Industrial Applications of Gasifiers

Presented
At
CGPL, Indian Institute of Science, Bangalore.

by

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Overview

- Company Profile
- Resources
- Solutions Offered – Systems & Services
- Attraction of Gasifiers to Industry
- The Gasification Process
- Applications Packages
- Projects executed

Company Profile

- Our Vision is to be significant contributors in a sustainable biomass economy, as providers of systems and service solutions and as innovators of downstream value added products.

- Our Mission is to provide the most cost-effective and user friendly solutions, systems and services, conforming to internationally accepted quality specifications, within budget and agreed time schedules.

Resources

- ABETS, Indian Institute of Science are the technology partners
- State of the art knowledge, technical resources and equipment at IISc ensure that the latest technical advances are passed on to the field
- Company incorporated in the Millennium Year
- Modern Manufacturing facility at Chennai with facility to manufacture to Third Party inspection
- Qualified and experienced professionals at all stages of project implementation from design through procurement, inspection, manufacture, installation, commissioning, training and service after sales
- Large Pool of Trained Manpower on permanent rolls of the Company
- Established linkages with other companies for specialised equipment and services

Solutions Offered - Systems

- Turn-key modular Thermal Systems from 100 kWth to 10 MWth capacity
- Turn-key Modular Power Systems from 20 kWe to 2 MWe capacity
- Larger capacity Combined Cycle Plants using Gasification & Steam Turbine/ORC modes resulting in lower costs from higher cycle efficiencies
- Customised solutions to meet Client needs for Combined Heat, Power & Refrigeration
- Components & Spares for installed systems

Solutions Offered - Services

- **Turn-key Technical Services for Project Implementation**
  - Project Reports & Biomass Assessment Studies
  - Project site location, water and grid availability
  - Techno-commercial services for subsidies and financial closure
  - Techno-commercial services for letting, PPA & statutory approvals
  - Detailed Engineering of complete Power Plant including civil, structural, electrical (LT & HT) work
  - Supervision of erection, testing and commissioning of power plants

Solutions Offered - Services

- Complete EPC services for sourcing, tendering, bid evaluation, techno-commercial negotiations, inspection and quality management of offsite equipment
- Managerial assistance for recruiting and training of technical manpower and staff

- **Operation & Maintenance Contracts at Client's site**
- **Annual Maintenance Contracts for installed systems**
- **Project execution on BOOT basis**

Attraction of Gasifiers to Industry

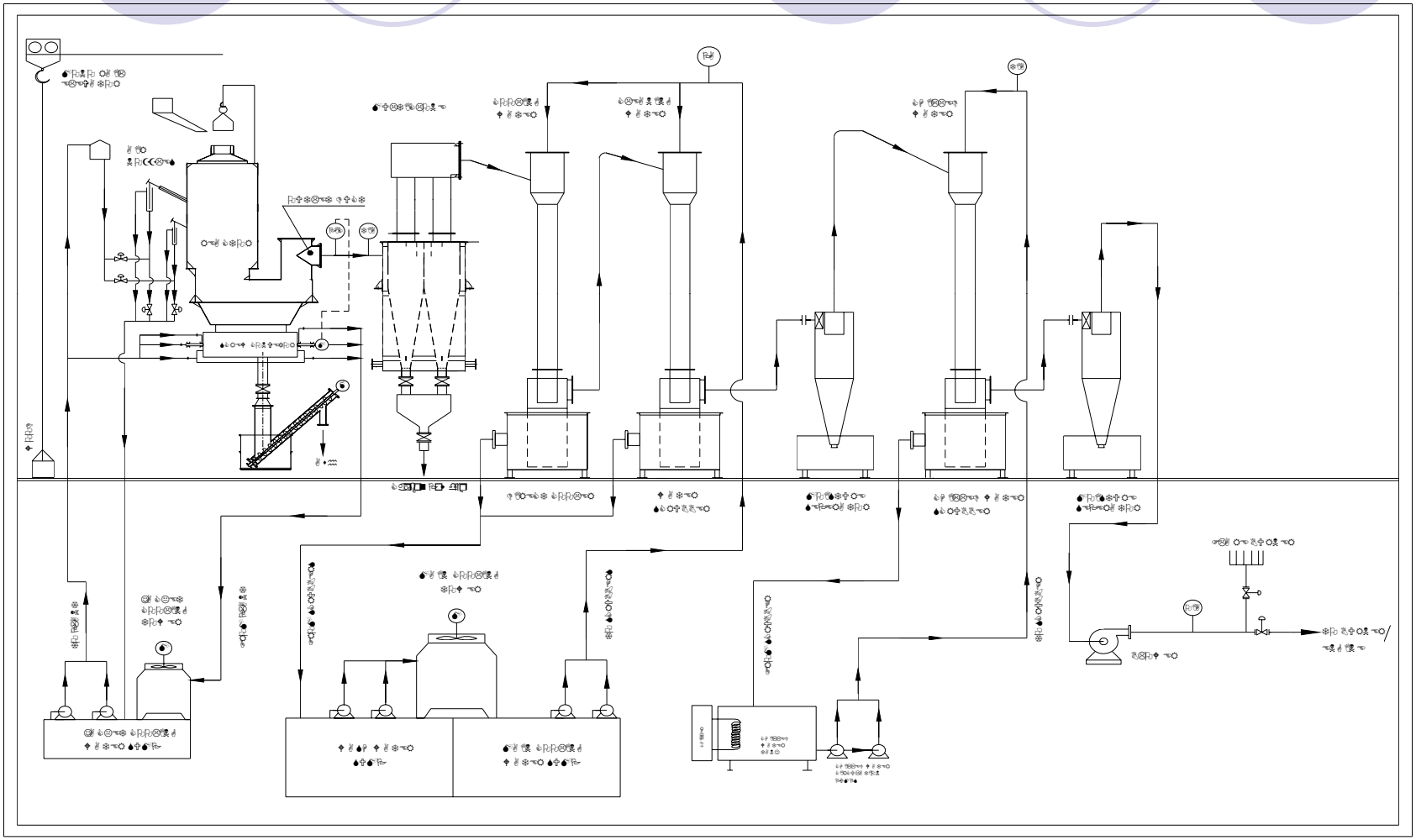
- *Specific to biomass*
  - Large and diverse resource base
  - Low cost of resource
  - Resource abundance
  - Energy security

- *Specific to IISc Gasifiers*
  - Multi-fuel capability
  - High gasification conversion efficiency
  - Low cost of installed capacity
  - Low cost of unit generation
  - Modular design for phased expansion
  - Higher efficiencies and lower costs in combined cycle
  - Revenue from by-products
  - High returns on investment
  - Low pay back periods
  - Perennial demand
  - Proven technology
  - Fiscal & Other Incentives

The Gasification Process

- Process Flow Diagram
- Open Top Downdraught
- Cooling & Cleaning Train
- Water Treatment & Re-use
- Automation & SCADA
- End Use Applications
- Applications Packages

Process Flow Diagram



Open Top Downdraught

- Our process is open top downdraught gasification using sized and dried biomass
- Gasification is partial pyrolysis when biomass is subjected to controlled oxidation
- Complete Combustion uses 6:1 Air to Fuel Ratio while Gasification needs 2.5:1
- After sizing the biomass is dried to MC <10% using a bleed from flue gases diluted with ambient air. This improves system thermal efficiency
- The biomass is then charged into the open top reactor and the biomass is fired under sub-stoichiometric combustion conditions
- The raw gas exiting the reactor bottom @ 450-600 ºC contains about 1000 ppm of tar/particulates which are then removed with downstream cooling and cleaning equipment
- The end product is Producer Gas, a combustible mixture of gases of the following composition

  20% H2, 20% CO, 2% CH4, 8% CO2, rest N2 and Calorific Value ~ 1,100 - 1,200 Kcal/nM3
- Crude solid bio residues are thus refined to gas phase affording fine control over a wide range of power levels

Cooling & Cleaning Train

- The Producer Gas is sent through a cleaning train consisting of cyclone, coolers and scrubbers
- It is sparged with water to reduce tar and suspended particulate matter from 1000 ppm to less than 50 ppm
- The gas is also cooled in this step and this renders it fit for different end uses
- The gas is then subjected to ultra high purity cleaning with chilled water scrubbing and filtering as per end use to reduce the particulates to ppb levels
- The chilled water is generated with Vapour Absorption Chillers using the Waste Heat in the flue gases, improving system thermal efficiency.

Water Treatment & Re-use

- Wash Water is cooled using cooling towers to remove sensible heat absorbed from the hot gases
- Entrained tar and particles are then flocculated off-line with Ferric Alum, and the floc is allowed to settle in a solar bed or centrifuged.
- The condensates picked up by the chilled water are likewise flocculated and this is added to the main sludge
- All the neutral sludge is dried and disposed of as landfill, for road laying or as a soil supplement owing to high micronutrient content
- Most of the supernatant water is recycled in a closed loop, rendering the process sustainable and eco-friendly
- Evaporation/blow down losses from the cooling towers are topped up regularly
- In areas of low/poor water availability, the cooling is effected with dry type cooling towers, which consume much less water but higher power
- This renders the entire process cost effective, eco-friendly and sustainable in resource use

Automation & SCADA

- The system is monitored on-line at various points with pressure, temperature and chemical sensors
- The data so collected is extremely useful in subsequent diagnosis of malfunction and rectification
- PLC based control system facilitates automatic start-up and shutdown for normal plant operation and automatic plant shutdown during emergencies
- Supervisory Control And Data Acquisition is optionally provided for on-line monitoring with state of the art software and this enables real-time control and budgeting besides user friendly preventive and shutdown maintenance schedules

Applications Packages

- Power Generation
- Thermal Applications
- Combined Heat & Power
- Combined Cycle Operation
- Trigeneration

Power Generation

- Retrofit to existing generators in the dual fuel mode
- Total replacement of grid power in existing industries in dual fuel or gas modes
- Sale of power to Utility as base-load station
- Sale of power to Third Parties by wheeling and banking on the Utility/local grid
- Power for remote rural electrification and village energy security
- Specific fuel consumption is 0.8 to 0.9 kg of biomass and 55 ml of diesel/HFO per kWh in Dual Fuel mode for 80% diesel replacement
- Specific fuel consumption is 1.0 to 1.2 kg of biomass per kWh in Gas Mode

Power – Economics Dual Fuel Mode

- 3 Phase HT Grid Power cost ranges from Rs. 4.50 (US¢ 10) to Rs. 6.00 (US¢ 13.33) per kWh in various Indian states
- Dual Fuel Mode (Unit Generation Cost, assuming Rs. 45/- per US$)

○ Cost of 55 ml diesel @ Rs.34.00 (US¢ 75.6) /Lt	= Rs. 1.87 (US¢ 4.16)
○ Cost of 0.9 kg biomass @ Rs.1.25 (US¢ 2.77)/kg	= Rs. 1.13 (US¢ 2.51)
○ Moisture loss @ 20%	= Rs. 0.17 (US¢ 0.38)
○ Cost of biomass sizing @ Rs. 0.25/kg	= Rs. 0.23 (US¢ 0.51)
○ Other costs such as maintenance, manning, water, lube oil, chemicals etc.	= Rs. 0.45 (US¢ 1.00)
Total cost of generation	= Rs. 3.85 (US¢ 8.56)

- Savings/kWh range from Rs. 0.65 (US¢ 1.45) to Rs. 2.15 (US¢ 4.78) per kWh without considering interest and depreciation
- Depreciation @10% per annum typically costs Rs. 0.25 (US¢ 0.55) /kWh and interest both long term and working capital Rs. 0.15 (US¢ 0.33)

Power – Economics Gas Mode

- 3 Phase HT Grid Power cost ranges from Rs. 4.50 (US¢ 10) to Rs. 6.00 (US¢ 13.33) per kWh in various Indian states
- Gas Mode (Unit Generation Cost assuming Rs. 45/- per US$)

○ Cost of 1.10 kg biomass @ Rs.1.25 (US¢ 2.77)/kg	= Rs. 1.38 (US¢ 3.07)
○ Moisture loss @ 20%	= Rs. 0.20 (US¢ 0.45)
○ Cost of biomass sizing @ Rs. 0.25/kg	= Rs. 0.27 (US¢ 0.60)
○ Other costs such as maintenance, manning, water, chemicals etc.	= Rs. 0.55 (US¢ 1.22)
Total cost of generation	= Rs. 2.40 (US¢ 5.34)

- Savings/kWh range from Rs. 2.10 (US¢ 4.66) to Rs. 3.60 (US¢ 8.00) per kWh without considering interest and depreciation
- Depreciation @10% per annum typically costs Rs. 0.55 (US¢ 1.22) /kWh and interest both long term and working capital Rs. 0.23 (US¢ 0.51)

Thermal Applications

- Product drying at 50°C -150°C either directly as in oil refining, chemicals or indirectly as in food processing, textiles, tea and other heat labile products
- Hot water/steam cooking at 80-120°C
- Heat Treatment Furnaces at 120-1000°C
- Non-ferrous melting at 600-900°C
- Thermal energy for Forging units up to 1100°C
- Ceramic industry upto a maximum of 1050°C
- Thermic fluid heating/ boiler service at 180-450°C
- Vapour Absorption Chilling for Space Cooling, Process Chilling directly or with hot water/steam at 80°C - 200°C

Thermal Applications - Economics

- Using special burners as replacement for liquid fossil fuels such as HFO, LDO & HSD or in place of electrical heating

	HFO/Lt.		Diesel/Lt.	
	(Rs.)	(US¢)	(Rs.)	(US¢)
○ Cost of fossil fuel	18.50	41.10	34.00	75.60
○ Cost of equi. biomass ~ 4 kg @ Rs.1.25/kg	5.00	11.11	5.25	11.67
○ Moisture loss @ 20%	0.77	1.78	0.81	1.80
○ Cost of biomass sizing @ Rs. 0.25/kg	1.00	2.22	1.10	2.44
○ Other costs such as maintenance, manning, water, chemicals, power	3.53	7.84	3.69	8.20
Total cost of gas equivalent	10.30	22.88	10.85	24.11
Net Savings per Lt of fossil fuel	8.20	18.22	23.00	51.11

- Depreciation @10% per annum typically costs Rs. 1.00 (US¢ 2.22) /Lt and interest both long term and working capital Rs. 0.60 (US¢ 1.33)

Combined Heat & Power

- Depending on generator size, about 25% - 39% of the energy in the biomass is converted into electricity, the rest is dissipated as heat and sound.
- Thermal energy of 1600-2400 kW of heat/MW of electricity generation is available in the flue gas and engine cooling loop which can be utilised for process heat directly, indirectly or with waste heat boilers or for Vapour Absorption Chilling

Combined Heat & Power -Economics

- Each MW of power installed can generate 0.6 to 0.9 TPH of steam @10 kg/cm2
- Industry normally adopts credit of Rs.600.00/MT of steam
- The avoided fuel cost for steam generation improves the payback of stand alone generators by a factor of 25% to 35%
- Our designs now offer biomass driers as standard equipment with waste heat utilisation, thus reducing the cost of drying

Combined Cycle Operation

- Higher capacities above 3 MW of power generation can be configured for Combined Cycle operation
- The plant will generate electricity using gasifiers and gas engine generators/Dual Fuel Generators
- Thermal energy in the flue gas is then used to produce steam with waste heat boilers or vapour in an Organic Rankine Cycle
- This steam/Vapour can be used in a Closed Loop Bottoming Cycle in turbines for generating additional power at zero fuel cost and marginal investment additions

Combined Cycle – Economics

- Electricity is generated in two modes using the same fuel, thus lowering specific fuel consumption and unit generation cost
- Higher Combined Cycle conversion efficiencies of 45% can be achieved with this configuration
- The incremental power generation improves the profitability of the entire system by 10-15%
- This additional generation would reduce the unit generation cost by about 10%.

Tri-generation

- Industries requiring electricity, steam and cooling such as food processing and cold storages find the concept of tri-generation very attractive.
- After generating power in the combined cycle, the exhaust steam derived from the flue gas of the generator is used to achieve cooling by Vapour Absorption further improving the cycle efficiency
- Each MW Power Plant can generate up to 300 TR of chilling both from the engine jacket with hot water and from the hot flue gas directly.
- Our Plant utilises this concept by using the engine cooling water/exhaust heat for VAC to meet gasifier process needs

Projects Implemented-Summary

- We have installed 17 gasifier systems of cumulative capacity of 6.3 MT/hr for both thermal and power applications
- Installed capacities range from 25 kg/hr in Brazil to 2x 860 kg/hr in Tamil Nadu
- We installed India's largest thermal gasifier 1100 kg/hr at Tanfac Industries Ltd. in 2003 and the largest grid connected Power Plant of 1.25 MWe at Arashi Hi-tech Bio Power in 2002/04
- We recently commissioned 3 x 215 kWe Power Plant at Hatsun Agro Product Ltd., Kanchipuram and a 2 x 215 kWe Power Plant for KPCL, Kolar
- We have on-going projects cumulating to 6 MT/hr at various locations in TN and Karnataka

Hatsun Biomass Storage Yard

Hatsun Multi Blade Saw Cutter

Hatsun Sized Biomass

Hatsun Biomass Drier

Hatsun Entrance & Flare Burner

Hatsun Columns & Staircase

Hatsun Biomass Chute and Reactor

Hatsun Reactor & Structurals

Hatsun Ash Extraction Screw

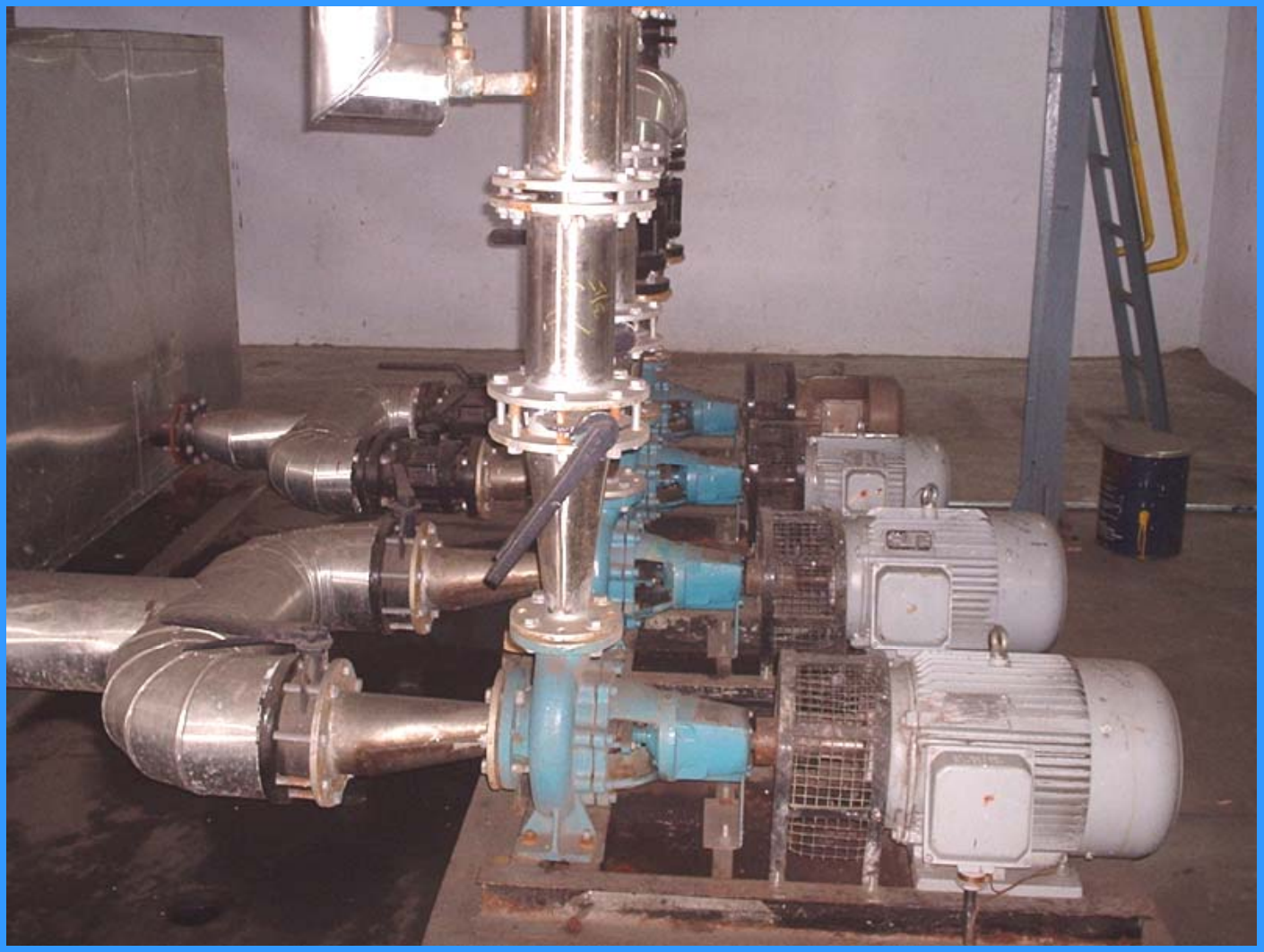
Hatsun Multiclone and Scrubbers

Hatsun Manometer Bank & Chiller

Hatsun Automatic shut down system

Hatsun Fabric Filters

Hatsun Scrubbing Pumps

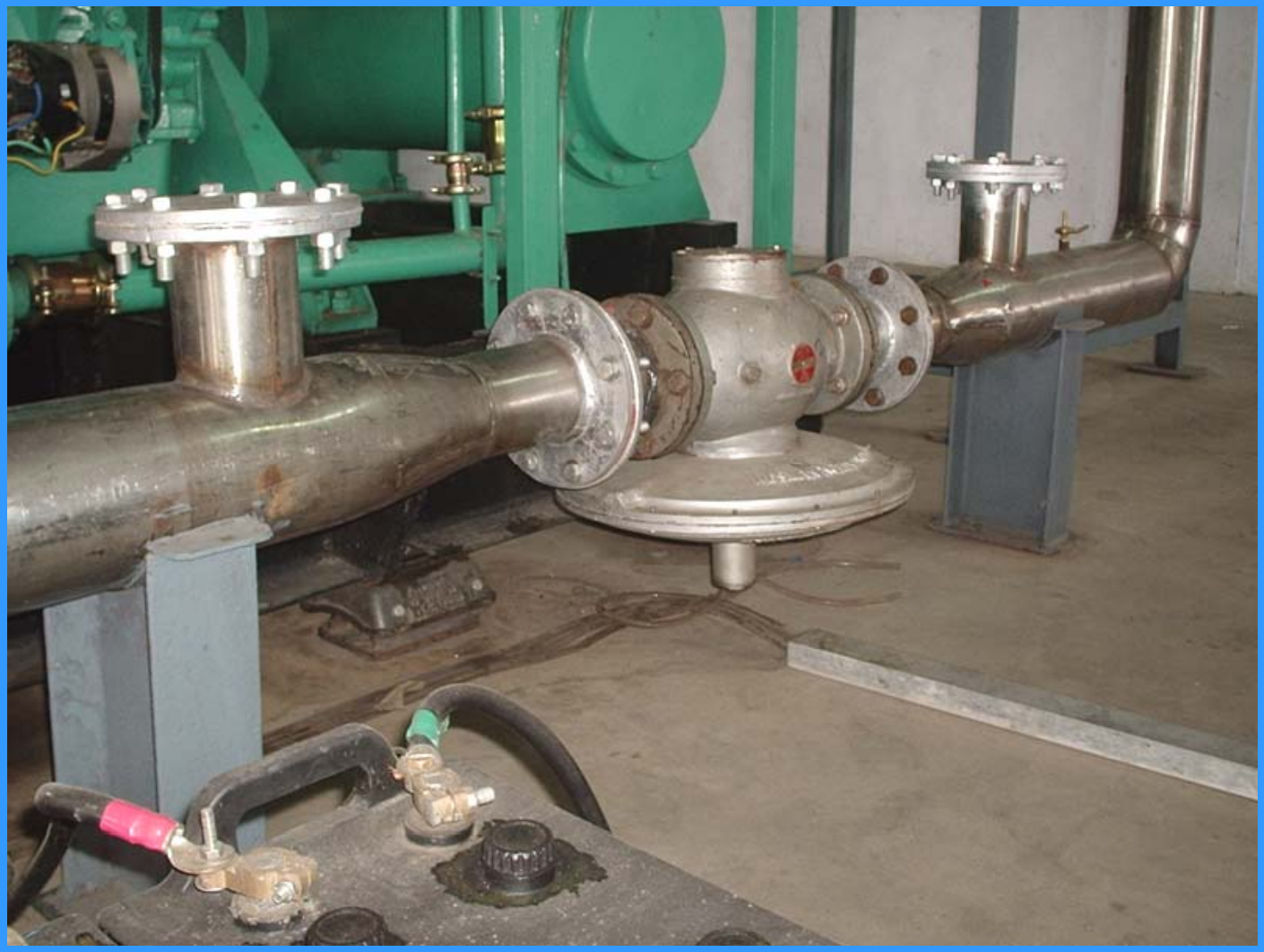


Hatsun Main Gas Blower

Hatsun PLC Control Panel

Hatsun Gas Carburettor

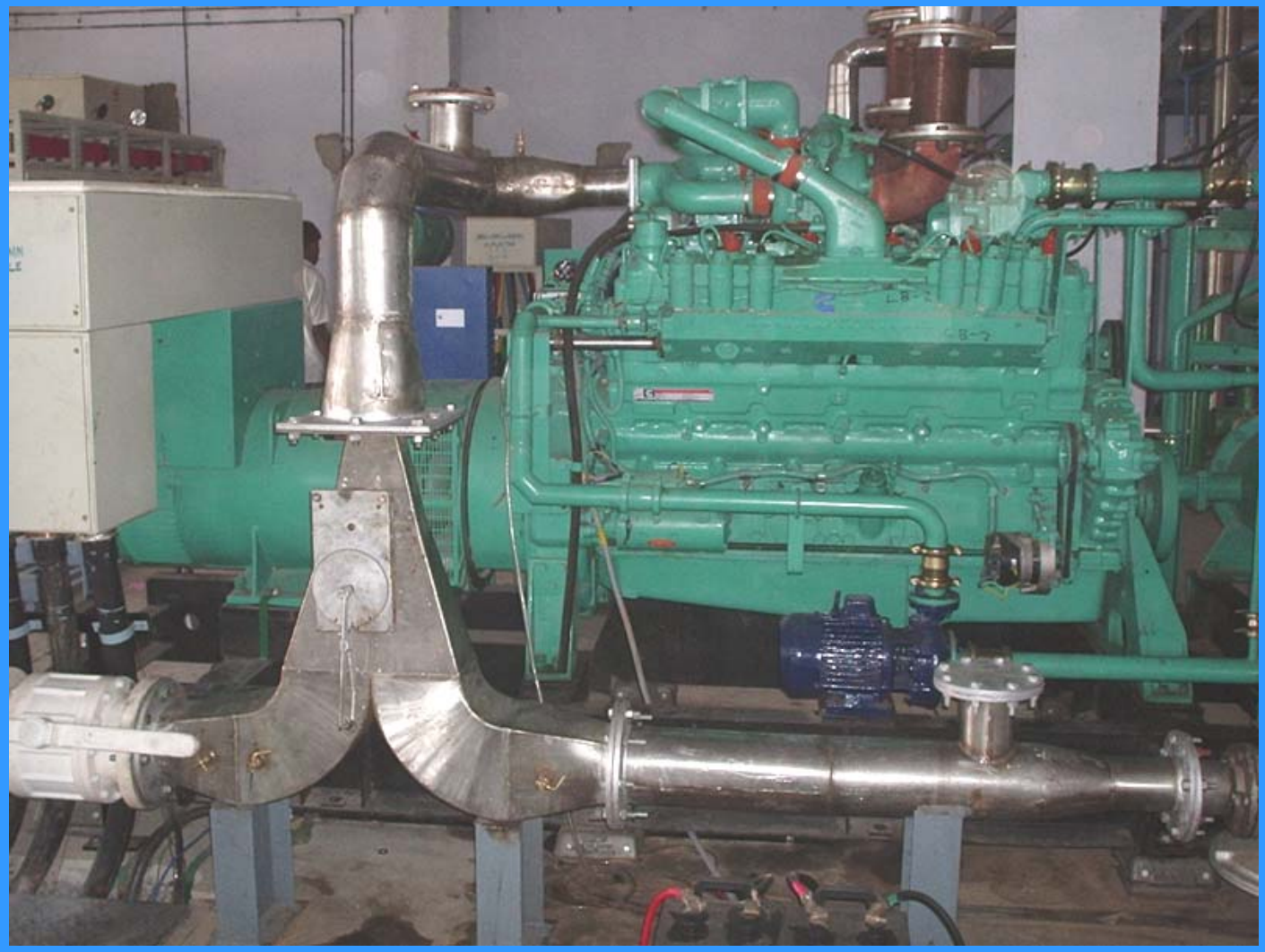
Hatsun Gas Regulator



Hatsun Gas Intake Lines

Hatsun Treatment Plant

Hatsun Gas Engine Generator



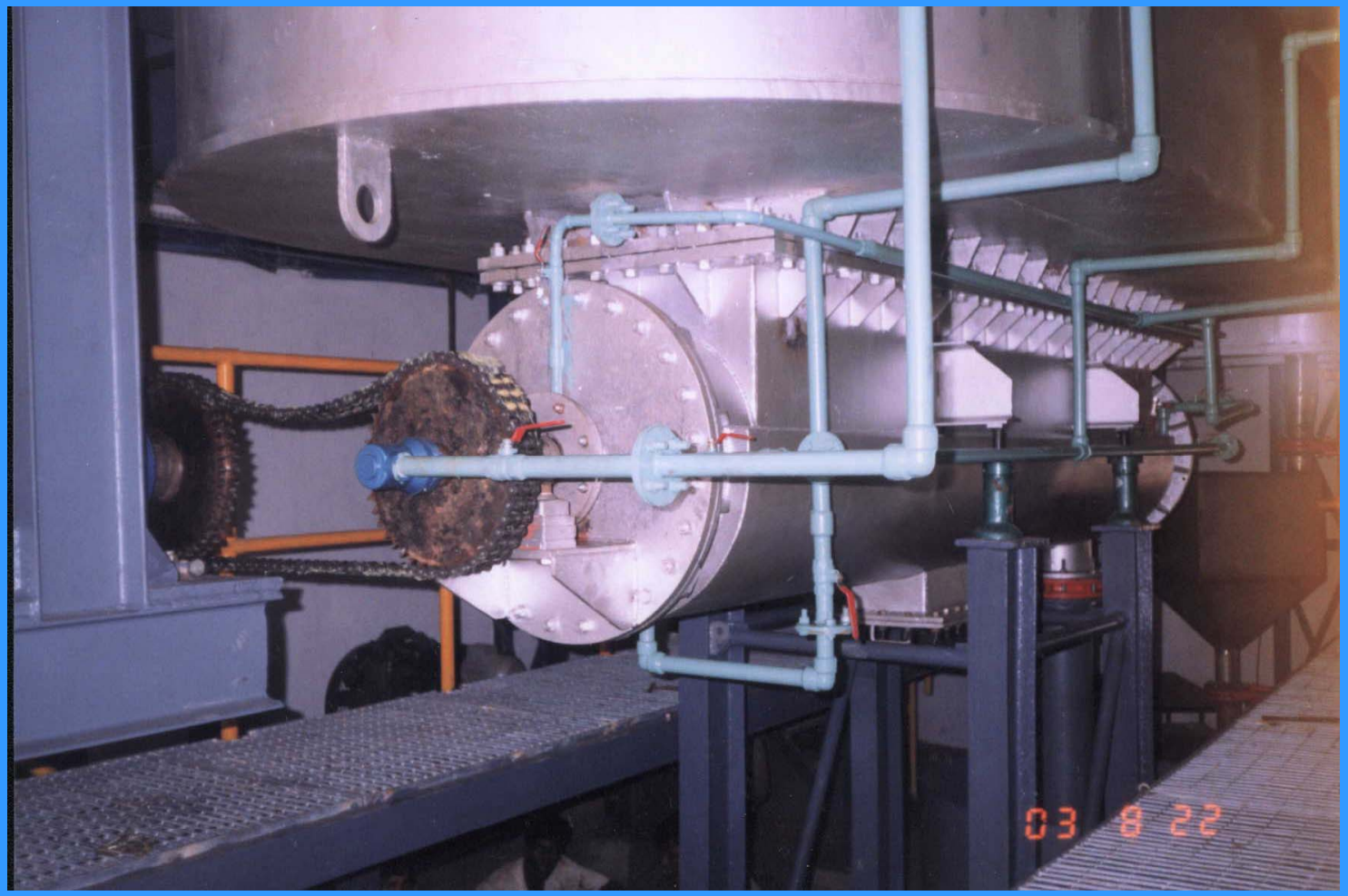
Tanfac – Construction

Tanfac – Feed Bucket

Tanfac – Feed Chute

Tanfac – Reactor

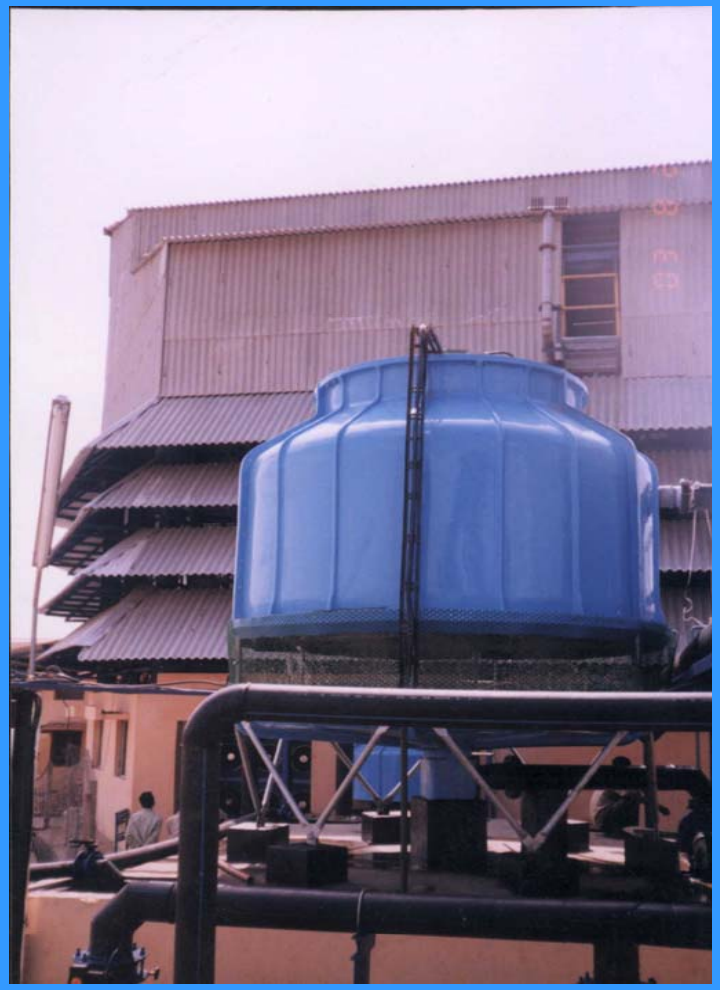
Tanfac – Ash Extractor



Tanfac – Multiclone Dust Collector

Tanfac - Coolers & Scrubbers

Tanfac - Main Cooling Tower



Tanfac - Flare Burner

Tanfac - Water Treatment Plant

Tanfac -PLC Control Panel