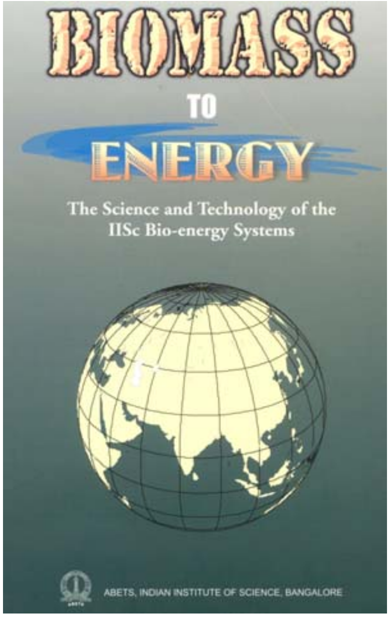
NEW BOOK PUBLISHED ON BIOMASS TO ENERGY



The Science and Technology of the IISc Bio-energy systems

A 154 page book that provides insight into the foundations of the development of a new technology at the Indian Institute of Science and provides a comparative account of the distinctive features of this technology in relation to the existing technology for less-than-a-few MWe class gasification systems for biomass including urban solid waste.

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Preface

*The **C**ombustion, **G**asification and **P**ropulsion **L**aboratory (CGPL), of the Department of Aerospace Engineering, Indian Institute of Science (IISc) has conducted work on bio-residue-based gasification for: (a) understanding the processes involved in the conversion of biomass to a combustible gas; (b) understanding the processes involved in the combustion of the gas with air inside the cylinder of reciprocating engines; (c) applying this knowledge to the development of the technology for power generation; (d) conducting field trials to appreciate field-related problems and improve the technology; (e) examining this renewable source of energy against centralized sources of energy and other renewables from the techno-economic viewpoint; and (f) creating a bio residue resource map of the country's bio-residues for power generation to provide for entrepreneurial initiatives in power generation. The laboratory has also developed technology to sweeten biogas generated using anaerobic digestion route. The sweet gas is used in gas engines to generate electricity.*

The current status of gasification has been achieved after about 300 man-years of effort with about 60,000 operating hours on 12 systems of power level from 3.7 kWe to 1000 kWe. The gasification systems range from 1 kg/hr to 850 kg/hr with operational duration on single gasification system exceeding 6000 hours in a year on an industrial system and 20,000 hours on a village electrification system.

Contents

Executive Summary

This document describes the science and technology of modern gasification systems that can generate *ultra-clean gas* with high gasification efficiency for nearly any given biomass or non-biodegradable organic dry material. This enables the use of the gas for high-grade heat or electricity generation via reciprocating engines or gas turbines in dual-fuel mode or gas–alone mode. Details include the experience derived from field studies on industrial installations as well as those for village electrification. The use in various sectors helps in appreciating the robustness of the technology that has remained maligned from the mid forties due to bitter experiences of "tar" in the gas stream. The robustness has largely been due to the reactor configuration central to cracking tar and a special cleaning system that invokes a physical process to drop the last of all fine particulate matter back in the gasification island. It is the expression of the feeling of "having arrived" in the intrinsic gasification methodology that has resulted in the design of reliable plants – thermal or electric – that benefit in addition, from modern automation and control technologies to ensure performance *comparable to centralized power generation plants.*

The design of the reactor allows the use of fuels with high alkaline content that are prone to ash fusion due to the lowering of the ash fusion point. Fuels like sugarcane tops and leaves, coconut coir pith containing copious amounts of potassium are handled through reducing the superficial velocity in the packed fuel bed to a level that maintains the integrity of the ash in the pulverized form enabling a 'smooth' screw extraction process. Fuels containing organic non-biodegradable material like plastics have been tested at less than 30% content and the ability to restrict undesirable component like dioxins from chlorine-based plastics (like PVC, Poly Vinyl Chloride) within the gasifier island without emission into gas has been established. It is important to understand that classical closed top throat based design does not permit the above choice, nor does the idea of a simple open top reactor used by the Chinese for rice husk meet the requirement of minimizing the tar content.

The final configuration for the reactor resembles very little of its parent of the mid-forties. It separates storage of biomass as a part of the reactor, as in classical design of the mid-forties and devotes it only to the conversion process. It draws air from the top and from the sides permitting re-burn of the gases, hence creating a second high temperature zone where tar cracking can occur due to the simultaneous action of heat and catalytic action of hot char. The bottom section has a vertical grate and screw extractor for the ash and perhaps some char. The choice of the screw system instead of grate arises from the need to extract much larger amounts of ash compared to what would happen with woody fuels with low ash. The first extraction of dust in the gas occurs in a cyclone. The gas may then have an indirect cooling system to extract clean heat. Subsequently, it passes through an ambient temperature ejector cooler-scrubber using water and chilled liquid ejector-scrubber before going through a very fine fabric filter. The gas qualifies for being ultra clean. The gas that goes into a furnace or an engine is sampled by bubbling it through a transparent clean solvent to enable the gasifier operator to be sure of the quality of the gas in terms of presence of tar or particulates. That the solvent remains clean and transparent hour after hour, day after day, gives innate confidence to the power plant operator that the engine or critical components of the control system in a thermal application will operate in a manner that he is accustomed to when using fossil fuels.

It is possible to operate the gasification plant running on coconut shells or wood chips with low ash content such that one can extract char about 5% of the throughput. This char has properties of activation directly or with thermal treatment. This product has a sale value that can pay or more than pay for the cost of the raw material.

In power plants – gasification or direct-combustion using rice husk, the residue after combustion has considerable carbon – typically, 10 % and amorphous silica, if the combustion process is handled with limited residence time at high temperatures. This residue is a waste and current uses are in brick making and cement industries; even so, the waste generation far exceeds current utilisation. Amorphous Silica is a valued industrial product that can be extracted from the rice husk char/ash at production costs lower than the current prices at which Silica from sand produced in large amounts is sold. This can be used in conjunction with the power generation plants using rice husk.

The state-of-the-art IISc open top reburn downdraft gasification is, thus, a new contribution to modern technology in the field of renewable energy.

Biogas from anaerobic digestion of (a) distillery effluents, (b) urban solid waste processing plants, and wastes from (c) dairies, (d) abattoirs and other industrial waste treatment plants contains largely Methane (55 to 65 %), and Carbon dioxide (30 to 35 %) along with 0.5 to 5 % of Hydrogen sulphide. The gas is usually used for steam raising with the emission of Sulphur dioxide. It cannot be used for power generation via reciprocating engines or gas turbines unless the Hydrogen sulphide is brought to negligible values, certainly not more than 0.15 % in the worst case. A chemical based treatment process has been developed towards "sweetening" the "sour" gas. This has been applied for throughputs of 600 m^3/hr to generate up to 1 MWe. System modifications to deal with much larger contents of Hydrogen Sulfide in industrial plants have also been understood.

Authorship is credited to "The Team"

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