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A Study on the Effect on Fuel Economy of a Two Wheeler by on Board Hydrogen Generation

Gurpartap Singh[1*], Kanwarpreet Singh[2] and Harpreet Singh[3]

[1]*Student, Department of Mechanical Engineering, UCOE, Punjabi University, Patiala, Punjab,India*

[2]*Assistant Professor, Department of Mechanical Engineering, UCOE, Punjabi University, Patiala, Punjab,India*

[3]*Associate Professor, School of Mechanical Materials and Energy Engineering, IIT Ropar, Punjab,India*

Email: er.gurpartap@yahoo.com

Abstract **- Considering high fuel prices, limited petroleum reserves and expanding market of two wheelers in India, an experiment was performed to investigate fuel consumption of a two wheeler running on hydrogen-gasoline blended fuel. A 2002 model two stroke, single cylinder SI engine Bajaj scooter was used for the research experiment. A little modification was done to the vehicle as per requirements and a hydrogen generation kit was installed to supply hydrogen on-board. Another unmodified vehicle of same model and manufacturing year was used for comparison. At about constant speed of 1500 rpm, fuel consumption of the vehicle was recorded. The test results showed that the modified engine with hydrogen- gasoline blend as a fuel consumed 60% less gasoline as compared to a similar vehicle in which same quantity of fuel was supplied.**

Keywords: **Fuel prices, Two wheelers, Hydrogen, Gasoline, Idle, Fuel Consumption**

I. Introduction

The two wheeler segment India is the biggest contributor to the automobile industry in India. Two wheeler industries like Honda motor Corp is the world's biggest motorcycle maker. Nowadays two wheelers in India are the most preferred automobile in India due to its low cost and better fuel consumption. Because of this trend the two wheeler market in India is expected to grow to 17.8 million units by 2015 [1]. Majority of economy class in India, unplanned and uneven roads, traffic problems are added catalyst to development of two wheeler industries. Stylish new features to the two wheelers and convenience has attracted the youth of the country towards two wheelers. Two wheelers in India fall in the category of bikes, scooters and mopeds. Motorbikes generally run on four stroke engine and scooters on two stoke engine. Scooters are generally cheaper in cost as compared to the motor bikes but are decreasing in trend due to high fuel consumption and high emissions. As the fuel prices are raising high up to 70 rupees per litre and there are limited fossil fuel reserves all over the world, we cannot afford to use high fuel consumption vehicles. At the beginning of 21st century, half of the fossil fuels available have been consumed. The 1000 billion known reserves of petroleum are predicted to be consumed in about next 40 years [2]. But alternate fuels are a better option as future fuels. Hydrogen is very promising alternate fuel. A small amount of H_2 mixed with air and petrol produces a good combustible mixture. This mixture, in a conventional SI engine can be efficiently burned at an equivalence ratio below lean flammability limit of gasoline- air mixture. Also burning velocity of air- H_2 mixture is about six times higher than air- petrol mixture. Higher burning velocity leads the actual indicator diagram closer to ideal one resulting in higher thermodynamic efficiency [3]. As compared to other hydrocarbon fuels, H_2 has higher diffusivity which results in improved mixing and enhances turbulence and increases homogeneity in charge. The lower ignition energy required for H_2 ensures good ignition and eases cold start[4].

II. Literature Review

Vadre[5] performed an experiment to investigate the combustion characteristics of single cylinder SI engine using H_2 enriched gasoline. He concluded that adding a small fraction of H_2 in gasoline could extend lean operation limit and thermal efficiency and increase in flame speed. Lucas and Richards [6] ran an engine on H_2 fuel at idling with increasing supply of gasoline along with increase in load. The

test results showed that blending reduced fuel consumption by 30%. Al Janabi and Al Bhagdadi [7] constructed a computer program by using a quasi-dimensional model with a set of semi empirical equation which can simulate combustion in SI engine fuelled by H_2 . The research showed that the thermal efficiency of the engine is maximum at 8-10% H_2 -fuel mass ratio and decrease in specific fuel consumption. Al bhagdadi [8] used a recardo single cylinder 4 stroke engine with variable compression ratio and H_2/ethanol blends as fuel. H found out that specific fuel consumption increases with increase in ethanol addition and decreases with increase of H_2 addition. Wallner , Henry and Peters [9] conducted an experiment on 6.0-L V-8 engine located in a hydrogen engine test cell running on hydrogen and methane blends The experiment results showed that with blends of methane less than 5% in H_2 , engine can be operated without adjusting the spark timing. Andrew and Sharma [10] ran a 3 wheeler on COMPRESSED NATURAL GAS/Gasoline blend with a payload of 150kg. The experiment concluded that H_2 - COMPRESSED NATURAL GAS fuelled engine has a 20-25% higher fuel efficiency than a conventional COMPRESSED NATURAL GAS engine and optimum percentage of H_2 for best performance of engine is 35% by volume. Bari and Mohammad Esmail [11] investigated performance of a CI engine running on blend of Hydroxygen (H_2 + O_2) produced by electrolytic hydroxygen powered by 24V external supply. The thermal efficiency of the engine was found to be increased with increase of Hydroxygen blending fraction. Pandya , Chaudhry and Patel [12] analysed performance of a two stroke petrol engine using methanol , ethanol and n-butanol blends with gasoline. Time to consume 10 cc each of fuel was observed which showed that 5% blends of methanol, ethanol and n-butanol to unleaded petrol lead to increase in brake power, brake thermal efficiency and fuel consumption respectively. Shahad and Abdul-Hadi [13] carried out a test on single cylinder four stroke diesel engine in which H_2 was supplied by a H_2 injector mounted on inlet valve at 45 degree angle. The specific fuel consumption decreased with the load as percentage of H_2 blending increased for constant speed and blending ratio of 10% hydrogen provided maximum reduction in specific fuel consumption by about 35%.

III. Experimental Setup

A single cylinder 150 cc SI scooter, manufactured by Bajaj motors is used for the experiment. The specifications of the engine are given in the Table I. As in figure 1, both sides of an unmodified vehicle are shown. The engine has been modified as per requirement. A twin spark plug has been installed on the engine head for better combustion and current coils are modified to increase supply of current. The hydrogen generation kit has been installed on the vehicle has shown in Figure 2. H_2 being supplied for the experiment is generated in the electrolysis tank and fed into the carburettor. The electrolysis tank is supplied with 12V direct current form a DIRECT CURRENT battery. The solenoid pump is able to supply H_2 up to 20 l/hr. The carburettor has been modified for H_2 inlet for which a hole is drilled just above

Fig. 1 Both left and right sides of an unmodified bajaj chetak scooter. Left side shows the empty compartment space for kit installation

the throttle sleeve to provide hydrogen inlet. The fuel supply is restricted by using modified jets. For calculating fuel consumption at idle conditions, a calibrated burette was used to supply the fuel and main fuel supply was cut off. Another vehicle of same make is used unmodified for the comparison. Inlet of Hydrogen is provided by modifying the carburettor and controlling the flow rate manually by using a valve. 87 octane gasoline fuel was used in the experiment for both the vehicles. A commercially available SMPS was used to control the output current and voltage.

III. Experimental Procedure

Table I Engine Specification of Vehicle

Engine specifications	
Make	Bajaj motors
Engine	145.45 cc single cylinder ,two stroke
Torque	7.5 BHP @ 5500 rpm
Max torque	1.1 kgm @3500 rpm
Ignition	CDI electronic
Gears	4 speed
Idling speed	1500 rpm approx.

Feg. 2 Vehicle installed with H_2 generation kit. 1-Electrolysis tank;2-safety device; 3- Water collector; 4- Solenoid pump;5- H_2 carrying hose to carburettor;6-Fibre glass lid;7- Battery and SMPS storage.

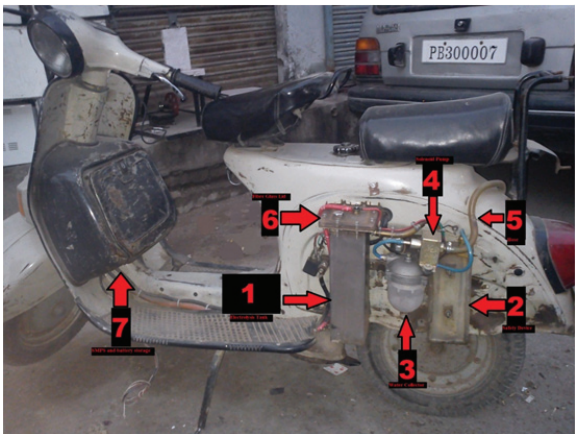


Table Ii Fuel Consumption Data of Vehicle A and Vehicle B

Fuel Consumption of vehicles on highway			
Vehicle type	**Speed**	**Fuel used**	**Km run**
Vehicle A (H_2 kit)	40- 45 kmph	500ml gasoline	33.9
Vehicle B	40-45 kmph	500ml gasoline	21

Before conducting the experiment, the H_2 production by the electrolysis kit was confirmed. The current supply was switched on by which H_2 generation started by the electrolysis process. As seen from the fibre glass lid placed at the top of the electrolysis tank, bubbles started emerging which confirmed the initiation of dissociation of water molecules. The presence of hydrogen at inlet of the manually adjusting throttle valve was confirmed by the flame test. When a burning matchstick was brought neat the end of the hose, the burner produced a pop sound which shows the presence of pure hydrogen as hydrogen always burn flameless with a pop sound. The experiment was started after the engine has warmed up for which both the vehicles were kept started for at least 5 minutes to allow any residual fuel to get consumed. Both the vehicles were then filled with equal amounts.5 litre of gasoline and test runs were performed on national highway 1 at a nearly constant speed of 40 kmph simultaneously. Fuel consumption was calculated in terms of time taken and distance travelled. Then the modified engine without H_2 supply was made to run on the same highway with a nearly constant speed of 40kmph and fuel consumption readings were taken. So the vehicles are categorized as Vehicle A (modified vehicle with H_2+gasoline fuel) and vehicle B (a similar vehicle with gasoline fuel only).The supply of hydrogen into the modified carburettor is adjusted accordingly by adjusting the throttle valve. The fuel consumption data of both the vehicles is show in the Table II below.

After straight runs were performed, the fuel consumption for 50ml, 100ml, and 150ml of gasoline of both the vehicles was measured and observed at idle conditions at about 1500 rpm respectively which are shown in the tables below. Table II and Table III show readings of fuel combustion for modified and unmodified vehicles respectively. The fuel was supplied by a calibrated burette directly into the carburettor fuel inlet so that the amount of fuel supplied should remain constant.

IV. Results and Discussions

After the test runs of each type of engine on the highway with 500 ml of gasoline at nearly constant speed of 40 kmph, the distance covered by each of the vehicle A and B is 33.9 km and 21 km respectively. The results clearly show that the engine with hydrogen – gasoline blend covered

the maximum distance. The engine performance was not affected the restricting the supply of gasoline and addition of hydrogen because a combustible mixture is formed by small amount of hydrogen to gasoline. This supplementary fuel leads to the reduction in specific fuel consumption of the vehicle. Moreover the self-ignition temperature of hydrogen air mixture is more than other fuels which helps in improving anti knock quality of the fuel.[14] Pure hydrogen SI engines require less fuel during the cold start as these are not affected by the fluid film effect. However due to high flame temperature of hydrogen and low ignition energy, gaseous hydrogen fuel can be ignited easily at lean conditions and low temperatures. [15]Thus adding a small amount of hydrogen improves the performance of the engine and leads to less fuel consumption.

At idle, the following graphs show the results. The time taken to consume the same amount of fuel is more in case of the modified engine with hydrogen- gasoline blends.

Table III Fuel Consumption of Modified Vehicle

VEHICLE A	Fuel consumed (in ml)		
	50	100	150
time (in sec)	314	622	946

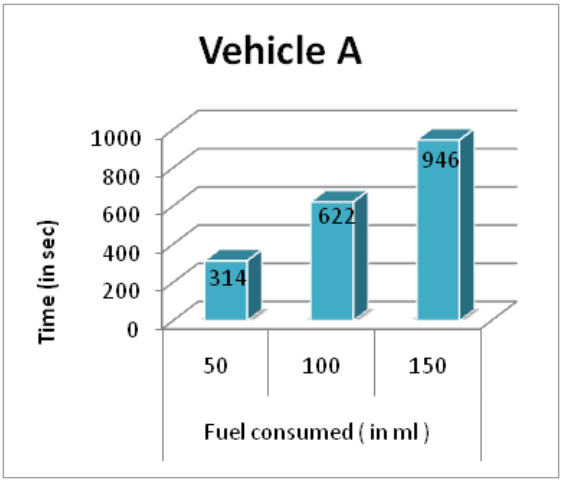
Table IV Fuel Consumption of Unmodified Vehicle

VEHICLE B	Fuel consumed (in ml)		
	50	100	150
time (in sec)	208	350	611

As seen in the above graphs showing time taken to consume specific amount of fuel at 1500 rpm, it is clearly seen that the modified engine with hydrogen blending takes more time than other two engines.

V. Conclusions

- Hydrogen blending decreases the fuel consumption of a two stroke SI vehicle.
- The fuel consumption with hydrogen blending is reduced by 60% as compared to conventional engine.



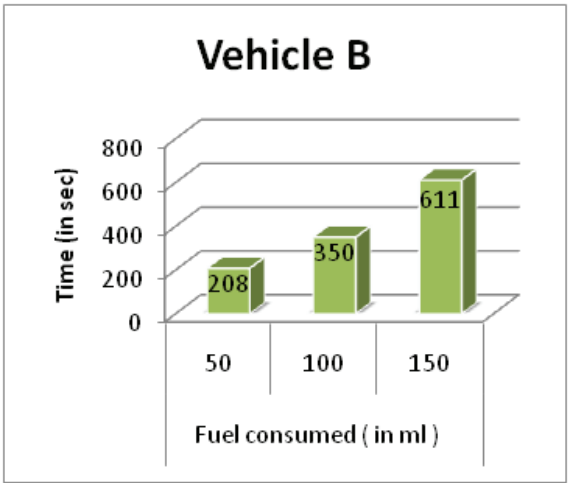


Fig 3 Graphs showing fuel consumption of vehicles

- Hydrogen can be efficiently used as a supplementary fuel in small quantity which eliminates the problem of hydrogen storage.

Nomenclature

H_2	Hydrogen
l/hr	Litres per hour
BHP	Brake horse power
Kgm	Kilogram-force metre per minute
RPM	Revolutions per minute
CDI	Capacitor discharge ignition
Kmpl	Kilometres per litre
Kmph	Kilometres per hour
SI	Spark Ignition
SMPS	Switched mode power supply

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