

Clean coal energy – some past, present and future

- My appreciation of the past
- Why only one owner of 500 MWe at Rs. 3000 – 3500 million? Why not also 50 owners of 10 MWe at 50 x Rs. 60 – 70 million?
- Biomass (first) to Coal (next) for electricity
- Status of Biomass-power at 1 to 1000 kWe.
- Simple experiments on coal in “biomass systems”
- Important conclusions
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My appreciation of the past

- Have visited (along with colleagues from CGPL) BHEL, Trichy and Hyderabad in 1998 - 99 and discussed with scientists on high pressure gasification system development and the updraft coal gasifiers
- After two major discussion meetings at Trichy and IISc, it appeared that the thermo-chemical basis of the high pr gasification system design needed major inputs
- The subject of 140 MWe IGCC plant has had a Checkered history

Conclusion: The space for "smaller" coal power systems must be explored without blinkers of large-being-great idea that is ruling the Coal world

Why only one owner of 500 MWe at Rs. 3 – 3.5 billion? Why not also 50 owners of 10 MWe at 50 x Rs. 60 – 70 million?

Big money is too difficult to come by. At roughly same investment cost of Rs. 6 - 7 crores per MWe, it would be possible to enthuse very large number of investors to build these plants and stabilize the grid - this is why?

What about efficiencies, one might say.

On efficiencies and...

- Large steam power systems enjoy a coal-to-electricity efficiency of 36.5 - 37 % in India (systems in Europe get around 40 % for the same class of parameters)
- 1 to 3 MWe class reciprocating engines (say Jenbacher, MWM, Deutz) allow gaseous fuel to electricity of 40 %

Conclusion: Small reciprocating engines are more than reasonable in terms of efficiencies. They aspirate the fuel gas at ambient pressure unlike gas turbines that need the fuel gas to be compressed

Therefore, we can make do with ambient pressure tested fixed bed gasification systems that are far simpler (reasonable first costs also) than high pressure variety.

Therefore....

- We can combine ambient pressure fixed bed downdraft gasifiers with r/c engines to get solid fuel to electricity at efficiencies of say $40\% \times 0.85$ (gasification efficiency) = 34 % in the open cycle.
- We still have exhaust at $300\text{ }^{\circ}\text{C}$ + other heat in the system available for use. These can be used along with heat from additional coal combustion if needed to run HRST to enable IGCC strategy

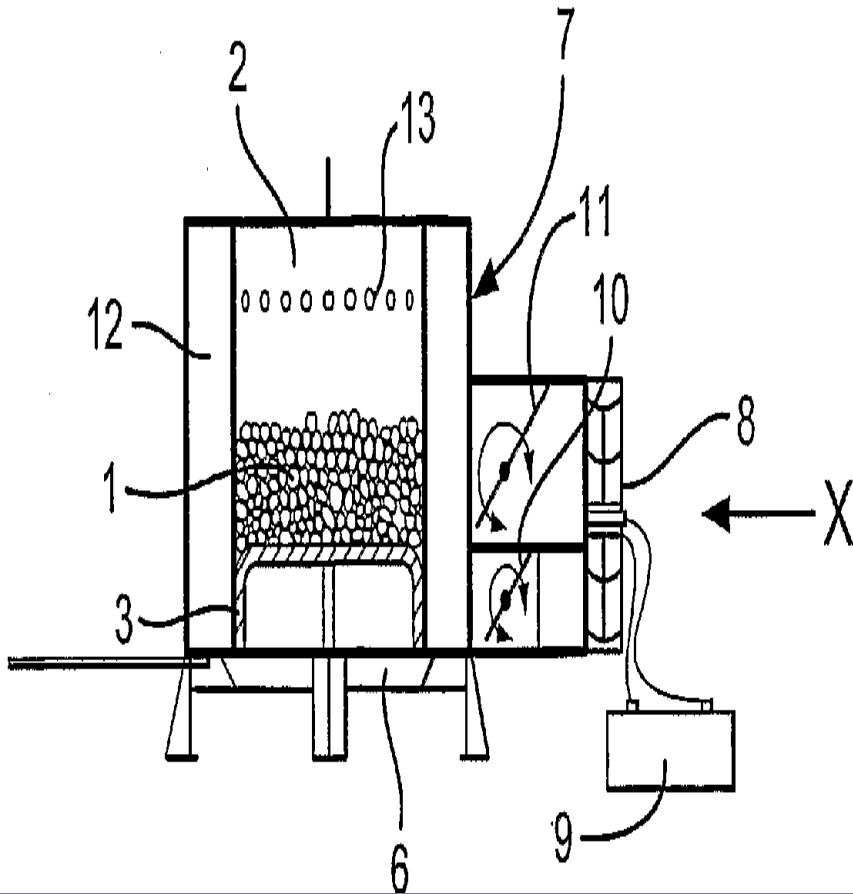
For 3 MWe with the steam cycle, we need to operate the gasifier-engine system at around 6 MWe.
The total cycle efficiency may touch 39 to 42 %.

Biomass (first) to Coal (next) for electricity

Status of Biomass–power at 1 to 1000 kWe.

- We recognize that biomass is 70:30 while coal is 30:70 in terms of volatile : carbon.
- At CGPL, IISc there is >25 years of work - scientific, technological and field operations of >100,000 hours on solid biomass fuel-flex gasifier systems at 1 to 1000 kWe
- Systems have operated in India, Japan, Brazil and Switzerland
- The IISc fixed bed reactor is an open-top **staged air supply** gasifier uniquely suited to run biomass or coal with **5 - 30 % char/ash** extraction.

Simple experiments on coal in “biomass systems”



Coal pieces ~ 3 – 10 mm

The reverse downdraft gasifier stove – air for gasification from the bottom and the air for combustion from the top holes. Flame in phase II (coal char combustion) right

Simple experiments on coal in “biomass systems” (contd)

Fuel	Volatiles	Char	Ash
Wood	75	24	1
Coal	22	50	28

Biomass Air (g/min)

Volatile combustion

10 15 (40 min)

Sup vel (SV) = 3.2 cm/s

Wood Char combustion

3-4 15 (40 min) (SV = 3.2 cm/s)

6-7 24 (20 min) (SV = 5.1 cm/s)

Coal Air (g/min)

Volatile combustion

10 24 (15 min)

SV = 5.1 cm/s

Coal char combustion

3-4 15 (extinction)

7 24 (burns well)



The 1 kg/h open top, staged air gasification system for research and demonstration. –coupled to a 1 kWe gas engine

Result of 3 hour run on coal

Operates steadily throughout the duration

At 1.8 kg/h, at a superficial velocity of 5.1 cm/s, the gas composition is:

Coal (+char bed) : CO = 13 %, H₂ = 13 %

Coal char bed only : CO = 19 % H₂ = 2.5 %

H₂S problem did not seem serious - Alkaline wash may be adequate; otherwise other strategies need to be adopted.

With increased SV, performance will improve to levels same as large gasifiers. Upper limit on the SV is due to ash fusion problem. This is about 10 cm/s (TBD)

Conclusion: Operating a biomass gasifier with 28 % ash coal seems to show no surprises.

Important conclusions

- IISc biomass gasification system has undergone successfully multiple tests in India and overseas both in lab and field conditions for its operability and efficiency. It has IPR in several countries.
- A 1100 kg/h system has operated for more than 30,000 hours in an industrial environment.
- Small systems and basic studies seem to show that these systems also work for coal.
- Additional proving tests on larger systems can always be performed at the laboratory as needed.
- Demonstration systems can be built. Better would be commercial demonstration with partners.

Future possibilities

1. CGPL group (PJP, SD, NKSR + team) has already a responsibility under MNRE to do R & D on steam-oxygen gasification of biomass. The objective is to obtain hydrogen rich gas. Preliminary experiments on stabilizing the flame and smooth operation are in progress.
2. This is the first step towards clean biomass technology.
3. Shifting from biomass to coal would be interesting and not-too-difficult to accomplish. This is along Clean Coal Tech.
4. Another important strategy would be to separate CO₂ from the engine exhaust and use it in the gasification system with oxygen.
5. Exercise options to use the gas in high temperature fuel cells (SOFC, MCFC whenever available).

.....so many new possibilities with reasonable investments at 1 to 10 MWe class systems