ELECTRIC MOTORCYCLE ANALYSIS

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I. Introduction

In this experiment a team of three mechanical engineers (Thy Dinh, Bryan Slater, and Branden Frazier) will be performing an analysis of the 1996 Kawasaki Ninja 250R that has been converted from a gasoline powered bike to an electric powered bike. Using the knowledge gained from previous engineering courses, the team members have sufficient knowledge and skill to complete the experiment. After the completion of the experiment, the results will determine which version of the bike is best for the environment and for the economy. The team will be using the data which was provided by last year's engineering students (Josh May, Bryant Gorrell, and Andrew Blatt) who have completed the conversion of the Kawasaki Ninja gas bike to electric.

II. Prepare Your Paper Before Styling

This experiment will consist of three main parts. The first part is to restore the motorcycle to operating condition. In order to complete this task, the team needs to determine the cause of no output in the lithium-ion batteries. Once this is completed the team can advance to the second and main objective; analyzing the electric bike in comparison to gasoline bike. As the final step, the team will compare and discuss the results in the second part and compare them to a commercial electric motorcycle. A figure of the motorcycle is included in figure 1.

III. Using the Template

Ideally, the team would find a way to measure the bike's performance in top speed, miles per charge, and watts to charge the bike. Unfortunately, due to unforeseen circumstances, the team will need to rely on the results produced from when the motorcycle was in operating condition. Next, the efficiency of the motorcycle will be analyzed by comparing the output power with the input power. After that, the gasoline section will consist of an analysis of the cost and environmental impact. Then, the electric motor analysis will cover the same points as the gasoline engine.

IV. Results

i. Efficiency

After researching the gas engine on the 1996 Kawasaki 250R, the specifications for the engine were found in two separate sources (1, 2) .To ensure accuracy, the two sources were compared. It was found that the sources were in congruence about the specifications of the bike. Therefore, the team felt confident proceeding to calculate the efficiency of the electric motorcycle. The team from the previous year had a goal of attaining 50-60 mph with 20-25 miles per charge. They were able to achieve 40 mph before the motorcycle was in the shop again. In using the formula for efficiency in conjunction with the results from last year the electric motor efficiency would be calculated (3).

$$\eta = P_{out}/P_{in}$$

Where η is the efficiency, Pout is the output power, and Pin is the input power. In this case, there was not enough information to obtain a percentage efficiency. Therefore, the team computed the efficiency in the form of cost per mile, cost per kWh, mile/kWh, and compares the results between all three motorcycles (Gas, Experimental, and Commercial Electric Motorcycle).

ii. Gas Engine

The original 1996 Kawasaki GPX 250R had a liquid cooled, parallel twin cylinder, DOHC, four valve per cylinder engine. This engine had a compression ratio of 12.4:1 and was capable of producing 45 hp and 2.5 kg-m of torque. The efficiency of the motorcycle was 52 mpg, and with a 4.8 gallon tank, the motorcycle had a range of 250 miles. As far as performance, it was able to reach a top speed of 94.9 mph and a standing quarter mile in 13.8 s at 82.3 mph (1). Currently, the cost per gallon of gasoline is $3.29. Using this cost with the efficiency of the gasoline engine produces a cost of $0.07/mile. During the combustion of a single gallon of gasoline 8887 grams of CO2 are emitted to the atmosphere. This means if the bike was to travel 100 miles it would use 1.92 gallons of gasoline which would produce 17,090.4 grams of CO2. This equates to 170.9 g/mile (4).

iii. Electric Motorcycle

The GBS LFMP20AH lithium-ion batteries are rated to have a capacity of 20 Amp hours (5).Using the formula:

$$E = QVN$$

Where E is the energy output, Q is the Amp hours, V is the Voltage, and N is the number of batteries, the energy required for one charge was found to be 1024 Wh(6) .

$$E = 20Ahr*12.8V*4Batteries$$

$$E = 1.024 \text{ kWh}$$

The current rate for Appalachian Power is 11.140 cents/kWh (7). This cost in conjunction with the amount of energy used per charge results in roughly $0.1141 per charge.

$$1.024kWh*11.140cents/kWh=\$0.1141$$

Since the bike is capable of 25 miles per charge, the cost per mile comes out to 0.5705 cents/mile.

$$\$0.1141/25 \text{ miles}=0.5705 \text{ cents}$$

The average output of CO2 per kWh is approximately 2.14 lb./kWh, which is equal to 970.69 g/kWh (8). This means, with the amount of kWh used per charging session, the amount of CO2 emissions per charging session is 993.98g/charge. This used in conjunction with the 25 mile per charge capability results in 49.699 g/mile of CO¬2.

$$970.69g/kWh *1.024 \text{ kWh} = 993.98 \text{ g/charge}$$

$$(993.98 \text{ g/charge})/ (25 \text{ miles/charge}) = 49.699 \text{ g/mile}$$

iv. Comparison

The cost of the modification of the bike was $2,392.22 and the cost per mile to operate the bike is $0.005705. So, the equation for the total cost of the electric bike is:

$$C = 2,392.22 + 0.005705(x)$$

Where x is the number of miles traveled by the bike. Then, on the other hand, the cost for the gasoline bike is $0.07 per mile. So, the cost for the gas bike is:

$$C= 0.07(x)$$

In order to find out when the cost of the modification will be equal to the amount saved, effectively "paying for itself", the two equations need to be set equal to each other. This results in the total number of miles being equal to 37,207. This means, for the modification to be cost effective, the electric bike needs to be driven 37,207 miles. If the bike was driven a full charge per day, this would result in a little over four years to "pay" for the modification.

$$2392.22+0.005705x=0.07x$$

$$x=37207 \text{ miles}$$

(37207 miles)/(25 miles/day *365 days/year)=4.08 years

In terms of the environmental impact, the comparison is more direct. The Gasoline engine produces 170.9 g/mile of CO2, while the electricity only produces 49.699 g/mile of CO2. This means, the gasoline engine produces a little over three times as much Carbon Dioxide compared to the electric equivalent. There is no disputing the fact, the electric motor has a lesser impact on the environment. As validation for the team's calculations, a comparison to a commercial electric motorcycle will be made. The comparisons are available in chart 1.

A. *Authors and Affiliations*

1) *Branden Frazier:* Associate student.

B. *Figures and Tables*

Figure 1. 1996 Kawasaki 250R

Comparison	Gasoline Motorcycle	Experimental Electric Motorcycle	Zero S Commercial Electric Motorcycle ([9])
Initial Cost ($):	100.00	2492.22	13,000
Range (Miles):	250	25	103
Cost/Mile ($):	0.07	0.005071	0.00932
Cost of Recharge ($):	15.79 (Fill-up Tank)	0.11	0.96
Charge Time (Hr.):	N/A	24.4141 mile/kWH	12.176 mile/kWH
CO_2/Mile(g/Mile):	170.9	49.699	80.105
Horsepower:	45Hp	15Hp	54Hp
Top Speed:	94.9	40	95

Chart 1. Result Comparison

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