



Evaluation of System Reliability: CNG Kit

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ABSTRACT

Rising petrol prices might be a reason for worry since a rise in the price of petrol will increase the price of every day today products. But, in the world of technology, there is a way out for every aspect. The alternative to petrol i.e., CNG (Compact natural gas) is an obvious choice for many people. Most people get these CNG kits to fit in their cars, although there are many disadvantages also which are coming into the limelight apart from their advantages. This paper focuses on analysing the positive and negative effects of fitting a CNG kit in a car. Also, we will evaluate the reliability of a CNG kit taking into consideration its components, their arrangement and working.

KEYWORDS : CNG, Reliability, Bootspace, Ignition, Carburetor.

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INTRODUCTION

CNG is not only the most fuel-efficient resource used in vehicles, but it is also environment friendly and most importantly gets gel with all kinds of motors of the vehicle. Any kind of four-wheeler can have the CNG kit installed in them.

CNG Kit can be said as an assembly of such components which are necessary to run a vehicle. Since a CNG kit is of many types which is there in the market but some of the components are universal in all the types of kits regardless of the type of vehicle, one is using.

These components are-

- Storage cylinder
- pressure gauge,
- high-pressure tube pressure regulator,
- high-pressure tube/fittings,
- change over switch,
- refuelling receptacle and air fuel mixer



ADVANTAGES OF CNG KIT

1. **Environment Friendly**- Since burning of CNG does not produce very less hydrocarbon than LPG and Petrol, therefore it is a clean fuel.
2. **Economic**- CNG is Cheaper than petrol.
3. **Clean Engine**- CNG does not cause harm to Engine as compared to LPG.
4. **Ease of Use and Flexibility**- Since the vehicle can run on both petrol and CNG as per comfort.
5. **Lubrication**- It requires less Lubrication.

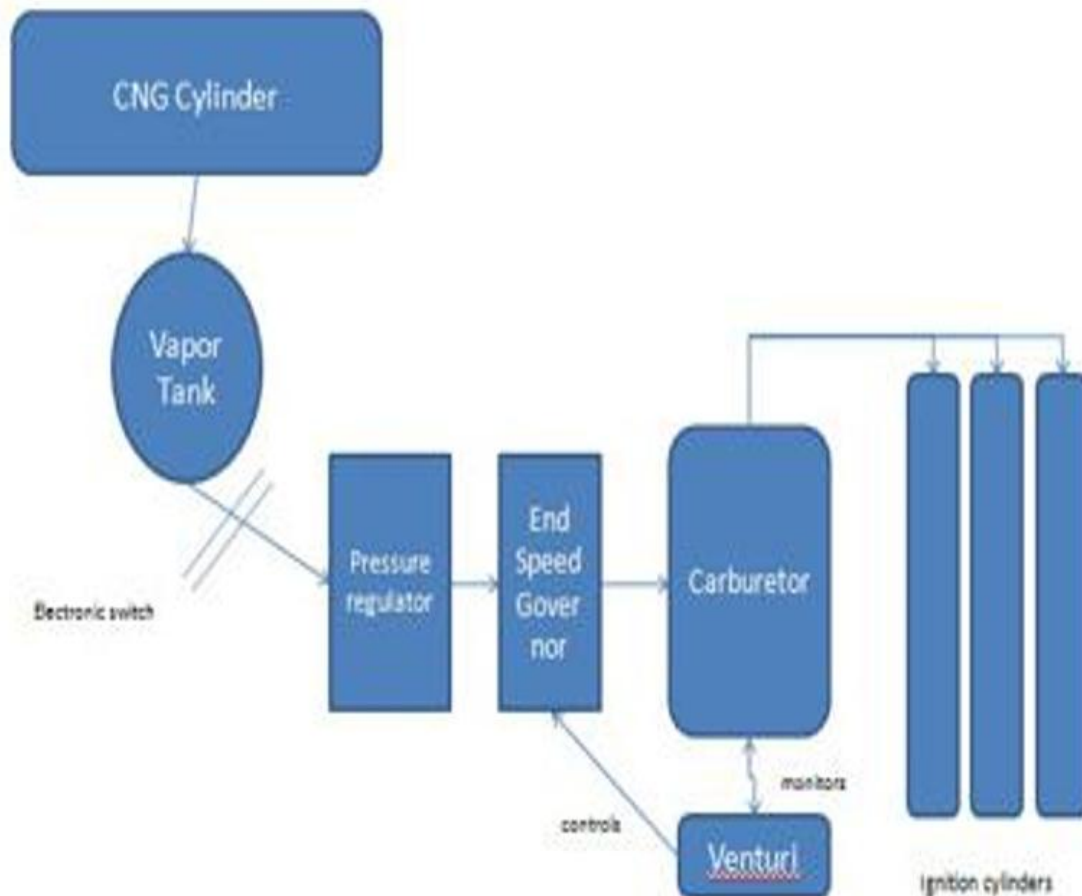
DISADVANTAGES OF CNG KIT

1. **Decreased Boot Space**- This is the first and foremost disadvantage of having a CNG kit as one is left with no boot space.
2. **Decreased Power Output**- Switching to CNG will drop the power of the engine esp. during summer.
3. **Frequent Service Intervals**- Spark Plugs and engine wear out more as a result the engine becomes dry.
4. **Decreased Resale Value**- There would be a price drop in the resale of a CNG-fitted car as compared to the petrol one.
5. **Long Wait For Refuelling**- Since the number of CNG-fitted vehicles has increased, therefore there would be a longer waiting time for refuelling.
6. **Hydrotesting**- Cylinders need to be hydro tested every 3 years.
7. **Lack of Knowledge**- Knowledge of Engine oil, the HP and LP filters is a must.

STRUCTURE OF CNG KIT

A CNG Kit can be broadly structured into the following subsystems i.e., CNG Cylinder, Vapour Tank, Pressure Regulator, End Speed Governor, Carburetor, Venturi and Ignition Cylinders.





- **CNG Cylinder** is the high-pressure Cylinder used for storing the CNG at a high pressure of about 200 bar.
- **Vapour Tank** is a PVC bag used to covering bag for the gas outlet valve.
- **Pressure Regulators** are used for reducing or minimizing the pressure of the gas.
- **Carburetor** prompts the correct ratio of CNG and air prior it goes into the ignition chambers.
- **Ignition System** ensures a better combustion by the introduction of spark plugs instead of injectors.
- **Venturi** is used to meter the gas flow proportion to the engine speed.

WORKING MODULE

A CNG Engine works in almost a similar way as a Petrol Engine works. In a gasoline engine, a mixture of gasoline droplets and air is produced and then fed into the intake manifold of the vehicle engine. A spark is then created, causing a controlled explosion that powers the engine. Similarly with a CNG engine. A connection is made and introduced into the carburetor where the CNG vapours are mixed with the air and then fed into the combustion chamber.

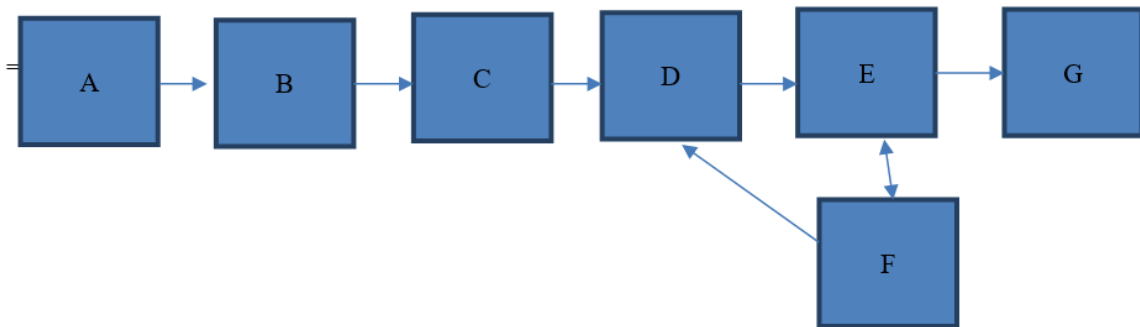
While CNG is commonly used in petrol engines, but nowadays it can also be used with diesel engines with suitable modifications and changes, whereas LPG can be used for petrol engines only.

Any machine or system is made up of parts or components combines or connected in a particular manner so as to enable a system as a whole. This combination could be of any type viz., serial, parallel or the parts/ components may work independently.

If we assume the reliability variable of different components of CNG Kit as

- **CNG Cylinder as A,**
- **Vapour Tank as B**
- **Pressure regulator as C**
- **End Speed Governor as D**
- **Carburetor as E**
- **Venturi as F**
- **Ignition Cylinders as G**

Then the circuit would be as



CALCUATIONS

$$\text{System Reliability would be} = SR_a * SR_b * SR_c * SR_d * SR_e * SR_g - SR_a * SR_b * SR_c * SR_d * SR_e * SR_f * SR_g + SR_a * SR_b * SR_c * SR_d * SR_e * SR_f * SR_d * SR_e * SR_g$$

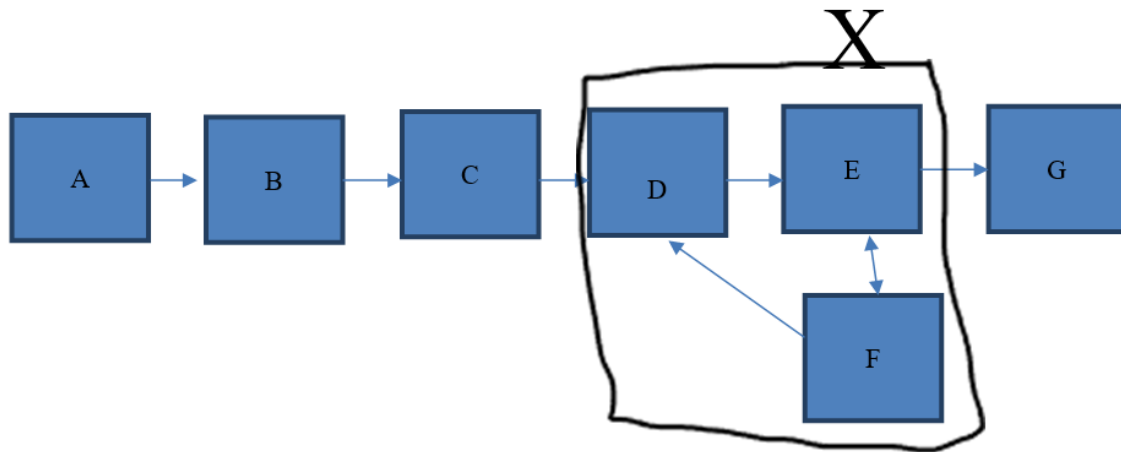
If we assume the reliability of each of the components as 99% i.e., 0.99, then the reliability of the system as a whole would be

$$0.941480 - 0.932065 + .913517 = 0.922932$$

System Reliability =

$$+e^{-1.5t} * e^{-2t} * e^{-2.5t} * e^{-0.8t} * e^{-1.9t} * e^{-1.5t} - e^{-1.5t} * e^{-2t} * e^{-2.5t} * e^{-0.8t} * e^{-1.9t} * e^{-0.7t} * e^{-1.5t} + e^{-1.5t} * e^{-2t} * e^{-2.5t} * e^{-0.8t} * e^{-1.9t} * e^{-0.7t} * e^{-0.8t} * e^{-1.9t} * e^{-1.5t}$$





This shows that the reliability of a system will always be less than the reliability of its components taken individually.

If we assume the components D,E and F as one component X(since these three form a cycle), then the reliability of the system (in series) would be given by:

$$SR = (1-\lambda_1) * (1-\lambda_2) * (1-\lambda_3) * \dots * (1-\lambda_x)$$

Where,

R=System Reliability

$\lambda_1 - \lambda_x$ = Failure Rates of each component of the system.

Let us assume the failure rate of each of the components of CNG kit as

A=25%,

B=30%,

C=15%,

X(D,E,F)=35%,

G=20%

$$R = (1-0.25) * (1-0.30) * (1-0.15) * (1-0.35) * (1-0.20)$$

$$= 23.21\%$$

CONCLUSION

Using a CNG car is now a well-known way to save money on fuel. The huge difference compared to the gasoline option justifies this, and it becomes even more urgent as gasoline prices continue to trend upward. However, CNG is very environmentally friendly as a fuel, and in practice, the mental hurdles of using CNG are not really significant. Hence, CNG is the way to go for those who care for environment but one has to compromise with the system durability and lifespan.



Though there are many advantages of CNG Kit, still there are many doubts and questions raised on the reliability and results of the same.

Here, we concluded that as the time increases from 0 to 1, the Reliability of the system decreases, i.e., Reliability of a system $R(t)$ is inversely proportional to time (t). Moreover, Reliability of a system $R(t)$, is always less than the reliability of its individual components i.e., $R(t) < \{R_a, R_b, \dots, R_n\}$, where n is the total number of components of the system.

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