Biomass gasification at IISc

Technology Development, Scale-up & Technology Transfer

Indian Institute of Science
Bangalore

Content

Background

Gasification research commenced in 1984

Over 350 Man-Years of R&D effort

Evolved State-of-the art technology

Undergone critical third party evaluation – by various groups

Technology commercialized ~ four years

Studies – Fundamental & Lab/Field Trials

Biomass fuel - size

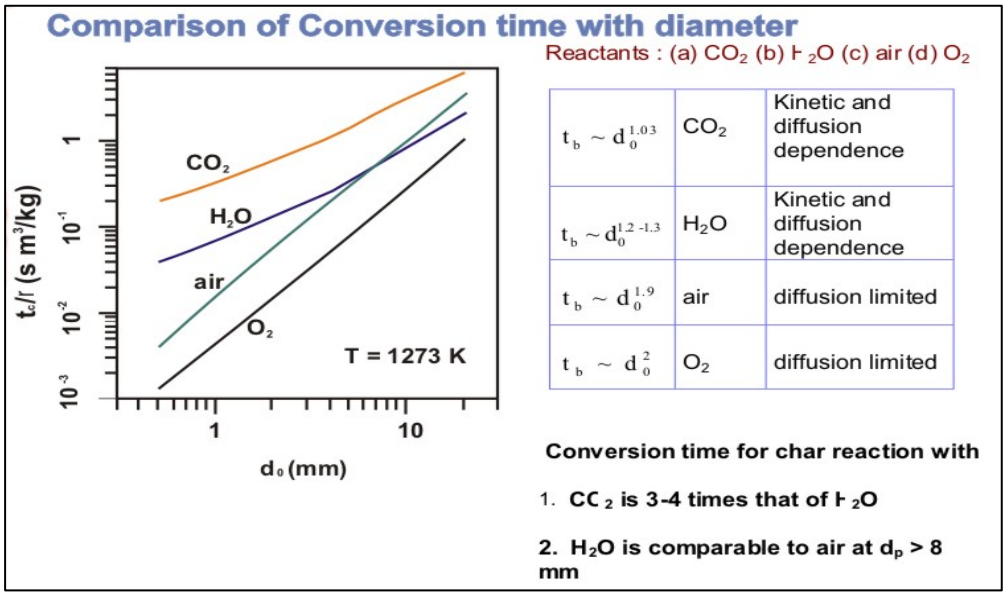
General philosophy:

To use as-is- where is condition fuel or use existing fuel processing equipment.

Chipper provide small size (flakes)

- Has serious implications on the process
  $t \sim d_o^2$
- particle size influences conversion time (both pyrolysis and char conversion)

- implications on gas quality

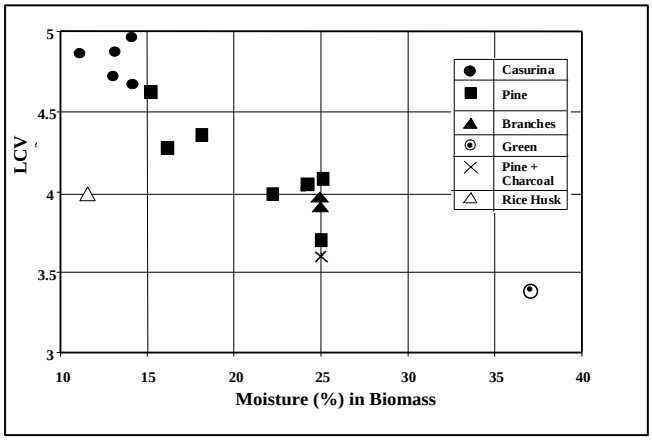


Moisture content

Higher the moisture content

lower the thermodynamic efficiency

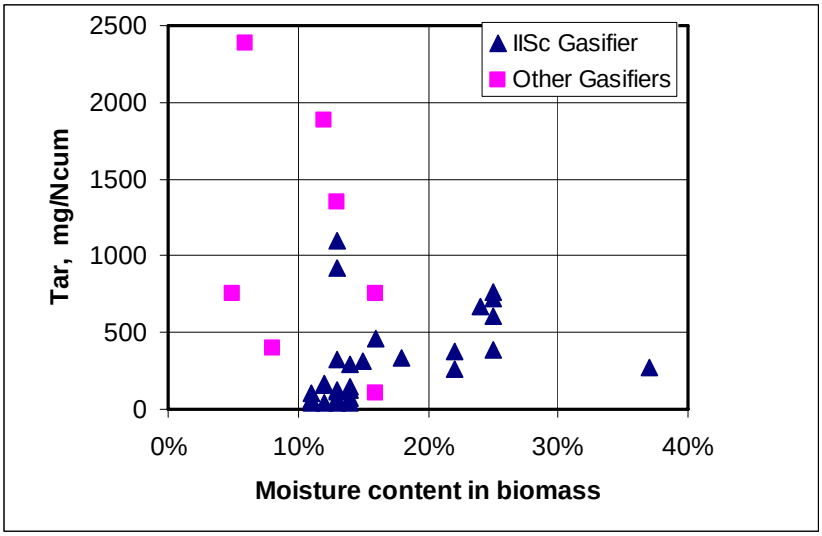
- lower the cal value and higher the hot gas contamination



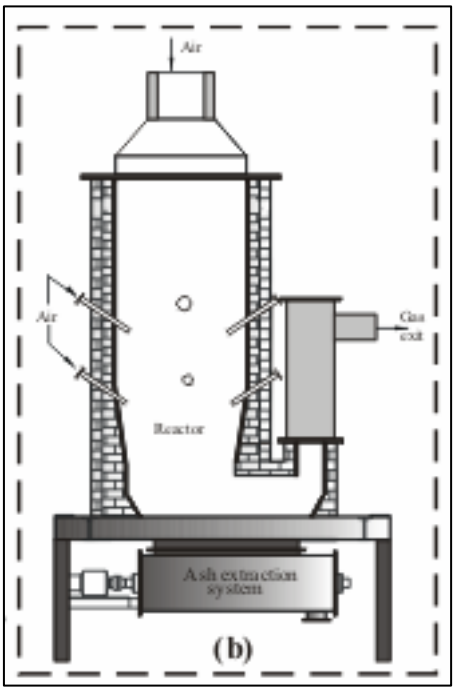
Ash content

Ash fusion issues

Lower gas conversion efficiency



Technology Development



- **Open Top, twin air entry, re-burn reactor conceptualized**
- **Reactor**

  ability to handle agro residues

  To handle corrosive environment

  scalability

  simple for operation

  ability to handle varying load conditions

- **Gas Processing**

  ability to handle the gas quality to meet engine/high quality thermal application

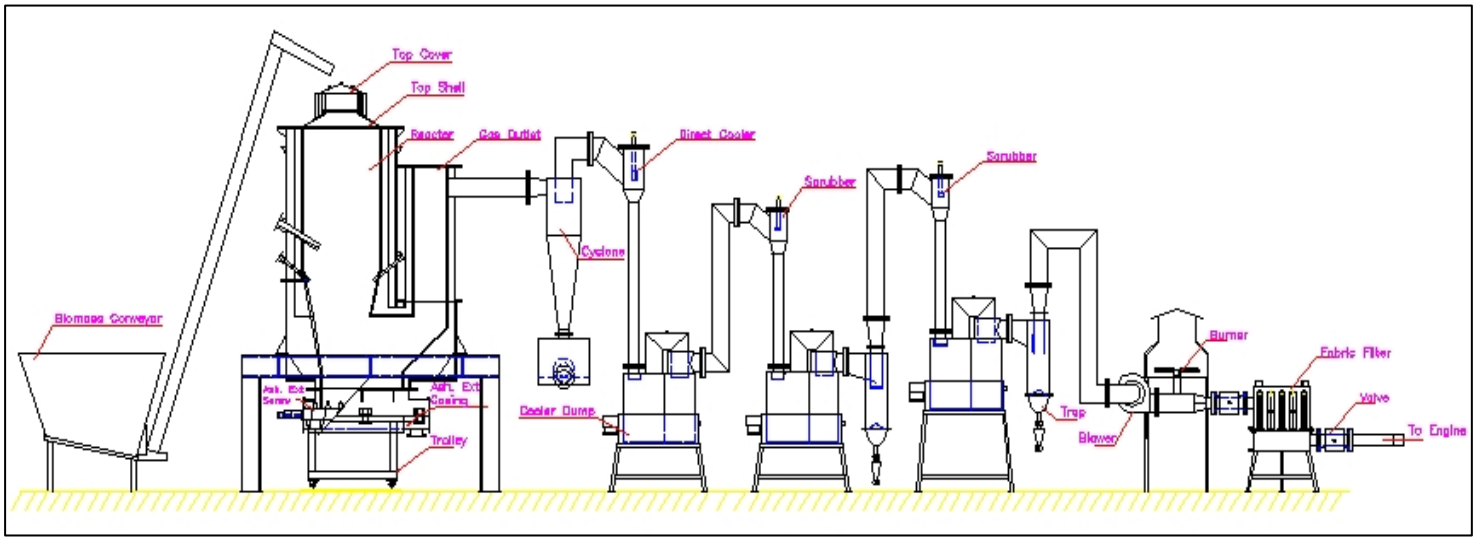
  ability to remove dry material and reduce the contamination in the cooling water

  Scalability

- **Water treatment**

  To reuse the water

  Meet the local environmental standards



Choice of material

High temperature zones – insulation, high temperature and high alumina material to take care of temperature and chemical corrosion.

Gas contact zones – use stainless steel / non metallic

Performance

Fuel - Agro residues and briquettes with ash content less than 5 %
In house consumption - 8 – 10 %

Gas composition - CO: 20 $\pm$ 1%; CH_4 : 3 $\pm$ 1%, H_2 : 20 $\pm$ 1%, CO_2 : 12 $\pm$ 1% and rest N_2.

Gasification efficiency - ~ 80 %

Clean gas – < 1 ppm on T and P

The Package

Multi-fuel option including agro residue

Capacity: 5 to 1000 kWe

Ultra clean gas ~ for turbo charged engines

Also, for high quality thermal applications

Dual fuel engine - ~ 75 % diesel savings
(operating experience >50000 hrs)

Gas engine - operating experience (5000 hrs)

Also, High pressure gasification for micro turbine

Wish list as perceived by a user

- To be able to use all types of fuel; nearly as is where is condition implying multi-fuel option.

  - More particular in the developing countries context – use of agro residue important.

- Developed countries generally centralized wood processing and hence woody biomass is available.

- To be able to operate like a liquid fuel system; simplicity in design technology to be simple, automation.

- Lower down time - reliability of the system; service support.

- Economic viability; return on investment- guaranteed performance.

- Environmentally benign - low on pollutants and emissions

- Should see a system of comparable application/capacity of what is being intended to be bought; not a guinea pig - no risk option.

- Fuel source to be identified - a necessity for substituting large scale fossil fuel technology package.

Challenges in Scaling-up

- Achieving uniform distribution
  - A feature easily achieved in an open top design
  - Air Nozzle Location & Numbers
  - Question on Air Nozzle material

- Reducing in-plant power consumption
  - Vapor absorption chiller ~ waste heat engine

- Biomass processing & conditioning
  - Large throughput cutter (to handle various weeds)
  - Drying ~ 15% moisture (using engine exhaust and heat from gasifier system)
  - Briquetting agro wastes

- Wash water treatment
  - For recirculation
  - Zero liquid discharge

Technology Transfer

- Internationally patented technology

- One of its kind in Technology transfer – South to North
- Currently 4 in India, 1 each in Europe & Japan
- Addressing large potential in other parts of Asia, Africa and Latin America on project basis
- Open for Technology transfer to other parts of the world

Field Installations

Total installed capacity

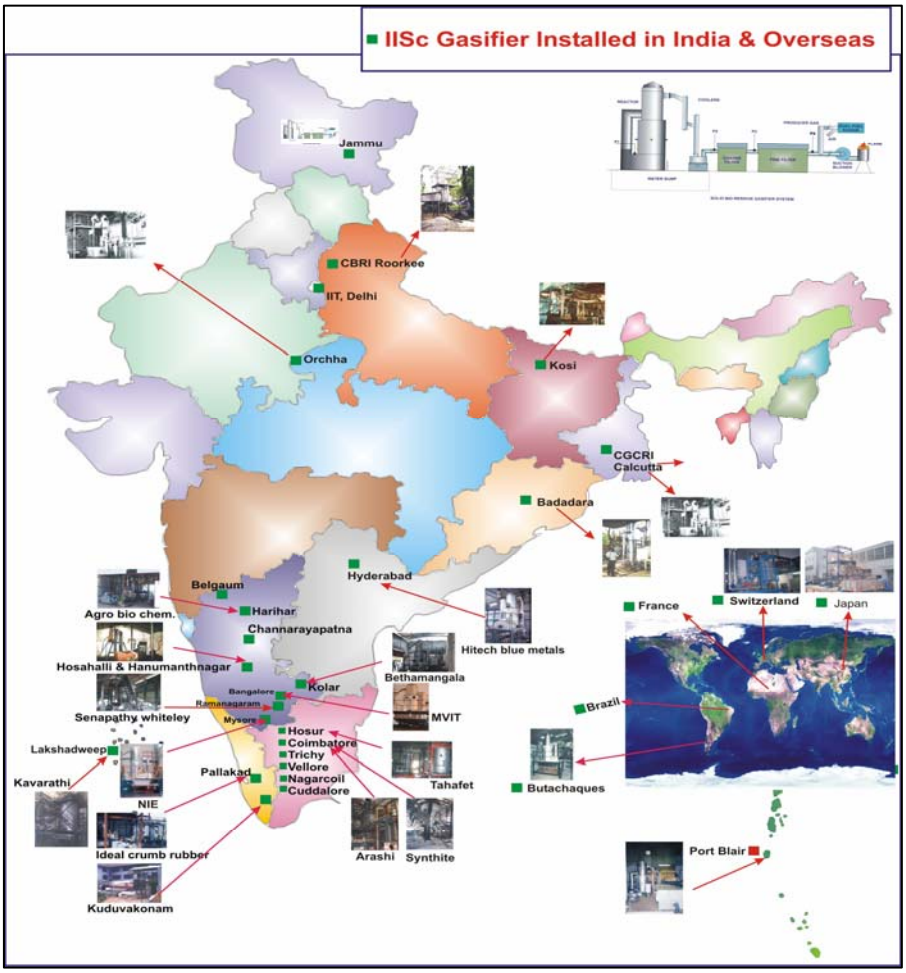
Thermal : 12 MWth

Power : 4 MWe

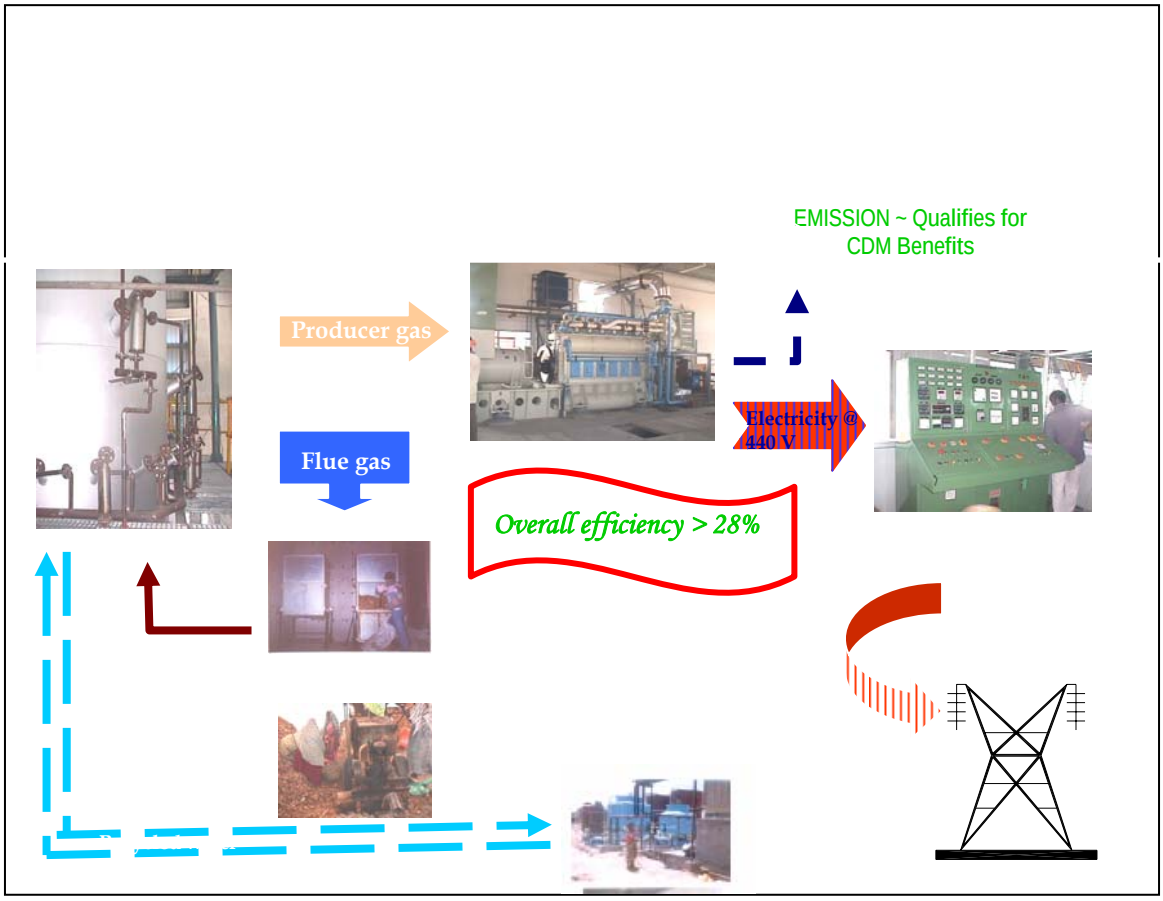
Over 100,000 hours of operation

Saving 18 -20 Tons of fossil fuel/day

4 Licensees in India and 2 in overseas



1 MWe Grid Linked – Arashi Hi-tech bio power system



Performance

Fuel used – coconut shells and prosopsis juliflora

Hours of operation – 6800

Units generated – 4.0 million units

Fossil fuel used – diesel, ldo, heavy oil (60 – 100 ml /kWh)

Biomass - 0.72 ± 0.04 kg/kWh

Overall conversion efficiency ~ 28 %

By product – activated charcoal (iodine no. ~ 500 – 650)

Lessons learnt

Agro residue is possible to be used as feed material with gas quality acceptable for turbo charged engines.

-Long duration operation possible

-Fuel flexibility is important

-Gas engine an economic option

1.2 MWth - Heat treatment –Tahafet

- Eight furnaces and temperatures vary from 600 C to 1000 C.
- Each furnace is fitted with two burners having air to fuel ratio control and also a PID controller to oversee the operations. The industry operates on three shifts for about 6 days in a week.
- Typical LDO consumption 1500-2000 Liters/day.
- 300-kg/hr gasifier capacity installed.
- All the eight furnaces are connected to the gasifier using WESMAN make dual-fuel burner with ratiotrol based A/F control and PID monitor servo controller. The temperatures in the individual furnaces are maintained independently.
- With 8 furnaces connected presently to gasifier saving is about 2000 liters/day.
- Average fuel consumed per day 5.2 T of coconut shells, wood chips

Performance

- Total hours of run 21000

- Total fuel saved 1680 kilo lts

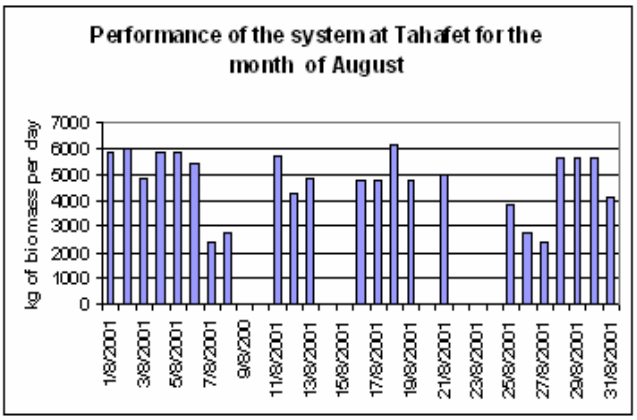
For the month of August 2002

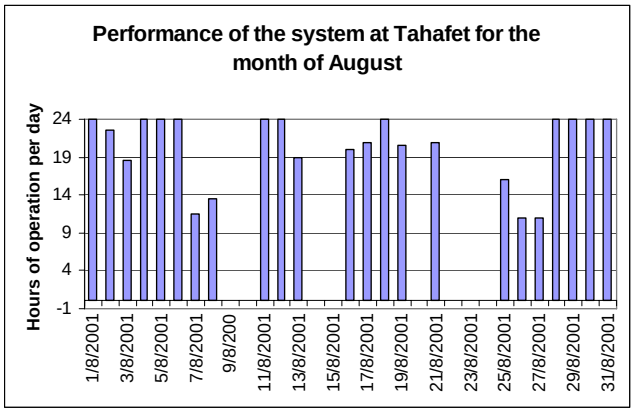
-Hours of run : 470

-Total biomass used :109.4 Tons

-Total LDO saved : 30000 lts

-Savings per day : 320 USD





Xylowatt SA

- Xylowatt Ltd was founded in February 2000 in Switzerland.
- taking back the activities of the CCC (R&D group).

  - 5 year of R&D with the support of the Federal Office Energy

  -Industrial prototype 60 kWe tested during 2'000 hours

- Integrated into an industrial group

  -Active since more than 30 years in CHPP with engine

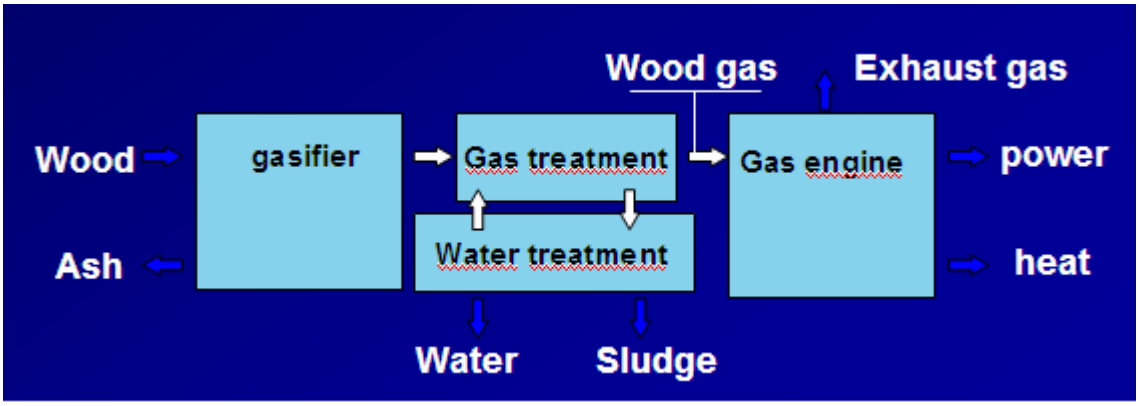
  -with 200 employees in Switzerland and Germany

- Set up a demonstration CHPP in 2002

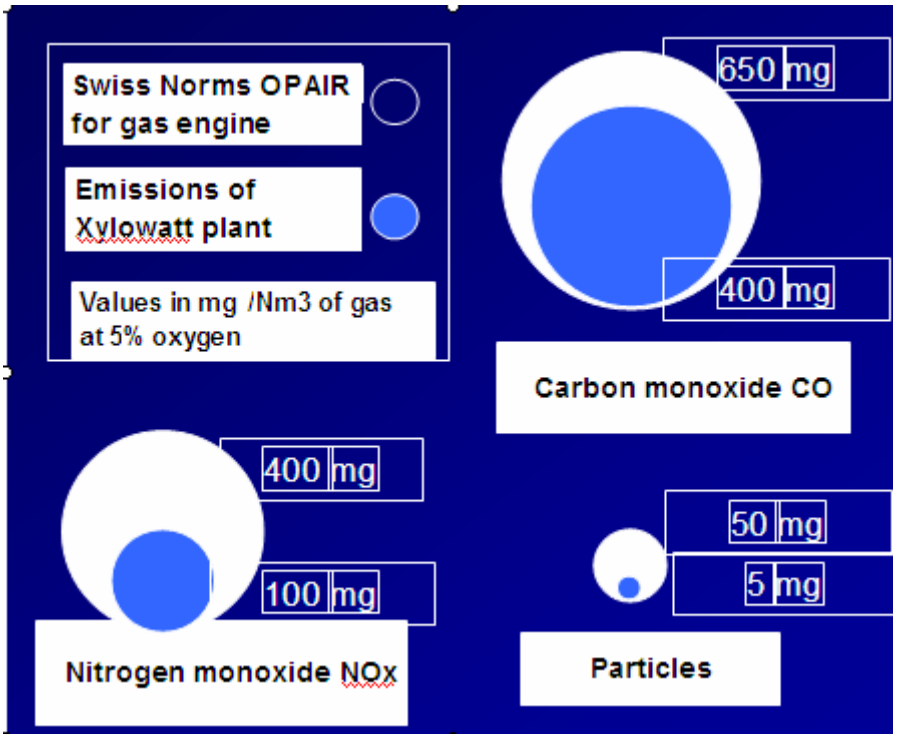
Installation in Bule

Performance

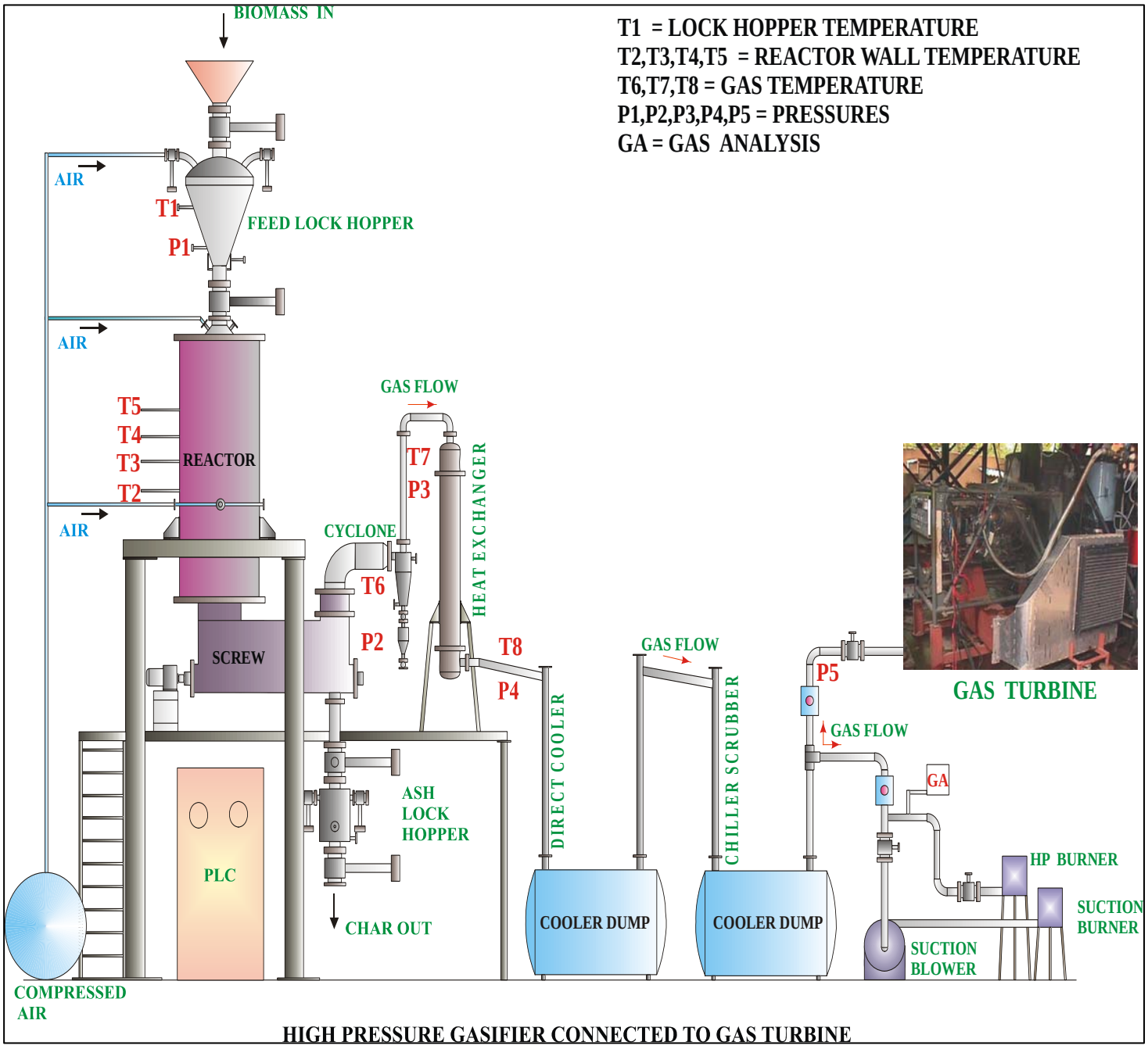
Wood :54 kg/h, 20 % moisture
Ash:1 kg/h (1.5%)
Water - Sludge : 14 litre/h - 0.2 kg/h
Cal value: 130 Nm3/h, LHV 4.9 MJ/Nm3
Heat – power : 108 kWth (48%) – 50 kWe (22%)



Exhaust gas emission



The Schematic of the high pressure gasification system for gas turbine application



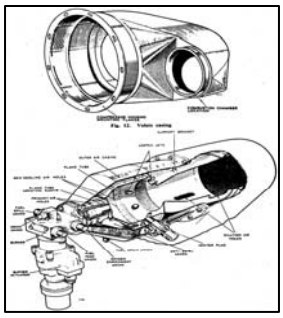
HIGH PRESSURE GASIFIER CONNECTED TO GAS TURBINE

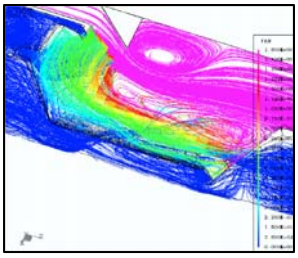
Adaptation of the Combustor

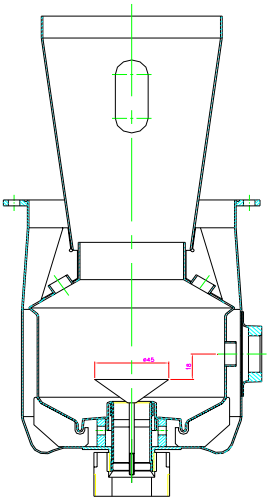
Numerical computations to check availability of the right mixture ratio near the igniter.

Stand alone mode experiments to test the combustor.

Experiments on the gas turbine.







Performance

- Gas turbine was run at 12 kW load.
- Ability to ignite the gas as a liquid fuel system – no changes in the ignition system.
- SFC very high (low efficiency).
- Gas quality acceptable for turbine application.

Overall Summary

- Technology transferred to 4 manufacturers in India and 2 overseas

- Over 35 plants of various capacity

- Total system packaging as IPP

  -Fuel preparation system, gasification system, ash handling system, water treatment, power generation, power evacuation system.

- Total of 100,000 hours of operation for various applications.

- Over 60000 hours of operation on 6 systems for power generation with average diesel savings in the range of 70 – 75 % and thermal systems of 200 – 5000 kWth.

  -Fossil fuel 20000 lts per day

- Power generation using gas engine at 120 kW capacity (3000 hrs) in industrial application