STAI 84TH ANNUAL CONVENTION | GOA, AUGUST 2026

Maximizing Boiler Yield via Advanced Cinder Recovery

A Paradigm Shift from Coal-Derived Below-Grate Ash Systems to High-Volume Top Cinder Silos with Ejector Re-Firing

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Presented by Airochem Engineering Pvt. Ltd., Kolhapur | Moving Air Efficiently Since 1975

"Will you like your boiler to yield 2.58 kg of steam per kilogram of 50% moist bagasse?"

— Unlocking latent energy by closing the unburnt carbon loop in bagasse-fired boilers.

** Note: Cinder recovery alone cannot make this happen. Other factors such as quality of bagasse, moisture content, boiler design, and operating parameters also play important roles.*

The Unburnt Carbon Challenge

⚠️Chronic Hopper Clogging

Bagasse combustion at 50% moisture leads to incomplete burning and high-carbon cinder formation.

Accumulation in fly ash hoppers under Economizer and APH causes frequent choking, requiring safety-risk manual clearing.

🔥The Re-Firing Opportunity

Traditionally treated as waste, cinder carries a substantial GCV of **3,000 to 4,000 kcal/kg**.

Re-injecting fine unburnt carbon into the high-temperature primary furnace zone recovers heat and pushes yields toward **2.58 kg steam / kg bagasse**.

Architectural Paradigm: Brazilian vs. Indian

Traditional Indian Design

Legacy Roots: Adapted directly from stoker-fired coal boilers.

Primary Focus: Bottom ash handling below the grate with small, low-capacity collection hoppers.

Drawback: High susceptibility to hopper bridging, severe ash choking, and lost unburnt heat potential.

Brazilian High-Yield Design

Clean Biomass Roots: Purpose-built specifically for fibrous sugarcane bagasse.

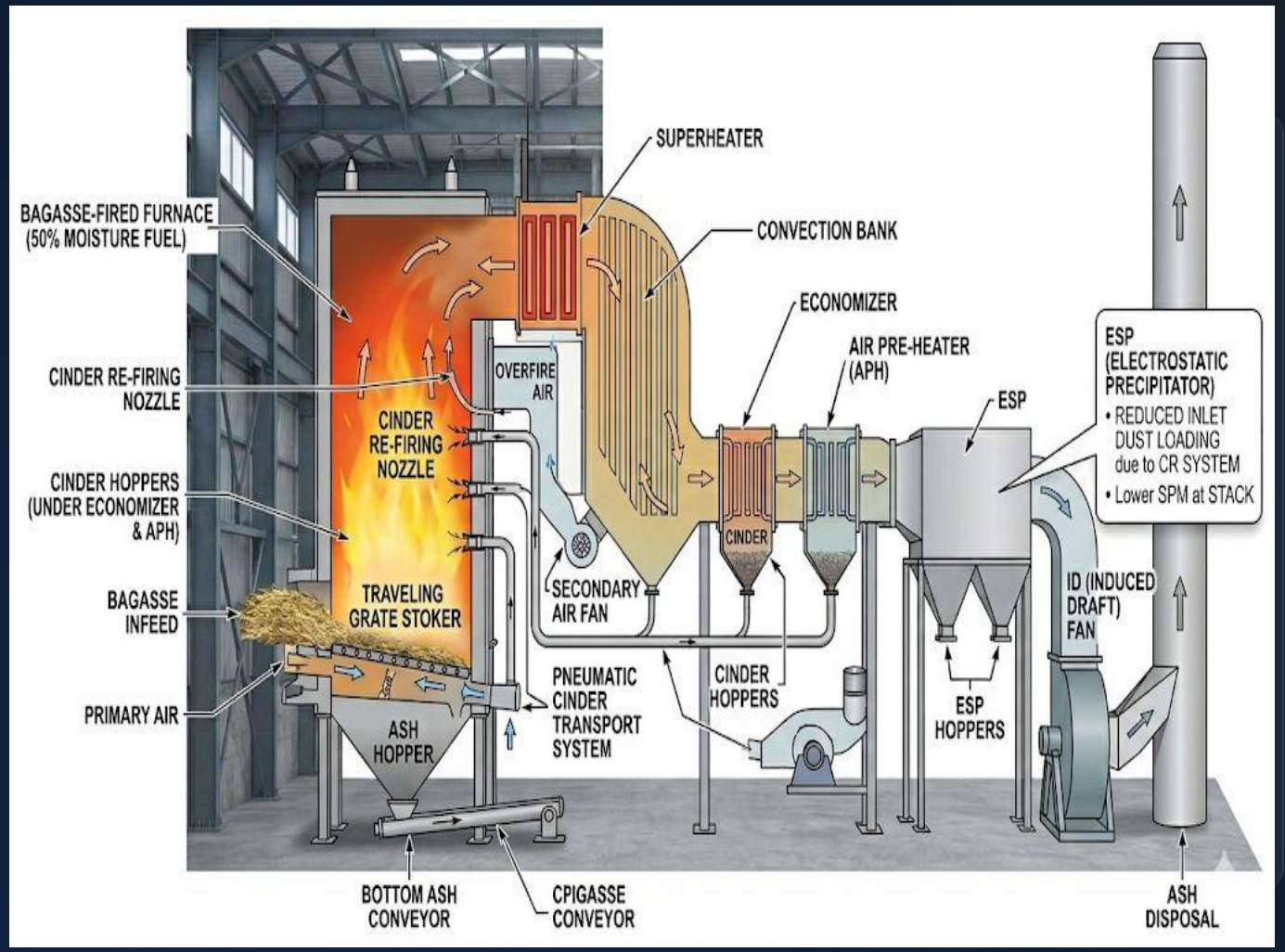
Primary Focus: Large furnace volumes coupled with massive **top-mounted storage silos** dedicated to cinder collection.

Benefit: Continuous hold-up capacity with steady, controlled pneumatic cinder re-firing into suspension.

Comparative Design Architecture

Design Parameter	Traditional Indian (Coal Origin)	Brazilian Design Philosophy	Airochem Ejector Retrofit
Primary Ash Zone	Below-grate bottom ash focus	Top furnace / Upper flue pass silos	Upper pass hopper recovery
Cinder Silo Volume	Small, restrictive hoppers	Large volume top-mounted silos	Optimized existing hoppers
Re-Firing Method	Standard Venturi or Passive Drop	Continuous High-Volume Pneumatic	Active Motive-Air/Steam Ejector
Clogging Susceptibility	High (Frequent manual clearing)	Very Low (Designed flow paths)	**Zero (Forced suction & sweep)**
Target Steam Yield	2.25 – 2.30 kg / kg Bagasse	2.50 – 2.58 kg / kg Bagasse	**2.38 – 2.58 kg / kg Bagasse**

Boiler Process & Cinder Recovery Schematic



1. Hopper Collection Zone

Captures unburnt carbon particles under Economizer and Air Pre-Heater (APH) flue passes.

2. Pneumatic Conveying System

Motive fluid entrains cinder and maintains high-velocity transport without settling.

3. Furnace Re-Firing Nozzles

Directs cinder back into high-temperature combustion zone above traveling grate stoker.

4. Downstream ESP Benefit

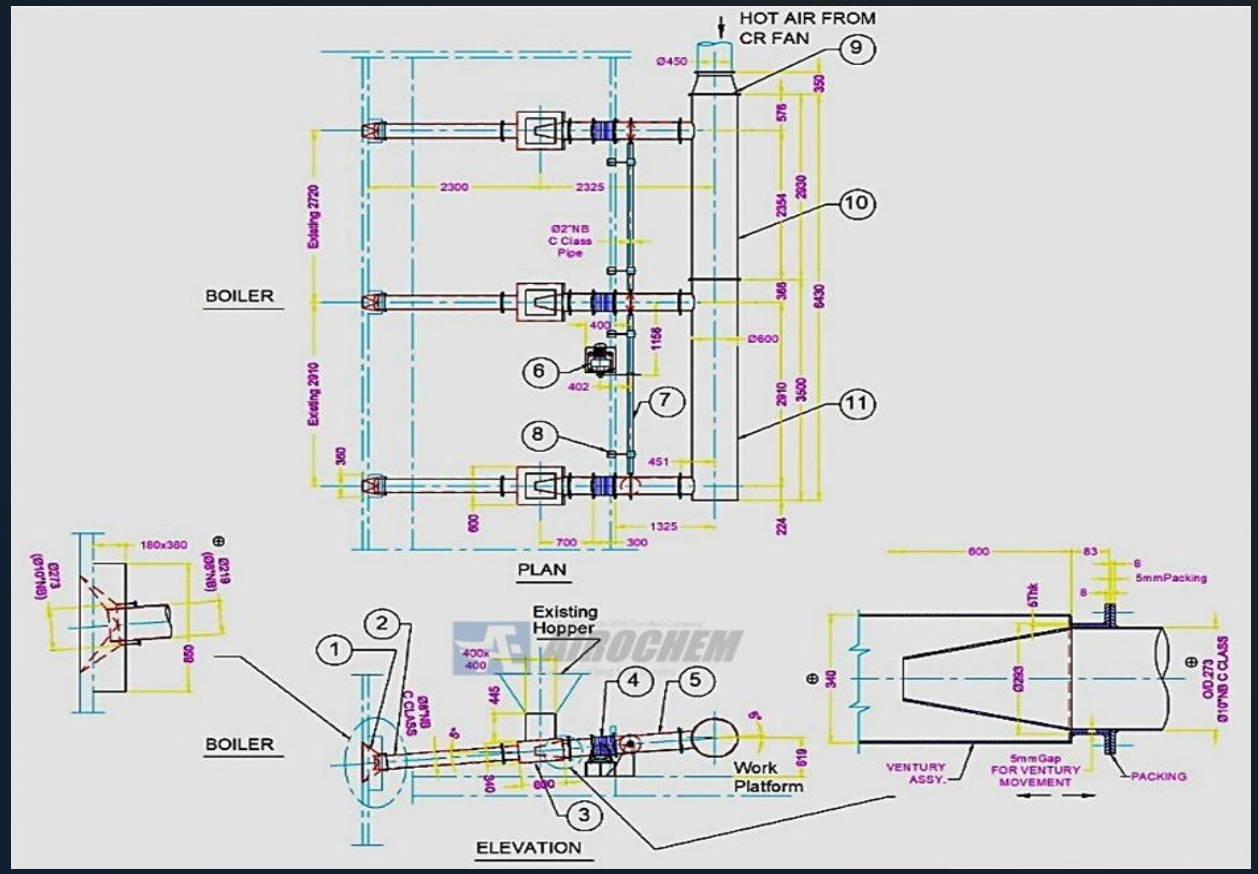
Drastically reduces inlet dust loading to ESP, resulting in lower stack SPM emissions.

Case Study: High-Capacity Boiler Modification

System Transformation (80 TPH & 140 TPH)

Full retrofits implemented on high-pressure power boilers to eliminate chronic hopper clogging and recover unburnt energy.

- **Modification:** Replaced restrictive venturis with active ejector recovery nozzles under ash hoppers.
- **Motive Force:** Pneumatic CR Fan / Jet entrainment for uninterrupted conveyance.
- **Result:** Direct injection into furnace high-temperature zone; zero hopper choking.



Quantitative Thermal & Economic Impact

₹3.17L

Daily Fuel Savings (140 TPH Basis)

Performance Gains & Financial ROI

Specific Fuel Consumption: Improved SFC from baseline 2.30 up to **2.38 – 2.58 kg steam / kg bagasse**.

Annual ROI: Reclaiming unburnt carbon yields **₹634 Lakhs annual savings** (200 days operation) with a payback period of **6 to 12 months**.

$$\text{Steam Ratio Gain} = \frac{2.58 - 2.30}{2.30} \times 100 = +12.17\% \text{ Thermal Efficiency Increase}$$

ANNUALIZED COST SAVINGS ESTIMATE		
Existing Steam to Bagasse Ratio	2.3	
Boiler Capacity	140	TPH
Bagasse Consumption	60.87	TPH
Improved Steam to Bagasse Ratio due to Cinder Recovery	2.58	
New Bagasse Consumption	54.26	TPH
Bagasse Savings	6.61	TPH
	158.54	TPD
Rate of Bagassse	2000	Rupees Per Ton
Cost Saving	₹ 3,17,087.97	Per Day
Days per Year	200	
Annualized Cost Savings	₹ 6,34,17,593.53	Per Year

Environmental Gains & ESP Relief

Dust Load Reduction

Capturing unburnt carbon before the ESP drastically reduces the inlet particulate dust loading.

Prevents carbon buildup on ESP collection plates, maintaining optimal electrical field efficiency.

Superior SPM Compliance

Recycling fly ash carbon lowers total Suspended Particulate Matter (SPM) levels at the stack exit.

Protects ID fans from abrasive erosion, extending overall hopper and ductwork equipment life.

Cinder Re-Firing Process Cycle

1. Flue Pass Capture

Cinder settles in collection hoppers under Economizer & APH flue passes.

2. Ejector Vacuum

Active ejector creates strong vacuum suction, entraining ash without throat bridging.

3. High-Velocity Transport

Pneumatic stream suspends heavy particles, preventing pipeline deposition.

4. Furnace Re-Injection

Cinder is blown back into hot combustion zone, burning remaining carbon completely.

Operational Integrity & Best Practices

- **Nozzle Erosion Monitoring:** Regularly inspect ejector and re-firing nozzle throat wear to maintain design velocity.
- **Air-to-Fuel Ratio Optimization:** Calibrate secondary air and CR fan pressures to balance furnace combustion without localized hot spots.
- **Bagasse Moisture Control:** Maintain fuel moisture near ~50% to prevent excess carryover of unburnt volatile matter.
- **Loss On Ignition (LOI) Testing:** Frequently test final disposal ash to verify unburnt carbon drops below target limits.

Global Standards & Future Roadmaps

Aligning Indian Sugar Mills Globally

By blending Brazilian top-silo storage concepts with active ejector re-firing technology, Indian sugar co-generation plants can achieve world-class steam generation ratios of **2.58 kg steam / kg bagasse**.

Retrofitting existing boilers provides an immediate, low-CAPEX pathway to fuel independence, expanded power export, and seamless operational reliability.

Thank You

Questions & Discussion

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