Design of 270 CC T2 gas capacity converter

F Azarul 1, M D Trisno 2 and D Dahlan 3

1 Mechanical Engineering Study Program, STT Muhamadyah Cileungsi-Bogor, Jalan Anggrek No. 25, Perum. PTSC, Cileungsi Village, Kec. Cileungsi, Bogor, Cileungsi, Bogor, West Java 16820, Indonesia
2 Mechanical Engineering Study Program, Faculty of Industrial Technology - ISTN, Jl. Moh. Kahfi II, Jagakarsa, Jakarta 12640, Indonesia
3 Mechanical Engineering Study Program Faculty of Engineering - Universita Pancasila, Srengseng Sawah, Jagakarsa, Jakarta 12640, Indonesia

Email: firmansyah.azarul@gmail.com 1, m.dwitris@yahoo.co.id 2, dddkamang@yahoo.com 3

Abstract. Fuel motor is a machine that converts chemical energy into mechanical energy. In the design of this approach, we look for a gas converter model in accordance with its capacity according to the volume of the cylinder used, where the thing that needs to be considered is the performance of the gas converter itself, namely from the art form/model, fuel efficiency and large pressure settings. gas supply that enters the combustion chamber. The GX270 general motor is a fuel motor engine used as a test tool. The design was carried out at the STT Muhamadyah Cielungsi mechanical engineering energy conversion laboratory. To understand the variables that affect performance, in making this converter, things that need to be considered are variations in rotation and variations in load. From the design of the gas converter, the results of the design calculation are as follows: T torque = 19.12 (Nm), effective power Ne = 5.003066667 (kW), average effective pressure Pe = 889.4340741 (kPa), total usage hourly fuel mf = 0.0675 (kG / hour), specific fuel consumption Be = 0.013491725 (kg / kN.m), fuel ratio with air F / A = 0.13781, ideal air mass flow rate mv = 0,001138242 (m3 / s), volumetric efficiency 843,30666 (%) and thermal efficiency 15,78 (%), the greater the engine rotation used, the more fuel level will be consumed, as well with effective engine power.

Keywords: Kit converter, constant pressure, effective power, efficiency, General GX270T2 engine

1. Introduction

According to Law (UU) No. 45 of 2009 concerning amendments to Law No. 31 of 2004, stated that small fishermen are people whose livelihoods are fishing to fulfill their daily needs by using the largest fishing vessel 5 GT [1]. Most of the Small Fishermen use boats with gasoline engines. Fishing requires operational costs of around 70% for fuel oil (BBM). If the fuel price rises, the operational costs of fishing will be high so that fisherman's income decreases. The scarcity of BBM and its high price make it a separate problem for small fishermen. The use of cheap, convenient, safe and compatible alternative energy to drive small fishing boat engines is very necessary [2].

Based on the Presidential Regulation of the Republic of Indonesia Number 5 of 2006, concerning the National Energy Policy, the important agenda of the national energy policy is the development of alternative energy sources to reduce dependence on energy sources such as fuel oil (BBM). The
government has called for fuel energy savings, given the availability of crude oil reserves that are increasingly lacking. There are many fuel resources that can be researched and utilized as alternative fuels, one of which is gas fuel in the form of Liquefied Petroleum Gas (LPG) which is one component of natural gas fuel with large enough reserves in Indonesia [3]-[6].

In general, boats/fishing vessels below 5 GT use a lot of gasoline engines. Therefore, there is a need for further research on modification of gas converters to produce design designs and create new gas converters for optimal boat/fish boat motors, in accordance with standards and prioritizing ergonomics, safety factors. Get it the right comparison of air and gas on a small fishing boat/fishing boat motor. Analyze and test machine performance validation, namely: Torque, effective power, fuel consumption. In optimizing fuel resources, one of the real steps in the development of energy conversion engine technology, through the study of engine modification.

This study is a continuation of previous research on converter kits. Some existing kit converters for the initial use of fuel oil after running are carried out by moving the gas fuel through the valve, and the membrane vacuum in the kit converter is not maximum. When the engine is off it does not automatically stop the gas flow.

This next research was carried out by modifying the design of the gas converter and the validation test. Modified gas converters designed to optimize the use of gas converters on gasoline motors. So that with the manufacture of gas converters it is expected to get the same engine performance, torque and effective power as the use of fuel oil with lower operating costs and easier operation compared to previous gas converters.

2. Literature Review

2.1. Fuel Motor
Fuel motor is one type of heat engine, which is a machine that converts thermal energy to do mechanical work or convert chemical fuel energy into mechanical power. Before becoming mechanical power, the chemical energy of the fuel is converted first to thermal energy or heat by burning fuel with excess air. This combustion is carried out inside the heat engine itself and some are carried out outside the heat engine and the otto cycle of the gasoline engine is also called a constant volume cycle, where combustion occurs when the volume is constant [7] [8].

2.2. Fuel Motor Classification
The fuel motor can be classified into 2 (two) types. The classification of the combustion motor is the external combustion motor and the internal combustion motor in the following:

2.2.1. External combustion engine
The external combustion motor is where the combustion process takes place outside the engine itself. The heat from the fuel is converted into motion but exceeds the intermediate medium and then changes into mechanical power. In general, steam and turbine engines have characters that can only be used as large-scale starters for example, locomotives, ships, and power plants and are not good when used as multipurpose generator drives, motorbikes, and vehicles (cars) and can be seen as in Figure 1. 

![Figure 1. External Combustion Motors](image)
2.2.2. Internal combustion motor

The internal combustion motor is the fuel combustion process that occurs inside the engine itself so that the heat from the direct combustion process can be converted into mechanical power construction and engine planning to be smaller and simpler, such as a diesel engine that can operate in high temperatures with repeated cycles and the use of this fuel motor has spread widely because it has a strong and reliable power besides that the use of fuel becomes more efficient and efficient.

The advantages of internal combustion motors are: Lightweight, small size, the power produced is large and very practical for vehicles. Another advantage can first be operated wherever there are air and fuel. Thus the area of operation is so large. Secondly, high thermal efficiency can produce considerable power with a relatively small amount of fuel.

The disadvantages of internal combustion motors are first valve opening and closing, air intake, exhaust combustion gas disposal and repeated bursts in each cycle causing vibration. The two can not be operated in a closed room for a long time because pollution will increase with the duration of use. The three fuels are limited, coal and wood cannot be used, because they cause ash. The internal combustion motor can be seen in Figure 2.

2.2.3. Working Principle of four-step fuel motor (4-stroke)

4-step gasoline motor (4-stroke) undergoes one process at each step, namely: the Suction step begins with the movement of the piston from the upper die point (TMA) to the lower die point (TMB), the open suction valve and the exhaust valve are closed. Through the suction valve, the fuel mixture, air enters the combustion chamber.

Compression step The rotating crankshaft moves the piston to the TMA after reaching TMB. The intake valve and exhaust valve are closed. The fuel-air mixture is compressed, the pressure and temperature inside the cylinder increases, so that this mixture is flammable. This compression process is also called the pressure step, which is when the piston moves from TMB to the TMA and the two valves are closed. Work step where both valves are closed. At the time the piston reached the TMA, there arose a jump of electric sparks from the spark plug and burned a mixture of high-pressure and high-pressure air-fuel.

Exhaust step After reaching the TMB the crankshaft moves the piston to the TMA, the cylinder volume decreases. When removing the entrance valve is closed and the exhaust valve is open. The piston presses the combustion residual gas out of the cylinder. so that the cycle occurs repeatedly as in Figure 3 [9].
The gasoline motor work cycle can be described in the indicator diagram, namely the P-V diagram (Pressure-Volume) and the T-S diagram (Pressure - entropy). This indicator diagram is useful for analyzing the internal characteristics of gasoline motors. In this 4-step gasoline motor, the combustion gas-only pushes the piston on the expansion step. Therefore, to allow the piston to move in the other three steps, some of the combustion energy during the expansion step is changed and stored in the form of flywheel kinetic energy. The way the engine works for the 4-step, in one cycle occurs in 4-steps. The steps that occur in the Otto 4-step engine are as shown in Figure 4.

![Figure 3. Step 4 engine work steps](image)

**Figure 3. Step 4 engine work steps**

2.3. **Boat / Ship**

Fishing vessels can be distinguished on non-motorized fishing vessels and motorized fishing vessels. This motorized fishing vessel is a vessel that uses a fuel motor as a driving source and propeller as a driving force. Based on the driving motor, fishing vessels can be distinguished on outboard engines and inboard engines. An outside motorized fishing vessel is a fishing boat that has a drive motor not located inside the hull but is mounted seated on the stern of the ship, on one side of the bulwark or on the stern deck of the ship. Deep motorized fishing vessels are fishing vessels that have a driving motor in the hull or below the deck in the engine room, mounted on the engine foundation so that the propeller shaft penetrates the stern wall or on the propeller height. [10] [4]

Outdoor motorized fishing vessels are often used by small-scale fishermen. In principle, this design is intended to facilitate maintenance. The motor used also has a lightweight construction, high engine
speed, and its service life is only one to two years, so that efforts to extend the service life, more efficient fuel consumption and good durability during operation are problems that are often experienced by fishermen small scale [9], [11]-[19].

Judging from the combustion, the driving motor is divided into two types, namely otto and diesel fuel motor. The otto fuel motor or better known as the gasoline motor, the combustion process uses fire from a spark plug with gasoline, while the diesel engine combustion occurs due to an increase in the temperature of the air and fuel mixture due to piston compression reaching the flashpoint. Because of the principle of fuel ignition that occurs due to pressure, the diesel motor is called a compression ignition engine and the gasoline motor is called a spark-ignition engine [7]. The inboard motor is the engine/motor of the ship which is located inside the hull of the ship or bottom of the deck and is mounted seated on the engine foundation so that the propeller shaft penetrates the hull wall.

The outboard motor is the engine/motor of the ship that is not located inside the hull. The drive motor is usually mounted on the stern transom so that the propeller shaft does not penetrate the stern wall.

3. Gas Converter Design Method.
The concept of this research is the initial stage of making a product. The stage that will determine the end result of an analysis that will be carried out almost as a whole in this study, many things must be reviewed first. To simplify the steps of the study or in a more regular analysis process, a research flow chart is made as shown in Figure 5.

From the design diagram above, the design results are obtained as shown in Figure 6.
3.1. Selection of Driving Systems

The rotary drive system that is used as a rotary drive for this braking disk uses a 4-step engine because the fuel consumption is more efficient, the engine specifications that will be used in the analysis of the drive rotation of the disk system are machines with specifications as follows:

- **Horse Power**: 8.0HP
- **Engine Type**: Single Cylinder, 25, 4-Stroke, Air-Cooled OHV
- **Bore x Stroke**: 77 x 58 mm (3.0 x 2.3 in)
- **Displacement**: 270 cm³ (16.5 cu in)
- **Compression Ratio**: 8.2:1
- **Net Horse Power Output**: 6.6Kw (9 HP) / 3600 rpm
- **Maximum Torque**: 1.95kgf-m (19.12 Nm) / 2500rpm
- **Net Torque**: 17.7 Nm (13.1 lbs ft) at 2,500 rpm
- **PTO Shaft Rotation**: Counterclockwise (from PTO shaft side)

**Ignition System**: Transistorized Magneto Ignition

**Starting System**: Recoil
- **Fuel Tank Capacity**: 6 Liters
- **Air Cleaner**: Semi-Dry
- **Carburetor**: Horizontal type valve
- **Oil Capacity**: 1.1 Liters

**Lubrication System**: Forced Splash
- **Governor System**: Centrifugal Mechanical
- **Dimension (L x W x H)**: 380 x 430 x 410 mm
- **Weight**: 25 kg

3.2. Determine the basic design of the main dimensions of the Gas Converter Based on the machine used.

The basic design of the main dimensions is adjusted to the data obtained by the machine and the calculation as follows:

- **Horse Power**: 8.0HP
- **Engine Type**: Single Cylinder, 25, 4-Stroke, Air-Cooled OHV
- **Bore x Stroke**: 77 x 58 mm (3.0 x 2.3 in)
- **Displacement**: 270 cm³ (16.5 cu in)
- **Compression Ratio**: 8.2:1
3.3. Calculation of Gas Converter Dimensions.

Basic calculation of Gas Converter / Carburetor To design a Gas Converter / Carburetor in certain conditions, it is necessary and existing data, namely machine specification data:

- Cylinder diameter \( D \) = 77 mm
- Step length \( L \) = 58 mm
- Engine rotation \( n \) = 2500 rpm
- Cylinder capacity = 270 cc
- Power \( P \) = 6.6 kW

then the basic calculation starts from:

1) Calculate fuel volume \( V_{bb} \)

\[
V_{bb} = \phi \times D \times D \times S / 4000
\]

Where \( V_{b} \) is cc engine volume, \( \phi \) for constant whose value is 3.14, \( D \) is mm piston diameter, \( S \) for stroke step from tma to tmb mm. The calculation is \( V_{b} = 3.14 \times 77 \times 77 \times 58 / 4000 = 269,94737 = 270 \) cc.

2) Calculate the diameter of the converter main hole/carburetor, \( D \).

\[
D = K \times \sqrt{(c.n)} \text{ (mm)}.
\]

Where \( D \) is diameter (mm), \( K \) is constant (0.6-0.9), \( C \) is cylinder volume (cc), and \( n \) is maximum rotation of the engine (rpm). The calculation is \( D = 0.65 \times \sqrt{0.27 \times 3600} = 20.26 \Rightarrow 20 \) mm. For gas used, the price of \( K \) is 0.25. \( D = 0.25 \times \sqrt{0.27 \times 3600} = 7.79934 \Rightarrow 8 \) mm. (https://www.facebook.com/spm.motor.pas/posts/129431253897523 and http://www.otosena.com/category/karburator/)

3) Relationship Between Torque and Engine Power - In-vehicle engine specifications, power is written in horsepower or kilowatt units at certain engine speed, and torque or torque with kgm units (Figure 7).

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{engine_performance_graph.png}
\caption{Engine performance graph}
\end{figure}
In the internal combustion engine, the combustion gas will press the piston connected to the crankshaft with the connecting rod. The compressive force of the gas produces a torque on the crankshaft and makes the crankshaft rotate. Power is torque multiplied by rotation (angular velocity): Moment of torque (Nm)

\[ T = p.l \]  
(3)

Where, \( p \) = force (kg); \( l \) = torque arm length (m); \( l = 0.81 \) m. From specifications, maximum Torque is 1.95 kgf-m (19.12 Nm)/2500 rpm.

4) Effective shaft power (kW)

\[ N_e = 2.\pi.n.T.10/60 \]  
(4)

Where : \( N_e \) = Effective shaft power; \( T = \) Torque (Nm); \( n = \) Crank shaft rotation (rpm).

\[ N_e = 2 \cdot \pi \cdot 2500 \cdot 19.12 \cdot 10/60; N_e = 5003066667 \text{ (kN/m/hours)}; N_e = 5003066667 \text{ (kW)} \]

5) Average effective pressure of \( P_e \) (kpa).

\[ P_e = N_e / (V.z.n.a).60.10^6 \]  
(5)

Where, \( V = \) volume step 270 (cm\(^3\) / cc); \( Z = \) Number 1 cylinder; \( n = \) rotation 2500 (rpm); \( a = \) number of cycles of rotation = 0.5.

\[ P_e = (50030.66667) / (270 .1.2500.0.5) .60.106 = 889.4340741\text{kpa} \]

6) The use of \( m_f \) hourly fuel (kG / Hour).

The use of fuel is expressed in kg / h; the amount of fuel used as much as 10 grams in seconds is:

\[ m_f = 10 / t.\rho b.3600 / 1000 \text{ (kg / h)} \]  
(6)

Where: \( t = \) fuel consumption time of 10 grams; \( \rho b = \) fuel type \( = 0.01875 \text{ kg / m}^3 \).

\[ m_f = 10 /10 x \rho b x 3600 / 1000 = 0.0675 \text{ (kg / h)} \]

7) Use of raw materials (Be).

The use of specific fuels is important for a motorbike, which is closely related to efficiency thermal motor. Specific fuel is defined as the fuel that is used hourly to produce

\[ B_e = m_f / N_e. \text{ (kG / h) / kW} \]  
(7)

Where, \( m_f = \) fuel consumption (kG / hour).

\[ N_e = \text{effective shaft power (kN.m / hour)} \]

\[ B_e = 0.0675 \text{ (kg / hour)} / 5.003066667 \text{ (kW)} = 0.013491725 \text{ kg / kWh} \]

8) The velocity of airflow passes through the venturi (vu).

\[ v_u = C \sqrt {2.g.\Delta h} \text{ (m / s)} \]  
(9)

Where, \( C = \) carbon composition in air 87; \( V_u = \) velocity of airflow rate passing through Venturi (m / s); \( G = \) earth gravity style (m / s\(^2\))=h = difference in water level on the manometer (mm).

\[ V_u = 87.\sqrt {2.9.8.0.001}= 12.18 \text{ m / s}. \]

9) The volumetric air flow rate is melwati venturi (mv).

\[ m_v = (\pi D^2) / 4 V_u x 106 \text{ (m}^3 / \text{s}) \]  
(10)

where, \( m_v = \) volumetric air mass flow rate (m\(^3\) / s); \( V_u = \) velocity of air flow; and \( D2 = \) diameter of the pipe venture (m).

\[ m_v = (\pi [0.02]^2) /4.12.18= 0.001138242 \text{ (m}^3 / \text{s}) \]

10) Vu air flow rate (kg / h).

\[ V_u = p_u.m_v.3600 \text{ (kG / h)} \]  
(11)

Where, \( V_u = \) air flow rate (kG / h); \( p_u = \) air density (kg / m\(^3\)); and \( M_v = \) volumetric air flow rate (m\(^3\) / s).

\[ V_u = 1,293.0,001138242 .3600= 5,29828921 \text{ (kG / h)}. \]
11) Comparison of fuel and air.
\[ \frac{F}{A} = \frac{mf}{Vu} \]  
(12)

Where, \(mf\) = fuel consumption (kg / h); and \(Vu\) = air mass flow rate (kg / h).
\[ \frac{F}{A} = 0.0675 / 5.29828921 = 0.012739961 \]

12) Ideal airflow rate (mid).
\[ mid = \frac{V1}{Z \times \rho_{u}} \]  
(13)

Where, \(mid\) = ideal air flow rate (kg / h); \(V1\) = step volume (m³); \(Z\) = number of cylinders; \(A = 0.5\) for a 4 step motor; and \(\rho_{u}\) = period of air (kg / m³).
\[ V1 = \pi / 4 \times D2 \times L = 3.14 / 4 \times 0.0772 \times 0.058 = 0.0002699 \, \text{m}^3 \]
\[ Mid = 0.0002699 \times 1.3600 \times 0.5 \times 1.293 = 0.628275509 \, \text{kg / h} \]

13) Volumetric efficiency.
\[ \eta_v = \frac{Vu}{mid} \times 100\% \]  
(14)

where, \(\eta_v\) = Volumetric efficiency (%); \(Vu\) = air flow rate (G / h); and \(mid\) = ideal air flow rate (g / h).
\[ \eta_v = (5.29828921) / (0.628275509) \times 100\% = 843.30666\% \]

14) Thermal efficiency ηt.
\[ \eta_t = \frac{Ne}{(mf \times LHV)} \times 100\% \]  
(15)

Where, \(\eta_t\) = thermal efficiency; \(Ne\) = effective shaft power (kN.m / hour); \(mf\) = usage of fuel material (kg / hour); and \(LHV\) = Heating value of LPG = 11,220 cal / kg = 46,966.92 (kJ / kg)
\[ \eta_t = 50030.66667 / (0.0675.46966.92) \times 100\% = 15.78\% \]

4. Calculation results and design drawings
The calculation result data from the design can be seen in Table 1.

| No. | Item | Unit | Results |
|-----|------|------|---------|
| 1   | Vbb  | cc   | 269.94737 |
| 2   | D    | mm   | 10.91085653 |
| 3   | T    | Nm   | 19.12 |
| 4   | Ne   | kW   | 5.003066667 |
| 5   | Pe   | kPa  | 889.4340741 |
| 6   | mf   | Kg/hours | 0.0675 |
| 7   | Be   | Kg/kNm | 0.013491725 |
| 8   | vu   | m/s  | 12.18 |
| 9   | mv   | m³/s | 0.001138242 |
| 10  | Vu   | Kg/hours | 5.29828921 |
| 11  | F/A  | Kg/hours | 0.012739961 |
| 12  | mid  | Kg/hours | 0.628275509 |
| 13  | ηv   | %    | 843.30666 |
| 14  | ηth  | %    | 15.78121499 |

Based on Table 1, we can get the design in Figure 8 to Figure 10, and Figure 11.
Figure 8. main case

Figure 9. Cover for gas fire
5. Conclusion and Suggestion

5.1. Conclusion
1) From the results of theoretical calculations the gas converter is obtained:
   • The diameter of 8 mm gas converter main hole.
   • 2500 rpm rotation.
   • Torque = 17.7 (Nm),
   • Effective power = 5.00306667 (kW).
   • Average effective pressure = 889,4340741 (kpa),
Fuel consumption = 0.0675 (kg / hour),
Specific fuel usage = 0.013491725 (gram.m / kN)
Fuel to air ratio = 0.012739961
Ideal airflow rate (mid). = 0.628275509 (kg / h)
Volumetric efficiency. Nv = 843,30666%
Thermal efficiency ƞt = 15.78%

2) The higher the torque on the crankshaft the more fuel consumption is used
3) To get validation data, it should be made a prototype, then tested, so that from the tests performed can be known that the level of braking is very influential on the amount of rotation on the crankshaft

5.2 Suggestion
1) Can be carried out the engine performance test with a capacity of 270 cc with a variety of rounds, so as to get maximum performance results
2) In testing for data collection, be careful to get the results we want
3) To obtain accurate results, maximum testing and validation should be held

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