CHAPTER 8
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MOTORIZED VEHICLE MODIFIED FOR CHILDREN WITH PHYSICAL IMPAIRMENTS

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INTRODUCTION

A battery-powered child's vehicle was modified to accommodate the physical abilities of a child who has spastic paraplegia. The client's recreation was limited, while her twin sister could use a commercial toy electric vehicle designed for children age five to eight. No vehicle on the current market was adequate for the client's use. With paraplegia affecting the left side of the body and legs, the client cannot walk but is capable of standing with assistance. She has a fully functional right arm. Using failsafe design criteria, and integrating forward/reverse controls and steering mechanisms, the vehicle was redesigned at an affordable price. The goal was to offer a modified vehicle (Figure 8.1) that would not resemble a wheelchair, and that the client may operate safely and independently.

SUMMARY OF IMPACT

The design of this vehicle had a positive influence on the client's as well as the family's quality of life. The child can do a variety of recreational activities on her own while she drives the vehicle (5 mph max. speed). She was extremely happy to test-drive the final product. The finished vehicle was delivered to the family along with an owner's manual, including instructions for safety, operation and maintenance of the vehicle.

TECHNICAL DESCRIPTION

The design was initiated with the modification of a commercially available Power Wheels X-treme machine manufactured by Fisher Price. The reasons for its selection were that it is:

- Suitable for children aged five through eight,
- Portable,
- Reasonable in price,
- Esthetically pleasing as a toy/vehicle (not resembling a wheelchair), and
- Adaptable for the proposed modifications.

Steering and accelerating controls are redesigned to specifically suit the client's abilities. Ergonomic seating and controls are incorporated. Safety features include an emergency stop-switch in the event of electrical or mechanical failure. The steering wheel is modified into a custom-made handlebar steering control. The design incorporates ½ in. diameter steel conduit with a 150° bend. It is attached to the spokes of the steering wheel. Two pieces of mica tubing are inserted into the conduit as sleeves for the screws that fastened the conduit to the spokes. The sleeves prevent buckling of the conduit when the screws are tightened. The plastic spokes are reinforced with 1/16 in. steel bar stock. The bar stock is cut and formed to fit the underside of the spokes. These bars are fastened with the screws holding the steel conduit to the spokes of the handlebar. The holes in the steel are threaded and lock nuts provide an additional mechanical fastening. The steel bar is also fastened in the inside of the steering wheel base.

A pushbutton switch and yellow handgrips were acquired from another toy vehicle called the LilKawasaki ® ATV, which requires only light force (avoiding finger fatigue as well) to engage contacts. This switch is housed in an enclosure (fabricated from steel and aluminum) ensuring electrical isolation for the operator. The enclosure is installed for right thumb operation and on the handlebars such that it would be canted at the same angle as the handlebars. The handlebar is sprayed with red plastic-dip to provide corrosion resistance and electrically insulate the switch enclosure. The coating also seals sharp edges created during handlebar fabrication. The coating improves the esthetic appearance of the handlebar as well. Other manufacturers have made factory recalls of toy vehicles for fire hazards and sticking of the pedal-operated, push button accelerator. These hazards are minimized in this design.

All wiring changes made to the vehicle incorporate heavier gauge wire for improved current carrying capacity. All exposed wiring is covered with heat shrink tubing or liquid electrical tape. A spiral wire wrap or a flexible plastic conduit is used for extra protection on all wiring not recessed in the vehicle body. The electric braking on the vehicle is modified by replacing the existing stock resistor (0.01 ohm, 5 W) with a 0.01-ohm, 10 W resistor. The higher power rating doubles the size of the resistor, but, more importantly, it increases the surface area for heat dissipation. During experimentation with the original electric circuit, the current flow was observed to exceed 17 amps through the foot-pedal control switch.

The switch was wired in series with the electric motors, so the load current to the electric motors passed through the switch. The high current at 12 volts dc is a minimal shock hazard, but can generate heat that can lead to thermal degradation of the plastic and insulator material. The pushbutton switch installed on the handlebars has a contact rating of 20 amps at 15 volts dc. Although the pushbutton switch has a sufficient contact rating for the observed load current, the circuit is designed to minimize the load current. A 12-volt dc relay is used to isolate the load current from the pushbutton switch on the handlebars. The pushbutton switch on the handlebar would control the current to energize the relay. This relay current is measured as 90 milliamps. The low current to the pushbutton switch improves the safety of the vehicle by reducing the fire hazard.

The relay has a mechanical life of 10 million cycles, and the contacts, 100,000 cycles. The rated current is 15 amps at 30 volts dc. The relay is a double-pull, double-throw relay. The circuitry only required a single-pull, double-throw relay; therefore, the appropriate contacts are connected in parallel to modify the relay. This modification provides dual paths through the relay for the load current thus improving the current carrying capacity of the relay.

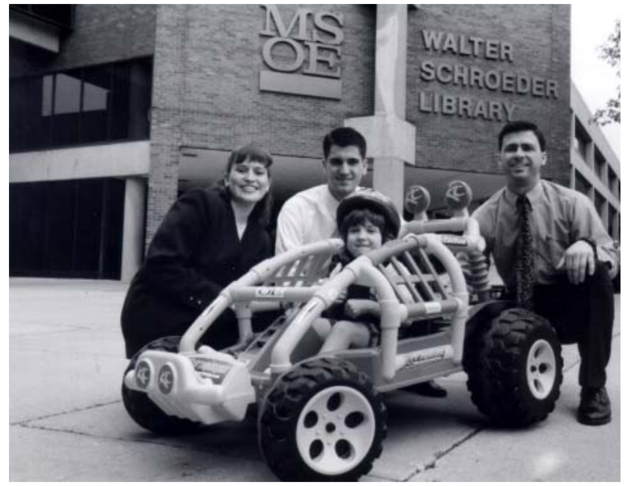

Figure 8.1. Modified Motorized Vehicle.

An emergency stop switch is installed in the steering console below the handlebars, facing the driver. The switch disables the current path to the motors in the event of a mechanical or electrical failure. A foam seat is obtained from Ken Whalen of Reliant Rehab, Milwaukee, WI who provided technical assistance in product selection and installation of the seat insert.

Velcro is placed on the existing seat and the insert, which allows the insert to be removed when needed. The insert provides additional lateral support and cushion. A four-point harness is added to the seat. Four guide slots are cut into the seat for harness strap alignment; two of the slots are located at the right and left top edge of the seat and the other two at the left and right lower sides of the seat. The four straps are inserted in these slots and fastened to the back of the seat.

The cost of manufacturing is $300, including the purchase of the commercially available vehicle that was modified.

A FISHING ROD AND REEL OPERATED BY ONE HAND

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INTRODUCTION

A fishing rod and reel was designed for people with the use of only one hand. A currently available fishing reel mechanism was modified to include an electric motor and a gearing system to be operated with the same hand with which the fishing line is cast out into the lake. This fishing rod design is for freshwater fishing, with the weight of the fish not exceeding 10 pounds. This design supports still fishing, trolling and cast-out/reel-in type fishing.

SUMMARY OF IMPACT

A normal fishing rod and reel poses a problem to a person with the use of only one hand. Current devices in the market do not address the frustration and challenge to people with the use only one hand. A fishing rod and a closed reel assisted by a permanent magnet dc motor, powered by a 12 volt sealed lead acid battery, are assembled along with a motor switch that is mounted on a small platform to the left of the pole. The finished product will help the client with an opportunity to pursue fishing activities.

TECHNICAL DESCRIPTION

The design began with a patent search on fishing rod and reel designs that can be operated by one hand. Some designs are found which are meant for deep-water fishing where the equipment is much larger and heavier. Our design focuses on still, freshwater fishing applications. The goal was to design a lightweight fishing rod and reel (3 to 4 pounds) that can handle fish weighing up to 10 pounds. These criteria were based on a force/torque analysis on the reel and ergonomic factors related to arm and finger strength. Instead of creating a new product, it was decided that retrofitting a current rod and reel setup was the most reasonable approach to the problem at hand. Accordingly, three reel types were considered: open, bait cast and closed. The closed reel type was chosen because it allows for one-handed operation without restriction.

Several mechanisms were analyzed to assist the reeling of the line. Two mechanical systems were considered:

- Winding a spring or set of springs and then using the wound spring(s) to turn the spindle, or
- Turning a thumb wheel, which turns the spindle through a set of gears.

It was found from experiments involving 300 casts that the spring-assisted mechanism is not a feasible option due to the low fatigue life of the springs. The thumb wheel option is found to be undesirable due to the high amount of input force required from a person's thumb even to achieve a reasonable spindle speed of 100 rpm. A mechanical system such as that described above might be utilized as a back-up or secondary system.

The final design has an electric powered reel-in mechanism wherein an electric motor turns the spindle that brings in the line. While the drawbacks such as added weight of the motor, noise and gear vibration, placement of a compatible power source are of concern, driving the fishing reel by means of an electric motor offers the most benefits by which the project goals could be achieved. The portable electric tool market has several attractive options that could be incorporated into this design.

The selected motor is a permanent magnet dc type that simplifies power supply requirements due to speed-torque linearity. Also, it requires less cooling and less frame size for a given output power. Several dependant variables, such as speed of the motor, speed of the fishing reel spindle, current through armature, motor power, motor efficiency along with independent variables, namely voltage and torque, were considered in the spreadsheet calculations to arrive at an optimal motor choice. The feasible selections were:

- A Maxom 15 watt S-motor (12 V nominal rating) with 35:1 reduction, 32 mm dia. shaft and plastic gear head, or
- A Maxom 18 watt RE (rare earth) (18 V nominal rating) with 33.2:1 reduction, 26 mm dia. shaft and plastic gear head

Due to the non-availability of the above to fit the senior design project schedule, Maxom 70 watt RE (18 V nominal rating) with 36:1 reduction, 42 mm dia. shaft and metal gear head was employed. The metal gear head weighs 2 lb, whereas the plastic gear head would weigh 0.5-0.75 lb. The client will receive the finished product that employs a motor with plastic gear head in due time.

The nickel metal hydride battery was considered but eliminated due to its loss of charge over time. A 12-volt sealed lead acid battery (Guardian, Douglas Battery Co.) rated at 1.2 amp-hours was selected as it is a relatively high-density, all-weather unit and is rechargeable. A momentary switch rated for 3 amps at 115 volts is mounted on a small aluminum platform to the left of the pole to accommodate the frequent on-off cycling of the motor.

As mentioned earlier, manual reeling is also incorporated as a back-up mechanism. A roller clutch is used to couple the motor and input shaft. When the reel is electrically powered, the clutch is locked; when the reel is manually operated, it slips. The motor and reel assembly is as shown in Figure 8.2. The pole is best operated with the reel and rod assembly upside-down, allowing the operator to balance the weight of the pole assembly with the hand. The pieces designed to hold the reel and motor are machined from 6061 aluminum.

Figure 8.2. Modified Fishing Rod and Reel for One- Handed Operation.

The tests involving lifting of several loads ensured that the design is feasible. The weights as well as the cost of the motor-gear box assembly are of concern. The total cost of the project is $700. A Maxom 15 watt S-motor with plastic gear head is placed on order that will be used as a final modification. The modified fishing rod and reel will be tested and shipped to the client by the school in due time.