Coal combustion & gasification and a low cost developmental route

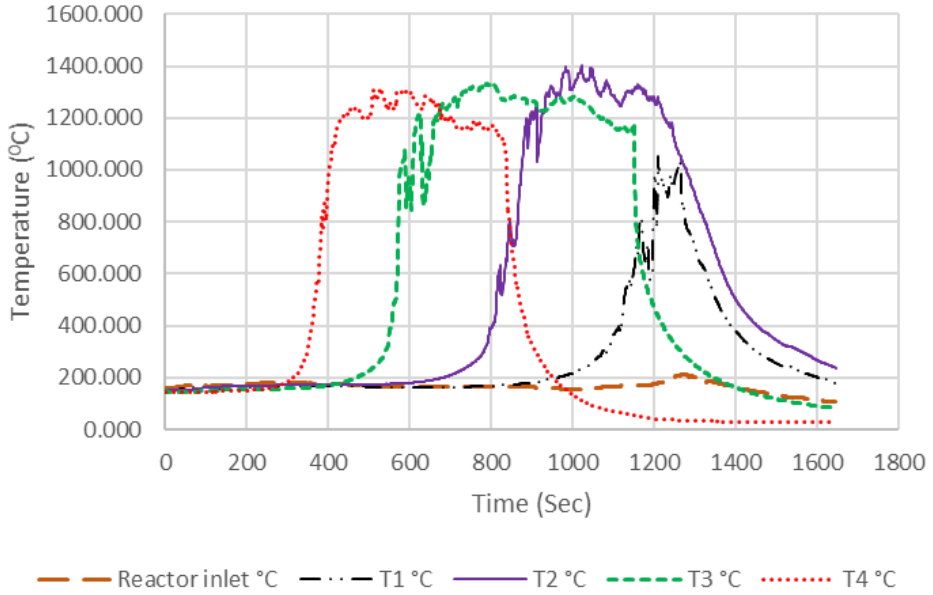
H S Mukunda,
IISc and Jain University
hsm.cgpl@gmail.com

Some considerations.

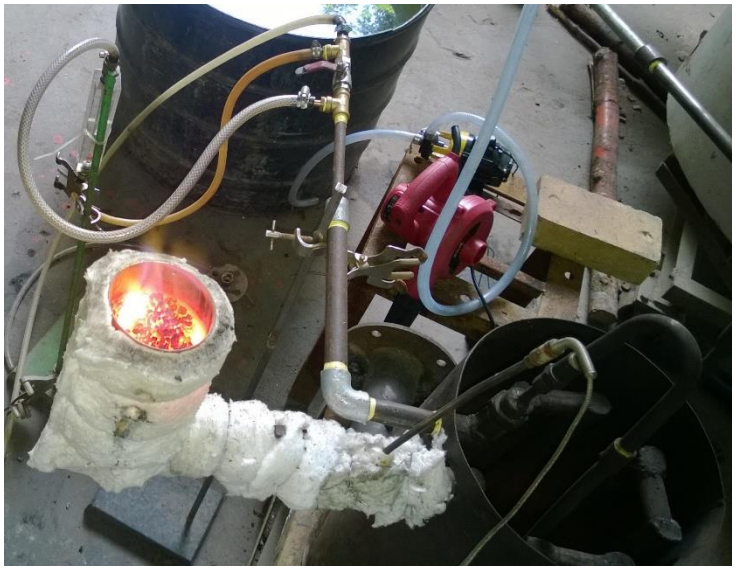
- Coal considered is <28 % ash available from the market.
- Studies made on 21 to 28 % coal.
- Coal sizing is expected to be limited to 3 to 8 mm (mean around 5 mm) to reduce the burden on grinding
- Questions asked are: Would the combustion of coal be diffusion limited? What is to be done to avoid ash fusion and clinkering? What are the conditions required to get the coal to undergo gasification.
- Results (see later) on REDS system at ambient pressure showed that the combustion is diffusion limited. *Temperature of fuel and air beyond 100 C is helpful for combustion as well as gasification (a new approach).*
- Limiting the temperature to less than 800 C and a particle residence time less than a few minutes is adequate for eliminate ash fusion.
- Using a specific air-to-steam ratio in a weakly fluidized bed provides excellent conditions for gasification.
- Subsequent ash separation with a cyclone and cooling techniques follow the successful IISc experience in biomass gasification.
- The cooled (and clean) gas is ready for use in reciprocating gas engines.

Item	Indian Coal with Air			Indian Coal Air + steam	
$\rho_{biomass}$, kg/m^3	1250			1250	
Size, mm	3 - 8			3 - 8	
Ash content, %	21			21	
Volatiles, %	27			27	
Sup. Vel, cm/s	5.7	19	28	43.89	68.03
Air temp (°C)	145	150	155	170	170
Fuel flux, kg/m^{2}h	126	728	960	799	604
ρ_{char}, kg/m^3	800	736	729	777	711
X_{H2O}	-	-	-	0.29	0.31
Coal size, mm	2 - 7	3-8	3-8	3-8	3-8

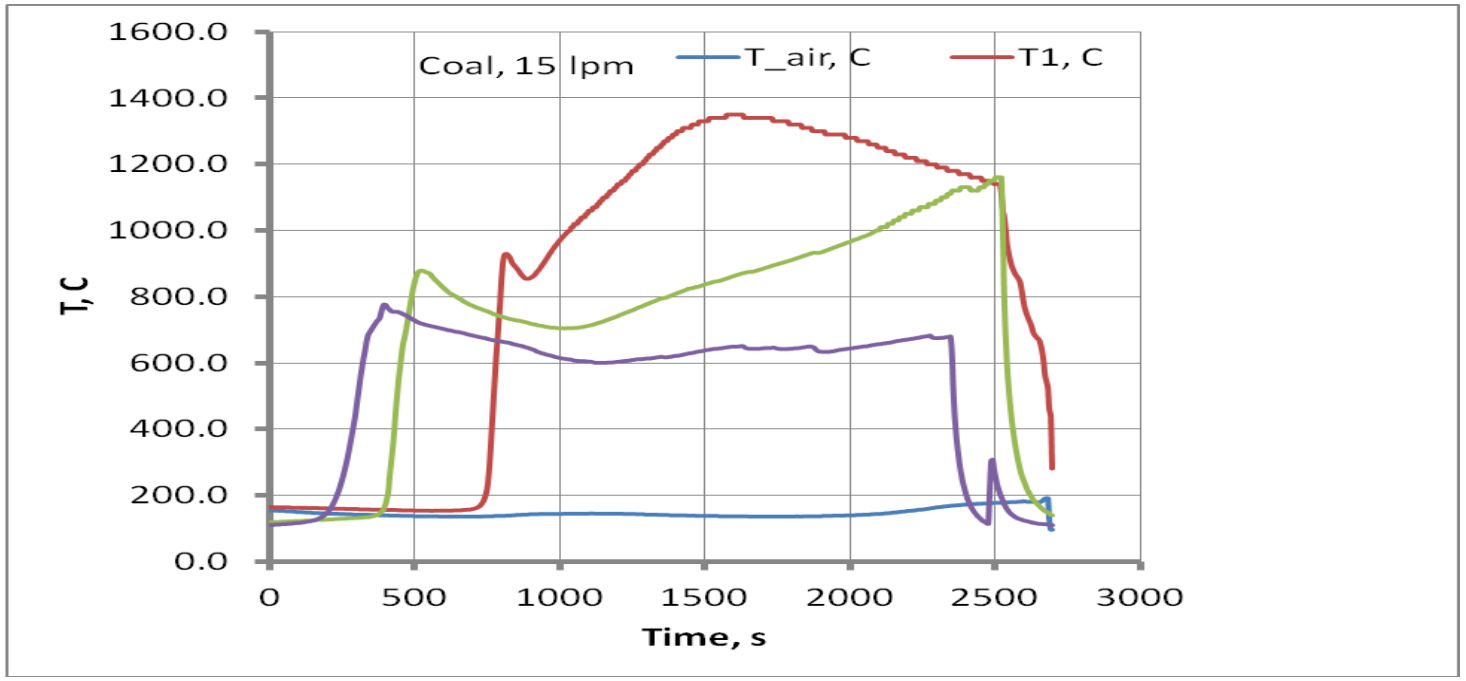
+ Steam



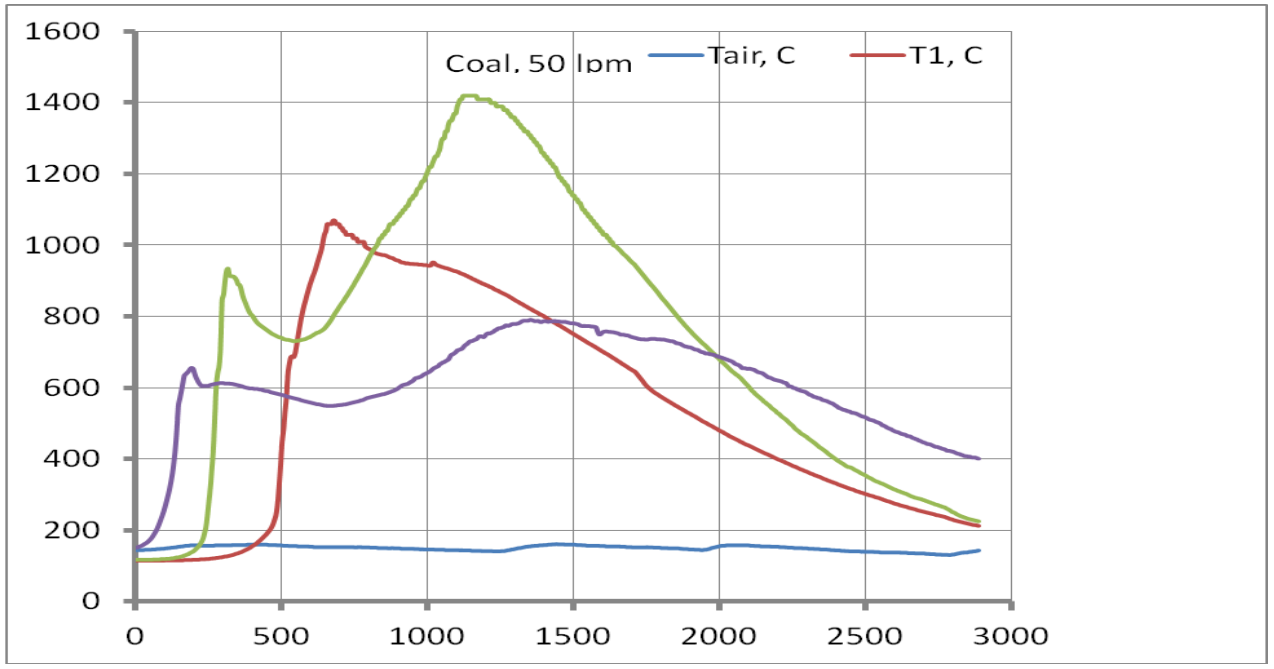
Air flow= 75 lpm, reactor dia = 71 mm, sup vel = 28.3 cm/s
Steam flow rate= 22.3 gms/min;
Initial coal packing density = 711.68 kg/m^3



In these experiments conversion was complete. The process is diffusion limited; ash remained unfused



Sup vel
5.7 cm/s



It appears that below 600 C reaction is very little. All conversion is complete

Sup vel = 19.4 cm/s

Summary

- Based on the studies that involved steam-air mixture in model reactors, diffusion limited approach to design with *heated* air and steam allows simplified designs of reactors *not contemplated earlier*

- With modest R & D funds (< 50 Lakhs), it is possible to demonstrate a electric power generation system using a gas engine based power pack at 25 kWe to instill confidence.

- Scaling up to about 250 kWe is also possible in a laboratory environment with suitable funding after the small system is shown to be successful.

- Once this demonstration is complete, scale up to several MWe is feasible. The economics of these systems (1 to 2.5 MWe +) looks reasonable and these can be undertaken with industrial participation