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

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and

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Plastic Waste Management

- A global concern and a priority issue to be addressed by industries as well as local bodies.
- Non-biodegradable nature.
- Recycled plastics are more harmful to the environment than the virgin products due to mixing of colour, additives, stabilizers, flame retardants etc.
- 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.
- 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

Plastic Waste Management (Amendment) Rules, 2022 (2)

Objective / Major New Guidelines

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).

Plastic Waste Management (Amendment) Rules, 2022 (2)

Objective / / Major New Guidelines

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.

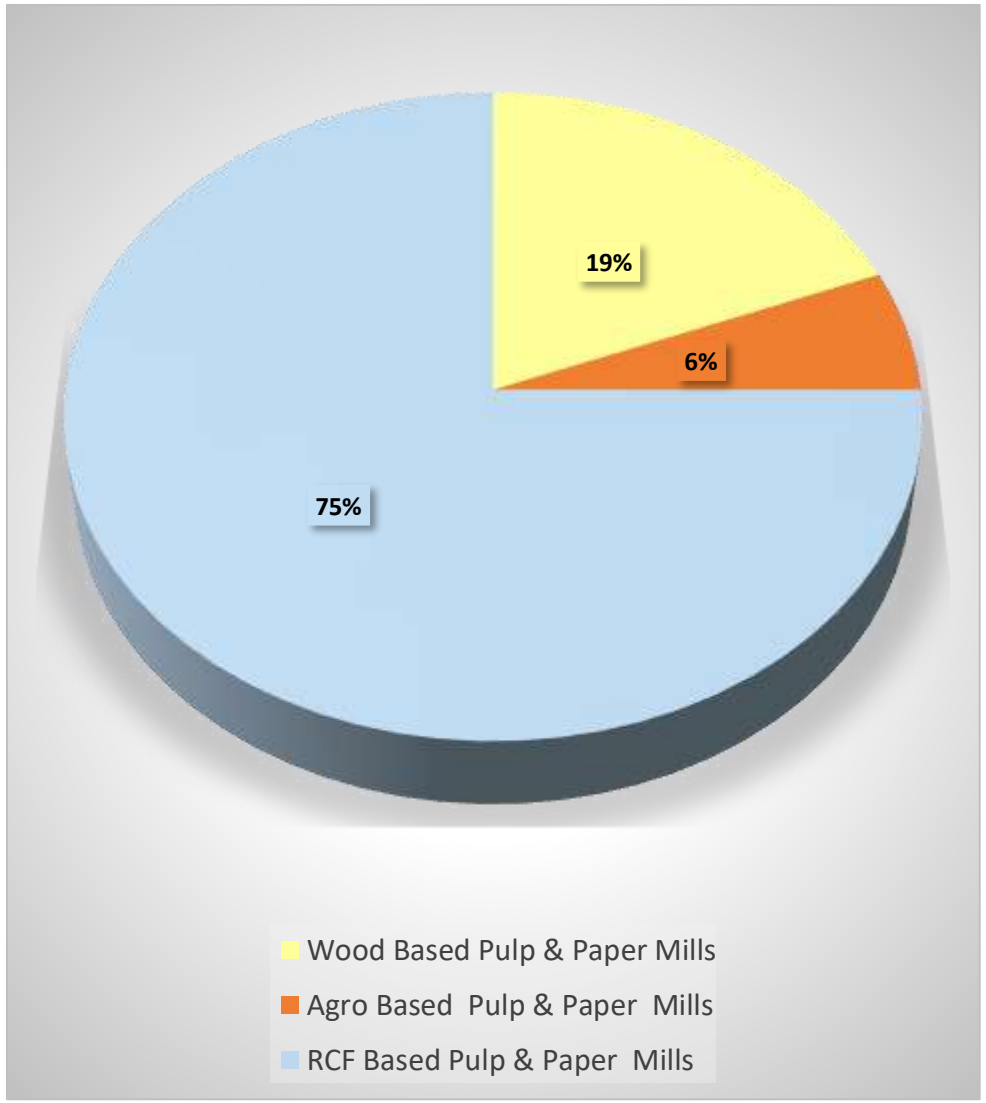
Classification of Plastic Waste *

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

**** As per Plastic Waste Management (Amendment) Rules, 2022***

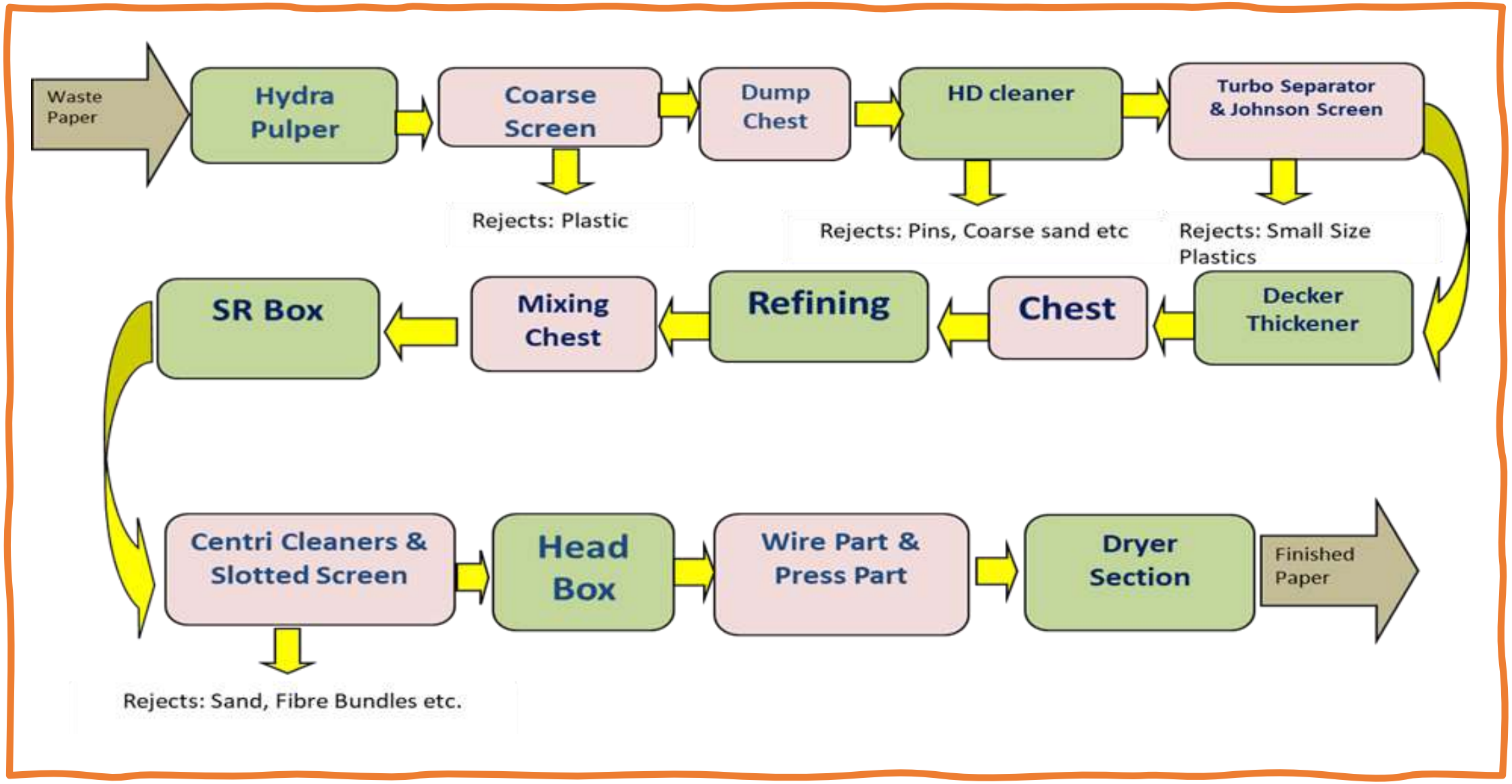
Amended Plastic Waste Management : Major Significant Features / Focus

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

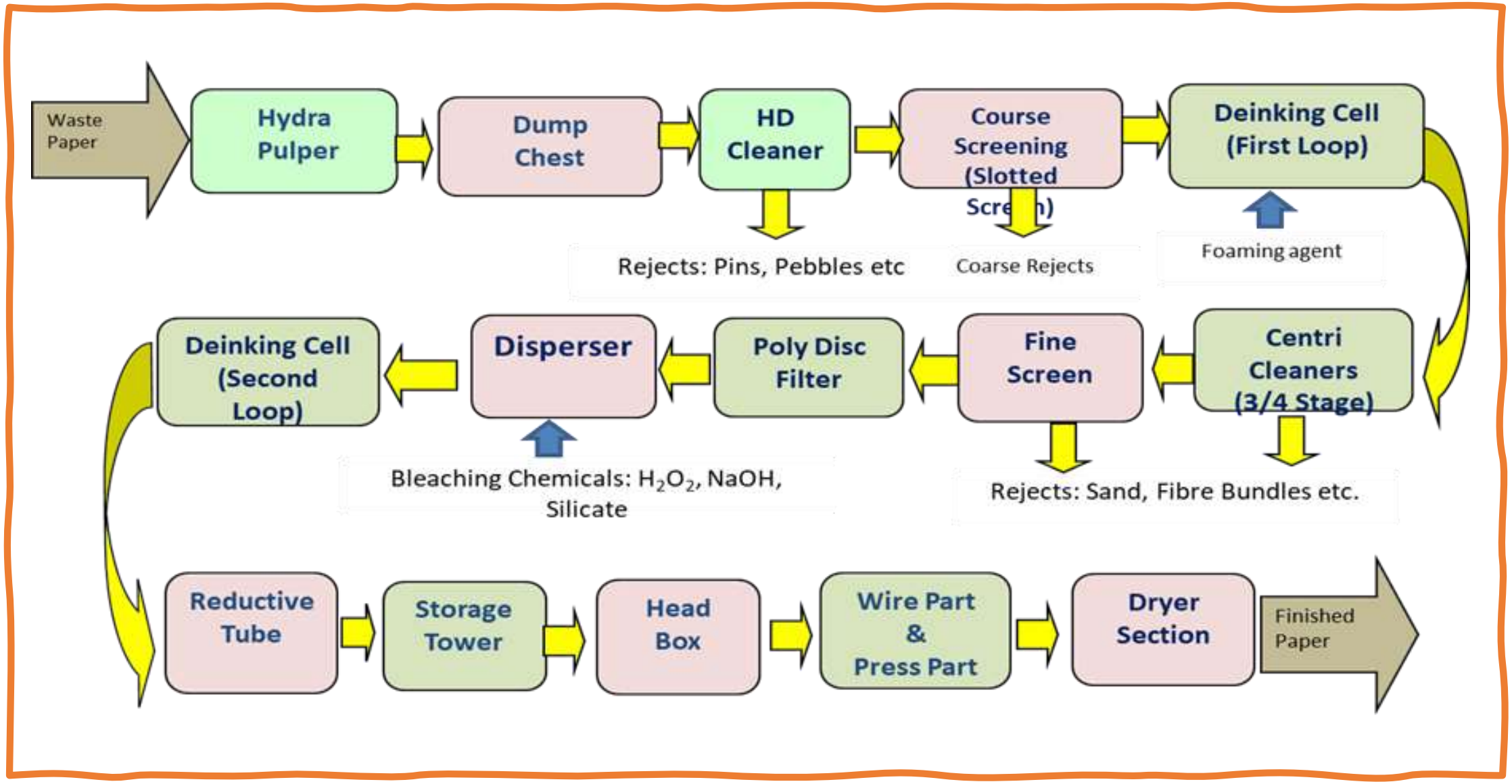


Plastic Waste Generation in RCF based Paper Mills

- Over 500 reported operational pulp and paper mills in India with around 25 Million Tonnes Paper & Paperboard Production
- Around 75 % of the paper production comes from recycled fiber or waste paper based paper mills
- Around 3.3 to 5.5 lakh tonnes (1.5 – 2.5 % of wastepaper consumption) per annum plastic waste generated by these 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
- Presently, due to regulatory directions and guidelines industry has to incur significant cost for handling, transportation & disposal through co-processing in cement industries or disposal through authorized recycler.



General Layout of RCF Based Kraft Pulp & Paper Mill



General Layout of RCF Based Writing & Printing Pulp & Paper Mill

Plastic Waste Generation :RCF Based Paper Mills

On an average plastic waste generation is around 1-1.5% per ton of paper which is generally stored in loose form

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

- *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.*

Plastic Waste at Mill Site

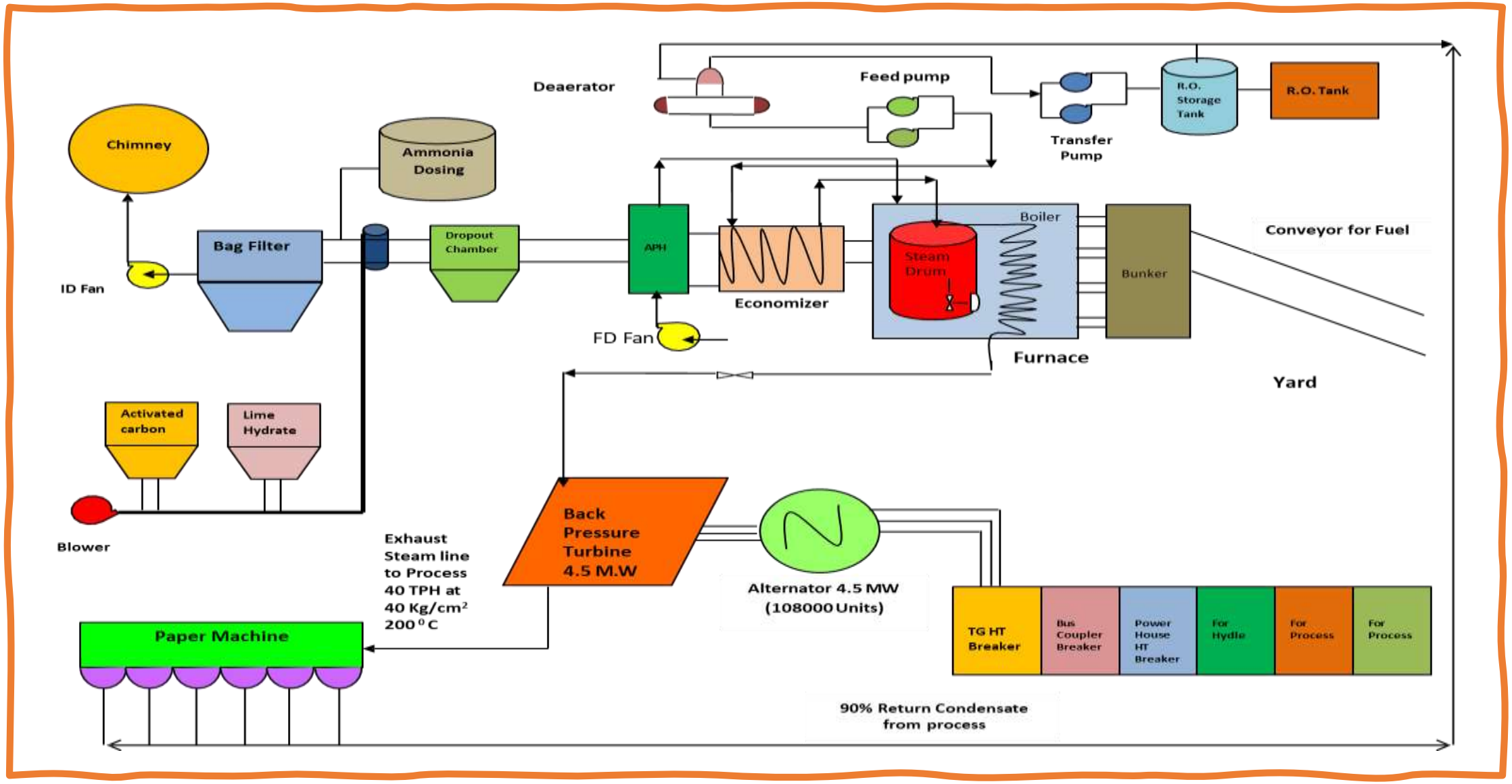
Municipal Solid Waste at Mill Site

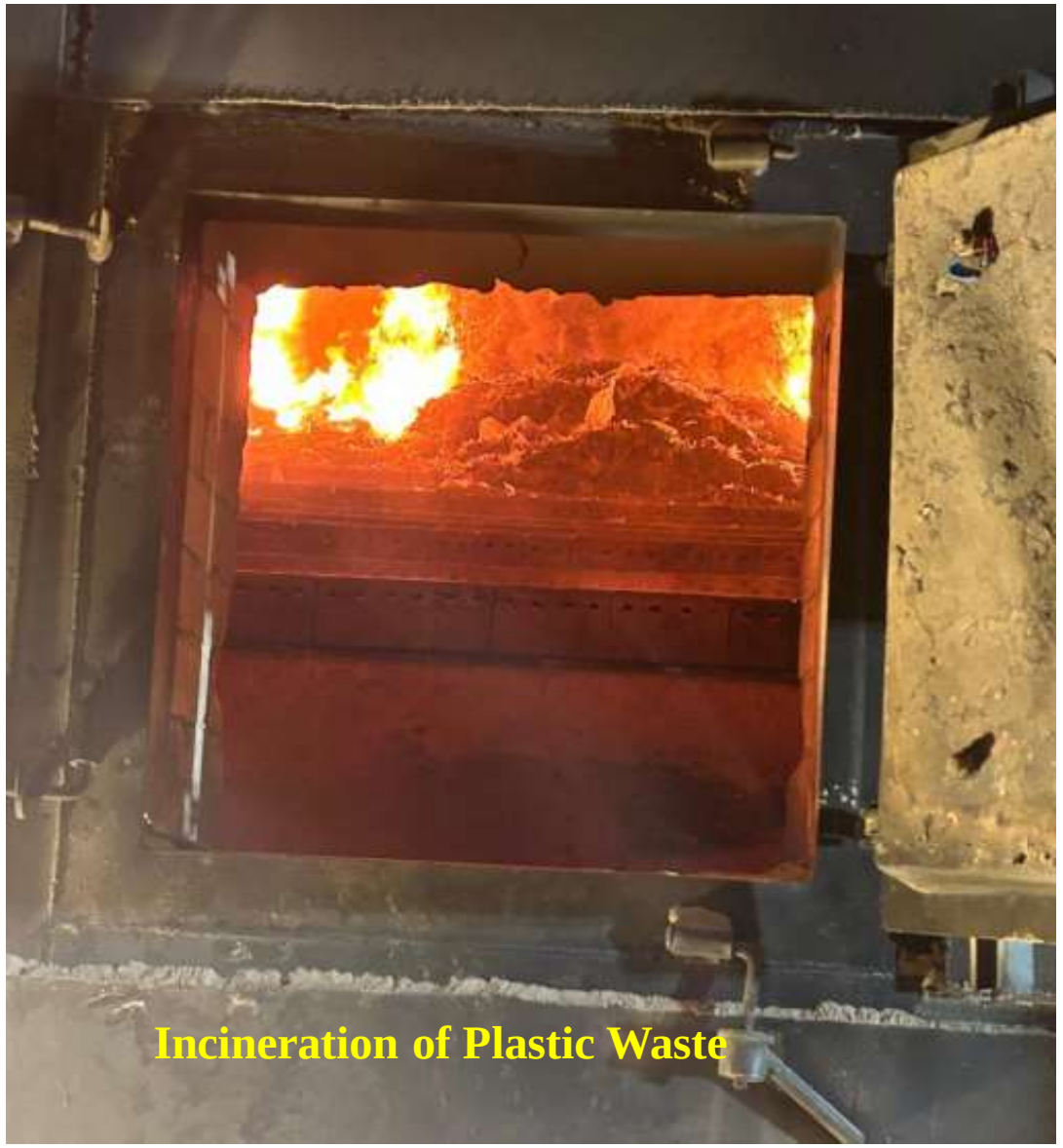
General Composition of Plastic Waste

- 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)
- 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 .

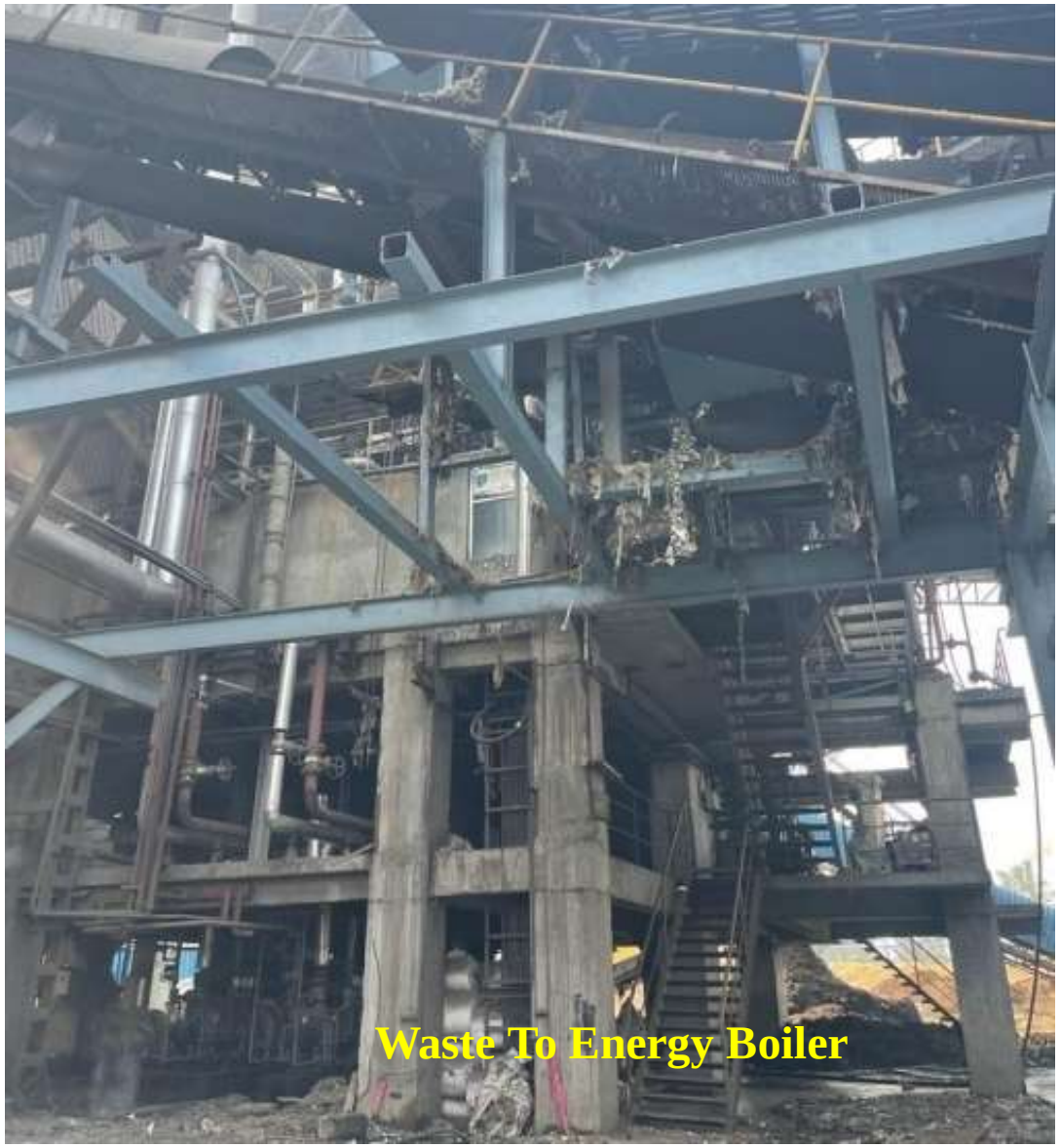
General Composition of Municipal Sold Waste

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.


Deaerator
Feed pump
Transfer Pump
R.O. Storage Tank
R.O. Tank
Chimney
Ammonia Dosing
Bag Filter
ID Fan
Dropout Chamber
APH
Economizer
Boiler
Steam Drum
Bunker
Conveyor for Fuel
FD Fan
Furnace
Yard
Activated carbon
Lime Hydrate
Blower
Back Pressure Turbine 4.5 M.W
Alternator 4.5 MW (108000 Units)
Exhaust Steam line to Process 40 TPH at 40 Kg/cm² 200 ⁰ C
Paper Machine
TG HT Breaker
Bus Coupler Breaker
Power House HT Breaker
For Hydle
For Process
For Process
90% Return Condensate from process



Incineration of Plastic Waste



Waste To Energy Boiler

- **Major stages**
- **Drying,**
- **Burning, and**
- **Burn-out.**
- Advanced Reciprocating Grate Technology
- Have better controllability and efficient combustion
- 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 ^{o}C.
- 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. T
- The heat from fuel burning is absorbed by boiler heating surface and after heater, it produces medium temperature - medium pressure superheated steam (400℃, 45 - 55 kg/cm2) that is induced into turbine for generation of electricity.

Flue Gas Cleaning System

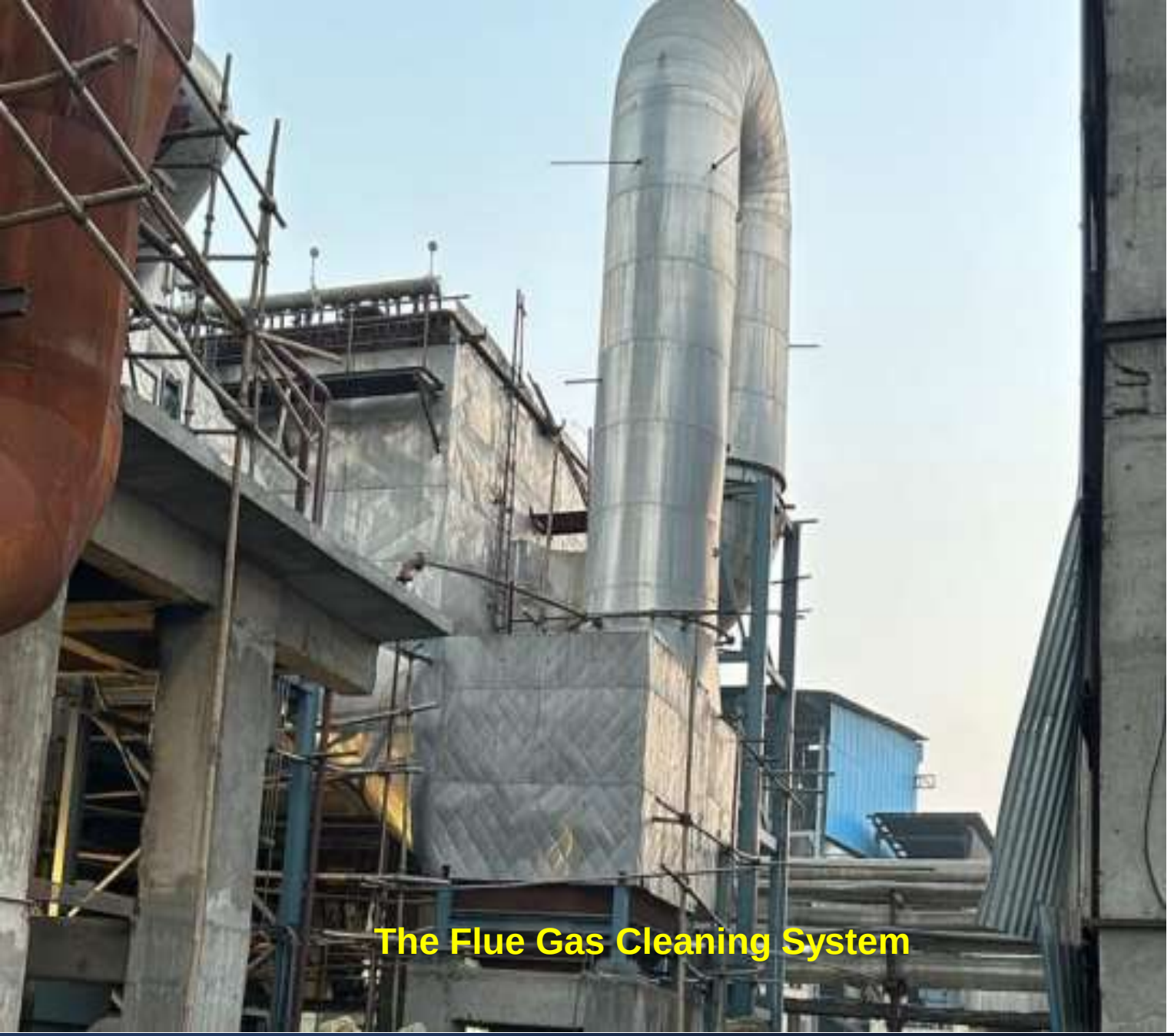
Hoppers for Collection of Boiler Ash

Reagent Storage, Preparation and Delivery Section

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

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 Flue Gas Cleaning System

Dioxins Control System

- Based on Activated Carbon System
- Activated carbon is injected into the gas flow. The carbon is filtered from the gas flow using bag filters.
- The activated carbon shows a high absorption efficiency for heavy metals as well as for PCDD/F.
- Different types of activated carbon have different adsorption efficiencies.

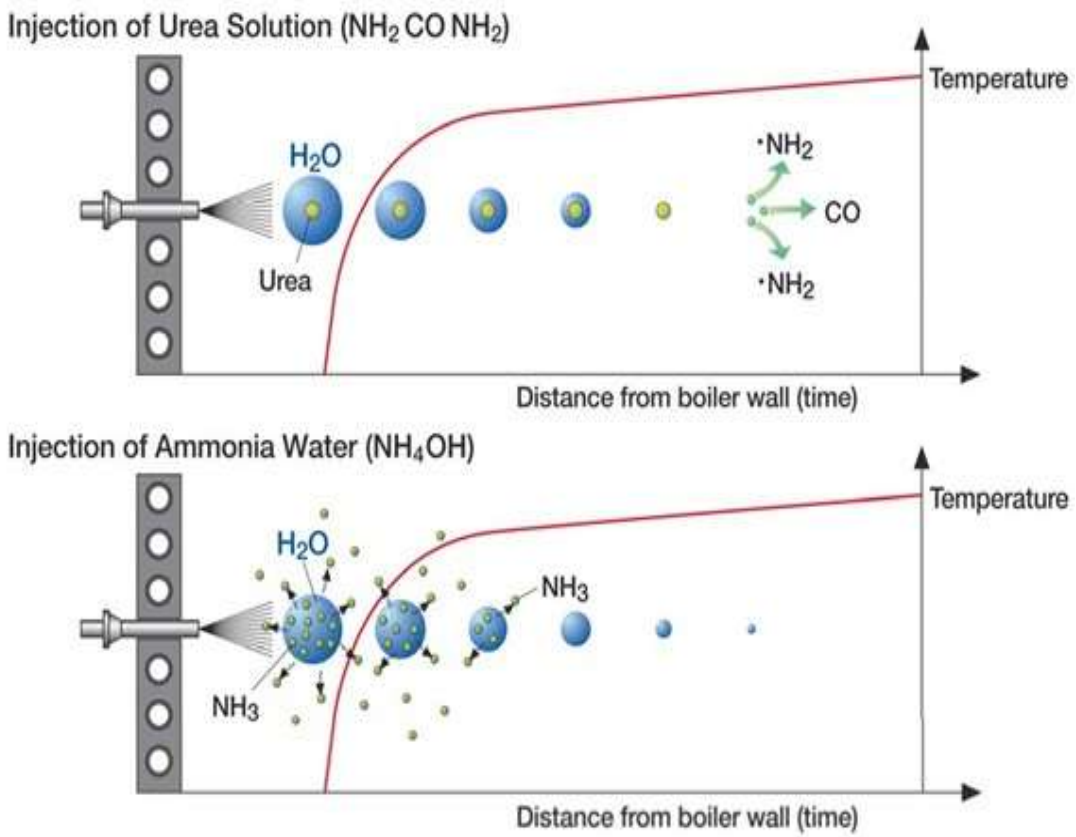
The Flue Gas Cleaning System

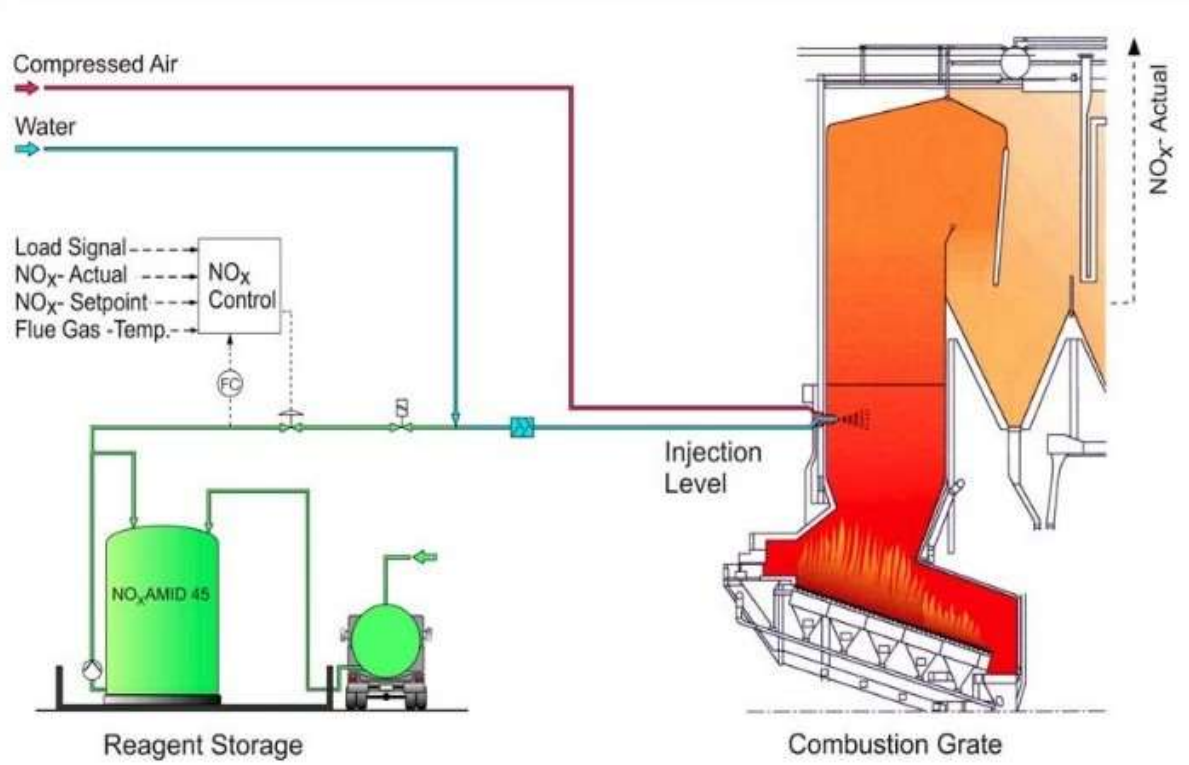
$$Ca(OH)_2 + SO_2 \longrightarrow CaSO_3 + H_2O$$

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

Selective non catalytic reduction (SNCR) technology is used to reduce the level of nitrogen oxides (NOx) without the presence of a catalyst.

Ammonia is injected directly into flue gas and reacts with NOx resulting in nitrogen (N_2) and water (H_2O).


Injection of Urea Solution (NH_2CONH_2)
Temperature
H_2O
Urea
$\cdot NH_2$
CO
$\cdot NH_2$
Distance from boiler wall (time)
Injection of Ammonia Water (NH_4OH)
Temperature
H_2O
NH_3
NH_3
Distance from boiler wall (time)


Compressed Air
Water
Load Signal
NO_X- Actual
NO_X- Setpoint
Flue Gas -Temp.
NO_X Control
FC
NO_X-AMID 45
Reagent Storage
Injection Level
Combustion Grate
NO_X- Actual

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 and removed.

- The steam generated is introduced into turbine for generation of electricity
- 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.

Turbine for Electricity Generation- Waste to Energy

Techno- economics : Estimated

Particulars	Waste to Energy Plant	Coal Based Energy Plant
Steam Generation Capacity , TPH	40 @ 70 % Operational Capacity	40 @ 80 % Operational Capacity
Project Cost, Rs.	40 Cr.	24 Cr.
Steam Generation Economy	2 tonne/tonne of waste	4 tonne/tonne of coal
Fuel cost, Rs.	1175/ tonne steam	1550/ tonne steam
Cost Difference from coal to waste, Rs.	375 /tonne of steam	
Cost difference per day, Rs.	28 x 24 x 375= Rs. 2,52,000	
Annual Cost difference, Rs.	300 x 2,52,000= 7.56 Cr.	
Project Cost Difference, Rs.	40 – 24= 16 Cr.	
Payback period, Year	16/7.56= 2.11 (Approx.)	

Upcoming Technology

Conversion of Plastic into Diesel into Gasoline

Developed by Indian Institute of Petroleum, Dehradun in collaboration with GAIL

Major Highlight

- Conversion of 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)
- Mechanism : Thermo catalytic conversion of waste polyolefinic (PE & PP) plastics into valuable hydrocarbons like gasoline, diesel and aromatics along with LPG by an environment friendly process.
- Estimated Production :

- 700 - 800 litre gasoline/diesel / tonne of plastic
- 500 litre of petrochemical (benzene, toluene, xylene)/one tonne of plastic

Upcoming Technology

Conversion of Plastic into Diesel into Gasoline

Developed by Indian Institute of Petroleum, Dehradun in collaboration with GAIL

Major Highlights

- Pilot Scale Capacity :1 ton capacity for conversion of plastic waste to diesel (Cost: 13 Cr, Payback period: 3 – 4 years).
- 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.
- 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.

Conclusions

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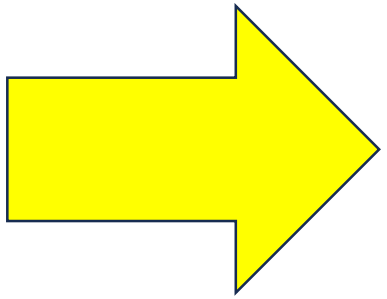
Plastic Waste Boilers : Merits



Management / disposal issues of plastic within the mill as well as in other mills of the cluster eg Muzaffarnagar & Kashipur

Incineration of MSW : Added Advantage

Waste volume after incineration can be reduced by more than 90 % and waste weight can be reduced by more than 95% through this process

Conclusions

. Plastic Waste Boilers : Merits

Supports **Sustainable Development Goals (SDG)**, **Net Zero Emissions, Mission LiFE (Life Style for Environment)** Goals & Objectives

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.

Conclusions

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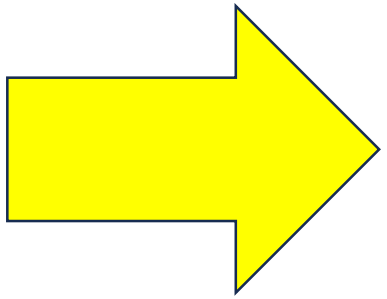
- Plastic Waste Boilers : Factors influencing Performance



Quality , quantity and characteristics (moisture content , organic content etc.) of Waste

Regular optimization of the the composition of mixed fuel fed to the boiler i.e. plastic waste and municipal solid waste through regular analysis of plastic and municipal solid wase for moisture and organic content

“Bailing Machine” – helps in reducing moisture , improves handling and combustion

Thanks

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