INVESTIGATION ON EVAPORATIVE EMISSION FROM A GASOLINE POLYCARBONATE FUEL TANK

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Abstract

It is estimated that about 15 to 20 percent of the vehicle hydrocarbon (HC) emission were due to evaporation of fuel. Hence a need was felt to understand the extent of evaporative emission from gasoline fuel system. A polycarbonate fuel tank that is predominantly used in two wheeled vehicles is considered for study. Emission can surface to atmosphere in three modes; diffusion through fuel tank wall, escaping through vent in tank and when fuel tank cap is opened for refueling. The average temperature condition which prevails in south India which is in the range of 27^o C to 34^{o}C was considered. From which temperatures which were at proximity to peak high and low day time were chosen. The complete set up was placed in open atmosphere to replicate the working environment. The emission constituents and its levels were measured by conducting the test particularly for averaged out day time high and low temperature condition. Further diffusion test was conducted within a range of 34^{o}C to 36^{o}C, this temperature is considered to be range of maximum temperature which prevails in south India. From which a temperature was chosen and the test was conducted. This comparative study gives an indication of emission and its quantity from the fuel tank at the ambient temperature.

Keywords: *Evaporative Emission, Fuel Tank, HC Emission*

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1. INTRODUCTION

Emission from the tail pipe is always considered the major cause of concern, where by evaporative emissions are ignored. Diurnal emissions are a type of evaporative emission that originate from the vehicle fuel tank as the fuel vaporizes due to the daily ambient temperature variations [1]. Two wheeled vehicles occupy a larger space on Indian roads [2].Diurnal emissions are prevalent in the polycarbonate fuel tank which is commonly used in two wheeled vehicles. These were not sensitive to fuel tank capacity or vehicle refuelling system geometry or configuration [3].Hence it is a surface phenomenon. This emission has become a cause for concern as fuel can evaporate from the tank which goes in to the atmosphere and reacts with air to form harmful pollutants. Under Indian condition where the vehicle is commonly parked in an open space are more prone to this type of Diurnal emission. Emission rate increases with both surrounding temperature and fuel volatility [4]. Evaporation led to permeation of fuel through fuel tank walls and escaped through vent which reached the outer environment. Fuel can also escape to atmosphere, when the fuel tank cap is open for refuelling. When the dispensed fuel temperature was higher than the fuel tank temperature, vapour growth occurred [3].

Permeation can be checked by heating up the fuel from 15.6^{o}C to 28.9^{o}C (60–84 F) within a period of 1 h as prescribed by the United States Environmental Protection Agency (US Environmental Protection Agency, 1991, 1992, 1994) and CONCAVE (CONCAWE, 1987, 1988, 1990)[1]. The tests were performed using a mini-SHED, which is a structure designed to enclose a fuel-tank instead of the entire vehicle [5]. Experiments were performed such that the quantities of emission constituents were measured and a comparative study was done for various temperatures.

2. EXPERIMENTATION PROCEDURE

During this experiment, a poly carbonate fuel tank of capacity 5000cc was used. The maximum exposed surface area to air, in tank, occurred at capacity of 1000cc of gasoline. Hence 1000cc of fuel was considered for study.

2.1 Permeability Test of Fuel Tank

The fuel tank was placed in a mini SHED, at ambient condition. As shown in Fig: 1 emission gas analyzer probe was introduced in the sealed chamber in order to measure the constituents of emission and its quantity. This tank had a capacity to retain heat, there by accelerated the experimental condition. Initially the ambient temperature and temperature inside the air-tight tank is measured. The whole set up is kept in an open environment and the constituents are measured in time steps of 10 minutes. This emission variation along with time is plotted and that gives a clear picture of time varying scale of emission constituents.

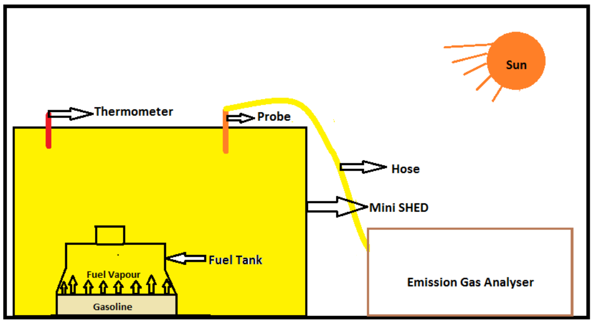

Fig: 1 Permeability Test on Fuel Tank

2.2 Break out Fuel Test

The ambient temperature is noted, as it must be correlated with the averaged maximum or minimum day time temperature which prevails in south India (11.0183° N, 76.9725° E). In this test, the fuel tank was placed in the open environment for 30 minutes as shown in Fig: 2, in order to reach a thermodynamic equilibrium. Hence this in turn will increase the temperature of fuel inside. After 30 minutes of time the fuel tank cap is open and thus the fuel escaped was measured with emission gas analyzer. The analyzer indicates the value of the emission constituents which escaped while opening cap of the fuel tank.The probe was kept at a distance of 1 cm from the opening of the fuel tank. The dilute fuel vapour will be sensed by the probe which indicates the actual condition of the fuel in atmosphere.

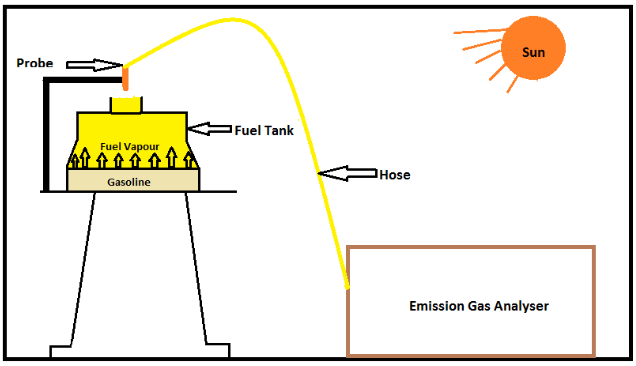

Fig: 2 Break Out Fuel Test

3. RESULT AND DISCUSSION

3.1 Break-Out Fuel Test at 29.8°c

The maximum surface area was considered, for the ideal case. The fuel had a surface area of 263.4 cm2 which is in contact with air. HC vapour's presence was more when in compare with NO, which is indicated as in Fig 3 and 4.

During the initial 30 minutes of tank's exposure to environment. The ambient temperature increased the kinetic energy of the top layer of liquid fuel particles such that it escaped the liquid boundary and attained gaseous state. After which the temperature of the liquid fuel reduced as the heat was carried away by the gaseous particles. This heated the surrounding air of gaseous particles thereby made nitrogen and oxygen which were the components of air present in tank, to react with each other. Thus this produced NO.

When the tank cap was opened after 30 minutes, the vapour pressure of the fuel tried to equalize with atmospheric pressure. Hence vapour in the form of HC and NO shot up. This dipped as it matched with atmospheric pressure.

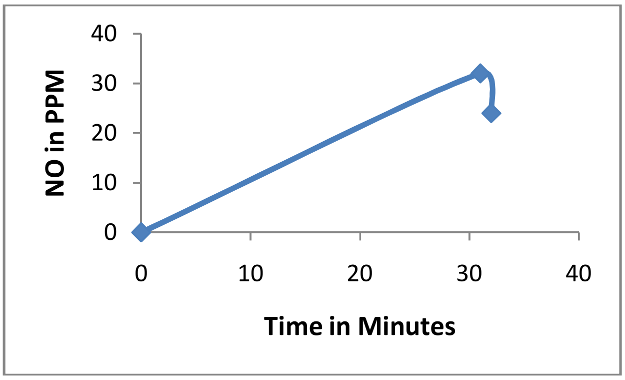

Fig: 3 NO Vs Time at 29.8°C

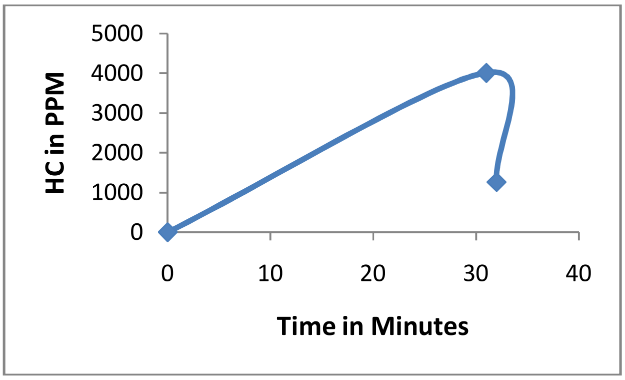

Fig: 4 HC Vs Time at 29.8°C

3.2 Break-Out Fuel Test at 34°c

The kinetic energy of top level of fluid increased with the increase in ambient temperature and hence the occurrence of NO and HC vapours were high at 34° C. This vapour accumulated inside the tank in the initial 30 minutes of experiment, when the fuel tank was kept in open space. After 30 minutes the fuel tank cap is opened to allow the fuel vapour to escape out of the tank, during which the measurement of the emission is made, which gave a plot as in the Fig 5 and 6.From both the breakout fuel test with different ambient temperatures showed noticeable increase in the emissions level.

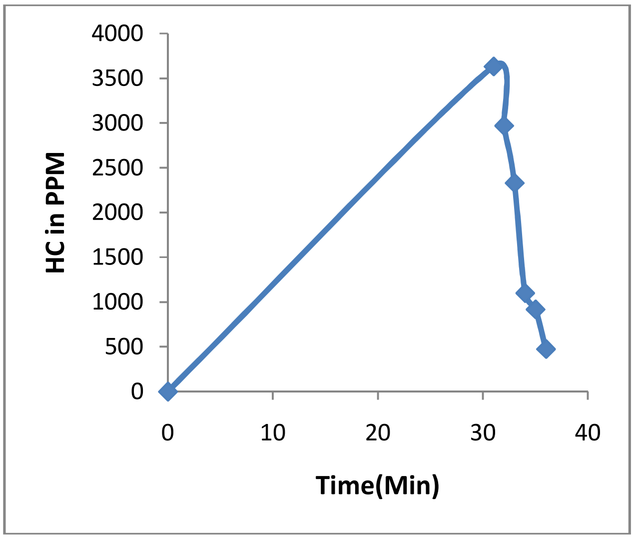

Fig 5 HC Vs Time at 34°C

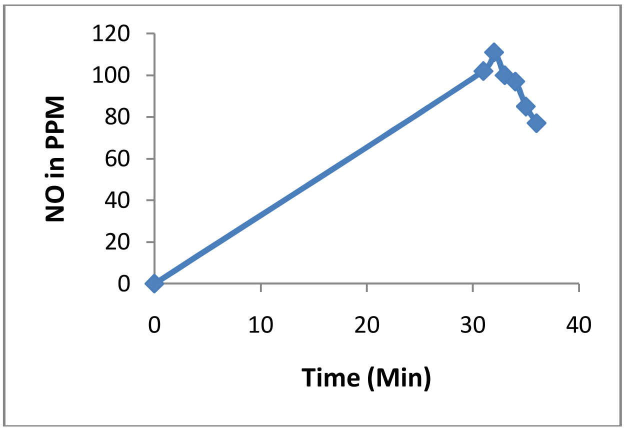

Fig 6 d NO Vs Time at 34°C

3.3 Emission Due to Diffusion

The diffusion of the fuel through the fuel tank membrane was checked at 32°C by using a mini SHED. During this experiment it was evident that the HC vapour emitted through the vent and percolated through the fuel tank walls. The HC content gradually went up to a point and then decreases as shown in Fig 7 .But the presence of NO which is visible from Fig 8 was very low, such that it is neglected. This is because the fuel in fuel tank is cooled by evaporative cooling and it starts cooling the surrounding. As it is place in SHED, confined domain, evaporative cooling effect reduced mechanism of NO formation.

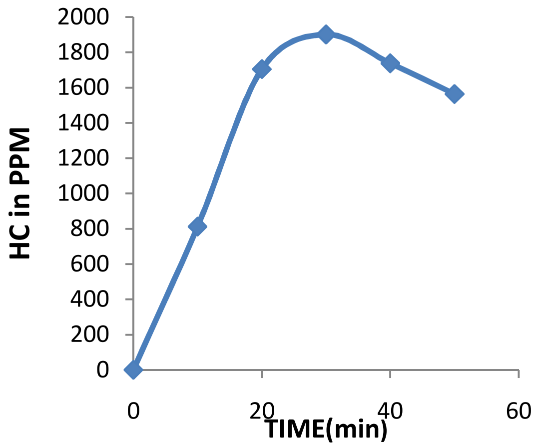

Fig 7 HC Vs Time at 32°C

This experiment was conducted for about 50 minutes, as per the EPA norms. The emission thus got was only for a stipulated time. It may vary according to the quantity of exposure to heat and time for which the tank is exposed.

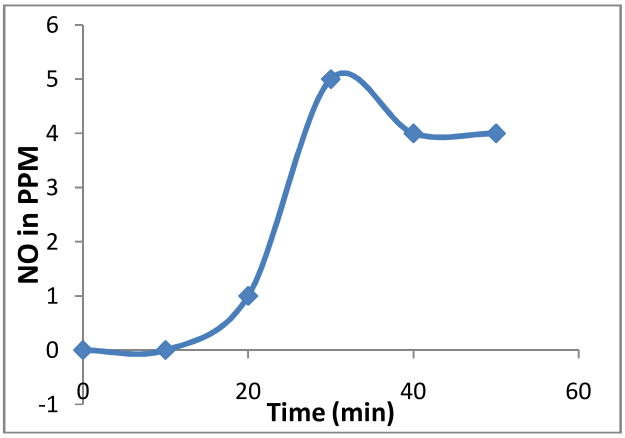

Fig 8 NO Vs Time at 32°C

CONCLUSIONS

From the result obtained, it was evident that the occurrence of evaporative emission increased with the increase in the ambient temperature condition. This experiment gives a clear picture of impact of environmental temperature effects by ignoring the temperature occurring (ex:engine) from the vehicle. The constituent like HC was predominant in the beginning and it gradually decreased at the end. Certain other constituents like CO CO_2 and NO were found only at higher temperatures.

It also stressed the need for eliminating the emission from the fuel tank through vent in the tank and due to diffusion through the fuel tank walls. However this emission might vary based on the climatic topography of the region.

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