Analyze Experiment For Vigas and Pertamax to Performance and Exhaust Gas Emission for Gasoline Motor 2000cc

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Abstract. The purpose and target for this analyze experiment is we get the performance variable from gasoline motor which used LGV for fuel and Pertamax, so can give knowledge to community if LGV can be using LGV for fuel to transportation industry and more economic. We used experiment method of engine gasoline motor with 2000 cc which is LGV and Pertamax for fuel. The experiment with static experiment tes above Dyno Test. The result is engine perform to subscribe Torque, power, fuel consumption. Beside the static test we did the Exhaust Steam Emission. The result is the used LGV with the commercial brand Vigas can increase the maximum Engine Power 20.86% and Average Power 14.1%, the maximum torque for Motor which is use LGV as fuel is smaller than Motor with Pertamax, the decrease is 0.94%. Using Vigas in Motor can increase the mileage until 6.9% compare with the Motor with pertamax. Air Fuel Ratio (AFR) for both of the fuels still below the standard, so still happen waste of fuel, specially in low compression. Using Vigas can reduce the Exhaust Steam Emission especially CO2.

Keywords: Gasoline motor, Vigas, Pertamax, Engine Perform, Emission.

1. Introduction
The vehicle which is used fuel in Indonesian always increase every year. In Traffic Indonesian Police Data Station noted, the total Vehicle in operation at 2013 is 104,211 million units, increased 11% from 2012 which is 94,299 million units. With the increased vehicle in operation, so fuel consumption or BBM that we called, follow being increase too. With big fuel consumption so we needed the fuel production more than now, but in the reality the oil in Indonesian since 2000 have been reduce, so in 2005, Indonesian be an Oil Importir. The high cost in crude oil, is making Governor should give the subsidy BBM. In 2013. As a planned, Head Governor would increase the point of subsidy BBM in APBN-2013 Changed 46 million kilo litre. So if the vehicle in operation will increase so the subsidy BBM will increase too which is the Governor should allocated every year. Beside energy source and that subsidy so another problem arises like environmental pollution from result Fuel combustion at Vehicle, such as CO2, PM10, and Pb. Data from Department of Transportation, The CO2 pollution in 2003 from Transportation system is 168 million ton, if linear with the incremental the vehicle operation so in 2007 will be approximately 324 million ton.

Growth the environment pollution will give the bad affect for the human healthy. The big sector is power plants and transportation, so need the special handling. The president ‘Susilo Bambang Yudhoyono’ in his speech at the meeting of Growing Country (Group of 77), promised
will reduce the emission 26% at 2020. For the action from he speech need clearly divide contribute reduce emission in every sector.

From transportation sector the main problem from the fuel, the used fuel give the big pollution. So need the change of fuel which is more adaptable in environment, one of is Liquid Petroleum Gas. Gas in here is means Liquid Gas for Vehicle (LGV). LGV had been choosen because still have more rest same with words in MP3EI (Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia – “ Masterplan quick and widely indonesian economic growth) with the rest natural gas is 165 TCF.

See from the big rest and the low price, resut pollution from LGV more small compare with Gasoline. So alternate to use LGV for change BBM is one of the choose which is should do by Governor.

Total Vehicle use Gas for fuel still increase since 1987 is approximately 300 units and in 2000 is 6633 units, but in 2001 had been decrease until 500 units at 2004, because the infrastructure is not ready enough. So the Governor at 2007 start socialize again Fuel Convert to LGV in Taxi, Bus and Bajaj with socialize and give the converter kit especially in DKI Jakarta but the result is not same with the willing so at 2012 Governor start socialize again Fuel Convert to LGV for 4 wheels vehicle.

2. Literature Review

2.1 Combustion Engine

Combustion Engine is one of calor engine, engine which is change from thermal energy to mechanism energy. Before being mechanism power the chemistry energy fuel had been changed to heat energy by fuel combustion with air. This combustion

What Happen inside calor engine itself and outside calor engine. This 4 steps combustion engine include in inside combustion engine category where the engine movement from the result combustion in cylinder. Engine 4 steps is called spark ignition engine too, is means the engine with the combine fuel – air ignition use spark fire from spark plugs.

2.2 Liquid Gas for Vehicle (LGV)

Liquid Gas for Vehicle (LGV) is gas fuel for vehicle use the spark ignition engine, with the combine propane C3 and butane C4. Some of literarure tell is LGV more compatible for vehicle with small cylinder volume like Bajaj, Taxi, public transportation, office operational car and personal car, because have big capacity tank for the same milleage compare with Oil Fuel (BBM). And have low pressure plus minus 15 kg/cm².

The benefit LGV compare with CNG such as :
- We have a lot of LGV in our country ,
- Quick help for Program using Gas in Transportation Sector,
- Decrease subsidy Premium BBM which is will change by LGV,
- Growth of SPBG LGV (Fuel Station LGV) more easy than SPBG CNG/BBG (Fuel Station CNG/BBG)
- More applicable at Areas that are not or have not been reached by gas pipelines,
- Low price for conversion kit LGV than CNG or BBG,
- The power of pressure in car and SPB LGV more low (maximum 15 bar than CNG or BBG (200 bar))

LGV already used since a long time ago for vehicle fuel in some country like United Stated of America, Mexico, Russia, Dutch, Germany, Ireland, Sweden, Finland, Italy, Indian, Turkey, Japan, China, Filipina, Thailand, Korea, Australia, and New Zealand. But in Indonesia LGV more fast develop being substitue energy BBM for Quick help Program blue sky and energy diversification beside CNG / BBG.
2.3 Combustion Theory

Combustion is a fast reaction between fuel and oxygen which is the heat and light is the result. One of the requirement can happen the perfect fuel combustion is the right oxygen for the source. The total oxygen ($O_2$) in free air until 20.9% from air. Solid fuel or liquid need to change to gas first before combustion in combustion chamber. Usually need heat for change liquid or solid to be gas. BBG will be fired in normal state if there is enough air.

The purpose from the good combustion is take out all the heat in combustion chamber. This is need to do with the 3 T Controlling combustion like:

a) High temperature for starter and maintain lightning fuel,
b) Turbulence or mixed between oxygen and good fuel, and

c) enough Time for the perfect combustion.

The used common fuel like natural gas and propan which is contain between carbon and hydrogen. The water vapour is the side product hydrogen combustion, which is can take heat from exhaust gas, and maybe can use for heat transfer continued. Natural gas contain more hydrogen and less carbon per kg compare oil fuel, so will more produce water vapour. And the affect, more heat will bring to waste when natural gas combustion. More or less fuel in some air combustion, will affect didn’t fire the fuel and will make Carbon monoxide. The quantity of specific oxygen need for perfect combustion with need the add some air for make sure the perfect combustion. Even that, more air will affect loose heat and efficiency.

2.4 Engine Performance

Engine Performance is the dimension for how big the efficiency form that engine, with the performance parameter contains as:

a) Torque,
b) Power, and

c) Specific Fuel Consumption.

For count the Torque need test bed at dynometer and shown as force times with length in Newton Meter (N.m). Combustion Type as shown in Figure 1.

![Figure 1](image)

**Figure 1.** (a) Perfect combustion, (b) Good combustion, (c) Bad Combustion (unperfect combustion)

Power is the big work for system result per times in Watt (SI) and horse power, horse-power; british-system. Rate of fuel consumption in engine per output power is called specific fuel consumption (sfc) and tell in fuel mass per power or kg/kWh, and this is the indicator too for economic rate from engine operational in use the fuel, more low the point sfc so need low cost and otherwise
2.5 Exhaust gas emissions

Exhaust gas emissions in conventional engine need more attention from all around the world. Because the affect form Exhaust Gas can destroy the environment. The affect from this can make the glass house which is not human wish.

In Conventional engine the output Exhaust gas emissions is HC, CO, CO₂, O₂, NOx and other particulars. Many experiment had been doing for reduce the content Exhaust gas emissions conventional engine itself. Output Exhaust gas emissions from the unperfect combustion in combustion chamber, where is only half fuel being reacting with the oxygen specially near the wall of cylinder between Torak and cylinder, commonly the reason is low fire and low combustion temperature. If the combustion temperature is low and spark ignition is low too and surrounding is wide with low temperature combustion chamber, this condition will meet at the new motorcycle starting or in idle, natural condition the motorcycle will give output Exhaust gas emissions more than usuallly and can give the bad affect for human healthy.

Some parameter from Exhaust gas emissions motorcycle like this:

- **Hydrocarbon (HC)** is Exhaust Gas from the fuel where didn’t fire and counting in part per million (ppm), light mass molecuł, unseen. Because have the characteristic can Binds hemoglobin so dangerous for health. If the Hydrocarbon is low so will be better.

- **Carbon Dioxide (CO₂)** is the element which is indicate combustion heat and count in presentage, The ideal around (11 – 16) %. Carbon Dioxide have unseen light mass and not dangerous, but main potential to Glass House, floral and Sea community As well as peat plants.

- **Carbon Monoxide (CO)** is Gas from Reaction the unperfect combustion, light mass, unseen, dangerous for healthy like Acute Respiratory Infections – “Infeksi Saluran Pernapasan Akut (ISPA)” , the cancer, and will reduce the Intellience. The ideal (0.3 – 3) %.

- **Oxygen (O₂)** is indicator from Combustion Quality, The ideal less from 2%, if smaller so the combustion was perfect, and didn’t dangerous for healthy.

- **Nitrogen Oxide (NOx)** is Exhaust gas emissions from Oxidized nitrogen because the pressure and heat when compression. This Gas is toxic so dangerous frо healthy and environment.

- **Particulate**
  - This Particulate will Wreathed in the lining cells of the lungs so the function will broken and will be black.

Method for reduce the bad affect from Exhaust gas emissions to combustion quality, healthy, and environment is :

- Revise the design and combustion system
- Increase the fuel quality.

One of the method can be use is use the Gas Fuel like LGV.

2.6 Previous Experiment

Using LGV in gasoline motorcycle without doing adjustment in injection pressure and injection timing give Carbon Monoxide, Hydro Carbon, More oxygen than Premium Fuel, but lamda levels and Carbon Dioxide more high [1].

Using the dual fuel (CNG-Solar) give the engine power same with solar engine. Beside that with dual fuel (CNG-Solar) give reduce smoke, but the hydrocarbon (HC) and NOx being increase than engine with 100% Diesel. [2], others experiment tell using CNG direct injection system with Combustion controlling, reduce the orifis nozzle dimentional and injection corner will help quality of
fuel mixed. This will give the combustion efficiency more high even knocking because there is rich mixed air – fuel in some areas in Combustion Chamber [3].

3. Experimental Method

The experiment of this research is engine with the cylinder capacity is 2000cc with carburator. After that the engine installed converter kit so this car have dual fuel system its means can use Liquid Fuel or Elpiji Fuel. Do the Engine Tune Up when the optimum condition for both of fuel, so while changing form one fuel to other fuel can run smooth.

The next step is Performance Trial and Exhaust gas emissions, Performance Trial above Static Dyno, and trial fuel consumption with the road test. The experiment flow as shown Figure 2.

![Figure 2. Flow of the experiment](image)

Engine specification can be found in table 1, below:

| Table 1. Engine Specification |
|--------------------------------|
| Type                       | 4 cylinder (in line),SOHC. |
| Cylinder Volume            | 2000 cc                    |
| Power                      | 102 HP/136 PS/5000 rpm     |
| Torque                     | 200 Nm/18.6 kgm/4000 rpm   |
| Cooling System             | Radiator                   |
| Weight                     | 1,480kg                    |

3.1. Installment Converter Kit

When we installing the Converter Kit for Dual Fuel in Vehicle. We can see as as shown at Figure 3. When we use Common Fuel, the flow will direct to solenoid and goes to Fuel pump, through in
Carburator. But when we are going to use Vigas then the solenoid will off and the flow will go to Reducer. And through in to carburator by mixer first.

The Reducer can reduce the pressure so the vehicle use Vigas is not in high compression.

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**Figure 3.** Installment Dual Fuel system in Vehicle

3.2. Measuring instrument

Measuring Instrument already calibrate, each used type as follow:
- Dynometer Static
- Emissions measurement tools.
- Digital Stopwatch
- Buret / Measuring Instrument solar fuel consumption with the capacity 30ml

4. Results and Discussion

4.1 Power

Follow the result above Dyno Static Test, trend of Maximum Power in motorcycle use Vigas is 42.3 HP with radius 4782 rpm, even the motorcycle with use Pertamax give the Maximum Power is 35 HP with radius 4211 rpm. So using Vigas can increase Maximum Power 20.86%, and average using Vigas can increase Power 14.1%.
4.2 Torque of engine
Average happened Torque in motorcycle use Vigas more big than motorcycle use Pertamax because the combustion more stable dan radius more high so didn’t knocking. The average increase torque 7.57%, but the maximum torque in Vigas Motorcycle smaller than Pertamax Motorcycle, the result show torque decreased 0.94%, and torque trend as shown at Figure 5.

4.3 Fuel Consumption
Measuring of Fuel Consumption as shown at below Table 2
Table 2. Fuel Consumption

| Step of Measurement | Vigas (km/l) | Pertamax 92 (km/l) |
|---------------------|-------------|-------------------|
| 1                   | 7.5         | 7.3               |
| 2                   | 7.8         | 7.2               |
| 3                   | 7.7         | 7.4               |
| 4                   | 7.9         | 7.2               |
| 5                   | 7.8         | 7.3               |
| 6                   | 7.8         | 7.2               |
| 7                   | 7.6         | 7               |
| 8                   | 7.8         | 7.2               |
| 9                   | 7.9         | 7.2               |
| 10                  | 7.5         | 7.3               |
| Total               | 77.3        | 72.3              |
| Average             | 7.73        | 7.23              |
| Incremental         | 6.9         |                   |

As shown in table 2, Vigas has more distance than Pertamax. Distance average can reach by Vigas motorcycle 7.73 km/l, even Pertamax motorcycle 7.23 km/l, so if compare by increase distance Vigas Motorcycle is 6.9%. It can received because in Vigas Motorcycle when combustion can direct inject to Carburator without smoke.

The result shows Air Fuel Ratio (AFR) parameters for both of them, still below from the standard, that its means fat Combustion (too rich mixture), or still waste fuel especially when low rpm of engine.

4.4. Emission

The experiment result for Exhaust gas emissions as shown at Table 3 [7].

| Parameter | Vigas (g/km) | Pertamax92 (g/km) | Verge according to LH 04/2009 |
|-----------|--------------|-------------------|-------------------------------|
| CO        | 0.95         | 0.12              | 2.2                           |
| HC        | 0.01         | 0.006             | -                             |
| NOx       | 0            | 0.027             | -                             |
| CO₂       | 182.5        | 206.8             | -                             |

As shown on table 3, using Vigas at Motorcycle can reduce effect of Glass House CO₂ 13.3% compare than the engine using Pertamax 92.

5. Conclusion

Follow the experimental result we get some points like this:

- Using Liquid Gas For Vehicle (LGV) with Commercial brand Vigas can increase Maximum Engine Power 20.86% and Average Power 14.1%.
- Maximum Torque from Vigas Motorcycle smaller than Pertamax Motorcycle, reduce around 0.94%.
- Using Vigas at motorcycle can increase distance around 6.9% compare than motor with Pertamax.
• Air Fuel Ratio (AFR) for both of this fuel still below the standard, so it happens waste of fuel, especially in low radius.
• Using Vigas at Vehicle can reduce Exhaust gas emissions especially CO₂.

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