Advanced Bioresidue Energy Technologies Society [ABETS]
Indian Institute of Science, Bangalore 560 012

ANNUAL REPORT 2008-09

ABETS

Combustion Gasification & Propulsion Lab.
Indian Institute of Science
Bangalore 560012
abets@cgpl.iisc.ernet.in
http://cgpl.iisc.ernet.in

Summary of achievements during the year 2008-09

During the period 2008 – 09, apart from the technological development, the R and D focus was on new areas. This has resulted in proposing to the MNRE projects in the area of Hydrogen generation and Biomass to liquid – frontier areas of research in biomass sector.

Gasification

- Use of digester waste for gasification
- Biomass to Hydrogen
- Producer gas filteration
- High rate char extraction
- MW level projects operational
- New producer gas filtering process

Field experience

- Over 80 % availability of systems for industrial operation
- Over 30 Tons of oil saved daily - 100 tons of CO_2 daily

Other areas

- Power generation using biogas
- Precipitate Silica for industrial purpose
- Stoves – an overview

New Areas

- Biomass to hydrogen
- Biomass to liquid
- 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 digestor waste as fuel for gasification

Further continuing the use of other raw materials, Envitec Biogas from Germany approached IISc to check if the digested waste from biogas plant can be used as a fuel for gasification. They have the problem of disposal and incineration does not provide any benefits towards energy. Some of the trails in Germany had indicated that it is a difficult fuel to gasify.

Focussed research was carried out to ensure the use of the digester waste as fuel. Basic studies revealed that the ash content is about 10 % and volatiles in the range of 70 %. Preliminary gasification studies were carried out to establish the operating flux for the system without ash fusion, etc.

Physical properties of pellets

Bio digested waste briquettes	
Dimension	Diameter = 65 mm, Height= 55 mm
Density	960 ±20 kg/m^3
Bulk density	480±20 kg/m^3
Moisture content	10 %
Ash Content	9 - 12 %
Volatilce content	70 %

Table: Ash melting behavior

Softening	T_E	1040	°C
Hemisphere temperature	T_H	1102	°C
Flowing temperature	T_F	1111	°C

The experimental setup consists of the stove along with other elements to blow controlled amount of air and instrumented with thermocouples as shown in figure. The system is run for a specified duration consuming most of the fuel. At the end of the experiment, air is turned off and top covered with ceramic wool insulation and the stove allowed to cool down. At this stage, the residue is examined to determine if there is fused ash. The experiment is repeated at various flow velocities and the maximum velocity at which the ash fused is determined. The results of the experiments are shown in Table.

After ignition at the top, a reaction front is created which propagates from the surface of the bed to the grate against the direction of flow of air. The heat generated in the reaction front is partly transported against the flow of air, due to radiation and conduction, resulting in devolatilisation of the raw fuel. This allows the reaction front to propagate. The heat generated in the reaction front originates from the oxidation of the fuel and, if not all oxygen is consumed in the narrow reaction front; a glowing char layer will be formed above the reaction front (Thunman et al). The experiment is repeated at different flow rates and the propagation rate is measured. Propagation rate is the rate at which the reaction front moves into the fuel bed. Thermocouples positioned along the length of the reactor as shown in the figure, provide the temperature – time data acquired on-line, by a computer. The temperature profile is further used to obtain the propagation rate.

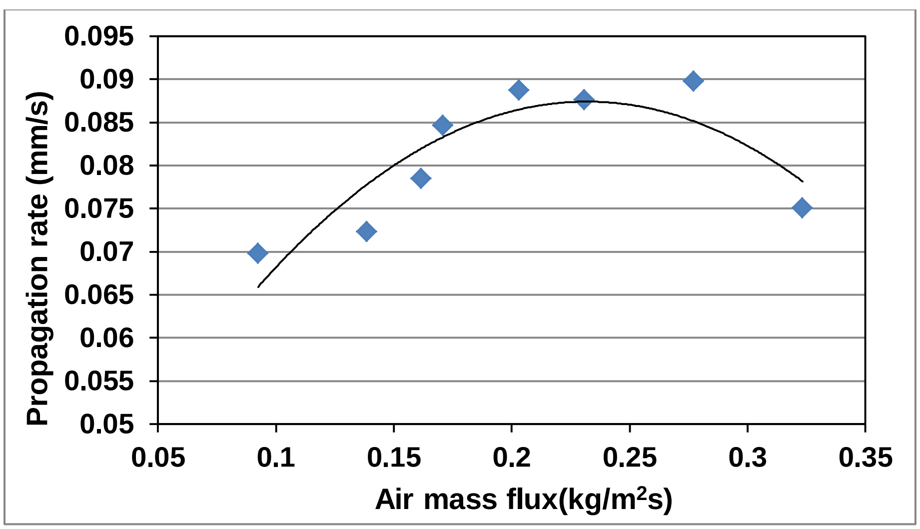


Figure : Propagation rate with respect to Air mass flux

Table : summary of various experiments on Propagation rate at different mass flux and the ash quality

Air flow rate (lpm)	Air mass flux rate (kg/m2s)	Propagation rate (mm/s)	Superficial air velocity (m/s)	Observation
40	0.09	0.06977	0.077	Soft ash
60	0.14	0.0723	0.115	Soft ash
70	0.162	0.0784	0.134	Soft ash
74	0.17	0.0846	0.143	Soft ash
88	0.20	0.0887	0.169	Fused ash
100	0.23	0.0876	0.194	Fused ash
120	0.28	0.08972	0.23	Highly fused ash
140	0.32	0.07655	0.26	Highly fused ash

Based on the investigations, it is clear that the clinker formation can be prevented or reduced significantly by maintaining a superficial velocity of about 0.14 m/s. These operating conditions will be used for further evaluating the briquettes in a open top dual air entry gasifier system.

The briquettes used were of 30-35 mm long and 65 mm diameter. The bulk density was found to be 455 kg/m^3 as against 480 kg/m^3 in the previous runs. The major emphasis was on the conversion efficiency and stable operating conditions. The gasifier was operated for 7.5 hours at 40 kg/hr after the initial warm up period. The gas quality was consistent with CO ~ 14 ±2%, H_2 ~ 15 ± 2 %, CH_4 ~ 0.6 ± .2, CO_2 ~ 17 ± 2 %. The plot of gas composition for the test duration is as shown in figure. The gas quality was found to have improved compared with the previous test runs. The gas flow rate was around 50 g/s. The ash extraction was set at 13 % of the input feed rate. The calorific value of the producer gas after the system is stabilized is as shown in figure.

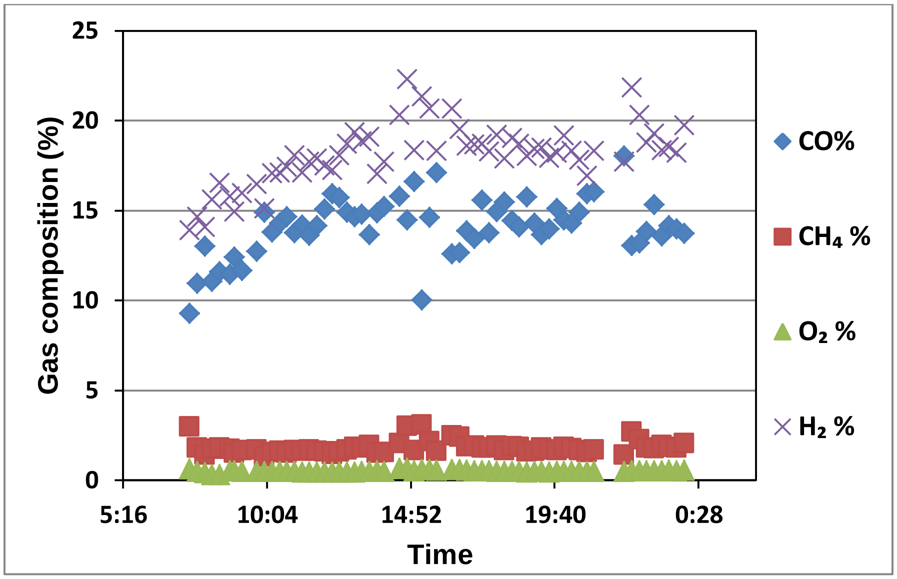


Figure : Gas composition using digester waste

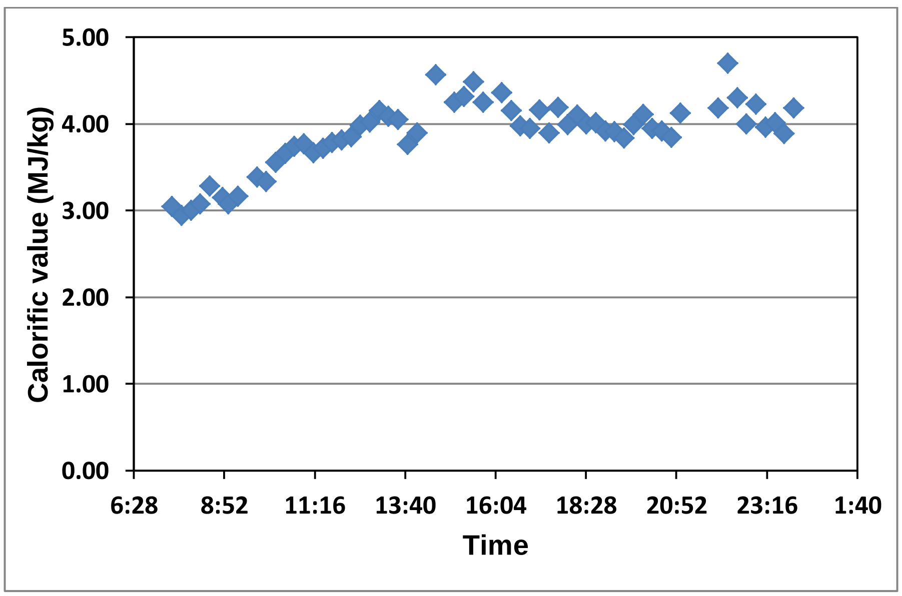
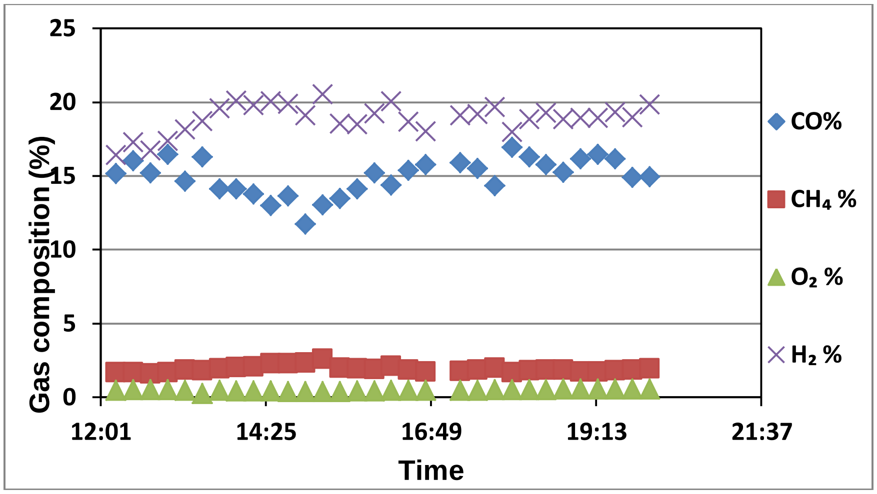
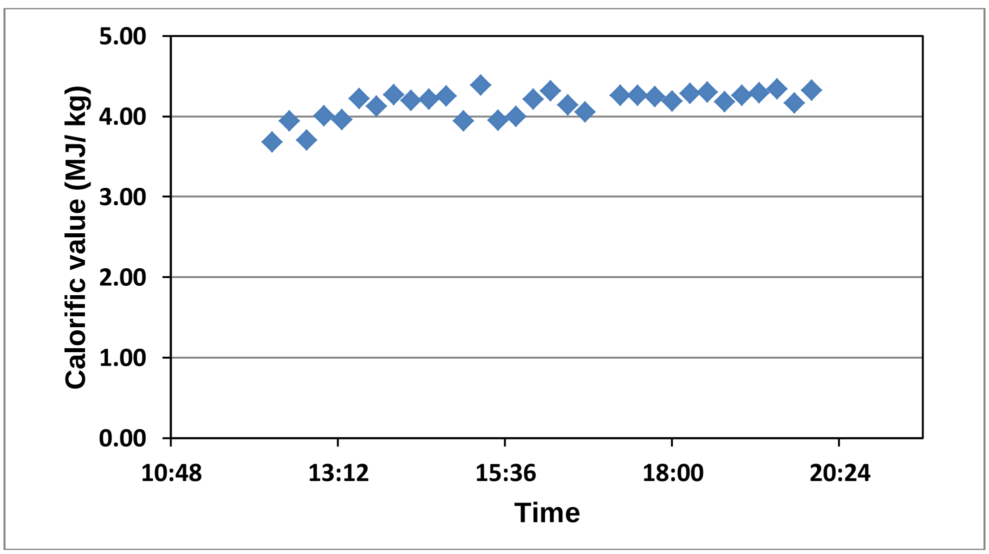


Figure : Calorific gas using digester waste

EXPERIMENTS WITH ENGINE

The 6B series Cummins gas engine is a six cylinder, naturally aspirated, water cooled engine coupled to a 35 kVA alternator. The gas engine designed for natural gas has been tested for a maximum output of about 40 kWe by Cummins. The gas engine was installed on the test bench with producer gas supply from the 80 kg/hr gasifier.





Figures provide the performance details of the gasificaiton system. The gas composition has been found to be good and the calorific value is in the range of 4.2

MJ/kg. Several test runs were carried out on the using the gas with the engine. One typical test is is presented in figure which represents load vs time. The engine has been loaded in the range of 22 – 24 kW, with the engine maximum load capabiliyt with producer gas has been 27 kW using wood as the fuel. Figure 8 shows the variation of voltage and frequency with time. It has been found the the engine has responsed satisfactorily. Except at the time of ash extraction some variation in the frequency, the engine has been stable.

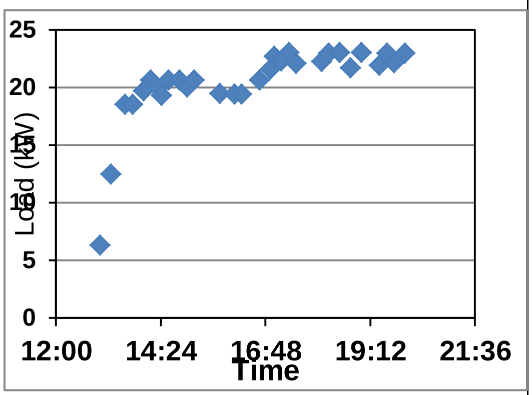


Figure 7: Load with Time

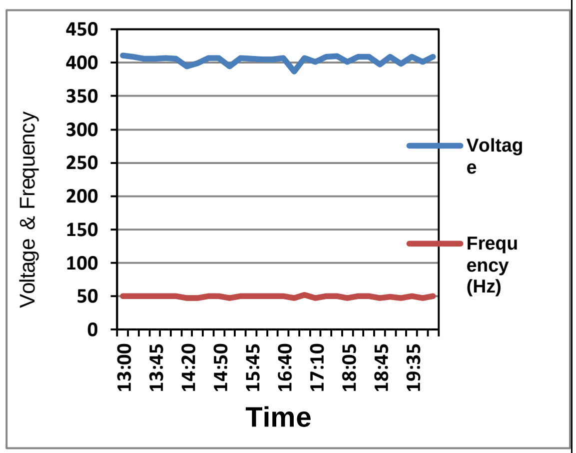


Figure 8: Voltage and frequency with time

Tests results on engine mode

Table contains the operational summary of the test with engine. The total duration of the test with this briquette was 7 hours with engine.

Table: Summary of Producer gas engine operation using briquettes

Load (kWe)	Duration of operation in min	Units generated kWh	Biomass consumed in kg	Specific biomass consumption per kg/kWh	Frequency (Hz)
22	180	70	121	1.7	50

Hydrogen from Biomass

Hydrogen is a clean and green energy source which has the potential for fulfilling energy need in every sense seeing to the vast resource of hydrogen. But generation of hydrogen is the key issue. There are numerous methods of hydrogen generation from renewable and non-renewable resources including Steam methane reformation, Partial Oxidation/Autothermal reforming, Electrolysis, Coal Gasification, Biomass Pyrolysis/Gasification, Thermochemical Process, Photosynthesis/Biological process and Photocatalytic Water Splitting (Miller and Penner). The hydrogen generated through the above process (except electrolysis) is contaminated with other gases and needs purification and separation of hydrogen to different level of purity depending on the requirement.

Fossil fuel based technological options have reached near commercial operations, especially methane reforming. Other processes either are at laboratory scale or at proving for commercial exploitation. Biomass as a process for hydrogen generation has never been a prime area of research across various group due to the current status of establishing gasification research for power generation. Thermo-chemical conversion of biomass has been identified as a possible process for producing renewable hydrogen. Most of the research spurred by this interest has been techno-economic in nature, based on gasifier performance data acquired during system proof of concept testing.

Present experiments

Set of experiments were conducted in a modified and scaled down version of open-top downdraft gasifier developed in IISc).The dual entry – from top and the nozzles at the bottom. The supply of air/oxygen through the nozzle partially burns the char in the char bed providing high bed temperature. This helps in high residence time at elevated temperature and reduces tar level. Provision for leak proofing at the top and ash extraction was provided. Same design was used with modification required for oxygen-steam gasification. Dual lock hopper was used to ensure air sealing throughout the operation with provision for biomass feeding at regular interval. Oxygen was supplied from the top of the reactor from oxygen cylinder (95% pure). Water scrubber was used for cleaning and cooling of syngas. Electric boiler was installed for steam generation at saturation temperature at pressure upto 4×10^5 Pa. Steam subsequently passes through electric super-heater which elevates the steam upto 1100 K. Steam and oxygen flow rates were controlled in desired quantity for different SBR and ER. Online Gas analyzer was used for analysis of syngas composition on dry basis. Eight K-type thermocouples were inserted in the reactor at a distance of 100 mm to record the bed temperature in different zones.

Results and discussions

In order to establish stable operating conditions several sets of experiments were carried out. During this period, parametric variations on flow rates and the oxidant were carried out to ensure right operating conditions for anchoring the flame front at a particular location as in the case of air gasification. The oxidant was injected from the top. Initially oxygen was used as the gasifying medium, high flame propagation rate resulted in incomplete pyrolysis in the bed, an undesirable condition resulting in lower bed temperatures. Flame propagation of over 100 times was noticed compared to air mode (over 10 mm/s against in pure oxygen against 0.1 mm/s in air mode). These are related to high reaction rate between biomass and oxygen. Several controlled experiments were carried out understand these using diluted oxygen with nitrogen. Measured propagation rate was 1 mm/s at 50 % oxygen, around 10 times higher than air gasification. High adiabatic flame temperature was found to be responsible for high propagation rates. Adiabatic flame temperature was very high compared to gasification with air. The exothermicity of the overall reaction resulted in higher temperature and higher reaction rate.

A simple approach towards ensuring steam as a reactant was planned, arresting the flame propagation rate. Experiments were conducted with wet biomass and oxygen amounting to an ER of 0.3. Extra moisture was injected in biomass under controlled condition. Moisture content was varied, moisture to biomass ratio as 0.5, 0.6 and 0.75 on molar basis. Decline in flame propagation front was observed which comes to around 0.1 mm/sec at moisture to biomass ratio of 0.75, typical rate in air gasification system.

With moisture to biomass ratio of 0.75, peak bed temperature of over 1200 K were achieved with volume fraction of hydrogen as 32% against equilibrium composition of 47 % amounting to hydrogen yield at this junction was 47 g/kg of biomass against equilibrium yield of 63 g/kg of biomass. As the moisture content was increased, the average bed temperature reduced resulting in high methane and tar content. Small fraction (10-15% of total oxygen supply) of oxygen was passed from the bottom nozzle that lead to partial combustion of char providing higher bed temperature. It helped in reducing the methane and tar level and subsequent increase in hydrogen content. Hydrogen yield of 70 g/kg of biomass was achieved with moisture to biomass ratio of 1.4 and ER value of 0.37 with average bed temperature of 875 K. Efficiency of 47% was achieved with moisture to biomass ratio of 1 and ER value of 0.34 with yield of 52 g of hydrogen/kg of biomass and average bed temperature of 975 K. Figure shows the results with details at various moisture to biomass ratios.

These results were better than obtained from work by Pengmei *et al.* even when water is used at ambient conditions.

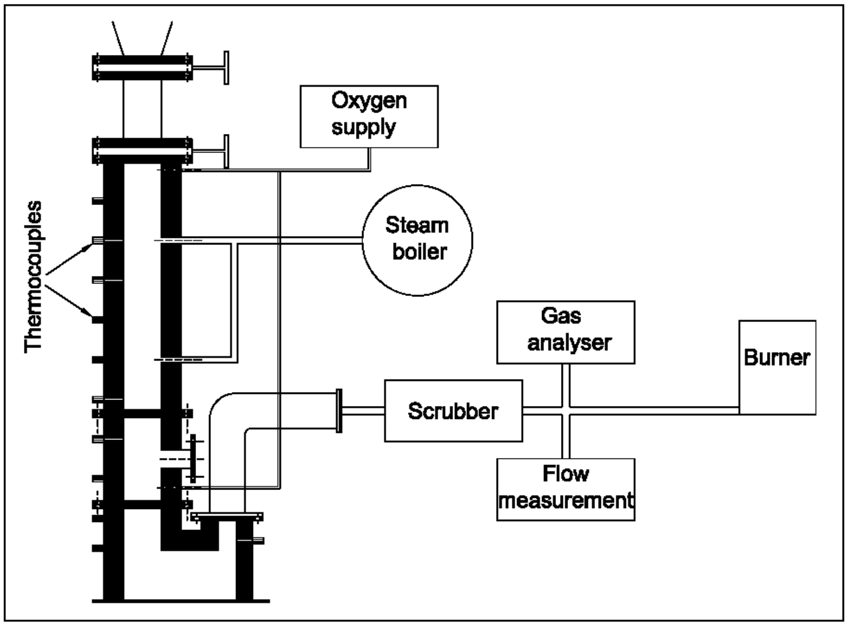


Figure 3 Experimental setup for oxygen-steam gasification

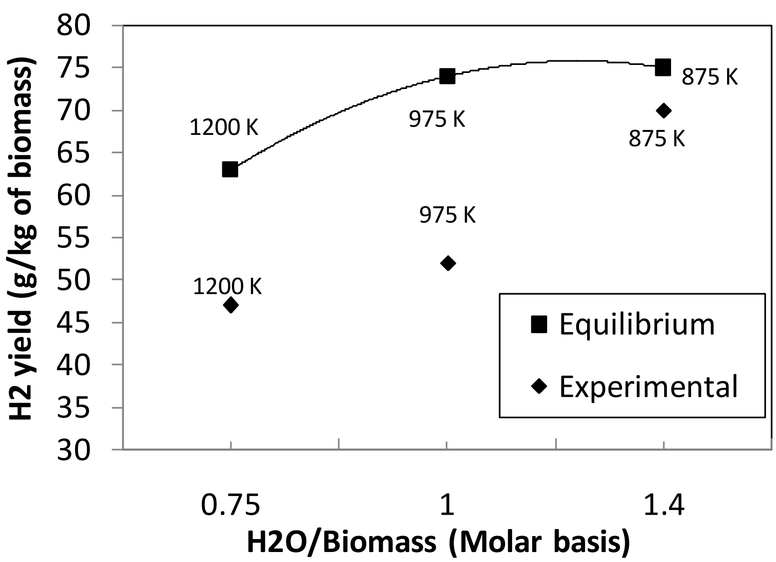


Figure Comparison of experimental and equilibrium hydrogen yield at different moisture to biomass ratio (molar basis)

Hydrogen sulphide scrubbing

The technology package developed earlier is being practiced by the licensees in setting up power plants to sweeten the sour gas. Further research in this sector has resulted in a cost effective technology package now being patented. In the new technology package, ejector based scrubbers are used to effectively establish contact between gas and liquid. This has helped in reducing the size of the scrubber and improve the effectiviness. Further, the maintenance of packed reactor is eliminated. On similar grounds, regeneration has also been researched and an effective concept to establish gas liquid contact through bubbling using controlled pore size has been established. Lab scale experiments have yielded excellent results.

The Scrubbed outlet solution's Fe^{2+}conc and H_2S outlet ppm was recorded for varying H_2S flow and column height . The results were compiled and plotted as seen in figure. The requirement of 4-5% H_2S gas in the gas mixture with the outlet ppm less than 100 ppm was reached in 3.25 m column.

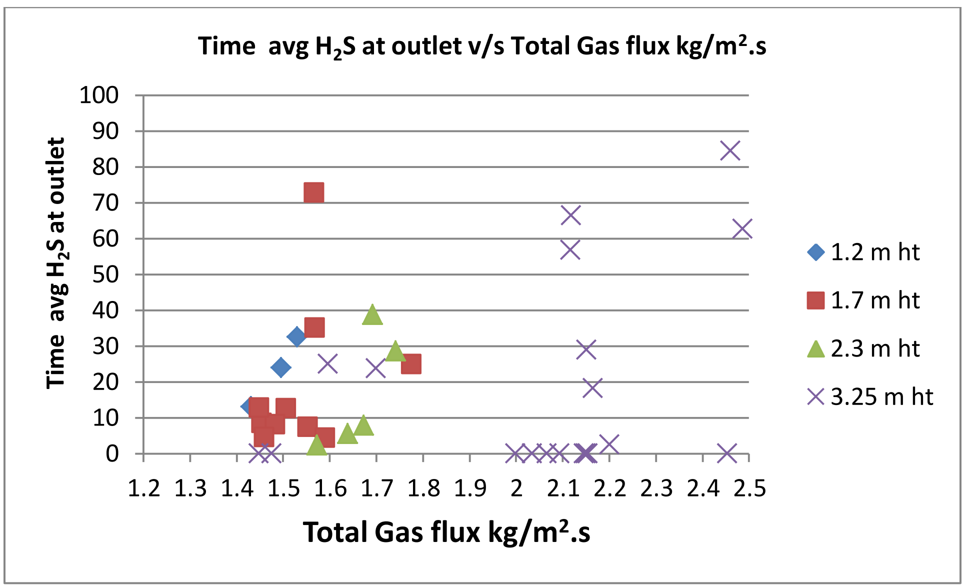


Figure : Time avg H_2S at outlet,ppm with Total Gas flux kg/m^2s

When total gas flux and H_2S outlet was plotted it showed that 3.25 m column could handle more H_2S gas and sweeten it with an outlet ppm of less than 100 ppm.

The set of experiments done for regeneration has shown that a 50 % lesser power consumption can be achieved if we use the latest setup using industrial spargers and lower air flow and pressure.

Producer gas filteration

The producer gas generated and filtered through fabric filter is being used in all the power station. In some of the projects where, long duration operation, in excess of 7000 hours annually, maintenance of various components would be critical. In view of this, pre coated filters were tried and found that they can be adapted easily for producer gas application. The final configuration for filteration is being established for full scale testing.

Water treatment for producer gas power plant

Producer gas is cooled to nearly ambient temperature using direct contact water scrubbers. The water is contaminated with dust and condensates. There are two operations in the water treatment. One is the removal of the suspended particulate matter from the water and the other removal of the dissolved organics from the water. Removal of the suspended particulate matter is done using flocculants and the dissolved organics like phenols etc are removed using activated carbon. These stages have been studied with two different set of process as discussed below.

Process using Activated carbon bed.

This is one of the established methods of treatment that is being followed currently in all the IISc gasification installations. The schematic of the same is given in Figure.

The dirty water is pumped from the sump tank to the flocculation tank. Flocculants in the form of alum and polyelectrolyte is added to flocculate the suspended particulate matter in the water. The flocculated suspended particulate matter after settling at the bottom is removed as sludge and the supernatant water is pumped through Pressurized sand bed filter to remove any small amount of unsettled matter. The clear filtrate is passed through the activated carbon bed filter. The activated carbon bed filter consists of activated carbon granules with a surface area of about 500 – 600 m^2/gram. It has been found experimentally that it requires about 30 minutes of residence time inside the activated carbon bed filter for removal of the color and the odor.

Process using activated carbon powder

A new method of using fine activated carbon powder which is a byproduct of activated carbon industry is being studied. The fine activated carbon powder is a byproduct from the activated carbon industry. The powder has a surface area of about 1000 m^2/g and is not useful in the industry as the particle sizes are less than 325 mesh. This powder was used at different concentrations or ratios for treating the water.

The dirty water from the sump is pumped into a settling tank with stirrer. Activated carbon powder is added to the tank at different activated carbon to water ratios varying from 1:500 to 1:2000. The mixture is stirred for about an hour and flocculants are added to flocculate the activated carbon powder as well as the suspended particulate matter carried by water during the cleaning of producer gas. The settled sludge is removed from the bottom and the supernatant water is pumped through the pressurized sand bed filter to remove any unsettled matter. The water is from that is taken to the fresh water side part of the sump tank from which it is pumped for the producer gas cooling and cleaning.

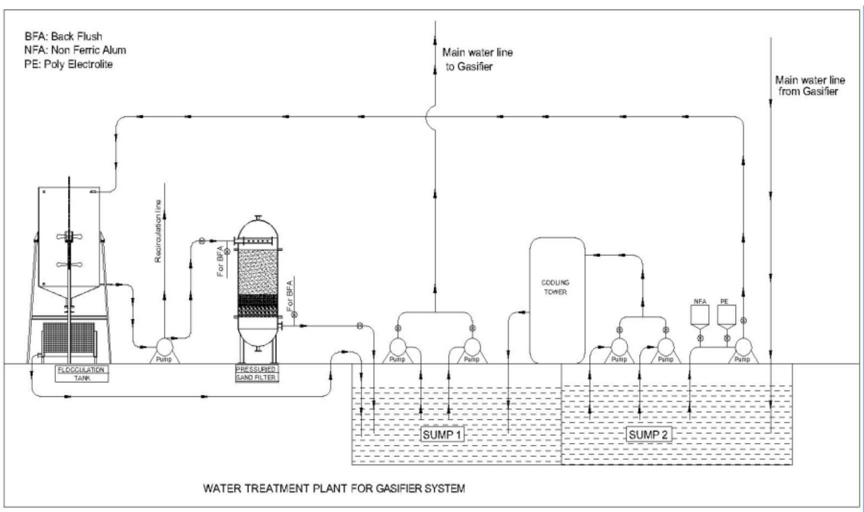


Figure . Treatment of water using powdered activated carbon.

Based on the results, the gasification water can be treated effectively to remove the suspended particulate matter as well as the dissolved organics from the water to meet the Pollution control norms with either of the treatment procedure followed. The water treated had no odor or color after treating with activated carbon. Further the longevity of the activated carbon bed filter in treatment Method 1 was studied in terms of amount of water that can be treated with the same output quality per 100 grams of the activated carbon used and this was compared with the ratios of activated carbon powder to water used in the treatment Method 2. It can be observed from Table 3 and Table 2 that the activated carbon power per unit weight is able to handle about 10 times more than the active carbon granules bed. This may be due to the fine particle size of the carbon powder increasing the surface area for contact, uniform dispersion of the carbon powder in water due to agitation which helps in increasing the contact between the contaminants and the carbon powder.

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.

Gasification Technology

On the gasification technology various developments have taken place towards enhancing the contribution of gasification systems in the energy mix. Institutions GE – Jenbacher, Waukesha, Shell, are interested in using IISc design gasification system in several projects.

- Allgreeen an power producing company registered in Singapore and operations in India has proposed a 65 MW program using biomass gasification and gas engines in the combined cycle mode at capacity ranges of 6.5 MW. The first project has got the clearances of State Bank of India. ABETS had to provide significant inputs on the technology related aspects of the projects.
- An industrial outfit manufacturing stationery items basically for export has finalized and taking for a 3 MW power station to be linked to the grid in Gadag. As a first phase of this activity, 1.5 MW is being taken up and is being tendered from IISc licensees.
- The charcoal generation has attracted additional investment from several groups and 1 ton per hour plant is being built.

Hydrogen Sulphide Scrubbing

- Hydrogen sulphide scrubbing system to remove H2S 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 m3/hr biogas flow rate and 5 % H2S and scrub the gas to less than 100 ppm of H2S 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 %

Summary of field related application and new adaptions

Low temperature application

Crumb rubber as a product is being used rubber industry. Large number of rubber industries accepts the dried granules of 3 – 8 mm material for further processing. Hot air is generally generated using fossil fuel, both diesel or kerosene burners and diluting the flue gas to 120 C.

The twin air entry, re-burn biomass gasification system of IISc has resulted in developing package for low temperature drier application. The technology package involves generating clean producer gas to be burnt in producer gas burners with right dilution to ensure a flue gas at 120 C or in a thermic fluid heater to replace oil. The technological challenge has been to provide a cost effective solution for safe and efficient operation of the drier to replace oil. Typical fuel consumption depending upon the capacity of the plant is about 20 – 50 lts per hour, being replaced by a gasification system of about 80 to 200 kg/hr of biomass.

The continuous tray driers are in the capacity output of 500 to 1000 kg/hr with a residence time of 2 hours. Over 50,000 hours of operation at one location has indicated that a fuel replacement of 3.25 kg of biomass per kg of fossil fuel. These systems are operated on 24 hours basis and operate for about 6000 – 7000 annually. A total of 12 systems in different industries totalling to a drier capacity of about 12 tons per hour of dried rubber has been in operation. This amounts to annual capacity of 72,000 tons of rubber coupled to gasification systems of about 2 ton per hour capacity distributed over 12 industries.

Gasification system for a 1.25 MkW th indirect drier

Use of gasification system to replace oil in a thermic fluid heater in the indirect drier, where heat exchange with the fluid and air is carried out. This application provides the client to have better quality rubber, sans contact with the flue gases.

The process requires, a high and low (Continuous modulation of) gas flow rate into the combustion chamber of the thermic fluid heater in order to maintain the temperature of the fluid medium. This has been achieved using gas regulation as soon as the fluid temperature is attained.

The schematic diagram provided in Figure details the process.

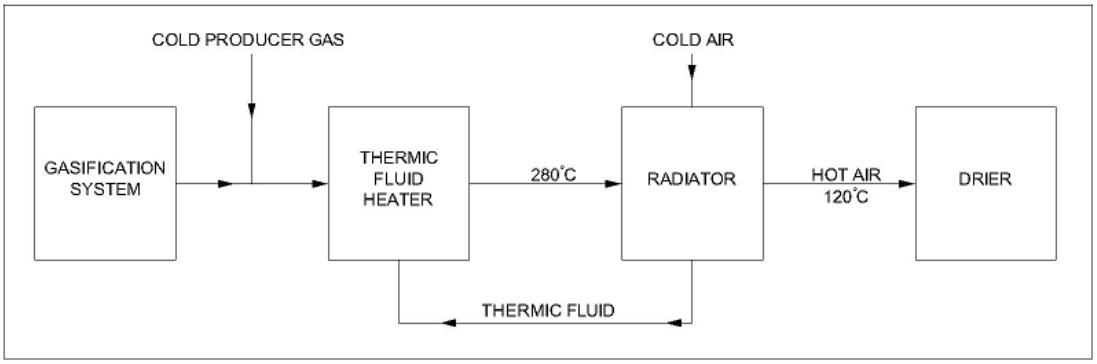


Figure: Schematic of the indirect drier

The gasification system

About 160 kg/hr gasification system has been installed in an industrial outfit of Rubber board to replace the about 40 lts of oil in the thermic fluid heating system. This system was slightly over designed for some inefficiency in the indirect process.

The system was installed during 2007 and has operated for over 10,000 hours. An average fuel consumption of about 130 kg for a drier output of about 1 ton per hour. Average daily consumption of biomass was in the range of 2.9 tons, with an average 600 hours monthly.

The gasification system is similar to the earlier system, except that the gas burner was to accommodated on the existing thermopac retaining the oil burner.

The operations were designed to incorporate PID controller to maintain the gas flow rate as per the requirement of the thermopac. a motorised valve along with a PID controller with the feedback from the thermocouple on the thermic fluid line acts to regulate the gas flow.

Thermocouples have been used to detect flame failure and divert the gas towards flare to ensure safety. Manually controlled valves are provided to override the control loop in case of an emergency. While maintaining the thermic fluid tempeature at 280 C, depending upon the load, the biomass consumption varies from 90 kg/hr to about 140 kg/hr.

As a part of safe operation, oxygen level in the gas is monitored continuously to ensure no premixed gas is in the line. The thermocouples in the flame zone performn the function of flame detection.

The total operation of the plant is in excess of 10,000. Operational data for the year 2008 is presented in Figure. On an average , the plant has operated for over 300 hours in a month, typical 12 – 15 hours a day and the plant has operated for over 4700 hours replacing about 100,000 kg of oil.

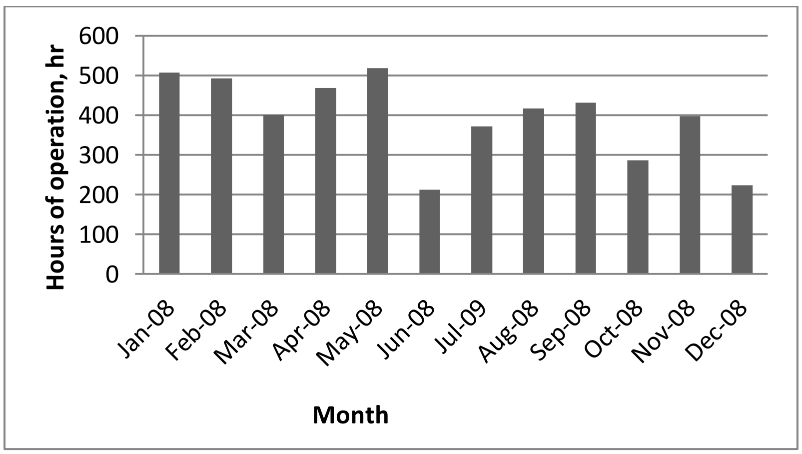
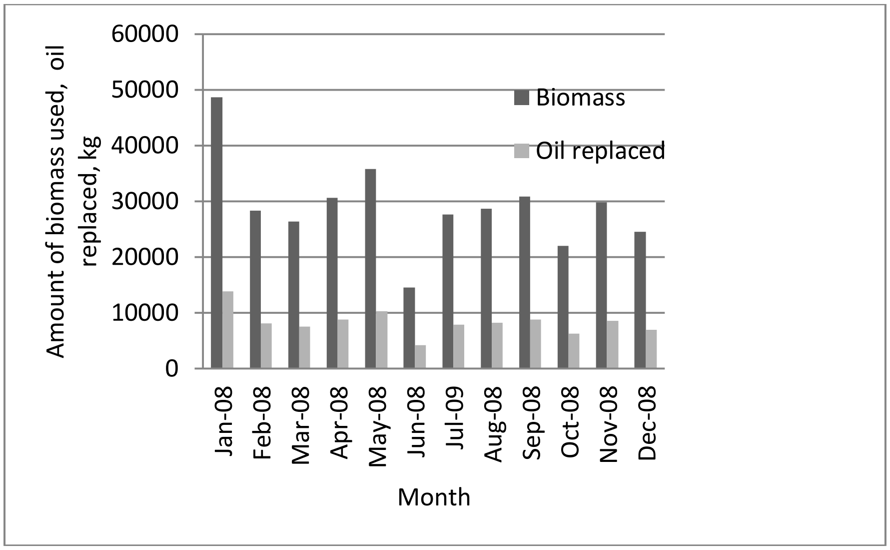


Figure: Operational details performance of the 1.25 MW plant for 2008

Figure details the biomass consumption and oil replaced during the 12 month period. About 350 tons of biomass has been consumed to replace about 100 tons of oil, amounting to about 3.5 kg of biomass to replace 1 kg of oil. During this period the biomass consumption has been in the range of 60 to 140 kg/hr depending upon the load.



A simple energy balance indicates that overall efficiency of biomass to drier product is about 40 %. This includes the efficiencies at device level like, gasification, thermic fluid heater and the drier.

The major outcome of this technology package has been;

- A green energy technology to replace fossil fuel for low temperature application
- Replacement of oil thermic fluid heater
- Specific biomass consumption has been about 8.8 kg dried output / kg of biomass
- A total savings of 2.5 million litre of fossil fuel annually
- Overall economics of operation are the motivating factor for this adaptation

Performance of the charcoal generation system

The field scale system has been commissioned and has been run for more than 500 hrs. During this period about 180 tons of biomass has been used and about 60 tons of charcoal has been generated with a yield of about 30 – 33 %. One important result has been reproducibility of the performance of the system at larger throughput levels. The gas composition data for a period of 10 hrs is given in Figure below.

On an average the Carbon monoxide and hydrogen were about 14 % each and about 6 % methane which indicates a lower energy content in the gas compared to normal gasification mode where gas is the product and where the carbon monoxide and hydrogen are about 20 % each and methane about 2 %. The presence of higher quantity of methane also shows the existence of larger higher hydrocarbons in the gas stream compared to the normal producer gas which in-turn results in a larger load on the cooling and cleaning system.

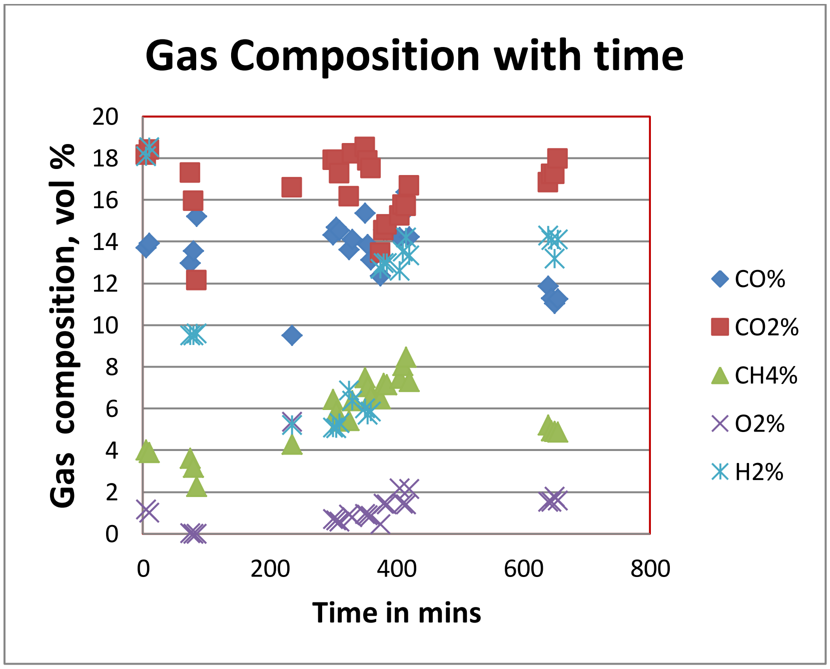


Figure : Gas composition at the field system

The char extraction was about 30 % during the test run period of about 110 hrs with total biomass feed rate of about 86 tons and 26 tons of char extracted during this period. Figure gives the details of biomass feeding and char extracted over this period.

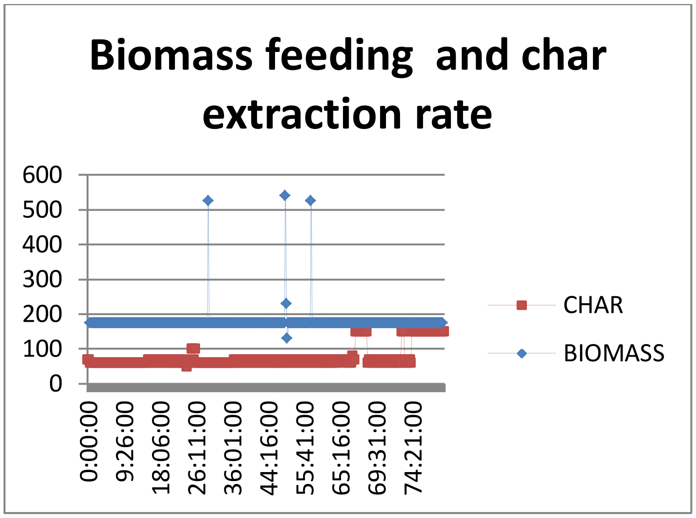


Figure : The biomass feeding and char extraction rate as a function of time.

The gas from the system is being planned to be used with steam boiler coupled to condensing type turbine for power generation required for the industry.

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 is keen and has made necessary market survey for the product. They have found the process to be cost effective and easy to operate. At the end of this year, one ton per day plant will be operational.

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

Comprehensive spatial estimation of biomass from all the resources including Agricultural lands, Waste lands and Forests for locating suitably the special projects of MNRE was proposed as an extension to NBRAP (National Biomass Resource Assessment Program). Initially the atlas containing spatial data has been developed for the selected 8 states- Maharashtra, Haryana, Punjab, Tamil Nadu, Madhya Pradesh, Gujarat, Rajasthan and Uttar Pradesh for the MNRE's program. The required Digital atlas has already been completed and deployed on IISc, CGPL website and that of MNRE. The revised and improved estimation will be done for all the states once the suitable data and maps are received from NRSA (National Remote Sensing Agency) sponsored by MNRE.

Gasifiers for urban solid waste

Last year it was proposed to MNRE to set up a demonstration plant at 200 kW capacity, after carrying out necessary R and D. The proposal is to install this package at a site in Bangalore where the municipal wastes is segregated and processed. The proposal has been approved by the R and D committee. Due to reduction in the sanction budget, ABETS brought it to the attention of MNRE and a meeting was sought with the Secretary MNRE. After discussion, the project requirements have been provided to MNRE and are awaiting formal clearances from MNRE to proceed in the project. In the meantime discussions have taken place with local agency which is providing the waste fuel for the gasifier and will the the user. Revised proposal aggreable to MNRE and workable to us has been made and is in the final stage of clearance at MNRE.

Biomass combustion devices

- BP due to its top management decision to withdraw from customer based programs has handed over the entire operation to First Energy Pvt Ltd. The major critical team which was addressing this in BP have continued with the First Energy and have planned the activitiy for the near future.
    - Around 400,000 stoves have been sold as of now.

- An adaptation of one of the devices to meet the cooking energy needs of Anganavadi schools for the mid day meal program is in progress through KSCST.

Interaction with International agencies

As a part of an advisory role being by ABETS to the project in Zambia, a 25 kW system to demonstrate the technology package and provide electricity to the ZESCO training centre. The training centre has courses at various levels from 2 weeks to about 1 year in the area of power generation. It had been decided in the National Steering Committee that this would help in ensuring capacity building activity as a part of the national program.

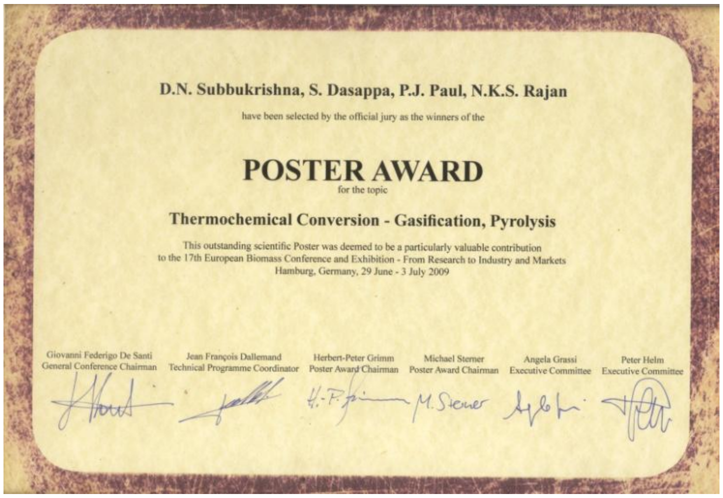
Two of the technicians from ABETS commissioned the plant in Dec 2008 and imparted on the job training for the people. Two photographs of installation are shown below.

Dr. Dasappa visited Zambia to participate in the Steering Committee Meeting in April 2009 and also formally handing over the plant to the project. The principal secretary power visited the plant and was impressed on the technology package and suggested it would be ideal for countries in Africa.

- Dr. Dasappa also visited Swaziland to advise the local government on the use of biomass for meeting the energy needs of rural community.

Dr. Dasappa visited Malaysia as an expert for the ICSU ROAP Science Planning Group on Sustainable Energy in Asia-Pacific region. He has authored the chapter on biomass energy as a Science plan on Sustainable energy.

Dr. Paul, Dr. Dasappa and Mr. Subbukrishna attended the 17th European Biomass Conference and Exhibition, 29thJune to 3 July 2009 at Hamburg, Germany. A total of 7 paper were presented and 2 of the posters were shortlisted for best poster award and one poster entitled "CHARCOAL AND POWER GENERATION USING BIOMASS GASIFICATION", was awarded.



D.N. Subbukrishna, S. Dasappa, P.J. Paul, N.K.S. Rajan

have been selected by the official jury as the winners of the

POSTER AWARD

for the topic

Thermochemical Conversion - Gasification, Pyrolysis

This outstanding scientific Poster was deemed to be a particularly valuable contribution to the 17th European Biomass Conference and Exhibition - From Research to Industry and Markets Hamburg, Germany, 29 June - 3 July 2009

Giovanni Federigo De Santi, General Conference Chairman
Jean François Dallemand, Technical Programme Coordinator
Herbert-Peter Grimm, Poster Award Chairman
Michael Sterner, Poster Award Chairman
Angela Grassi, Executive Committee
Peter Helm, Executive Committee

During this visit Dr. Dasappa and Mr. Subbukrishna visited the plant in Wila and provided necessary advice for plant. The performance of the system of 350 kW capacity in Swizerland was found good. It is become one of the reference plants in Europe.

Dr. Dasappa made a presentation on "Science and technology of gasification at IISc" in a seminar at Paul Scherer Insitute, Zurich, Switzerland.

Prof. PJ Paul represented IISc in an exchange program with Low Carbon Research Institute which is a collaborative effort among different universities in Wales, UK. The visit was organized by the British Council India and he visited several universities in Wales, UK conducting research on renewable energy technologies. The common areas of interest identified include biomass gasification and hydrogen from biomass.

Mr. Subbukrishna visited Nepal to evaluate a site for a possible 600 kW of power generation using Biomass gasification. The technical specifications for the power station is being worked out to be executed using tendering process within IISc licensees.

A project with University of Florence, Italy with support from MNRE, Italian Embassy and the local governing body is sanctioned. MNRE has released the first installment and the Italian partner is processing for necessary clearances from Italy. 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.

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