

# SHAFT POWER FROM PRODUCER GAS

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## **NERDC Experience In Producer-Gas Driven Engines**

Studies were commenced by the National Engineering Research & Development Center of Sri Lanka to develop gasifier technology for use in various application where internal combustion engines are involved (1980 onwards). These are road vehicles, a boat, power generator sets, water pumps, and a farm tractor etc. The technology is developed entirely from scratch making use of information available in technical literature as a starting point. No technology transfer from abroad has been made use of and the effort has been entirely local.

One of the main problems of the use of gasifier technology has been the high cost of the gasifiers available in the developed countries. These costs have removed most of the advantages in economy that could have been achieved by the use of the gasification process. It was, therefore, the aim of the work done to reduce the cost if these gasifiers drastically to make the gasification process economically viable under the Sri Lankan conditions. It can be reported here, that this objective has been achieved and gasifiers of high quality have been produced in the proto-type stage for various applications, at a fraction of the cost of the cost of those that are available from manufactures abroad, especially, Sweden and the Federal Republic of Germany.

Gasifiers for the following purposes have been developed using local resources with no assistance from outside.

The applications covered by these developments are:

1. Passenger vehicle
2. Power generation sets of small capacity
3. Irrigation pumps (2" to 6" discharge)
4. Battery charging generators for rural areas as part of the rural lighting projects of NERDC center.
5. Boat propulsion

The development work was carried out over a period of about three years during which time a considerable amount of experience was gathered in the various problems associated with gasification. It has been possible to achieve these results during this comparatively short period, because of the intensity with which the work on this project was carried out in view of its national importance. The performance of these gasifiers is comparable with those developed and manufactured in advanced countries like Sweden and the Federal Republic of Germany, in spite of the fact that they cost very much less. The lower cost has been achieved by the use of cheaper materials and cheap labour, which are available in Sri Lanka. In view of the fact that the manufacture of gasifier is skilled labour intensive, there is a considerable cost difference between the gasifiers produced in the developed countries where labour is very expensive and those produced in Sri Lanka and certain other developing countries.

As an indication of the cost it can be reported that the conversion of a Toyota Hiace van (6-cylinder) to operate on producer gas with coconut shell or coconut husk as a fuel, is not more than Sri Lankan Rupees 20,000 which is approximately 1,000 US Dollars (1982). It is, therefore, seen that these units can be produced in developing countries like Sri Lanka where engineering technology exists at a reasonable level without being subject to the high cost of collaboration with manufactures from developed countries. This development has taken place in the Philippines as well and a number of useful applications of gasifier technology can be seen in the country, adding considerably to the national effort.

### **History Of Gasifier Vs IC Engine**

The gasifier was first used in the fields of transport, power generation for electricity and for water pumping, quite sometime ago before the discovery of petroleum. With the advent of petroleum and the internal combustion engines, the economics of the day forced the lagging off of the gasifier in favour of cheaper petroleum consuming IC engines.

During the second world war when the supply lines were disrupted and petroleum became scarce, the gasifier once more became economical and popular. Again with the end of world war and the resumption of petroleum supplies the use of the gasifier declined.

With the world oil price hikes initiated by the OPEC in 1973 and again in 1981 and the realization that over dependence on imported oil the price of which could be unilaterally increased by the oil producing countries caused economic rises, many developing countries began using alternative energy sources. Hence the gasifier has now become popular for the third time.

Most of the work on the gasifiers over the last 100 years has been directed towards their use with engines, and one of the great attractions of producer gas is that it can be used in virtually any type of internal combustion engine. Usually, the necessary adjustments to the engine are simple enough so that any reasonably well-equipped vehicle or engine repair workshop can carry them out. This opens the way for many uses for gasifiers in the developing world.

### **Producer Gas : A Substitute For Diesel**

Gasoline engines, in which a spark plug ignites the gasoline air mixture, can be converted to run entirely on producer gas. But diesel engines, in which the fuel is usually ignited by compression only, cannot be completely converted to gas. A little diesel fuel must be injected in each engine cycle to ensure ignition. (This simultaneous use of diesel and producer gas is referred to as "dual-fuel" operation). The maximum replacement of diesel is about 90%. In practice, diesel savings of 50-80% are more typical because extra diesel is generally used to take up temporary needs for more power and to help with acceleration. In fact, most engine gasifiers operate best when power requirements are fairly constant, especially when the fuel is wood. So gasifiers are unsuitable when engines are run intermittently or when loads vary sharply.

Converting an engine to producer gas reduces the maximum power output. This "derating" effect result mainly from the low heat of the gas. With diesel engines, the power loss is usually about 20%, but with gasoline engines it can be as much as 10-50%. However, this is not always a problem, since engines are often over-sized, especially those employed for industrial purposes and in pumping. But gasifier-powered vehicles tend to be some what sluggish, and rely on greater use of their low gears.

Generally, if a local economy can keep many cars and trucks running it should be able to cope with gasifiers. Mechanics who are able to maintain and repair motor vehicles should have little difficulty with gasifiers- once they have been properly trained. But if there are problems in looking after existing engines or boilers, the introduction of gasifiers will doubtlessly make things worse, eventually resulting in an expensive failure. Gasification is not what is popularly known as a "village technology".

### **Gasifier Coupled Engines**

Industrial engine gasifiers can be best used in rural areas where grid electricity is either expensive or unavailable, and diesel or gasoline are the main alternatives. In towns, even the biomass fuels are available free, grid electricity will usually be a cheaper source of power than gasifiers. Electricity from the grid also has the obvious advantages of versatility and convenience.

Engine gasifiers appear to be well-suited to isolated, rural sawmills and crop-processing activities such as maize milling. Saw mill wastes and maize cobs can both be used as gasifier fuel, though cobs have only been used for a long period in one experimental project in Tanzania. The best sawmills for gasification are those where grid electricity is unavailable, diesel is expensive or scarce, and the mill is unable to earn much money by selling its waste products locally. Most such sawmills are located in forest areas with low population densities.

### **Gasifier Powered Generators**

For the sake of flexibility and convenience, it may be better to use gasifiers to generate electricity to run machinery - rather than running machines directly from gasifiers. This is especially true when one gasifier is to

provide fuel for several machines. The shelling and milling of maize cobs need one of several machines, the activities of which require small engines and produce dry, low-value residue. Others include peanut shelling, coffee hulling and rice milling. But very little gasification experience exists with most of these materials. Also, crop residues are seasonal resources. Using them as a fuel would raise problems of supply and storage. But if they do prove suitable as fuels, some processing industries could become partially or completely energy self-sufficient through gasification.

Diesel powered electricity generators are used widely in developing countries, particularly in the countryside where the grid electricity is unavailable or unreliable. Using gasifiers to run generating sets can only be feasible where the electricity demand is relatively steady and sufficient fuel can be provided. The best cases can be made in forest areas, where a local demand exists for electricity for village use or for small industries.

In areas where wood is scarce, tree plantation will be needed to prevent rapid deforestation. For instance, a village of 100 people, with a fairly low per capita electricity demand of, say, 200 kWh per year, would require 140 tonnes of wood per year to run a gasifier powered generator. At an annual wood yield of 10 tonnes per hectare (4 tonnes /acre), which might be expected in a region with moderate rain fall, a 14 hectare (35 acre) plantation would be needed. This is equivalent to 0.035 hectare (0.086 acres) for each person in the village. To meet a per capita demand of 2,000 kWh/year, which is approximately the consumption in rural areas of Costa Rica, a 400-person village would need a plantation area of 140 hectares (9346 acres). Providing such plantation would be difficult where land is scarce.

## Gasifier Driven Water Pumps

Sri Lanka being largely composed of a predominantly agriculture oriented community based in the rural sector, the need for and the supply of water for irrigation has been of primary importance from ancient times.

The water pumps driven by internal combustion engines became widely used. But due to sudden changes in price of crude oil in the world oil market for instance the price hikes in 1973 and 1981, and the subsequent rise in cost of pumping water, an effort was made to find alternative cheap methods to pump irrigation water. The gasifier powered pump is one such achievement.

The diesel engine driven water pump could be successfully, modified for gasifier operation. Producer gas is found to be capable of substituting for a large portion of the diesel fuel requirements for this application. The efficiency is improved since flowing water is available from the water pump outlet for cooling the hot gases coming from the gasifier, almost to the atmospheric temperature

Gasifiers could provide an alternative to diesel pumped irrigation in areas throughout the third world where diesel fuel is expensive and interruptions in supplies common. The power required to irrigate a hectare of land depends on the pumping depth and the quantity of water applied, but typical range is from 0.3-0.7 kW (0.4-0.9 hp) per hectare (about the output of one hardworking bullock). However, irrigation requirements are generally seasonal, so systems will often be needed for only part of the year, perhaps between 600 and 1,200 hours annually. Where usage is towards the low end of this range, gasifier-powered irrigation will often be uneconomical to use.

The question of the fuel supply is also important. If one were using gasifiers to power irrigation pumps, one might have to use part of that irrigated land to grow trees for gasifier fuel. The balance sheet of a sample pump might work out as follows:

- Pump with a power demand of 0.5 kW/ha (0.2 kW/acre) working 800 hours per year would require a total of 400 kWh.
- A reasonably efficient gasifier system, with a dual-fuel diesel engine, uses approximately 1.4 kg (3 lb) of wood per kWh of shaft power generated.
- This means wood consumption will be approximately 560 kg per year, for every hectare (500 lbs/acre) irrigated. Assuming wood is specially grown for the purpose, an area equivalent to between 3% and 11% of the irrigated land area would have to be planted trees to supply enough wood to run the pump.

In many places, marginal land can be used for wood plantation. Otherwise, there may be a case for devoting part of the field to tree growing. Since irrigation can boost crop yields by much more than 115% agricultural production need not necessarily suffer.

But less efficient gasifier and pump equipment could drastically alter this arithmetic and rule out gasification. Small-scale pumping systems are notoriously inefficient. Also, with leaky pumps, sloppy drive belts and a badly operated gasifier and engine unit, wood consumption could well be two or three times the amount calculated above. A plantation requirement of 33% of the irrigated land area would be far more difficult to accommodate, and would almost certainly require fuel to be brought in from other areas.

Table 1. A typical run of a producer gas and diesel-fueled engine coupled to a centrifugal water pump. (1985, NERD Center )

(3-cylinder Lister engine; rated power 45 hp, rated diesel consumption 5 l/hr)

Test no.	Diesel total lt	Consumption rate lt /hr	Firewood total kg	Consump. Rate kg / hr	Time duration of test mts	Diesel saving %
Y/ 201	1.1	2.2	6	12	30	56%
Y/ 202	4.8	2.4	22	11	120	52%
Y/ 203	1.9	1.6	17.5	14	75	68%
Y/ 204	3.3	1.5	31	14.3	130	70%
Y/ 205	2.7	1.2	34	15.1	135	76%
Y/ 206	0.8	1.1	12	16	45	78%

The fuel consumption rate of approximately 3 liters/hours of diesel was required for pumping 30,000 gallons/hour of water. After conversion to gasifier operation this was reduced to 1.1 liters/hour of diesel plus 6 kg firewood/hour.

### **A Case History From Sri Lanka**

#### Experience From Test Operation Of A Producer Gas Truck (1986 - 87)

The truck under test was purchased in used condition and was converted to producer gas operation by Gotland Gengas, Sweden, in 1982. The gasifier system was designed according to recommendations given by the Swedish National Machinery Testing Institute which has carried out extensive tests with producer gas operated tractors and trucks since 1951. The modification of the truck included replacement of the original diesel engine by a V8 spark ignition engine, with a cylinder volume of 7.5 liters. A truck of similar size, with basically the same gasifier system, but with a diesel

engine, is being operated in Sweden since 1969 and has covered over 110,00 km.

The modified truck was brought to Sri Lanka in the end of 1982. Due to unforeseen organizational problems, it was only operated for a short time in 1983. The actual tests were started in February 1986 after bringing the truck to the National Engineering Research and Development Center (NERD). Technical support to the NERD center is provided by the Beijer Institute, Sweden.

The total operating record in Sri Lanka in the end of November 1986 covered 1,963 km (70 hours). Except for problems originating from the fact that the truck was brought in used condition and has been standing idle for three years, the driving experiences have been favorable. A load of some 2,200 kg was brought from Ja-ela to Kandy and back, a distance of about 200 km, in six hours without difficulties on the steep roads.

Rubber wood, cut to 3 - 5 cm pieces has been the main fuel. Coconut shell has been used for about one hour, when no other fuel was available.

The average wood consumption has been about 1.4 kg/km (40 kg/h), but the tests made in November 1986 indicate that the consumption should not exceed 1.0 kg/km (31 kg/h) when the vehicle is driven for longer distances without frequent stops. With the present prices for fuel wood and gasoline in Sri Lanka, producer gas operation could then save about 1.9 Rs/km on fuel cost. If this saving is large enough to justify the investment in gasifier equipment is yet to be evaluated.

There have been no problems with condensation of tars in the pipe system, filters or engine. Condensation of moisture in the engine has caused starting problems on some occasions. This problem will probably not appear again after the installation of an additional drain valve and modification of start-up procedure.

The only serious problem observed with the system is the rapid wear of the fiber-glass filter bags. Inspection after the test period in November 1986 revealed holes caused by chaffing in all 16 filter bags. The bags must be replaced or repaired. Chaffing of filter bags has been observed also for operation of similar filters in Sweden, but only after 500 - 1,000 hours of operation. The reason for the more rapid wear in Sri Lanka is probably the more violent vibrations caused by the less smooth roads.

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