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Energy Recovery through Plastic Waste in Cement Industry: A Review

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***Abstract*-- This study deals with a quantitative analysis of the energy, environmental and greenhouse gas effects of replacing fossil by plastic waste in cement production. Firstly the use of plastic waste was done with a focus on this practice at ACC cement plant. Today surplus plastic waste are being produced due to the growth in the use of plastic products. The newly adopted mechanism has shown that recyclable and non recyclable components of plastic waste in municipal solid waste can be taken care of in a scientific manner through co-incineration in cement industries. Therefore plastic waste can be converted into energy, an environment friendly and a desirable option. With the popularization of this scheme we shall be able to take care of plastic waste to a very large extent.**

The main focus of this work is to facilitate development of enabling policies and framework by regulatory agencies (State and Central Pollution Control Board) to facilitate use of urban & industrial waste as raw material alternate fuel in the cement industry, thereby moving towards a low carbon economy.

I. INTRODUCTION

In today's scenario the waste created by human activities, and the ways that waste is handled, stored, collected, and disposed of can pose great risks to the environment and to public health. Municipal Solid waste management (MSWM) includes all activities that seek to minimize health, environmental, and aesthetic impacts of solid waste. Due to urbanization there is a rapid growth of MSW which has led to severe waste management problems. The vast amount of waste generated necessitates a system of collection, storage, transportation and disposal. Recycling of waste as well as energy generation and employment opportunities from waste management also have immense potential. The local participating bodies like municipalities and industries are first encouraged, for exploring and adopting "Reduce-Reuse-Recycle" (3R) principle, for managing their waste.

Conventional methods of disposal are land filling and incineration. The option of co-processing in cement kilns which is the best disposal option with complete energy and material recovery. Therefore, it means co-processing lies higher to land filling and incineration in waste management hierarchy. Therefore our motivation towards this research is co-processing of plastic waste for the generation of energy.

II. MSW POTENTIAL IN THE INDIA

The municipal solid waste (MSW) generated by Urban India is 188,500 tpd (tons per day) (68.8 million tons per year) at a per capita waste generation rate of 500 grams/person/day [1]. The total waste generation figure is achieved by extrapolating the total tonnage of wastes documented for 366 cities (70% of India's urban population) India, account for 17.5% of the world population (Census of India ,2011) with a population of over 1.21 billion. 377 million people live in the urban areas of the country according to the provisional figures of Census of India 2011. This is 31.16 % of the Country's total population. India has 475 Urban Agglomerations (UA), three of which has population over 10 million. Improper planning and poor financial condition coupled with very high rate of urbanization has made MSW management in Indian cities an exceptional task. According to the research, if the trend continues, urban India will generate 160.5 million tpy (440,000 tpd) by 2041 and over the next decade some 920 million tons of MSW that needs to be properly managed. The study finds that the composition of urban MSW in India is 51% organics, 17.5% recyclables paper, plastic, metal, and glass) and 31% of inert (Jan. 2012 Waste-to- Energy Research and Technology Council.

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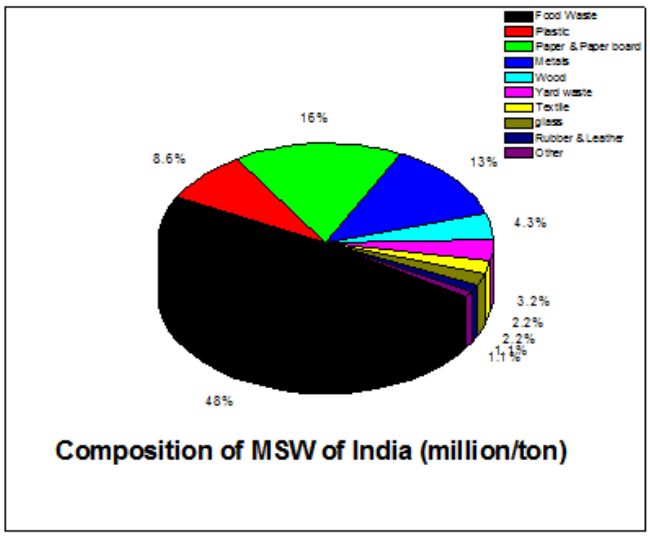

Fig.1: Composition of MSW in India [2]

III. Disposal Of Plastic Waste Is A Serious Concern In India

Several new technologies have been developed to minimize their adverse effect on the environment. The most accepted technology which is worldwide accepted for the plastic disposal is incineration. Today, the incinerators designed poorly, releases extremely toxic compounds (chlorinated dioxins and furans) therefore, they are strongly opposed from various non-government organizations. In India to introduce a safer disposal technology various new technologies were experienced enclosed in Figure 2. Approximately 5.6 million tons per annum (TPA) plastic waste is generated in country, which amounts to 15342 tons per day (TPD) [2].

Plastic products have become an integral part in everybody's daily life. In India approximately 8 Million tons plastic products are consumed every year [3]and its production crosses the 150 million tons per year globally, It has broad range of application in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. Once plastic is discarded after its utility is over, it is known as plastic waste.

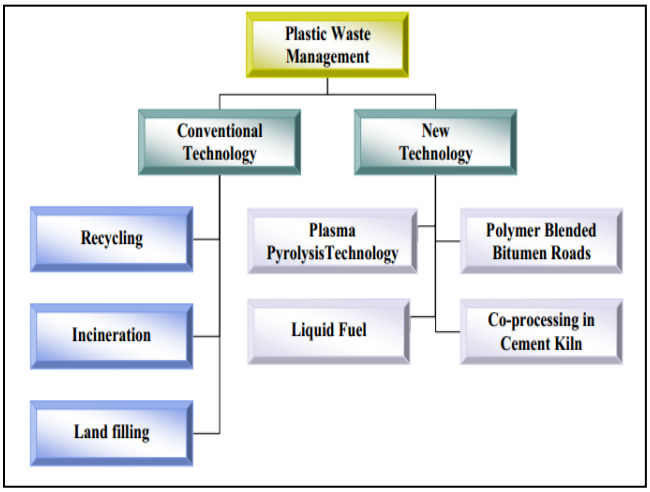

Fig. 2: Plastic Waste Management [3]

IV. Co-Processing Of Plastic Waste In Cement Kiln

About 70 per cent of the total cement production of the country is contributed by the top 20 cement companies [4]. One of the most effective methods of recycling of plastics waste for recovery of energy is its use as an alternative fuel in cement kilns. There are various projects adopted from recycling of plastic for making new products and saving energy, there are also projects which aim to turn plastic into new energy sources. Plastic is prepared from crude oil, which is the same raw material from which fuel is made. There are researchers where some scientists have made it their goal to turn waste plastic back to crude oil so that it can be reused for powering engines. This method will not only help to put waste plastic to actual use, but it also helps to save the scarce crude oil resources left on earth. The high temperature used in the cement kilns gives a scope for use of even some type of plastic waste contaminated with toxic chemicals like pesticides and some other plastic materials without creating any increased emissions in the air or water. These type of disposal do not require any segregation or cleaning for such type of disposal. Low-end plastic waste, which creates a waste management problem, may provide the vital energy to the cement industry. 170 Cement Kilns in India could dispose of the entire plastic waste generated in the country today at 10% replacement rate, with additional benefit of reduction in the use of fossil fuel- coal.

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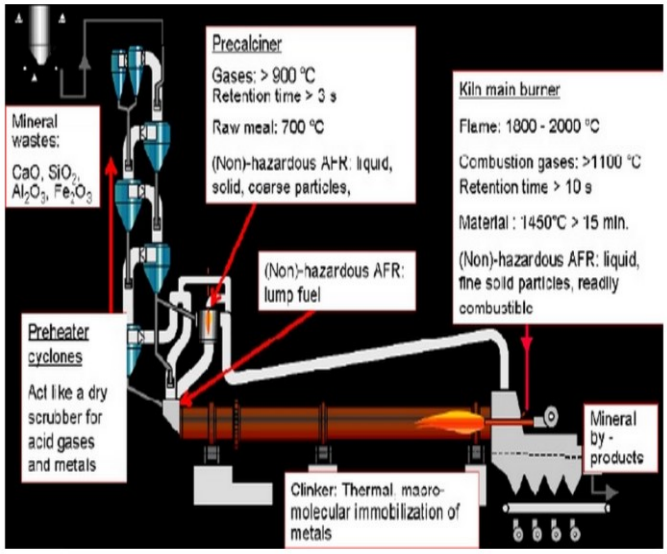

Figure 3: Co-processing of plastic waste Plastic Waste Management [3]

V. Merits And Demerits Ad Co-Incineration Of Plastic Waste

India has a highly developed and mature plastic recycle industry due to which it provides ample opportunity for the growth of Energy generation. Moreover plastic recycling industry has provided engagement and livelihood to a large number of workers in the country [5]. Almost all of the plastics that have surpassed utility in one application and are economically feasible to recycle into another application gets recycled through a well established systems of collectors and recyclers facilitating societal growth in a sustainable manner. There are some of the plastic waste which is not economical to recycle and therefore is not picked up by the collectors and it ends up in dump yards. This waste plastic poses a serious threat to the ecosystem and is a cause of concern of the present time. The management and disposal of plastic waste poses a major threat today in the country. These are either dumped or burnt in uncontrolled manner, thus leading to noxious and toxic emissions. A sustained solution to manage this plastic waste problem is Cement kiln co-processing.

There are wide range of temperature zones in cement kiln process with different residence times which provide opportunities to fine tune waste management systems appropriately. Different wastes can be Co processed at different points within the kiln system depending on their physical and chemical characteristics. The temperature in the cement kiln process varies from about 850 ^{o}C to 1800 ^{o}C [6].

A high degree of turbulence is added to the process by excess level of Oxygen and counter flow operation with flue gases moving in a direction opposite to the materials. The presence of an alkaline reducing environment (lime) and the pre-heating of the raw materials by a pre-heater tower (>100m tall) acts as an ideal scrubber for hot flue gases before they are emitted into the atmosphere. The 3 Ts- Time, Temperature and Turbulence in cement kilns provides an extremely high destruction removal efficiency (DRE) for all waste types (>99.9999%). The benefits of Co-processing are that it leaves no residue as the incombustible, inorganic content of the waste materials are incorporated in the clinker matrix.

VI. Benefits Of Co-Processing

Around the world, co-processing in cement kilns is recognized as the best waste disposal option, much ahead of conventional land filling and incineration, owing to 'nil residue' after disposal and complete material and energy recovery.

The organics, in the wastes, are completely destroyed and the inorganic are immobilized in the clinker matrix – the intermediate product of cement. After the waste is co-processed, it becomes a part of the product (i.e. cement) and therefore, no liability lies with the waste generators, whatsoever. Cement kiln co-processing respects waste management hierarchy. It undertakes waste management only after the options of reduce, reuse and recycle are exhausted and avoids the options of resource destruction by way of incineration and containment by way of landfill that do not promote sustainable development. Landfills of wastes and incineration ash have long-term potential liabilities in the wake of remediation, if required. As compared to other disposal options, co- processing in cement kilns needs no major investment and leaves no residue and hence, such potential liabilities are completely avoided. A comparison of co-processing and conventional waste disposal options is tabulated below.

VII. Results And Discussion:

Burning of omnipresent plastic bags, is normally done at around 800 degrees Celsius. At this temperature, burning of polythene (out of which plastic bags are made) produces plastic gases. Therefore disposing of plastic bags by burning them has thereby been almost universally banned. They are therefore disposed off by burying in landfills, where they will take hundreds of years to decompose.

Cement kilns however, operate at 1200 to 1500 degrees Celsius, to produce clinker. Polythene burns up completely, at these high temperatures without producing any noxious gases. Some cement factories in Madhya Pradesh have received permission from environmental agencies, including the State Pollution Control Board, to carry out trials of burning used polythene bags, as a supplementary fuel, along with coal.

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