Cost Analysis and Economic Evaluation of Gasifier Engine and Conventional IC Engine

Khin Hnin Si

***Abstract*— There are many kinds of energy, such as heat energy, light energy, mechanical energy and electrical energy, etc. Nowadays, the electrical energy is the most important for every regions such as to build up the education and living standard of rural areas and industrial regions. In the rural areas of developing countries, small amount of mechanical or electrical power have been produced by utilizing locally available renewable fuels. Wood, charcoal and other biomass materials are gasified to generate power of electricity in gasification process. Gasification systems basically consists of a gasifier unit, purification system and energy converters, burner or engine. The total cost of the gasification plants has been analyzed. This technology could be economic and where, because of lower wage, the appear to be posibilities to build cheap equipment and it can be used for a long time. In this research, the economic evaluation method and depreciation method are used.The electrical power generation by downdraught wood gasifire for 30 kW IC engine, it is found that the payback period is 2.12 years, the return on investment is 43% and benefit-cost ratio is 1.3 which are more than power generation by petrol (or) diesel fuel. The total investment is MMK 9,250,000, the annual operating cost is MMK 5,365,000 and the net cash flow is MMK 4,355,000.**

***Keywords*—benefit cost ratio, downdraught gasifier, payback period,wood gasifier.**

1) Introduction

The objective of this paper is to compare the cost of production heat and power as small scale from biomass fuels. Biomass gasification represents a competitive alternative to direct combustion for optimization of the electricity production. The interest in the gasification technology has undergone many ups and downs in running century. Today, because of increased fuel price and environmental concerns, there is renewed interested in this century old technology. Gasification has become more modern and quite sophisticated technology.

Gasification is basically a thermochemical process which converts biomass materials into gaseous components. The result of gasification if the producer gas, containing carbon monoxide, hydrogen, methane and some other inert gases. Mixed with air, the producer gas can be used in gasoline or diesel engine with little modifications. Gasification processis the conversion of solid carbon fuel into carbonmonoxide by thermochemical process. The gasification of solid fuel is accomplished in air sealed, closed chamber, under slight suction or pressure relative to ambient pressure. It includes drying, pyrolysis, oxidation and reduction.

The author visited to gasifire plant which was situated in Momeik, Northern Shan State of Myanmar. This plant was established in 2010 and the owner wanted to build new gasifier plant with 30 kW electrical power output.

Installation of gasifier system with IC engine involves a certain investment, leads to somewhat impaired performance, and increased time required for service, maintenance and repair. Woods gas operation is only economically feasible if these costs are outweighted by the saving on fuel costs. It can be inferred from this that wood gas operation will be most competitive in situation where the annual utilization of the electrical and mechanical power is high, the labour wages low and the price difference between petrol fuel and wood is large.

2) Downdraught Gasifier

Types of gasifiers

Design of gasifier depends upon type of fuel used and whether gasifier is portable or stationary. The most commonly built gasifiers are classified as updraught, downdraught, cross-draught, twin-fire and fluidized bed gasifiers.

Working principle of downdraught gasifier

A solution to the problem of tar entrainment in the gas stream has been found by designing downdraught gasifiers, in which primary gasification air is introduced at or above the oxidation zone in the gasifier. The producer gas is removed at the bottom of the apparatus, so that fuel and gas move in the same direction as shown in figure 1. The main advantages of downdraught gasifiers lie in the possibility of producing a tar-free gas suitable for engine applications. Because of the lower level of organic components in the condensate, downdraught gasifiers sulphur less from environmental objections than updraught gasifiers. [1]

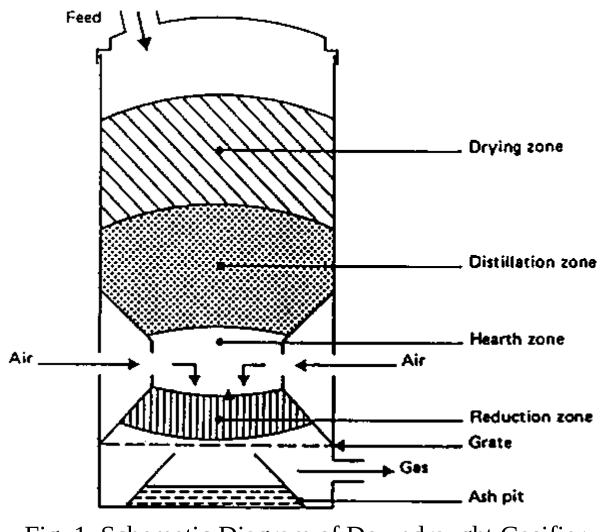

Fig. 1. Schematic Diagram of Downdraught Gasifier

3) SELECTION OF FUEL

A wide range of biomass fuel such as wood, charcoal, wood waste (branches, roots, barks, and saw dust) as well agricultural residues that maize cobs, coconut shells, cereal straws, rice husks, can be used as fuel for biomass gasification. Theoretically, all kinds of biomass with moisture content of 5-30% can be gasified, however, not every biomass fuel leads to the successful gasification. Most of the development work is carried out with common fuels such as coal, charcoal and wood. Each type of gasifier will operate satisfactorily with respect to stability, gas quality, efficiency and pressure losses only within certain ranges of the fuel properties of which the most important are energy content, moisture contents, volatile matter, ash content and ash chemical composition, reactivity, size and size distribution, bulk density and charring properties.

Moisture content can be determined on a dry basis as well as on a wet basis. Moisture content is defined as:

$$M.C_{dry} = \frac{\text{wet weight - dry weight}}{\text{dry weight}} \times 100\% \quad (1)$$

$$M.C_{wet} = \frac{\text{wet weight - dry weight}}{\text{wet weight}} \times 100\% \quad (2)$$

Bulk Density

Bulk density is defined as the weight per unit volume of loosely tipped fuel. Average bulk densities of wood, charcoal and peat are shown in table 1.

TABLE I
AVERAGE BULK DENSITIES

Fuel	Bulk Densities(kg/m^3)
Wood	300 – 500
Charcoal	200 – 300
Peat	300 – 400

Gasifier efficiency

The gasification efficiency is defined if the gas is used for engine application

$$\text{Gasification efficiency} = \frac{\text{Chemical Energy output}}{\text{Energy input from feedstock}} \times 100\% \quad (3)$$

4) COST ANALYSIS

Typical investment decision include acquisition of facilities, acquisition of equipments, revision or expansion of existing facility layout, research and development, make or buy new products, repair and maintenance of equipments and facilities.

Table II shows the capital investment for gasification and power generation.

TABLE II
CAPITAL INVESTMENT FOR GASIFICATION AND POWER GENERATION

Description	Costs (MMK)
Building	2,400,000
Drain Channel	60,000
Water Tank	140,000
Engine	1,500,000
Engine Modification	150,000
Engine Frame and Mounting	800,000
Gasifier Unit	4,200,000
Total Investment	9,250,000

All costs are in MMK = Myanmar Kyat
(1US$ = 1400 MMK)

Operating and Maintenance Cost

The total annual operating and maintenance cost include labour wages, fuel costs, and the cost of lubrication and spare parts of engine. Table III shows the operating and maintenance cost on gas producer and engine.

TABLE III
OPERATING AND MAINTENANCE COST

Item	Costs (MMK)
Operting Labour 1 Machine Operator 1 Helper	 1,440,000 900,000
Fuel cost Fuel wood at 50 kg/hr	 900,000
Maintenance cost Lubricant and spare parts	 925,000
Fixed cost	1,200,000
Total annual operating cost	5,365,000

Fuel cost for petrol engine and gas engine

Table IV shows the comparison between the fuel cost for petrol engine and gas engine.

TABLE IV

Engine Type	Fuel consumption	Fuel cost	Annual cost (MMK)	Remark
Petrol	3.5 gal/hr	4000 (MMK/ gal)	42,000,000	Operating time is 10 hrs/day and 25days/month
Gas	50 kg/hr	6 (MMK/ kg)	900,000	"
Annual saving			41,100,000	

5) ECONOMIC EVALUATION METHOD

Economic evaluation of total annual cost

Overall power costsof the system can be calculated on the following assumptions:

System cost, c = 9,250,000 MMK
System life time, t = 6 years
Interest rate, i = 8.00%
Maintenance cost = 10% per year of initial investment
Additional labour costs = 1 man-year
Fuel cost = 6 MMK/kg
Operation time = 3000 hrs/yr

Annual capital charges are calculated using the relationship,

$$ACC = c \times \frac{i}{1-(1+i)^{-t}} \quad (4)$$

ACC = 2,000,917 MMK
Maintenance cost = 925,000 MMK/yr
Additional Labour cost = 2,340,000 MMK/yr
Fuel cost = 900000 MMK/yr
Annual cost = 6,165,917 MMK/yr

Depreciation[2]

It is an accounting procedure to periodically reduce the value of an asset on the book of a firm.

Method of depreciation

Many methods are available, from the depreciation methods available, the following three methods will be investigated which account for most of the industrial practices.

i. The straight line method
ii. The sum of years digits method
iii. The declining-balance method

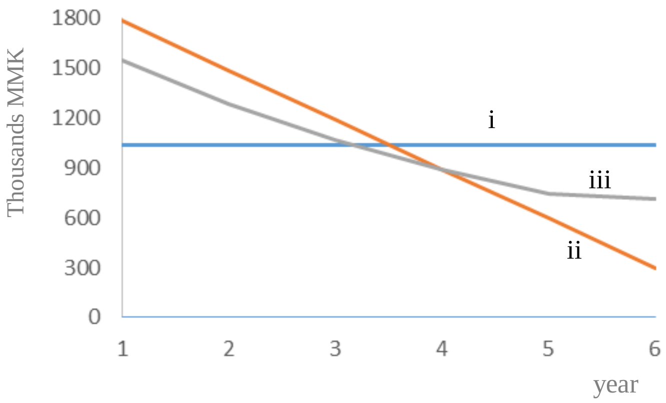

Fig. 2. Comparison of Annual Depreciation Charge

Ranking investment alternatives

1. General Income or Savings

Assume transmission efficiency, η_t = 90%,

$P_E = \eta_t \times P_M = 0.9 \times 30 = 27$ kW

where P_E = Electrical power output (kW)
P_M = Engine Power output (kW)

Annual income from selling of electricity

$$= 27(\text{kW}) \times \frac{120\ \text{MMK}}{1\,\text{kWhr}} \times \frac{10\ \text{hr}}{\text{day}} \times \frac{300\ \text{days}}{\text{year}}$$

= 9,720,000 MMK

Annual operating cost = 5,365,000 MMK
Net cash flow = 4,355,000 MMK

2. Pay back period = $\frac{\text{Net investment}}{\text{Net cashflow}}$ = 2.12 years

3. Return on investment (r)

$$I_o = \sum_{j=1}^{n} \frac{A_j}{(1+r)^j} + \frac{S_n}{(1+r)^n} \qquad (5)$$

where I_o = investment at time 0 (MMK)
A_j = net cash flow in time period j (MMK)
S_n = salvage value in time period n (MMK)
n = life time of the project (year)

r ≈ 43%

4. Net-present worth (NPW)

$$NPW = -I_o + \sum_{j=1}^{n} \frac{A_j}{(1+i)^j} + \frac{S_n}{(1+i)^n} \qquad (6)$$

It gives, NPW = 10,882,641 MMK

5. Benefit-cost ratio [3]

$$B/C = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \qquad (7)$$

Where B_t (t = 0, 1, ... n) = benefit or saving in time period t
C_t (t = 0, 1, ... n) = cost in time period t.

It gives B/C = 1.3.

6) Conclusion

The conclusions were based on the following facts:

- The possibility of avoiding use of fossil fuels for power generation
- Utilization of the forest residues and suitable for industrial processing
- Reducing the costs of farmers preparing new agricultural land
- The fuel wood area will cover with needs of the power plant for a long time
- Avoiding the transportation of fuel oil overlong distances
- Considerably lower cost for production of mechanical power with wood gas than with diesel or petrol
- Decreasing the need for imported oil.

Since the return of investment is greater than the cost of capital, net present worth value is positive, and B/C ratio is greater than 1.0, the design of downdraught wood gasifier for 30 kW IC engine is desirable from the point of view of economics.

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Khin Hnin Si, currently working as a lecturer in Technological University (Mandalay). She got B.E. (Mechanical Engineering) degree from Yangon Technological University in 1992. The first appointment of her work was in Mandalay Institute of Technology as an instructor in 1994. And she continued her further study in Yangon Technological University in 1997. She achieved Master of Enineering (Mechanical) degree in 1998. She did a research on Micro-Hydro Power Plant during her studies. She supervised many Master thesis in Mandalay Technological University from 2001 to present.She is also a member of Myanmar Engineering Society of Mandalay

Region Chapter and participated in women engineers' activities. Then, she worked as external examiner in National Conferences on Science and Engineering which were held in Mandalay Technological University from 2017 to 2018. She is also a member of Policy and Planning Group of Technological University (Mandalay). She has a lot of teaching experiences in Industrial Engineering and Management, Enineering Thermodynamics, Design of Machine Elements and so on. Now she is about 51 years old, working and participating in university research and laboratory activities such as Renewable energy, Mechanics of Materials, Internal Combustion Engines Research in the department of Mechanical Engineering, Technological University (Mandalay).