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ABETS

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Summary of achievements during the year 2009-10

Gasification

- Biomass to Hydrogen and Liquid Fuel
- Producer Gas Filteration

Field experience

- Operation of the BERI project
- Experience in food industry for replacing oil

Other areas

- Power generation using biogas
- Precipitated Silica for industrial purpose

Further on

- Waste to energy

Details follow.

Research Highlights

There has been expansion in the field implementation of the technologies developed in the laboratory, in (a) Biomass gasification, (b) Producer gas engines, (c) Activated carbon from the gasifier, (d) Precipitated Silica from rice husk ash and (e) biomass stoves for various applications. Some of the important research contributions are highlighted below.

Gasification

It has been challenging to ensure multifuel capability of the gasification system to handle different biomass and this is **probably the only system design in the world** which uses various agro residues for generating producer gas. This has been possible due to the innovative reactor design and the engineering of the components.

Use of wood chips as fuel for gasification

Wood chips in the form of flakes has been an issue for gasification. This is due to the high surface area per unit volume in a reactor.

It has been found in literature that size of the fuel is important to achieve certain conversion rate with acceptable quality of gas in the case of downdraft gasification systems. This fact arises from the requirements of completing sub processes involved in a typical solid fuel conversion. It has been found (Mukunda et al, Dasappa et al) that the pyrolysis and the heterogeneous charcoal conversion processes are diffusion limited. This has an important bearing on the conversion time scale, which depend on the particle size; with time for conversion ~ d_0^2. Some of these features are addressed (Dasappa et al) by tracking the particle temperature along the length of the reactor. This parameter in particular becomes critical while addressing a closed top down draft reactor with a choke plate. In the case of an open top due to the flame propagation front moving towards the reactor top, the combustion zone is extended and hence effectively increasing the residence time for the gas. This has profound influence on the reduction of higher molecular weight compounds.
As particle size reduces, the effective exposed surface area per unit volume of the bed increases and thus influencing the rate processes. Experiments were conducted on wood flakes and coconut shells for obtaining the flaming time; a reflection of pyrolysis process. Tables 1 and 2 apart from providing details on the flake size and flaming time of the particles, has density, equivalent diameter and exposed surface are.

Table 1

L(mm)	W(mm)	D(mm)	Eq.Dia (mm)	Rho (kg/m^3)	Bulk Den (kg/m3)	Flaming Tf(s)	Surface area mm2	R SA/Ed
24	21	4	15.8	358	200	36	1144	0.57
23	22	4	15.5	341	200	33	1120	0.52
27	24	4	17	347	200	40	2310	0.48
24	22	4	16.1	368	200	37	1508	0.52
26	22	4	16.6	372	200	39	1682	0.52
25	20	4	15.7	355	200	35	1144	0.57
26	24	4	16.9	356	200	43	1120	0.52

Table 2

L(mm)	W(mm)	D(mm)	Eq.Dia (mm)	Rho (kg/m^3)	Bulk Den (kg/m3)	Flaming Tf(s)	Surface area mm2	R SA/Ed
24	21	4	15.6	1347	410	158	1392	0.55
23	22	4	15.7	1353	410	160	1380	0.56
27	24	4	17	1346	410	179	1728	0.53
24	22	4	16	1372	410	166	1440	0.56
26	22	4	16.3	1356	410	169	1560	0.54
25	20	4	15.7	1367	410	155	1400	0.55
26	24	4	16.7	1320	410	173	1664	0.53

For an equivalent 15 mm diameter the flaming time for a wood sphere is 120 s whose density is about 600 kg/m^3.

Table 3 : Analysis of different fuel flaming times

Fuel	t/rho s/(kg/m3)	Ratio = Surface area/equi dia
Wood sphere	0.2	1
Wood flakes	0.105	2
Coconut shells	0.121	2.2

From the above data it is clear that the surface area is nearly double in the case of flakes and shell compared with the wood sphere of equivalent diameter. This is reflected in the data on the flaming thus increasing the pyrolysis rate in a given packed bed reaction volume. The normalized flaming time in both cases has reduced by half while the surface area is increased twice compared with wood sphere. Increased rate of pyrolysis enhances the gas volume fraction and reduces the residence time in a given packed bed geometry. Further it is also important to identify that under reactor operation temperature conditions at elevated temperatures fast pryrolysis can also predominate based on the energy flux received on the small size particles resulting higher fractions of long change hydrocarbon in the pyrolysis gases. With the reduction in residence time, cracking of the higher molecular weight compounds is greatly affected. These factors increase the Tar fraction in the producer gas.

Experiments conducted on an open top down draft gasifier using wood chips and flakes provide an insight into the above facts. Hot gas sampling of the gas is presented in table 4 & 5. The tar fraction is higher in the case of flake compared with the wood pieces.

Table 4 : Tar and Particulate tests conducted for hot gas at full load (45kg/hr) for wood flakes

Test No.	Load (kg/hr)	Total flow (m^3)	Total time (hr)	Rate of sampling (m^3/hr)	Total particulates (ppm)	Total tar (ppm)
1	45	0.469	1	0.5	1103	351
2	45	0.417	1	0.5	929	376
3	45	0.41	1	0.5	1054	336
4	45	0.883	2	0.5	1516	416

Table 5 : Tar and Particulate tests conducted for hot gas at full load (45kg/hr) for wood pieces

Test No.	Load (kg/hr)	Total flow (m^3)	Total time (hr)	Rate of sampling (m^3/hr)	Total particulates (ppm)	Total tar (ppm)
1	45	0.965	2	0.5	875	77
2	45	0.904	2	0.5	638	43

A simple analysis based on the air flow rates between the open top and the nozzle and the pressure drop across the bed reveals that the air flow through the nozzle has been high compared with the standard wood configuration. As per the design based on the resistances, about 70 % of the air flow is drawn from the top and about 30 % from the nozzle. In the case of wood flakes, the bed resistance is about 3 times higher than that of wood pieces resulting in an increased air flow from the nozzle in the case of wood flakes compared with the wood pieces. This affects the propagation rate and reduces the effective reactive bed height. This has an influence on the residence time of the gas in the hot bed influence the cracking process.
Field experience with coconut shells gasification in a closed top gasification reactor design has significant amount of tar. Experiments in the lab towards this will be carried along with wood flakes.

Hydrogen from Biomass

The proposed methodology suggests gasification using Oxygen and steam as gasifying agent. Compared to Air Gasification, it enhances the Hydrogen fraction in output gas (Syngas) by removing the Nitrogen from the system and adds extra Hydrogen through inducing steam as gasifying agent in the system.

Research towards Oxygen-Steam gasification for hydrogen generation using different reactor configuration is in progress. Use of a down draft gasifier configuration reduces the complexity in the condensable that are generated during gasification and improves the gas handling. Performance with different Oxygen/Steam ratio and Steam/Biomass ratio has been studied. The effect of temperature and residence time has also been studied. The current research is to use a novel down draft gasification system for generating hydrogen rich gas. The gasification medium is superheated steam and oxygen as oxidizing and gasifying agent. Experimental setup includes scaled down downdraft gasifier in which oxygen is supplied at different position and steam at around 800^0C is injected in the oxidation/combustion/reduction zone.

70 gm of H_2/kg of Biomass has been achieved so far with Steam-to-Biomass ratio (molar basis) of 1.4.

The results from the equilibrium analysis and compared with the experiments. The different process parameters like temperature profile, mass flux rate, oxygen/steam ratio and steam/biomass ratio is being studied.

Process	Steam Methane Reformation	Coal Gasification	Oxy steam gasification	Air gasification
Process parameter (S/B,Pressure,Temp,ER)	T=1050 K P=1atm S/B=4	T=1050 K P=1atm S/B=4	T=1050 K P=1atm ER=0.05 S/B=4	T=1050 K P=1atm ER=0.25
gm of H2/Kg of fuel	430	268	133	49.8
Fuel used(Kg)/Kg of H2 generated	2.3	3.7	7.5	20.1
H2O input(Kg)/Kg of H2 generated	10.5	22.4	22.5	0
Effective H2O used(Kg)/Kg of H2 generated [assuming complete recycling of condensed water in flue gas]	3.8	9.0	5.1	0.0
Volume fraction of H2 in dry flue gas	80 %	60 %	60 %	20 %
Kg of CO2/ Kg of H2 produced	0.8	2.3	0	0
Energy input for steam generation (MJ/kg of H2)	42.4	90.7	91.3	0.0

Steam was generated through an electric boiler and then passed through an electric superheater. Steam was superheated to over 1100 K. Steam was injected at various zones in reactors, i.e. Pyrolysis/Oxidation/Reduction and performance was analysed. Stable operation were achieved when Steam was injected just above the oxidation zone:

- It was arresting the high flame front rate to move in dry biomass.
- High bed temperature was maintained with superheated steam and thus rate of reaction were enhanced in reduction zone.
- It resulted in higher conversion rate with better gas quality and H2 yield.

H_2 yield of 70 g/kg of Biomass with 37% volume fraction has been achieved so far with conversion rate of over 90% at S/B ratio of 1.5.

Liquid fuel from biomass

This research involves conversion of biomass to liquid fuel. Biomass is converted to syngas by gasification process. Syngas (also called as synthetic/producer gas) has its primary composition of hydrogen, carbon-monoxide, carbon-dioxide, and methane. This syngas is converted to liquid fuel, via the Fischer Tropsch (FT) reaction. FT reaction is a catalyzed reaction, and the ratio of hydrogen to carbon-monoxide decides which catalyst needs to be used. Steam gasification of biomass is known to have gas composition with H2 to CO ratio 2:1. Under this condition, Cobalt serves as an ideal catalyst for the FT reaction.

This catalyzed reaction involves the polymerization of CO and H2 reactants. The FT reaction yields predominantly straight chain hydrocarbons (α-olefins and alkanes) and is generally viewed as a methylene (= CH2) polymerization reaction. The products are formed by hydrogenation of CO to generate methylene monomer. Polymerization occurs through initiation of chains, chain propagation, and chain termination steps.

The reactions of the FT synthesis can be simplified as a combination of the FT reaction and the water-gas shift reaction:

$$CO + (1 + m/2n)H_2 \rightarrow (1/n)C_nH_m + H_2O - \Delta H_{FT} = 165 KJ/mol$$

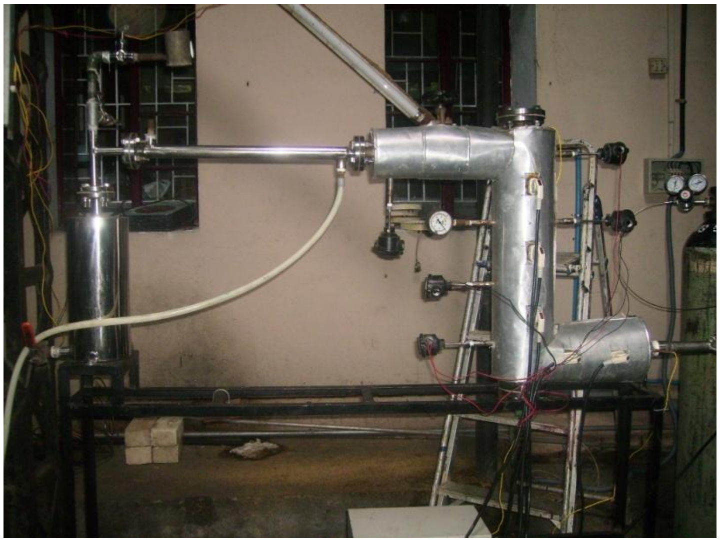
$$CO + H_2O \Leftrightarrow CO_2 + H_2 - \Delta H_{wgs} = 41.3 KJ/mol$$

where, ‘n’ is the average carbon number and ‘m’ is the average number of hydrogen atoms of the hydrocarbon products. Water is the primary product of the FT reaction, and CO2 can be produced by the WGS reaction. The WGS activity can be high over potassium promoted Fe catalysts and is negligible over cobalt or ruthenium catalysts.

The most common FT catalysts are group VIII metals, viz., Co, Ru, and Fe. In our current research, Cobalt is used as a catalyst promoted by potassium on Alumina or Silica support. In obtaining highly selective catalysts for the synthesis of hydrocarbons from CO and H2, an important factor is the selection of the support and the method of catalyst preparation. Impregnation of a support by cobalt nitrate offers a simple method for obtaining strong adhesion intensity of the catalyst on the surface of the support material.

The product distribution in the FT process tends to obey the Anderson-Schulz-Flory (ASF) chain length statistics. This product distribution is affected by the occurrence of secondary reactions - hydrogenation, isomerization, reinsertion and hydrogenolysis. At high CO and H2O pressures the most important secondary reaction is readsorption of olefins resulting in initiation of chain growth process. Secondary hydrogenation of olefins may occur at high hydrogen pressures and on certain catalytic systems, such as Co and Ru based catalysts.

A simple fixed bed reactor, with gas condenser is set up for the FT process. Initial work included, preparation of the catalyst and identifying its physicochemical properties, viz., surface area, composition, pore volume, and studying the changes in these properties by varying the catalyst preparation method. Current catalyst, $Co_{0.19}$-$K_{0.01}$ / Silica, was prepared by impregnation method. The catalyst was reduced in an environment at 400 ^{0}C for 4 hours.



Producer gas filteration

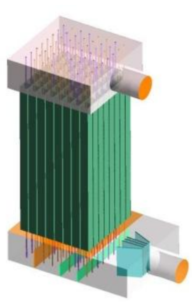
Electro-Static Precipitators (ESPs) are well known particle separation devices used widely in several industries. The gas output from the biomass gasifiers contains particulates, dust and tar (P&T) at a fairly low concentration levels of the order of a few PPM and still can be objectionable to applications and devices where the gas is used over a period of time. The current practice of having finer fabric filters work with a demand for higher O&M operations. In this context it is found essential to bring the P&T to as lower level as possible so that the equipments using this in the downstream do not get affected. Keeping this in background the work on development and testing of an electrostatic precipitator was started with focus for providing additional cleaning that could be cost effective and have better operating characteristics that could lower O&M costs and improve reliability of the plant.

Approach:

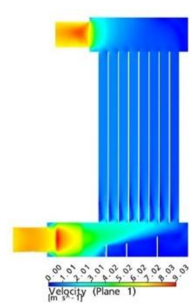
It is found that applications of ESPs for gasification based power plants are not reported and there is no clarity on its performance in this environment. In view of this, preliminary experimental studies were initiated at the lab with simple configurations of ESPs built with the electrodes having geometrical variations that included rectangular plates, rectangular plate & wires, cylindrical conduits & wires, hexagonal conduits & wires and square conduits & wires. The results indicate that electrode combinations made of square conduits and wires show the best performance in terms of the filtering effectiveness. The results have been quite encouraging and a more rigorous study and testing is scheduled before freezing the parameters on the design of ESPs for PG applications. The present studies are conducted on a 75 kg/hr gasification system at the laboratory.

To begin with, a plate to plate system of electrodes was tested. A number of experiments were conducted to study the collection behavior of the ESP. With the functionally acceptable configuration, evaluation of geometrical optimization based on the performance was taken up. A series of tests were conducted with different geometries of the electrodes and associated arrangements, and it was decided to make detailed tests and compare the performances for the geometrical configurations specified earlier. It was observed during these experiments that from gases coming out of gasifier, the P&T carried mostly cat-ions that were getting collected on positive electrodes. A high voltage power source was designed, built and was used during the tests to provide the required electrical potential to the electrodes variable in the range of 1kV to 20kV. Experiments were done with different electro-static potentials to reach the optimum parameters in terms of the effectiveness of collection.

The other important factor of the performance of ESPs was recognized to be having flow uniformity throughout the ESP device to see that the residence time for the gases are at their best. A simpler construction revealed un-uniform performance of the electrodes within the device, indicating the flow distribution playing a significant role. A set of CFD simulations that lets to examine the uniformity of the flow structure and consequent geometrical fine-tuning for the flow paths was made with the required parameters. Sample results of this CFD analysis is shown in the figures below. It was found that the optimal residence time for the gases be maintained while the choice of applied electrical potential gives leverages in controlling the charged particles to get collected on to the electrodes. This study was done with the experiments by connecting the ESP to the gasifier and having test runs conducted with necessary measurements. During all the test runs the data have been collected and effectiveness of collection is established.



Modeled view of the square tube electrode



Velocity plot in one of the simulation results on the cross sectional plane

Dates	Area m^2	Dust inflow (mg/m^3)		Measured T&P Captured %	Duration hr, min	Total Flow m^3	Elc. Pot. (Tube)	Cond-itions
		Before	After					
12.11.09	2.713	169.0	39.0	78.00	4:00	500	13 to 12 kV	3 S+CH, No Fabric Filter
25.11.09	2.713	77.8	9.3	77.00	3:45	470	12.5 to 11 kV	3 S+CH, No Fabric Filter
30.11.09	2.713	65.5	8.3	82.00	3:00	378	12.0 to 11 kV	3 S+CH, No Fabric Filter
04.12.09	2.713	121.0	13.6	73.70	4:00	500	13 to 12 kV	3 S+CH, No Fabric Filter

A Sample set of Experimental Results

The tests have been repeated for different electrode geometries. All the essential factors – effectiveness of collection, ease of fabrication and maintenance and functional consistency have been observed and appropriate modifications brought between the tests. It is found that square conduits used as the electrode for collection appear to fit best among these configurations.

One of the sample test results in this study with the applied electrical potentials (and related discharge currents), gas flow rates, thimble based measurements of the residual P&T and the resulting effectiveness of collection – are shown in the table above. Following are some of the photographs taken during the experiments.

Cleaning of the ESP Electrodes:

With traces of tar vapors carried along with the particulates in the gas, the collected P&T would have a sticky behavior and leads to a need for cleaning of electrodes. This turns out to be an important aspect for the continuity of operation of the ESP to work with consistent effectiveness of collection. During a continuous operation, the thickness of the layer of P&T builds leading to reduction in electrical exposure and consequently loss of effectiveness of collection. These depositions are found to be particulates with micro tubular shape resulting in internal electrical breakdowns. Once these discharges begin, it is necessary that the ESP is cleaned to reset it for operation. The process of cleaning is quite an involved operation during field operations. Alternative approaches are being attempted in order to provide suitable solution for this, few methods of regenerative liquid wash are being tried out. The liquids tried out include methyl alcohol and gasoline petrol. The method appears to have provided the required cleaning of the electrodes but still requires a study on the performance as regards to their repetitive operations and regenerative capability. In the field operations, the cleaning operations need to be provided with required automation allowing for online cleaning of the ESPs enabled in batch mode between two concurrent devices put in tandem. Study of optimizing approaches of these aspects and evolving the design parameters are being taken up subsequently. The activity in the nut-shell for the development of the regenerative cleaning system for the ESPs for PG applications require efforts of another 5-8 months.

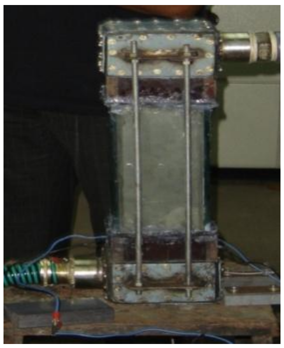
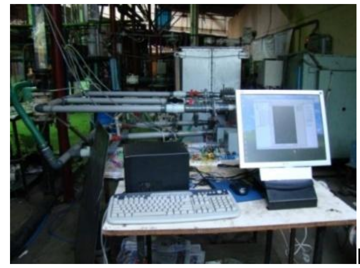


Plate-Plate ESP

Plate-Wire, Plate-Plate and Cylinder-Wire ESPs, in a Parallel Test

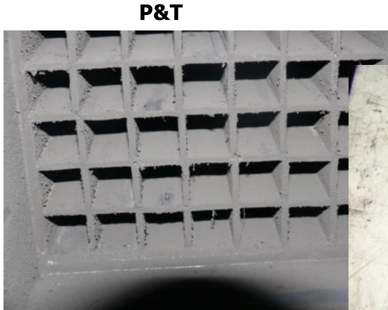


Data Acquisition for the ESPs

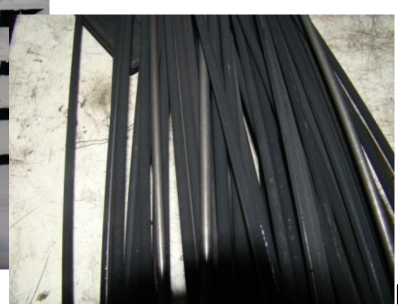
Thimble Based Sampling of P&T

Flame With ESP Inactive

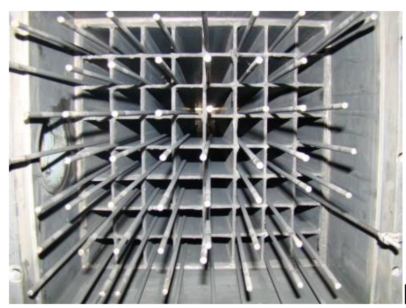
Flame With ESP Active



P&T Collected on Square Conduits of ESP



Depositions on Charging Electrodes



Electrodes After a Wash with Methyl Alcohol

Further Activities:

The square tube ESP is re-configured and fabricated to support online cleaning and to take in the full load of the gasifier in test, for the filtering tests. The basic filter passage was fabricated with specific designs made. Additional fixtures for the testing and measurement accessories are now being put-up in the laboratory. With these additions it would be connected to the gasifier output gas-line and for further test runs. Tests are scheduled to be made with different biomasses and evaluate the performance variations at different operating conditions. The cleaning method would be established and stabilized with evolving of appropriate procedures and practices. Presently these test runs are scheduled that would be completed in the next 4-5 months. Integrated ESP and electrode cleaning systems would be taken up subsequently to arrive at design parameters of a working system in about 10-12 months from now.

Technical Highlights

This year has seen significant research input the technology and consolidating the operations in the plant. Further development in the area of dual fuelling, gas engines, silica product, stoves and combustors. Progress made in these fields is described below.

Hydrogen Sulphide Scrubbing

- Hydrogen sulphide scrubbing system to remove H_2S in the biogas from the distillery effluent treatment plant at Tilaknagar Industries Limited, Srirampur, Ahmednagar District, Maharastra. The plant has been designed for inlet conditions of 380 m^3/hr biogas flow rate and 5 % H_2S and scrub the gas to less than 100 ppm of H_2S in the sweet gas. The gas is being utilized in a lean burn Schmit Engines (2 X 350 kWe) from Germany. The plant has been commissioned and has been running successfully with an average load of about 500 – 550 kWe and generated more than 1.0 million units in the last 3 months which amounts to a Plant Load Factor of about 65 % on the peak load of the engines and the plant availability has been more than 80 %

Following gives the plant configuration data,

- System capacity - 380 m^3/hr bio gas (700 kWe)
- Average inlet H_2S concentration in the gas - 3 % (Designed for 5 %)
- Average CH_4 Concentration in the gas - 55 %
- Engines used - Schmit Enertec - 350 kWe X 2 No's
- Waste heat recovery - Steam generation from the engine flue gas

The sweet biogas is the fuel for two biogas engines of Schmit Enertec make engines of 350 kWe each. The two engines are synchronized and the power generated from them is used for captive application to meet the electricity demand of the factory. The plant has operated about 6,214 hrs, Gas scrubbed 1,259,078 m^3, recovered sulfur of 26,982 kg and generated power of 2,219,462 units.

Typical data from June 2009 to February 2010 is given below.

Month	Hrs of run	Raw Gas consumed m^3	Sulphur recovered kg	Energy generated kWh
June	650.00	N/A	N/A	316,549.00
july 1-19	380.00	N/A	N/A	175,107.00
July 20-31	280.00	27,251.00	363.00	65,746.00
Aug	671.00	90,880.00	2,411.00	202,043.00
Sep	561.00	119,881.00	2,541.70	200,815.00
Oct	690.00	124,663.00	2,585.37	208,815.00
Nov	594.00	158,106.00	3,405.50	264,881.00
Dec	703.00	153,321.00	3,275.00	256,837.00
Jan	723.00	138,053.00	2,918.02	231,432.00
Feb	95.00	15,163.00	323.00	25,402.00
Total	5,347.00	827,318.00	17,822.59	1,947,627.00

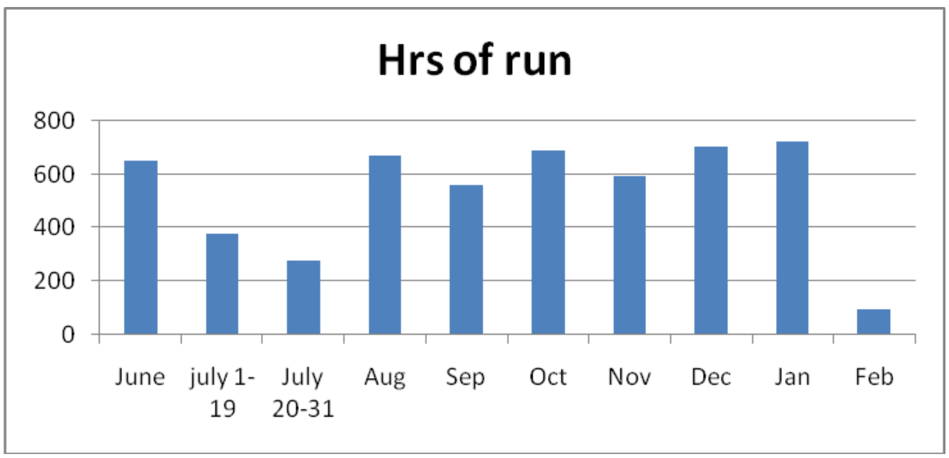


Fig 1: The graph shows the monthly hours of run

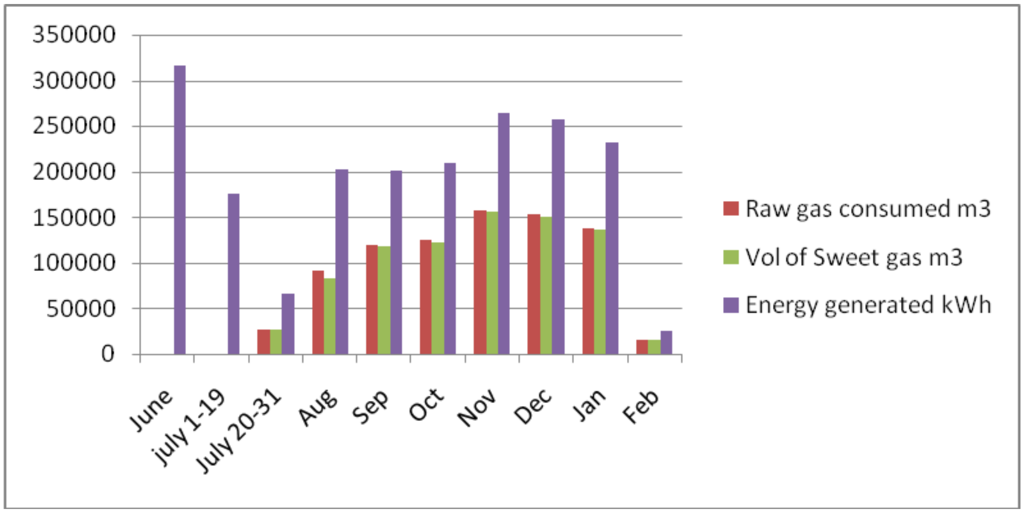


Fig 2: The graph shows the Gas consumed, gas scrubbed & energy generated

Summary of field operation on Rural Grid based electricity

Biomass Energy for Rural India a program under GoK/UNDP/MNRE implemented gasification based power generation with an installed capacity 1 MW distributed over 3 locations to meet the electrical energy needs in the district of Tumkur apart from other energy initiatives. The operations on one of the 100 kWe power plant by the local team was found unsatisfactory and not meeting the designed performance, the technology developer, Indian Institute of Science, Bangalore took the initiative to ensure the system operation and prove the performance.

The power plant connected to the grid consists of a IISc gasification system which includes reactor, cooling and cleaning system to meet the producer gas quality for turbo-charged engine. The producer gas is used as a fuel in Cummins India Limited, GTA 855 G model, turbo charged engine and the power output from the alternator is connected to the grid. The system also consists of a water treatment plant to with closed loop water recirculation to meet the water quality required for the plant operation and also the pollution control norms for discharge. Engine exhaust based fuel drying system is part of the technology package to ensure the required moisture removal from the biomass and ash handling system are the essential auxiliaries in the technology package.

The system has operated for over 1000 continuous hours, with only about 70 hours of grid disturbance. The total biomass consumption for 1035 hours of operation is 111 ton at an average 107 kg/hr. Total energy generated is 80.6 MWh saving over 100 tons of CO_2. The overall specific fuel consumption is about 1.36 kg/kWh, amounting to an overall efficiency from biomass to electricity of about 18 %. The present operations have shown to have a maintenance schedule for the plant can be at the end of 1000 hours.

Figure 4 depicts the electricity generated by the producer gas engine generator set during the 1000 hours operation. From the figure it is clear that the average load on the engine is in the range of 85 ± 6 kWe. The electricity generated was exported to the grid. It is important to recognize that the entire power package has been able to generate nearly constant load. Some of the lower loads recorded are due to the grid failure and reloading the system. During the grid failure the entire system was operated on the internal load without stopping either the engine or the gasification system. There were about 10 grid failures during this operation, amounting to about 70 hours of non-export operation.

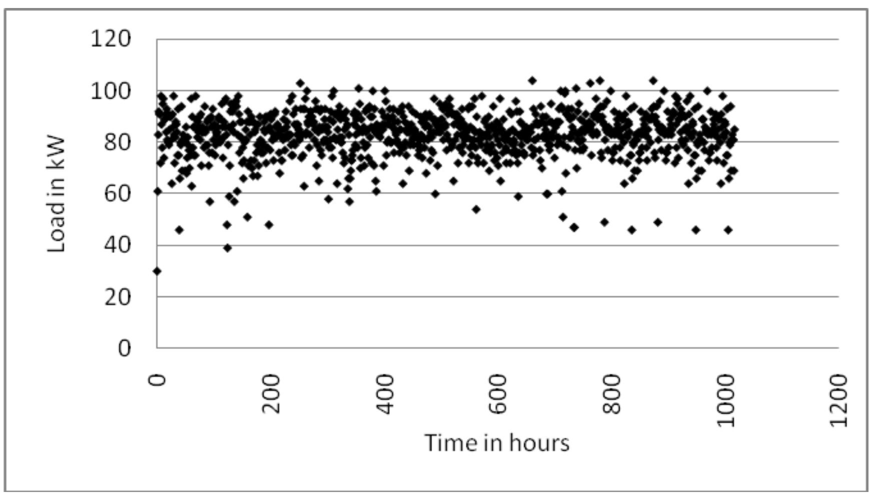


Figure 4 : Electricity generated during the 1000 hour operation

Gas composition

Gas composition was measured using an online gas analyzer. The gas composition measurement was restricted to part of the duration due to the portability of the equipment between the laboratory and the project site. A typical gas composition trace is presented in Figure 5. The gas composition was measured over a period of about 5 hrs during the plant operation.. Measured compositions indicate CO and H_2 in the range of 18±1 %, CH_4 1.8±0.4 %, CO_2 9±1 % and the rest N_2. The composition would result in a gas calorific value of about 4.5±0.3 MJ/kg.

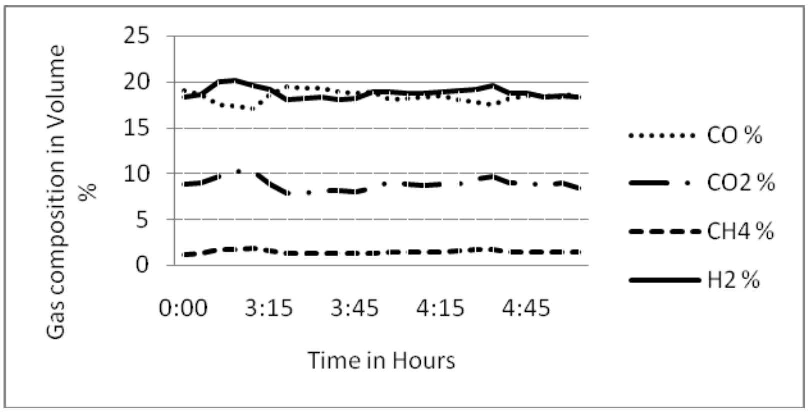


Figure 5 : Producer gas compostion at 90 kWe

Summary of field related application and new adaptions

Food industries like biscuit and confectionary use significant amount of fossil fuel for thermal energy.

ITC 600 Kg/ Hr thermal gasifier for ITC biscuit baking application was installed to replace about 150 lts of furnace oil. Configuration of the plant is Reactor, Multicyclone, Water Scrubber - 2 Nos, Moisture Trap, Main blower and a booster blower is fixed for maintaining the constant pressure in the header. Gas is piped to the oven located about 200 meters away from the gasifier. Fuel used is coconut shells.

User	ITC Ltd
Capacity	600 Kg/ Hr thermal plant
Fuel Replacement	150 liters of Furnace oil/ Hr
Operation Hours	24 Hours
Plant Commissioned by pilot mode	06.06.2010
Hours of Gasifier Operation from 27.07.10 – 05.09.10	783 Hours
Total Gasifier Down time	27.2 Hours
Total Biscuit Production	2056 Tons
Amount of oil saved, lt	~ 100,000
CO_2 saved, tons	~ 300

The ITC group was interested in total automation of the system for safety and operational convenience. This is being currently implemented by the licensee.

Precipitated Silica Technology

Most of the research and development activity was carried out to meet various high end uses for precipitated silica from rice husk; a commercial plant was yet to be in place. Recently, a group in India has approached IISc to use the process for generating silica to be used in various sectors. The group was keen and has made necessary market survey for the product. They have found the process to be cost effective and easy to operate.

Usher Agro Ltd. is the flagship Company of Usher Group, having business interests in various core sectors of the economy including agriculture, alternate energy, logistics and agro food processing. The Company has been successfully operating at present 35 tons/day paddy processing unit at Mathura which is being expanded to 70 tons/day and further is setting up a 15 MWe biomass (rice husk) based power plant at the same location. Presently 1 MWe co-generation bio-mass (rice husk fired) based power plant has been in operation to meet the power and heat requirement for the present plant at the Mathura.

The company generates about 10 to 12 tons of rice husk ash, per day from the Boiler, which has a disposal problem. To convert this waste into a marketable product Usher Agro Limited signed a Technology Transfer Agreement with CGPL, IISc on 25th February 2010 for the production of Precipitated Silica from Rice husk ash.

Usher Agro Limited is setting up the first commercial plant using IISc technology for 5000 kg/day Precipitated silica from rice husk ash near Mathura in UP. The plant is fast coming up and is expected to go into trial production early next year. The detailed engineering of the plant with the following work has been completed:

- Basic design
- Layout plan and layout marking at site
- Generation of equipment data sheet
- Detailed equipment drawing
- PFD for the complete plant
- P & ID for the complete plant
- Process flow details

Status of Projects

Many of the projects in the pipeline did face a significant delay in sanction and receipt of finances during this year. Various developmental activities that were initiated had to be continued along with manpower.

National Focal Point for Biomass Resource Mapping

Biomass Atlas as a part of ABRC activity is to enhance the Atlas developed earlier with inclusion of biomass assessments from forest and waste lands in addition to agro-biomass for entire country apart from other visual and functional enhancements and is envisaged to be useful in preliminary studies of viability of biomass based projects. This activity is an extension of the biomass atlas developed earlier in one of the MNRE projects for selective eight states. The outcome is focused on generating an estimation of biomass accrued from Agricultural Lands, Wastelands and Forest Lands and integrated to a spatially resolved GIS data. The development resources, experience and special tools developed under the work carried out in the earlier projects are made use of during the process. Highlights of the project including other features envisaged for ABRC biomass atlas are provided below.

- Incorporation of RSD (Remote Sensing Data) provided earlier by ISRO for land-use.
- Analysis of the ground agro-data for 3 to 5 years (depending on the availability of data) and establish a complementary database for consistent estimates of biomass and its power potential.
- Inclusion of Biomass Estimates from Forest and Wastelands for all the states.
- Inclusion of information for forest and wasteland from FSI (Forest Survey of India) and NRSA (National Remote Sensing Agency).
- Adaptation of the tools developed to produce digital maps by distributing the statistical & survey information using AI techniques.
- Testing of the integration and implementation of the software developed.
- Inclusion of an additional layer of GIS data that provides graphics for distribution of biomass resource intensity based on a normalized index and that helps locating regions of high and low biomass potentials.
- Provision for generating reports of the biomass availability in any user selected regions to get an outlook of the biomass spread, for use in the preliminary feasibility study of the power projects considered.
- Estimation of Biomass that could potentially replace fossil fuels in existing thermal plants.

Status

Incorporation of forest and wasteland biomass assessment has been completed and developed atlas has been deployed at http://lab.cgpl.iisc.ernet.in. The biomass estimation from wasteland at this point is considered to be a projection assuming that the same species as available in forest area will be grown in waste lands and may need a few sample surveys to complement the projected data for the consistency. The existing agro-data generated under NBRAP program earlier has been retained and continued in these maps. Based on the availability of data the agro-data were added during the process and additional data validations made to reduce inconsistencies.

Interactive graphic outputs for visualizing distribution of intensity of biomass potential that could help locating regions of high and low biomass potential resources are deployed for all the states.

The existing and reported biomass power installations are mapped and displayed where the information is available. Such additions would be made on a continued basis as and when the data flows in.

The assessment of possible replacement of biomass for fossil fuels in the existing thermal plants needs some more information and is attempted to be obtained along with studies on the type of fuels currently used, any biomass used in such plants, their consumption factor for thermal power and economic factors.
Following enhancement specified above, the estimated biomass and power projection at the national level from the biomass atlas is as follows.

State	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)	Power Potential (MWe)	Biomass Class
Total	262363.8	495845.6	666515.0	249074.0	33295.4	All
Agro-Total	143540.9	495845.6	511041.0	145026.6	18728.7	Agro
F & W-	118822.9	NA	155474.0	104047.4	14566.6	Forest &

Gasifiers for urban solid waste

The proposal to MNRE to set up a demonstration plant at 200 kW capacity, after carrying out necessary R and D was sanctioned. The proposal was to install power generation package at a site in Bangalore where the municipal wastes is segregated and processed.

The design has been completed and the project is under implementation. Intitial evaluation of the residue is being carried out for ash, moisture content and calorific value.

Interaction with International agencies

Cuba

UNIDO has sponsored a project for demonstration of biomass gasifier at Cocodrilo in Isle da Juventad of Cuba. The package consists of 70 kg/hr open top down draft (IBG - 70) gasifier and 68 kWe diesel engine. The system was packaged and tested at Combustion, Gasification and Propulsion laboratory of Indian Institute of Science, Bangalore. As a part of the project, a technical team of two specialists, Mr. Alfredo Curbelo and Mrs. Carmen Lopez from Cuba were trained in the operations at the laboratory during 2nd July to 6th July, 2007. The system was later dismantled, packed and shipped to Cuba in July 2007. The installation and commissioning of the gasifier system at Cocodrilo was delayed because of some large scale devastation in the Island due to Cyclonic Storm.

In continuation of this project related activity, a technical team of two senior technicians from Combustion Gasification Propulsion Laboratory, IISc were sent to Cuba in March 2010 and were stationed in Cuba from 15th March 2010 to 1st May 2010. The main task of these two technicians were to reassemble the gasifier system, test run the system to the required power level, train the designated local staff in operation and maintenance of the plant and hand over the system to the local authorities to continue thereafter.

The gasifier assembly work at the project site was started on 17th March involving the local staff in all the assembly related activity. The civil construction activity of water sump, water treatment plant area etc got completed only by 6th April. The first test run of the gasifier system was taken up on 16th April. The gasifier was operated on flare mode for about 2 hours and the engine was test run without any loading. The system was again put into operation with the engine load of about 40 kW on duel fuel mode with a diesel replacement of about 75%. Training on all aspect of gasifier operation was imparted to the local staff during these test run period. The system was not put into continuous operation mode as the local evacuation setup was not ready to receive power on continuous mode. The practical training session for about 13 local staff continued till 23rd April and the system was handed over to the local authorities in good working condition to continue forward.

Thailand

The power plant at A+ Power, Thailand is based on IISc gasification system coupled to gas engines for power generation. It is envisaged as an IPP (Independent Power Producer) which is grid linked. The system design consists of

- Two Gasification system based on woody biomass of 1100 kg/hr capacity each.
- Two Gas gensets of Waukesha make, of 900 kWe capacity each (on Natural gas) to deliver about 1.5 MWe power with producer gas.
- Waste heat recovery from the engine exhaust
  - Through Vapor Absorption machine (VAM) for generating the chilled water to meet the cooling demands of the producer gas.
  - For biomass drying after appropriate dilution with air for biomass drying


The engine is designed for natural gas as the fuel. For the first time a single large capacity engine in the range of 600 kW is be connected to producer gas. The gas carburetion system, a critical component in maintaining the air-to-fuel ratio for producer gas has been designed and implemented.
Test runs are being planned in about 2 months. Detailed measurements are being planned at the site during commissioning.

Dr. Dasappa visited Europe to present a paper at the 4th International Conference on Application of Biomass Gasification, in Stuttgart, Germany in March 2010.
During this visit the first meeting on the project " Gasification for power generation using residue" with Univerty of Florence, Italy,. Jointly funded by the MNRE and the Italian government took place in Florence and action plan was discussed. The project envisages setting up a 70 kW gasification in a farm sector which has to meet European emissions standards using spent meal from biofuel plantation.
He also visited the Wila plant which has been operation well in Switzerland and had technical discussion towards establishing many more plants in Switzerland.

Dr. Dasappa visited Nigeria and Benin on behalf of UNIDO to address power requirements for communities. This has resulted in 2 projects of 25 kW capacity to be set up in the respective countries.

Dr. Dasappa visited Cambodia and Thailand to advice on the gasification programs being carried in these countries. Also visited the project site in Thailand being implemented by Satake, to review the progress.

Research Activities Planned for the near Future

The following proposals are cleared and are in advance stage of releases.

- MSW based power project 250 kWe
- Biomass Atlas
- Combined proposal for Hydrogen Generation and liquid fuel Biomass gasification
- Support with Cummins India Ltd for 500 kWe engine
- Producer Gas Engine Performance Evaluation