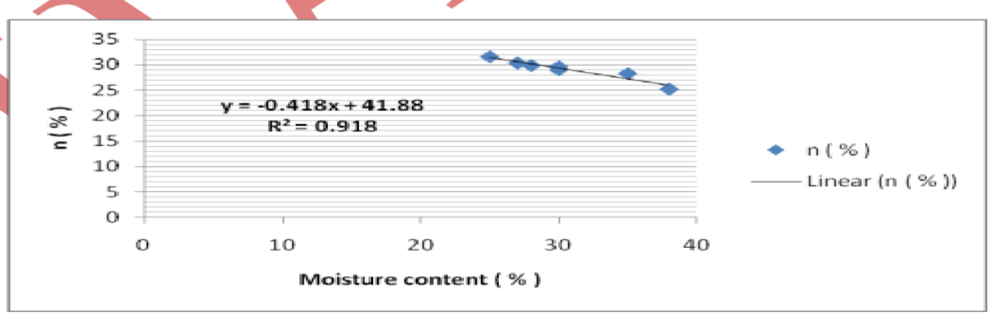


Fig. 5 Quantity of heat of stock (air) in kCal with specific efficiency for that heat



Quantity of heat of stock (air) in kCal with specific efficiency for that heat

Results

The management of municipal solid waste in India has surfaced or continued to be a severe problem not only because of environmental and aesthetic concerns but also because of the enormous quantities generated every day. Even though only 31% of Indian population resides in urban areas, this population of 377 million (Census of India, 2011) generates a gigantic 1,43,449 metric tonnes per day of municipal solid waste, as per the Central Pollution Control Board (CPCB), 2014-15 and these figures increase every day with an increase in population. To further add to the problem, the total number of towns (statutory and census) in the country have also increased from 5,161 in 2001 to 7,936 in 2011, thus increasing the number of municipal waste generation by 2,775 within a decade. The management of municipal solid waste is one of the main functions of all Urban Local Bodies (ULBs) in the country. All ULBs are required to meticulously plan, implement and monitor all systems of urban service delivery especially that of municipal solid waste. [11,12] With limited financial resources, technical capacities and land availability, urban local bodies are constantly striving to meet this challenge. With the launch of the flagship programme by the Government of India, Swachh Bharat Mission in 2014 that aims to provide basic infrastructural and service delivery with respect to sanitation facilities to every family, including toilets and adopting the scientific methods to collect, process and disposal of municipal solid waste. The mission focuses on quality and sustainability of the service provision as well as emphasising on the commitment on every stakeholder to bring about a visible change in society. This manual on Municipal Solid Waste Management provides guidance to urban local bodies on the planning, design, implementation and monitoring of municipal solid waste management systems. Issues of environmental and financial sustainability of these systems are a critical consideration. The manual clearly defines the planning process to be adopted by urban local bodies for preparing, revising and implementing Municipal Solid Waste Management Plans (MSWM Plans). The long term planning horizon of 25 years is further divided into short term plans to be prepared once every five years, with a mid-term review once every 2-3 years within this 5 year period, as per requirement.

The MSWM plan should consider a long term planning horizon of 20–25 years. Short term implementation plans covering 5 years each should be slotted within the long term plan for ease of implementation. The short term plan should be reviewed and updated once every 2–3 years for any midcourse correction as required. Local authorities should ensure that the short term plan is aligned with long term planning and implementation [13,14]

1. At source reduction and reuse: The most preferred option for waste management in the ISWM hierarchy is to prevent the generation of waste at various stages including in the design, production, packaging, use, and reuse of products. Waste prevention helps to reduce handling, treatment, and disposal costs and various environmental impacts such as leachate, air emissions, and generation of greenhouse gases (GHG). Minimisation of waste generation at source and reuse of products are the most preferred waste prevention strategies.
2. Waste recycling: The next preferred option for waste management in the ISWM hierarchy is recycling of waste to recover material resources through segregation, collection, and re-processing to create new products. In the waste management hierarchy, composting is considered as an organic material recovery process and is often considered at the same hierarchical level as inorganic waste recycling.
3. Waste to energy: Where material recovery from waste is not possible, energy recovery from waste through production of heat, electricity, or fuel is preferred. Biomethanation, waste incineration, production of refuse derived fuel (RDF), co-processing of combustible nonbiodegradable dry fraction from MSW in cement kilns and pyrolysis or gasification are some waste-to-energy technologies. [15]

4. Waste disposal: Residual inert wastes at the end of the hierarchy are to be disposed in sanitary lined landfills, which are constructed in accordance with stipulations prescribed in SWM Rules, 2016. All over the world, landfills which integrate the capture and use of methane are preferred over landfills which do not capture the landfill gas. As per the hierarchy, the least preferred option is the disposal of waste in open dumpsites. However, Indian laws and rules do not permit disposal of organic matter into sanitary landfills and mandate that only inert rejects (residual waste) from the processing facilities, inert street sweepings, etc. can be landfilled. In cases where old dumps are to be closed, there is a possibility of capturing methane gas for further use. However, repeated burning of waste significantly decreases the potential of capturing methane

Cleanliness pledge

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed. Mahatma Gandhi secured freedom for Mother India. Now it is our duty to serve Mother India by keeping the country neat and clean. I take this pledge that I will remain committed towards cleanliness and devote time for this. I will devote 100 hours per year, that is two hours per week, to voluntarily work for cleanliness. I will neither litter not let others litter. I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place. I believe that the countries of the world that appear clean are so because their citizens don't indulge in littering nor do they allow it to happen. With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns. I will encourage 100 other persons to take this pledge which I am taking today. I will endeavour to make them devote their 100 hours for cleanliness. I am confident that every step I take towards cleanliness will help in making my country clean.[16]

Conclusions

Action points for awareness generation through information, education, and communication activities for special waste including domestic hazardous waste:-

- ✓ Provide information to the community on different types of special wastes including domestic hazardous waste and their related impacts on human life and environment.
- ✓ Generate awareness in the community about segregating special waste at household level to prevent its mixing with MSW. Equally important is to provide information on collection and disposal systems for special waste and related initiatives taken up by the ULB.
- ✓ Encourage usage of sustainable material such as jute or cloth bags, energy efficient lighting and electronic appliances, and multi-use consumables as an effective strategy to minimise special waste generation.
- ✓ Provide and communicate incentives to the community for making use of dry waste and domestic hazardous waste collection centres.
- ✓ Inform public about economic and environmental benefits of reducing, reusing, and recycling special waste.
- ✓ Engage with local businesses or electronic suppliers and create awareness on EPR initiatives around special waste. Promote incentives to encourage such initiatives.
- ✓ Educate public about prevalent EPR initiatives.[17]

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