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DDK/R 5/10157-2

The Electric Moped

February 26, 1981

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The Electric Moped

Department of Energy
Midwest Appropriate Energy Technology Program
grant no. DE-FG02-79R510157

February 26, 1981

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Brief Summary of All Work Done

Two electrically powered mopeds were designed and built. These vehicles offer single-person transportation which is convenient, quiet, low-cost, smooth, and pollution-free.

The first moped has a 12 volt electrical system. The second has a 24 volt electrical system. They both have top speeds of about 20 miles per hour. They both use transistorized speed controls and deep-discharge, lead-acid batteries.

These mopeds were put through a 750 mile test program. In this program, the 12 volt bike had an average range of nine miles. The 24 volt bike, with a smaller battery capacity, had an average range of six miles.

Introduction

This report describes work done to develop two electrically powered mopeds. A moped is a lightweight, single-person, two-wheeled vehicle. It is designed to operate at moderate speeds over urban distances.

Many gasoline powered mopeds are in use throughout the world. A small percentage of these are in the United States. However, their popularity here is growing because of an increased awareness of energy conservation needs and because legislation is now favorable to moped use.

These gasoline powered mopeds are relatively inexpensive to own and operate. They are convenient and maneuverable in urban areas. Mopeds are typically used for commuting, such as from home to place of employment and return, from home to school, to run errands, and for other short trips.

They are generally not used for long trip lengths. In Milwaukee, Wisconsin for example, the median automobile trip length is 5.9 miles.¹ The median moped trip length is probably close to this number.

¹Motor Vehicle Facts and Figures 1978 (Motor Vehicle Manufacturers Association), p. 52.

If mopeds continue to be used primarily as commuting vehicles, then an electrically powered moped using available technology appears to have use as an urban secondary vehicle.

The electric moped has all the qualities of the gasoline powered version, but in addition it offers immediate starting, low energy-use costs, and operation which is smooth, quiet, and pollution-free.

Project Description

The first bike operates on a 12 volt electrical system and uses the frame of a Batavus Starflite moped. It has a one horsepower, permanent magnet, DC motor and a 12 volt, 105 amp-hour, deep-discharge, lead-acid battery. The battery is mounted between the front and rear wheels. The motor is mounted transversely and is below the battery. It uses the existing engine mount support brackets on the moped frame. The single speed transmission uses a V-belt primary drive and a chain final drive. The vehicle is geared to achieve a top speed of 20 miles per hour. A transistorized speed control is used. The vehicle has an estimated empty weight of 180 pounds and a gross weight of 350 pounds. It has a useable range of over ten miles before battery recharging is necessary.

The second bike operates on a 24 volt electrical system and also uses the frame of a Batavus Starflite moped. It has a $1\frac{1}{4}$ horsepower, PM, DC motor and two 34 amp-hour, deep-discharge, lead-acid batteries. Its construction is similar to that of the 12 volt vehicle. It is geared to achieve a top speed of 22 miles per hour. This vehicle has an estimated empty weight of 165 pounds and a gross weight of 350 pounds. It has a useable range of over eight miles.

Pictures of both mopeds can be found at the end of this report. The 12 volt moped is painted blue and the 24 volt moped is painted green.

These mopeds were ridden over 750 miles under electrical power in the test program. Data has been obtained on vehicle range for different vehicle speeds and operating conditions. The average trip length for the 12 volt moped was 8.7 miles. The average trip length for the 24 volt moped was 5.9 miles.

The average time to accelerate with fully charged batteries from 0 to 10 miles per hour was 7.3 seconds for the 12 volt bike and 5.3 seconds for the 24 volt bike. The average time to accelerate with fully charged batteries from 0 to 15 miles per hour was 14.6 seconds for the 12 volt bike and 11.6 seconds for the 24 volt bike.

These vehicles can effectively use only about 75 percent of the stored energy in the batteries before recharging is necessary. The average recharge time is three hours for the 34 amp-hour batteries and ten hours for the 105 amp-hour battery when a tapered-rate 10 amp battery charger is used.

At 4.5 cents per kilowatt-hour, the "calculated equivalent mileage" for each electric moped is over

175 miles per gallon. These are the mileage figures obtained by calculating the total cost of electrical energy used (from a standard wall outlet) per moped mile and comparing these energy cost per mile figures to the current price of gasoline. A typical gasoline powered moped has a mileage of 125 to 150 miles per gallon.

Here are the mileage calculations for the 12 volt bike:

$$\frac{75 \text{ percent battery discharge}}{8.7 \text{ miles}} \times \frac{9.8 \text{ hours to charge}}{75 \text{ percent battery discharge}} \times$$

$$\frac{72 \text{ watts average charger power output}}{\text{calculated } 54 \text{ percent charger efficiency}} \times \frac{4.5 \text{ cents}}{\text{kilowatt-hour}}$$

$$= 0.675 \text{ cents/mile}$$

$$\frac{\$1.20}{\text{gallon of gasoline}} / 0.675 \text{ cents/mile} = 178 \text{ miles/gallon}$$

Here are the mileage calculations for the 24 volt bike:

$$\frac{75 \text{ percent battery discharge}}{5.9 \text{ miles}} \times \frac{3.2 \text{ hours to charge}}{75 \text{ percent battery discharge}} \times$$

$$\frac{72 \text{ watts average charger power output}}{\text{calculated } 54 \text{ percent charger efficiency}} \times \frac{4.5 \text{ cents}}{\text{kilowatt-hour}} \times$$

$$2 \text{ batteries} = 0.650 \text{ cents/mile}$$

$$\frac{\$1.20}{\text{gallon of gasoline}} / 0.650 \text{ cents/mile} = 184 \text{ miles/gallon}$$

The electrical circuit diagrams for both mopeds are in Appendix I.

The drawings for the mechanical parts are in Appendix II.

Description of Parts Designed

The motor mount is used to attach the motor to the engine mount support brackets on the moped frame. The engine mount support brackets permit adjustments in the position of the motor. The speed control potentiometer is attached to the motor mount. The speed control actuator is a small disk mounted on the potentiometer. It connects the potentiometer to the throttle mechanism. A detent position on the actuator allows the contacts of the solenoid microswitch to open when the throttle twist-grip is in the "off" position.

The solenoid microswitch holder attaches the solenoid microswitch to the motor mount and allows the microswitch to be adjusted properly. The motor mount spacers permit the motor mount to be properly connected to the existing engine mount support brackets.

The battery mount provides a surface on which the battery rests. It is attached to the main tubular frame of the moped. The battery hold-down is used to securely attach the battery to the battery mount. The battery cover encloses the battery and the battery hold-down.

The speed control mount is a C shaped bracket which allows the speed control box to be fastened to the main frame.

The pedal crank shaft is the shaft on which the foot pedals are attached and to which the pedal drive sprocket is mounted. In addition, this shaft acts as the jackshaft for the motor drive. The take-up pulley and drive gear arrangement ride on this shaft. The electric moped uses a longer shaft than the one supplied by the moped frame manufacturer. The pulley spacers are large rings which allow the smaller take-up pulley to be attached to the two Batavus take-up pulleys and drive gear. The pedal drive sprocket holder fastens the pedal drive sprocket to the pedal crank shaft.

The right side cover encloses the right side of the motor and pedal area to keep the rider away from the moving parts. The left side cover protects the rider from the moving parts on the left side of the bike.

The throttle spring return piston terminates the throttle cable and is mounted in the throttle spring return cylinder. The connecting arm connects the spring return piston to the speed control actuator. The throttle spring return bracket connects the entire throttle spring return mechanism to the moped frame.

The throttle spring return mechanism forces the throttle to return to the "off" position when the rider's hand is removed from the twist-grip handle.

Additional Comments

The batteries contain acid and are relatively heavy. In the event of an accident, serious injury and skin burns may occur because of the rider's proximity to the batteries. The two mopeds contain water bottles which may be used to dilute the acid if it comes in contact with skin or clothing.

Electric mopeds which use batteries that contain acid need to be designed to minimize the chance of an acid spill in an accident.

Because no tests were run to verify the crash worthiness of the two electric moped designs and because of a concern for user safety, the user evaluation and public demonstration programs were removed from the original list of project objectives.

In the 750 mile test program, some vehicle repairs were required. The motor solenoids for both bikes were replaced with heavier duty models. The speed controller for the 24 volt moped had poor performance at lower air temperatures and was returned to the manufacturer for adjustment.

Recommendation and Conclusion

The major problem to be addressed with electrically powered mopeds is with rider safety. Electric mopeds which use batteries that contain acid need to be designed to minimize the chance of an acid spill in an accident.

In order for electrically powered mopeds to receive wide public acceptance, batteries with significantly improved energy densities will probably be required.

12 Volt Moped Circuit Diagram

24 Volt Moped Circuit Diagram

Side View - Motor Mount Bracket - Minnesota Motor
and Honeywell Motor

December 7, 1979
by Michael S. Fersch

Bottom View - Motor Mount Bracket - Minnesota

$\frac{1}{8}$ Sheet Steel

December 10, 1979

by Michael S. Fersch

Rear View - Motor Mount Bracket - Minnesota Motor

December 10, 1979

by Michael S. Fersch1

$\frac{1}{8}$ Sheet Steel

Rear View - Motor Mount Bracket - Honeywell Motor

December 11, 1979

by Michael S. Ferschl

Solenoid Microswitch Holder

January 1, 1980

by Michael S. Fersch

Aluminum

Motor Mount Spacer

December 29, 1979

by Michael S. Ferschl

105 Battery Hold Down

December 7, 1979

by Michael S. Fersch

$\frac{1}{8}$ Steel

34 Amp-hour Battery Hold-down

January 1, 1980

by Michael S. Fersch1

$\frac{1}{16}$ Sheet Steel

SPEED CONTROL BRACKET

November 5, 1979

by Michael S. Ferschl

-.629 $\pm$.002 DIA

Steel

Case Harden

Pedal Crank Shaft

December 17, 1979

by Michael S. Fersch1

II-13

Pulley Spacer

December 17, 1979

by Michael S. Fersch1

Steel

Pedal Drive Sprocket Holder

December 29, 1979

by Michael S. Ferschl

December 29, 1979

by Michael S. Ferschl

Left Side Cover

December 29, 1979

by Michael S. Ferschl

January 1, 1980

by Michael S. Ferschl

UPPER TAP 4-10

Aluminum

Throttle Spring Return Cylinder

January 1, 1980

by Michael S. Fersch

1/4 Aluminum

Connecting Arm

January 1, 1980

by Michael S. Ferschl

$\frac{1}{16}$ Sheet Steel

Throttle Spring Return Bracket

January 1, 1980

by Michael S. Ferschl