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Design and Review of Fuel Vaporization System

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ABSTRACT

Fuel vaporization system of a SI (spark ignition) internal combustion engine, is the system by which liquid fuel (petrol/gasoline) is heated to partially vaporize the liquid fuel prior to being inducted into the combustion chamber of the engine. In this paper we are addressing the problem of initial fuel delivery. Taking principles of surface chemistry into consideration atomization results in more efficient combustion of the fuel. With the help of some additional fittings, the partially vaporized fuel is carried to the fuel induction system and then carried in the usual manner to the combustion chamber. We found the temperature and area dependence of vaporization system. No special heating system is required as the heat of exhaust gases is utilized for heating the fuel, which is otherwise wasted and controlled by ECU. With such kind of setup on can run engine partially or fully on fuel fumes.

Keywords- ***Engine, Fuel Induction, Carburetor, Fuel Vaporizing System, Efficiency.***

INTRODUCTION

Various devices have been developed to improve internal combustion and reduce emissions in internal combustion engines. These devices include those that operate by physically changing the form of the fuel from liquid to vaporized fuel. Studies have shown that fuel in the form of gas has been found to be more efficient and cleaner burning than liquid fuel. The systems that have been suggested for heating and vaporizing the fuel are all very complicated utilizing electrical heaters and other complex systems. Of these complex systems, one is using exhaust gases or using heated engine coolant. Some systems imply the use of the vehicle's heating and cooling system while some others are using electrically heated plugs.

Typically, a spark ignition, internal combustion engine includes an air intake system which conducts combustion air into the cylinders or combustion chambers of the engine. Liquid fuel (e.g., gasoline) is mixed with the combustion air in proper proportion either by means of a carburetor or by fuel injection.

Many developments in this field are disclosing heaters disposed in the intake manifold of the engine downstream from carburetor for heating both the combustion air flowing through the cylinders and the liquid fuel drawn therein. Thus, these prior systems required relatively large capacity heaters. One of the patent discloses an electrical control circuit for heating automotive fuel during cold start conditions so as to ensure that the liquid fuel is readier atomized when injected into the intake system. Some earlier works disclose fuel induction systems which include a vacuum chamber in which fuel vaporizer is provided, which initially is heated by an electric coil. After the engine comes up to temperature, is heated by means of air surrounding the fuel line which in turn has been heated by the exhaust gases of the engine. The vaporized fuel is discharged into the vacuum chamber and then is drawn into the intake manifold. Additionally, a vacuum feedback system is provided which controls the supply of fuel to the vaporizer. A particular patent discloses a fuel vaporization system in which fuel is heated by means of a magnetron microwave heater.

Our objective is to design a simple system for heating and vaporizing a portion of the fuel before it is passed into the combustion system. A safe and energy efficient method for pre-heating and vaporizing a portion of the fuel which can easily be added to any existing vehicle since it does not have to be directly connected to any other vehicle heat source. The provision of such a system which is feasible and economical to manufacture, which is relatively easy to maintain, and which may be readily repaired, if repair is required.

EFFECT OF FUEL VAPORIZATION SYSTEM

Combustion of a liquid fuel in an oxidizing atmosphere actually happens in the gaseous state. Therefore, a liquid fuel will normally catch fire only above a certain temperature (known as Flash Point) at which it can form an ignitable mixture with air. All liquid fuels have a specific vapour pressure, which increases with increase in the temperature. Hence the concentration of the combustible vapour which is necessary to sustain combustion is dependent on the temperature. The fuel vaporization system is designed to attain and sustain required high temperature so as to initiate and accomplish the process of more efficient combustion.

Table:1 Properties of Fuel

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Fuels	Vapour Pressure (at 20°C)	Flash Point	Auto-ignition temperature
Crude Oil	5-20 kPa	230 K	700 K
Gasoline	50-90 kPa	230 K	553 K
Diesel	1-10 kPa	323 K	529 K
Jet Fuel	>1 kPa	311 K	483 K
Kerosene	0.04 kPa	311K	473K

From the above data we can see that the vapour pressure, flash point, auto-ignition temperature depends upon fuel to fuel and it depends upon the octane number of fuel as well.

PROBLEM DEFINITION

A lot of developments have been made on the fuel vaporization system which would result in more efficient combustion of fuel in internal combustion engine. Most of the developments made are usually complex as they are either using an external energy source or some extra device. We have plan to developed such system which satisfactorily answers the question of vaporizing the fuel initially during cold start. No explanation has been given prior which addresses this issue through some feasible solution. Adding some extra instrument or device and providing an additional energy source will pose several challenges. Our motive is to make the combustion of fuel more efficient thereby increasing the mileage and performance of the vehicle. To achieve this task through some additional energy source makes no sense. We need to propose a system in which one has to define a proper system through which one can deliver the fuel in the initial state.

CONDUCTED EXPERIMENT

Objective: Study the evaporation rate of liquid fuel.

Aim:

1. To determine the dependence of temperature with evaporation rate.
2. To determine the dependence of surface area with evaporation rate.

Theory: Fuel Vaporization is an effect by which liquid fuel is heated partially to change the state of the fluid from liquid to gaseous. Whereas evaporation is a type of vaporization which occurs from the surface of a liquid into a gaseous phase that is not saturated with the evaporating surface.

Temperature	Time	Amount of Fuel	Evaporated Fuel
50°C	4 min	10 ml	1.2 ml
60°C	4 min	10 ml	1.2 ml
70°C	4 min	10 ml	1.4 ml

Required Utilities:

1. Liquid fuel.
2. Beaker of different diameters.
3. Electric Heater.
4. Thermometer.

PROCEDURE:

1. 10 ml fuel is measured using a measuring cylinder and left aside.
2. A beaker is placed on heater to get desired temperature. Temperature is monitored using a thermometer.
3. After reaching the desired temperature of 50°C liquid fuel is poured into the beaker and again placed on the heater to maintain the temperature.
4. After maintaining 50°C for 4 minutes the fuel is again poured into the measuring cylinder to remeasure the amount of fuel. In this way we can find out the volume of evaporated fuel.
5. Similarly, following the above procedure for 60°C and 70°C and noting down the respective observations.

Temperature	Time	Amount of Fuel	Evaporated Fuel
50°C	4 min	10 ml	1.4 ml
60°C	4 min	10 ml	1.6 ml
70°C	4 min	10 ml	2.2 ml

6. Following the above mentioned procedures and performing the experiment with different beakers of different diameters – 4.3 cm, 6.2 cm and 7.9 cm.

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OBSERVATION:

For Beaker of Diameter 7.9cm

Temperature	Time(min)	Amount of Fuel(ml)	Evaporated Fuel(ml)
50°C	4 min	10 ml	2.2 ml
60°C	4 min	10 ml	2.2 ml
70°C	4 min	10 ml	2.9 ml

For Beaker of Diameter 6.2cm

For Beaker of Diameter 4.3cm

The reference engine used for calculations:

Honda GX 35 mini 4 stroke engine (air cooled)

Net power: 1.3 HP @ 7000 rpm

Fuel Consumption at net power = 0.71 l/hr @ 7000 rpm

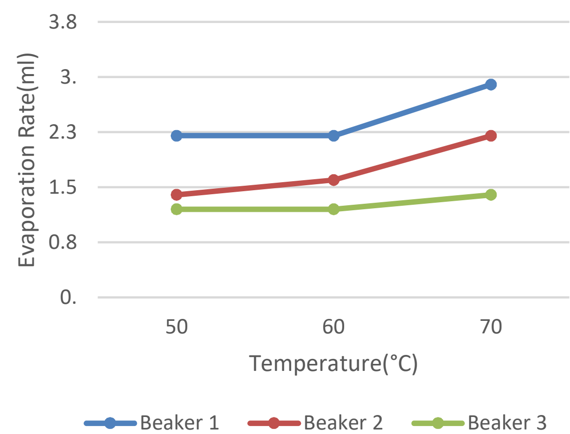
= 0.5467 kg/hr

CALCULATIONS :

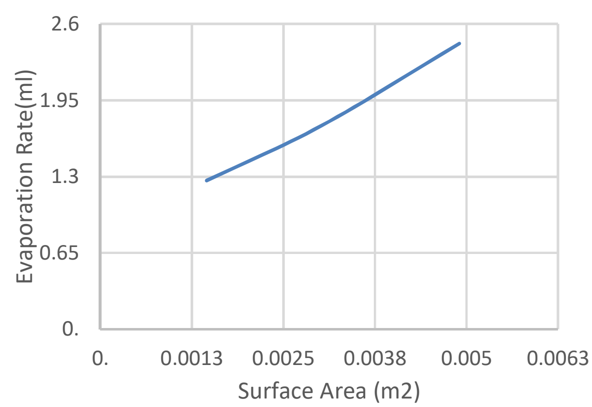
For Beaker of diameter 7.9 cm, At 70^0 C
Fuel evaporated in 4 min = 2.9 ml
Fuel evaporated per hour = 43.5 ml
= 0.033495 kg
Percentage of fuel demand which can be fulfilled by fumes 0.033495/0.5467 X 100%
=6.27%

For Beaker of diameter 6.2 cm, At 70^0 C
Fuel evaporated in 4 min = 2.2 ml
Fuel evaporated per hour = 33 ml
= 0.02541 kg
Percentage of fuel demand which can be fulfilled by fumes 0.02451/0.5467 X 100%
=4.648%

For Beaker of diameter 4.3 cm, At 70^0 C
Fuel evaporated in 4 min = 1.4 ml
Fuel evaporated per hour =21 ml
= 0.01617 kg
Percentage of fuel demand which can be fulfilled by fumes 0.01617/0.5467 X 100%
=2.96%



Graph 1: Dependence of temperature with evaporation rate



Graph 2: Dependence of surface are with evaporation rate

EXPERIMENT

A. Carburetor Working

The carburetor is mounted on the top of the intake manifold and has both air and fuel inlets. The air inlet is sometimes a duct attached to the carburetor or can be just an air filter housing mounted directly on top of the carburetor. The fuel is supplied by a fuel line coming from the fuel tank. The carburetor is responsible for atomizing fuel and spraying it into the air that enters the intake manifold.

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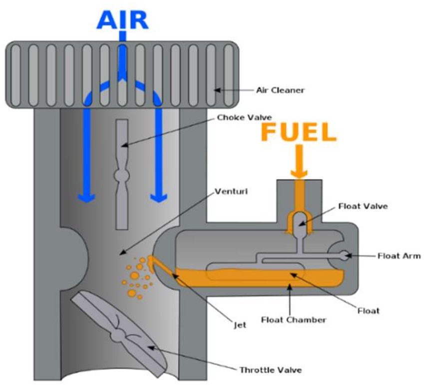
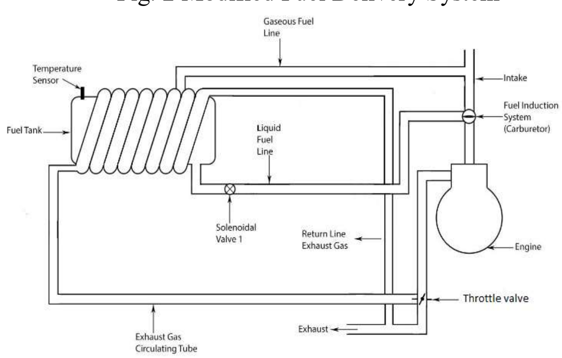


Fig. 1 Basic Carburetor Cross-section

B. Basic Working of Proposed System

The fuel delivery system will have everything same as conventional system except that the exhaust gas will be directed through a pipe that will work as a heat exchanger to provide as a source of heat for the fuel to vaporize.

Fig. 2 Modified Fuel Delivery System



1. The exhaust gas from the engine is used to heat the fuel tank.
2. The exhaust gas which will heat up the fuel tank will be redirected to the main exhaust outlet which will eventually move out to the surroundings.
3. While doing so we need the fuel should not be heated beyond 70°C as we have to protect the fuel from reaching the flash point.
4. This mission will be accomplished by using a cut off temperature sensing valve which, when the required temperature achieved will send a signal to ECU which in turn will close the throttle valve as shown in the figure. This ensures that the apparatus works properly without any risks.
5. We solve the problem of initial fuel delivery by providing two delivery lines to the fuel induction system of the engine. Namely liquid fuel delivery line and gaseous fuel delivery line.
6. The fuel flows through the liquid fuel delivery line initially until enough fumes are generated so that the engine can run 100% on fumes on full throttle. Once enough fumes are generated we close the liquid fuel delivery line with the solenoid valve
7. With such kind of set-up, one can run the engine partially on the vapor or fully on fuel fumes thus resulting in much more efficiency.
8. The fuel injected along with the inlet air is controlled by a butterfly valve. The Fuel vapors are injected into the air stream which is entering the engine via the intake valve.
9. The mixture injected will be more homogeneous and thus result in more efficient combustion.

Note

1. Materials which can be used for the Exhaust Gas Circulation Tube and fittings – Type 326Ti Stainless Steel and Type 439 stainless steel.
2. High temperature gas valve- Stainless steel throttle valve made up of Steel A276 Type 316 + Ni-Cr alloy which can withstand temperatures of up to 500°C.
3. Solenoid valve is used in fuel delivery line.

C. Heating Fuel Tank

The fuel tank will be heated by the 'Exhaust gas circulation tube' tube which will be controlled by a throttle valve which is High temperature gas valve, although the exhaust gas temperature after crossing the catalytic convertor is around 200°C and the valve will be used to monitor and regulate the temperature of the fuel tank.

CONCLUSION

From our study & research we found that the efficiency of the engine can be increased via fuel vaporization system.

Experiments conducted above gave us the inference that the vaporization of fuel is dependent on the surface area of the tank showing linear relationship. From the theoretical calculations we found that a Honda GX 35 engine (1.3 HP) we can meet 6.127% of fuel demand if the surface area of fuel tank is 49.01 cm^2 and 100% of fuel demand if the surface area of fuel tank is 1244.10 cm^2.

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