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PLASTIC WASTE DISPOSAL IN RECYCLED FIBER BASED PULP & PAPER MILLS – RECENT TECHNOLOGICAL DEVELOPMENTS

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Abstract:

The management & disposal of plastic waste generated in recycled fiber based pulp and paper mills is one of the major environmental challenge that required to be addressed on priority in context of Plastic Waste Management (Amendment) Rules, 2022. Generally, the plastic waste generated during processing of waste paper is sold to authorized recyclers or co –processed in cement. Recently a few mills in Uttarakhand & Uttar Pradesh have come forward and installed waste to energy boilers to incinerate the plastic waste along with municipal solid waste. The high pressure and temperature steam generated is being used in turbine for electricity generation followed by use in paper making process for drying purpose. Through this, the mills have not only been successful in managing their plastic waste at site but also are helping other paper mills in the cluster to dispose their plastic waste thus saving cost of transportation and disposal to cement industries as well as helping the local bodies in disposal of municipal solid waste. In addition, Indian Institute of Petroleum (IIP) has also developed a technology to convert plastic waste into diesel, aromatic compounds etc. CPPRI in collaboration with IIP is exploring possibility to demonstrate the technology on pilot scale in pulp and paper mills

Keywords: Plastic Waste Management Rules, Extended Producers Responsibility (EPR), Municipal Solid Waste (MSW) , Waste To Energy

1.0 Introduction

Plastic waste management is a global concern and a priority issue to be addressed by industries as well as local bodies. Management of plastic waste has been traditionally a challenge in context of its non-biodegradable nature. The recycled plastics are more harmful to the environment than the virgin products due to mixing of colour, additives, stabilizers, flame retardants etc. Further, the recycling of a virgin plastic material can be done 2-3 time only, because, after every recycling, the strength of plastic material is reduced due to thermal degradation. It is to mention that no authentic estimation is available on total generation of plastic waste in the country however, considering 70% of total plastic consumption is discarded as waste, thus approximately 5-6 million tons per annum (TPA) of plastic waste is generated in country (1). The Plastic Waste Management Rules 2016 (now recently amended as Plastic Waste Management (Amendment) Rules, 2022 (2) have been enforced to address the issue of plastic waste management and disposal with aim to:

- Increase the minimum thickness of plastic carry bags from 40 to 50 microns and stipulate minimum thickness of 50 microns for plastic sheets also to facilitate collection and recycle of plastic waste.
- Expand the jurisdiction of applicability from the municipal area to rural areas.
- To bring in the responsibilities of both producers and generators in the plastic waste management system and to introduce collect back system of plastic waste by the producers/brand owners, as per extended producers responsibility (EPR).
- To introduce a collection of plastic waste management fees through pre-registration of the producers, importers of plastic carry bags/multilayered packaging, and vendors selling the same for establishing the waste management system.
- To promote the use of plastic waste for road construction or energy recovery, or waste to oil, etc. for gainful utilization of waste and also address the waste disposal issue.

- All institutional generators of plastic waste shall segregate and store the waste generated by them as per the Solid Waste Management Rules, and hand over segregated wastes to authorized waste processing or disposal facilities or deposition centres, either on their own or through the authorized waste collection agency.

Further as per Plastic Waste Management (Amendment) Rules, 2022 the plastics can be classified into 4 categories as indicated in Table 1 :

Table 1: Classification of Plastic Waste

Category 1	Rigid plastic packaging
Category 2	Flexible plastic packaging of a single layer or multilayer (more than one layer with different types of plastic), plastic sheets and covers made of plastic sheet, carry bags, plastic sachet or pouches
Category 3	Multi-layered plastic packaging (at least one layer of plastic and at least one layer of material other than plastic)
Category 4	Plastic sheets or like used for packaging as well as carry bags made of composite plastics

The major significance features / focus in the amended Plastic Waste Management Rules include:

- It provides instructions on Extended Producer Responsibility (EPR) for plastic packaging.
- It encourages development of new alternatives to plastics and aids the move towards sustainable packaging.
- It is focussed to promote circular economy of reuse, refurbishing, and recycling.
- It aims for reduction in plastic waste in the country and improve plastic waste management
- It is also targeted towards protecting aquatic ecosystems from plastic waste
- It also focus to invoke responsible behavior from citizens to change and contribute to waste management.

Plastic Waste Generation in RCF based Paper Mills

Of the total over 500 reported operational pulp and paper mills in India, around 75 % of the paper production comes from recycled fiber or waste paper based paper mills (2) which generate 0.33 to 0.55 million tonnes per annum plastic waste. The general layout of the production process of writing and printing grade and unbleached packaging grade pulp and paper mills is indicated in Fig.-1 & 2

Though production of paper from recycled fiber / waste paper is comparatively simple with less environmental impact compared to wood and agro based paper mills, handling and disposal of plastic waste generated during processing of waste paper is a major management and disposal issue before these category of mills in context of Plastic Waste Management Rules (3). Presently, due to regulatory directions and guidelines industry has to incur significant

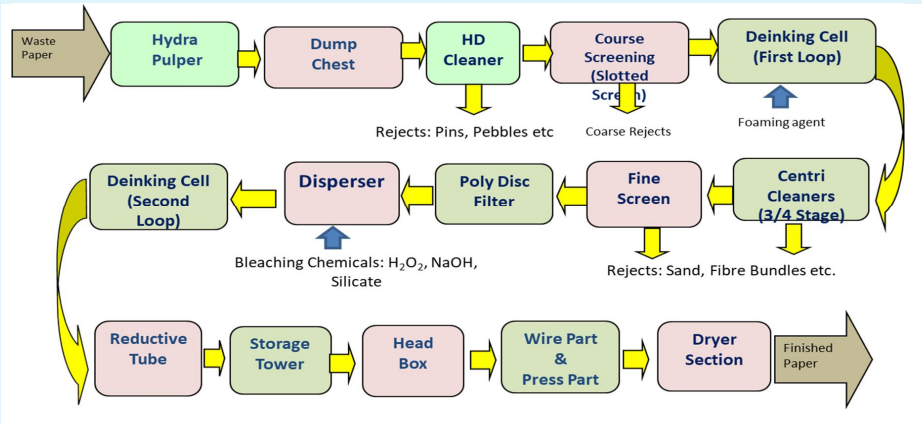

Fig.- 1: General Layout of RCF Based Writing & Printing Pulp & Paper Mill

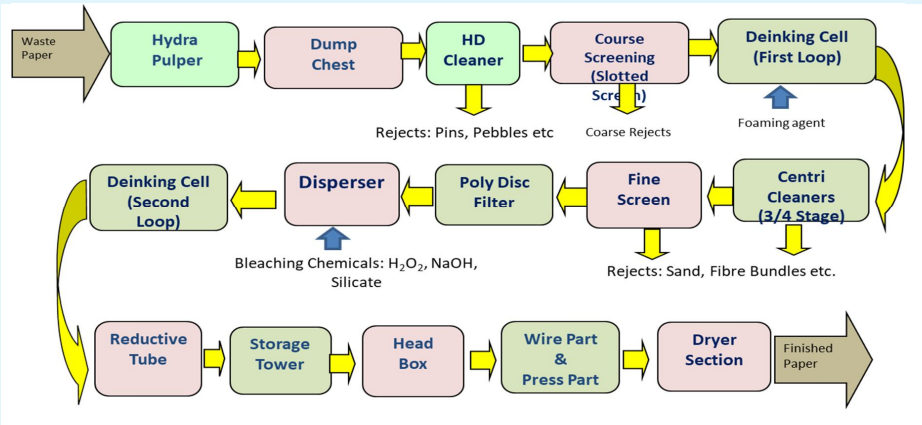

Fig.- 2: General Layout of RCF Based Kraft Pulp & Paper Mill

cost for handling, transportation & disposal through co-processing in cement industries or disposal through authorized recycler.

As indicated in Fig.- 1 & 2, in RCF based paper mills Poire system/ Hole Screen is used to remove the plastic waste from pulp slurry that comes from the Hydro /Hicon Pulper . On an average plastic waste generation is around 1-1.5% per ton of paper which is generally stored in loose form (4, 5). This plastic waste generated has a calorific value in range of 2000- 3000 kcal/kg. Due to this significant calorific value of plastic waste, it has a potential to be used as fuel in boiler. However burning in existing coal fired power boiler leads to emission of oxides of sulphur & nitrogen, volatile organic toxic / hazardous compounds including dioxins and furans which has restricted its burning in existing boilers. Today with realisation of Waste as Resource / Wealth as well as increased focus to promote Circular Economy technological options are being explored for management of plastic waste at mill site through mechanical

recycling, chemical recycling, waste-to-energy approaches, and bio-based polymers to address the issue. Recently two recycled fiber based paper mills namely Bahl Paper Mills Ltd, Kashipur, Uttarakhand & Silvertoan Papers Ltd, Muzaffarnagar, Uttar Pradesh have taken a lead by commissioning a dedicated waste to energy boiler for incineration of plastic waste along with municipal solid waste to generate power & steam . The steam generated is used in turbine to generate electricity. On the other hand Indian Institute of Petroleum, Dehradun has developed a technology on pilot scale to extract value added products like diesel, gasoline, aromatics along with production of LPG.

General Composition of Plastic Waste & Municipal Sold Waste

Plastic Waste involves a wide spectrum of plastic compounds such as , polyethylene (PE), polypropylene (PP), and polystyrene, polyurethane, nylon, and polyethylene terephthalate etc. Plastic polymers like Polyethylene (PE), Polypropylene (PP), and Polystyrene have potential to be used for energy production in context of their higher calorific value (2000- 3000 kcal / kg) where as polyurethane, nylon, and polyethylene terephthalate appear most competitive for chemical recycling. Compared to conventional fossil fuel energy sources, polyethylene (PE), polypropylene (PP), and polystyrene are the three main polymers with higher calorific values suitable for energy production. The characteristics of plastic waste have significant variations in terms of moisture % (30-50%), impurities (40-50% metals, pins, staples,) etc .

The composition of municipal solid waste (MSW) in general is organic 50 % (kitchen waste, agro-waste, vegetable waste, garden waste etc), recyclable 20 % (plastic, rubber, paper, syringe, tin, metals, glass etc), inert 22 % (sand, pebble, gravel etc.) and others 5%. The calorific value of the municipal solid waste in general is 1500 - 2500 kcal / kg depending upon the organic content.

Waste to Energy Boiler Recently Commissioned by RCF based Pulp & Paper Mills

The waste to energy boilers recently commissioned at Bahl Paper Mills Ltd & Silvertoan Papers Ltd are nearly similar in basic configuration and are capable to handle both plastic waste and municipal solid waste together. The plastic waste (Fig.- 3) is sourced from mill itself as well as from other paper mills and vendors in the cluster while the municipal solid waste (Fig.- 4) is sourced through local municipal bodies. The existing operational steam generation capacity of the power boilers in Bahl & Silvertoan Paper Mills is 14 & 28 tph while the installed capacity is 15 and 40 tph while respectively. To achieve a stable steam generation with high temperature and pressure, the waste is homogenized and then fed into incinerator as per requirement of design specifications. The general layout of the power boiler is indicated Fig.-5 and the onsite photographs indicated in Fig.- 6 & 7

Fig.-3

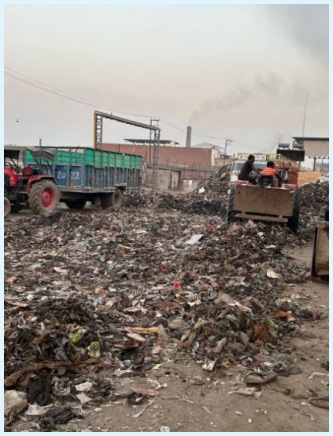

Fig.-4

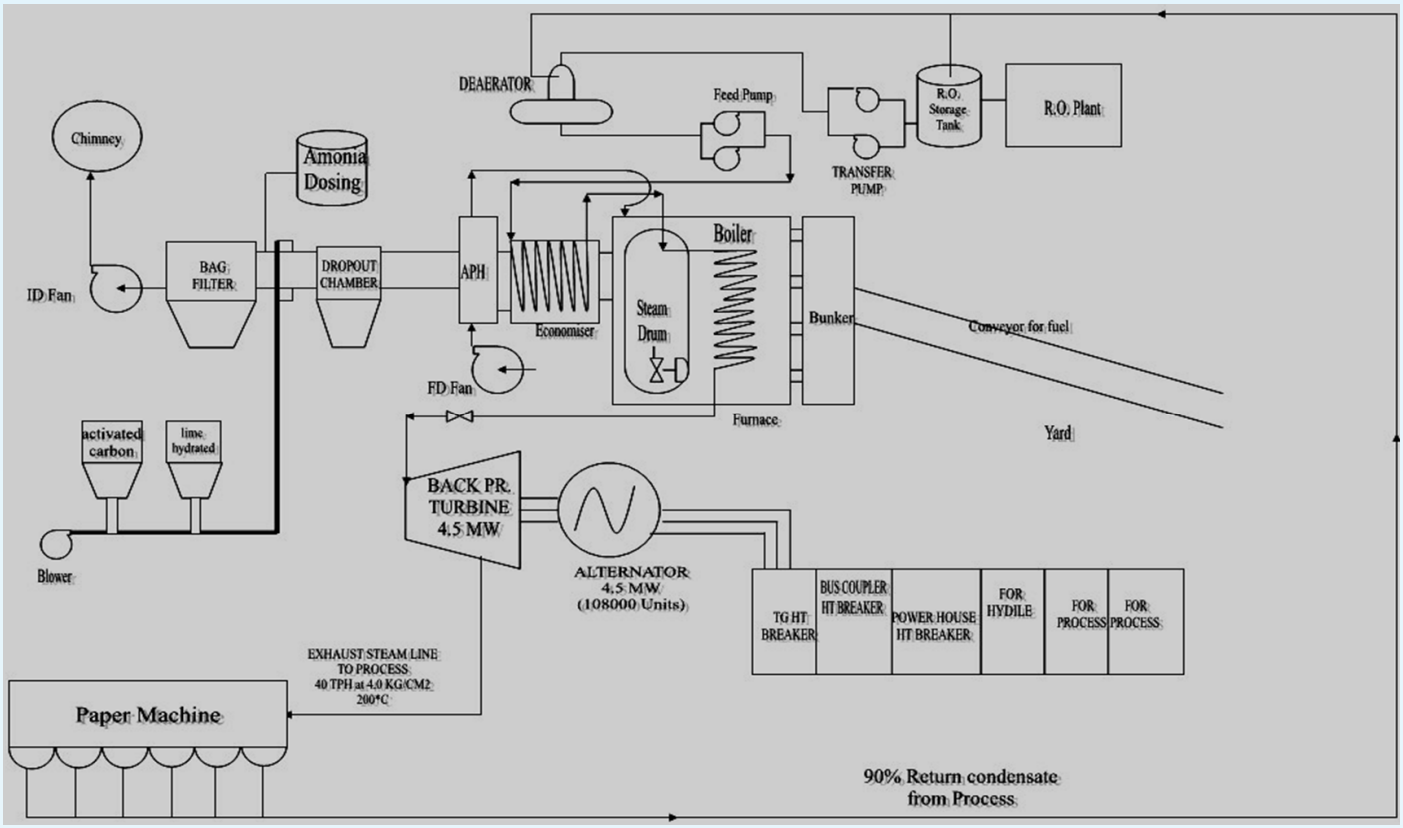

Fig.-5: Layout of Plastic-MSW Power Boiler

Fig.-6: Waste To Energy Boiler

Fig.-7: Incineration of Plastic Waste

Waste to Energy Boiler – Principle & Mechanism

The waste incineration processes involve stages of drying, burning, and burn-out. The boiler is based on advanced reciprocating grate technology and claims to have better controllability and efficient combustion The ash generated is collected through hopper and is mostly inorganic in nature. Air Cooled reciprocating grate is provided in the boiler for effective combustion of the non recyclable solid waste such as plastic and municipal solid waste. The combustion process such as drying and ignition is carried out in the boiler on grate with low carbon loss in bottom ash. To avoid high temperature flue gas corrosion first pass is refractory lined. The flue gasses generated from combustion then passed through the heat recovery system. The furnace is designed to ensure complete combustion and provide sufficient residence time for complete combustion of fuel and decomposition of toxic gases including dioxin and furan at high temperature of 850 oC. The superheater coils are arranged in a fashion to prevent exceeding of metal temperature beyond permissible limits to prevent high temperature chlorine corrosion. The flue gasses are passed further through the Economizer. The CO values are maintained by ensuring high temperature residence time and providing Over Fire Air (OFA) ports for complete combustion. The heat from fuel burning is absorbed by boiler heating surface and after heater, it produces medium temperature - medium pressure superheated steam (400^0C, 45 - 55 kg/cm^2) that is induced into turbine for generation of electricity.

To address the issues related to emission of gaseous and particulate emission , flue gas cleaning system (FGHS) has been provided (Fig.-8). The Flue Gas Cleaning System constitute of two sections namely (a) Reagent Storage, Preparation and Delivery Section which involve SO_2 and HCl control section where hydrated lime powder is used and powdered activated carbon (PAC) injection is provided for treating Dioxin / Furans, Hg and heavy metals. (b) Bag Filter Section to arrest the Particulate Matter. The SO_2 & Chlorides in the flue gas reacts with the hydrated calcium to form calcium sulfite ($CaSO_3$) and Calcium Chloride ($CaCl_2$) and CO_2. The reaction is as under:

$$Ca(OH)_2 + SO_2 \longrightarrow CaSO_3 + H_2O$$

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

Selective non catalytic reduction (SNCR) technology is used to reduce the level of nitrogen oxides (NO_x) without the presence of a catalyst. Ammonia is injected directly into flue gas and reacts with NO_x resulting in nitrogen (N_2) and water (H_2O).

The Bag Filter is designed to provide continuous particulate collection. When the dust laden gases enter the Fabric Filter the heavier dust particles immediately fall into the hopper, while the light dust is distributed and deposited on the outside surface of the bags. When a uniform layer of dust has been formed on the surface of the filter bags, it is removed, by a predetermined cycle of medium / high pressure pulses. Dislodged dust falls into the collection hoppers (Fig.- 9) and removed. Thus air pollutants such as CO, NOx, SO2, particulate matter, and polycyclic aromatic hydrocarbons (PAHs) are exhausted / controlled in the boiler itself through chemical treatment (6)

The steam generated is introduced into turbine for generation of electricity (Fig-10). The power generation capacity of Bahl Paper Mills Limited & Silvetoan Papers Limited is 2.5 & 4.5 MW respectively which is approximately 45000 - 48000 and 60000 – 65000 units respectively. While the plastic & MSW waste disposed through the boiler is 100 - 110 tpd in Bahl Paper Mills Ltd and it is 300 - 350 tpd in Silvertoan Papers Ltd. The steam to fuel ratio is generally 1.80 – 2.0 ton steam per ton of waste.

Upcoming Technology - Conversion of Plastic Waste into Fuel

Recently Indian Institute of Petroleum, Dehradun in collaboration with GAIL has been successful in developing and demonstrating a novel technology on pilot scale by which polyolefinic waste plastics like polyethylene and polypropylene can be converted exclusively into gasoline or diesel or aromatics along with simultaneous production of liquefied petroleum gas (LPG) (6). The technology involves thermos catalytic conversion of waste polyolefinic (PE & PP) plastics into valuable hydrocarbons like gasoline, diesel and aromatics alongwith LPG by an environment friendly process. The institute claims that 700- 800 ml gasoline/diesel or 500 ml of petrochemical (benzene, toluene, xylene) can be produced from one tonne of plastic by incineration through this technology. The institute has set up a 1 ton capacity demo unit for conversion of plastic waste to diesel. As indicated above due to variation in characteristics of plastic waste, the yield of the products generated through this technology can also vary. The institute is looking for an industrial partner to scale up this technology. In this perspective CPPRI & IIP have recently signed an MoU for mutual collaboration under which possibility of demonstration of this technology on pilot scale in a RCF based paper mill is being explored.

Fig.-8: Flue Gas Cleaning System

Fig.-9: Hoppers for Collection of Boiler Ash

Fig.-10: Turbine for Electricity Generation- Waste to Energy

Conclusions

The setting up of waste to energy boilers involving incineration of plastic waste along with municipal solid waste in RCF based paper mills along with cogeneration of steam is a welcome initiative which not only address to management / disposal issues of plastic within the mill itself but also of other RCF based paper mills located in the cluster like in this case Kashipur & Muzaffarnagar. Incineration of municipal solid waste along with plastic waste is the added advantage which can assist local municipal bodies in its management to a certain extent. Waste volume after incineration can be reduced by more than 90 % and waste weight can be reduced by more than 95% through this process. The management of plastic waste and municipal solid waste through this technology will help the country in achieving the committed targets/ objectives of Sustainable Development Goals (SDG), Net Zero Emissions, Mission LiFE (Life Style for Environment) . The electricity / power generated through utilisation of steam generated after incineration of plastic waste / municipal solid waste further help in sustainability of the process and payback.

Though the technology has been demonstrated successfully, the performance will vary depending upon the quality , quantity and characteristics (moisture content , organic content etc.) of the plastic waste as well as municipal solid waste . To improve the performance installation of an onsite "Bailing Machine" which can compresses the loose plastic waste into bails of appropriate dimensions can help to increase the density or reduce moisture as per requirement of and thus facilitate in ease of handling, reduced and improved combustion. The composition of mixed fuel fed to the boiler i.e. plastic waste and municipal solid waste needs to be optimized regularly through regular analysis of plastic and municipal solid wase for moisture and organic content. However the mills should take care to adopt appropriate health and safety measures for the personnel handling municipal solid waste. The technology option developed by Indian Institute of Petroleum is to convert plastic into fuel also appear to be interesting but has to be tested for its potential in a RCF based paper mill.

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