*Low Cost Gasifier Engine System*

**RURAL ENERGY & INFRASTRUCTURE SECTION**

**Mahatma Gandhi Institute of Rural Industrialization**

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# Gasifier-Engine System

## Introduction

In the past few decades, biomass gasification has emerged as a promising route to efficient utilization of biomass, a renewable energy source which is widely available in tropical countries like India. This involves conversion of the biomass, a solid fuel, into a gaseous fuel called the producer gas. The producer gas can either be burnt in a burner for thermal applications such as furnaces or can be used in an internal-combustion (I.C.) engine as a substitute for petroleum based fuels, to get motive power or electricity. Since I.C. engines are particularly suited for small scale applications, the gasification technology enables the use of biomass for decentralized power generation, which is being increasingly looked upon as viable alternative to provide electricity and motive power to the remote rural areas of our country. Availability of electricity can, in turn, act as a catalyst for promoting rural industrialization and development.

While commercial systems of this kind are already available, many organizations have put in efforts to make simple low cost gasifiers, fabricated locally. In the same spirit Navreet Energy Research and Information (NERI), an NGO, developed a gasifier-engine system and tested it in the field for running a flour mill and an irrigation pump, for more than a year. However, for disseminating the technology even locally, the system needed better engineering. IIT Delhi gave the required inputs for improvement in the system and a prototype has been made and tested in IIT Delhi. The present booklet gives information about this system.

## Biomass Gasifiers

Complete combustion of any biomass should result in formation of carbon-dioxide and water vapour, with ash as a residue. On the other hand, in a biomass gasifier, the biomass is burnt in limited supply of oxygen, not sufficient for complete combustion. This results in the formation of a combustible mixture containing carbon-monoxide, hydrogen and methane, besides the non-combustible components of carbon-dioxide and water vapour. Typical composition of producer gas is: CO 15-30%, $H_2$ : 10-20%, $CH_4$ : 2-4%, $CO_2$ : 5-15%, water vapour 6-8% and the rest $N_2$. The process involves drying of biomass followed by pyrolysis, i.e., breaking up of biomass into char and volatile matter. The reactions between the combustion products and the char at high temperature lead to the final gaseous mixture called producer gas. The final products also include some unburned volatile matter in vapour form, which can condense when the gas cools to form a sticky substance called tar.

When gas is burnt in a burner for thermal application, tar does not pose much problem. However, for use in an IC engine, the gas needs to be cleaned of tar more thoroughly. The tar content must be less than 50 mg/m$^3$, which needs an elaborate cooling and cleaning system. The tar content in the producer gas depends strongly on the design of the gasifier. Low tar content requires high temperatures, around 1200$^o$C in the combustion zone of the gasifier. It also needs high residence time of the gas in the high temperature region.

Most of the gasifiers in the field are of two types: (i) updraught type where the gas flow is upwards through the biomass and char bed, while the biomass moves down. (ii) downdraught type where the gas also flows downwards, in co-current with biomass. The downdraught type of design gives much less tar in the final gas as compared to the updraught design. However, an updraught gasifier is much simpler to build and operate but produces more tar. Hence, updraught gasifiers are more commonly used for thermal applications.

The problem of tar can be overcome through another route. If charcoal is used as feedstock in the gasifier, the tar produced is much less since most of the volatile components of biomass causing tar formation have already been removed at the time of charcoal formation. Consequently a simple updraught gasifier of charcoal can be used with a simple cleaning arrangement for gas to get producer gas quality suitable for use in an IC engine. This is the strategy adopted by NERI in developing their simple system for power generation.

**Use of Producer Gas in Engine**

Producer gas can be used in I.C. engines in two ways : (i) in dual-fuel mode along with diesel in a compression-ignition (CI) engine and (ii) in single fuel mode in a spark-ignition (SI) engine. Till recently, most systems used dual-fuel mode of operation. In this mode, a diesel engine is run on the combination of producer gas and diesel. With the use of producer gas, the diesel requirement can be reduced to about 20% of the normal requirement in the pure diesel mode. The diesel requirement is higher when the engine is run in part load. Dependence on diesel for this mode of operation can pose a problem in regions where diesel is not easily available. More importantly, with the rising cost of diesel, the economics of this mode of operation may not be very favorable.

On the other hand, operation of an engine only on producer gas requires spark-ignition. While a petrol engine can be directly used for the purpose, it has the disadvantage of a low compression ratio of 9:1 or lower. Producer gas can be used successfully on engines with a much higher compression ratio of about 17:1. Since efficiency of operation of an engine improves with increase in compression ratio, it is more advantageous to convert a diesel engine to run on spark-ignition mode. This involves replacing the injection system of a diesel engine by a spark plug and ignition system. The engine used in the present system is a spark-ignited engine that runs on producer gas alone, which has been converted from a commercial diesel engine.

**Charcoal Gasifier-Engine System**

Figure 1 gives a photograph of the charcoal gasifier-engine system developed jointly by NERI and IIT Delhi. The system consists of a batch-fed updraught charcoal gasifier, where charcoal is fed from the top. The air supply for the process is from the bottom of the gasifier. The gas outlet is connected to a sand filter for removal of tar and particulate matter from the gas. The gas pipe then branches into two. One of them goes to a flare or a burner through a water bubbler, a flame safety device. The other one is connected through a mixing chamber to the intake manifold of the engine so that a mixture of air and the gas are sucked in together by the engine. Ball valves are provided on each line for regulating flow rates of air, gas and the mixture. The engine is connected to an alternator for electricity generation. The flare is meant to check the quality of the gas before it is directed to the engine. If the gas is found to burn with an invisible, colorless flame, it indicates high percentage of the combustible gases, CO and H2 and hence good quality gas. The gas is, then, directed to the engine and the burner is put off manually by operating the appropriate ball valves provided for the purpose.

Figure 1: Gasifier engine system

For initial start up, the gasifier is filled with charcoal and closed from top. A small hand-held electric blower or a simple hand blower is used at the gas outlet end of the gasifier so as to create suction inside the gasifier. From the air inlet end, a torch with a flame is used to ignite the lower part of the charcoal. Once the charcoal gets ignited, as indicated by a red zone visible from the air-inlet end and smoke exiting the blower, the blower can be used at the air-inlet end, and the gas can be diverted to the flare. After a few minutes, the gas would be ready for flame testing for the quality of the gas. After a few minutes of flaring, the flame becomes transparent and the gas is now engine-worthy. Once the gas has been directed to the engine, the blower can be removed from the air inlet, and the suction of the engine is sufficient to extract gas from the gasifier.

During a normal operation, the gas flow rate must be adjusted for a given load for smooth operation of the engine. If the gas flow rate is very small or large, or the gas quality is not good, and the engine would stop.

**Design of Charcoal Gasifier**

The gasifier developed by NERI is essentially a metallic cylinder in two parts as seen in the photograph shown in figure 2. The lower part has a ceramic lining in the interior so as to withstand high temperatures due to the combustion zone. This lining has to be cast along with the outer mild steel sheet. The upper part is made of only mild steel. The lower part has two openings at the bottom: one for the air inlet and the other for ash removal. The outlet for producer gas is from the top of the lower half as shown in the figure.

Figure 2. Gasifier and sand filter

**Conversion of Engine**

The engine used is originally a diesel engine of ALAMGIR make of rated capacity 9 hp at an rpm of 1500. This is coupled with an alternator of 6 kW rating. For converting this engine to

SI mode, the injector and the fuel pump were removed. A spark plug was fitted in the position of the injector. For ignition, a commercially available contact-breaker type magneto-ignition system of a two-stroke scooter engine was used.

The shaft of the ignition unit was fitted on to the crank shaft with the help of threads as well as tack welding. Due to placement of a two-stroke ignition system on the crank-shaft of a four-stroke engine, this system gives a spark once in every rotation, i.e., twice in a cycle. This could be avoided if the unit could be connected to the cam shaft. However, this could not be done since the speed of the cam shaft is not sufficient to energies the primary coil of the magneto-ignition system. Alternatively, a battery ignition system could be mounted on the cam shaft. Since battery has the disadvantage of additional capital cost as well as need for charging, the magneto type of system was preferred.

The spark timing of the engine has been set to about 30 deg before TDC (Top Dead Centre). For initial setting, provision has been made for running the engine on gasoline. A carburetor has been provided for the purpose with a small tank for gasoline. The converted engine can give an output of about 4.5 kW with producer gas. Figure 3 shows a photograph of the engine.

Figure 3. Producer Gas Engine

**Applications**

This system can be used for various applications requiring electric or motive power up to 4.5 kW, for example, a flour mill, an irrigation pump, and lighting purposes. Use can be made of the electric power output or directly the shaft power output of the engine.

**Production of Charcoal**

Since traditional charcoal making involves controlled pyrolysis of biomass, and the emanating volatiles are allowed to escape, a large fraction of the heating value of the biomass is lost in the process. In order to utilize this energy, improved charcoal making devices that permit the use of the volatiles for thermal applications have been developed in the past. The Paru stove developed by the Chemical Engineering Department of IIT Delhi is one such device. Use can be made of such devices in charcoal making for the present gasifier in order to improve energy utilization from biomass.

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