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ChemE car

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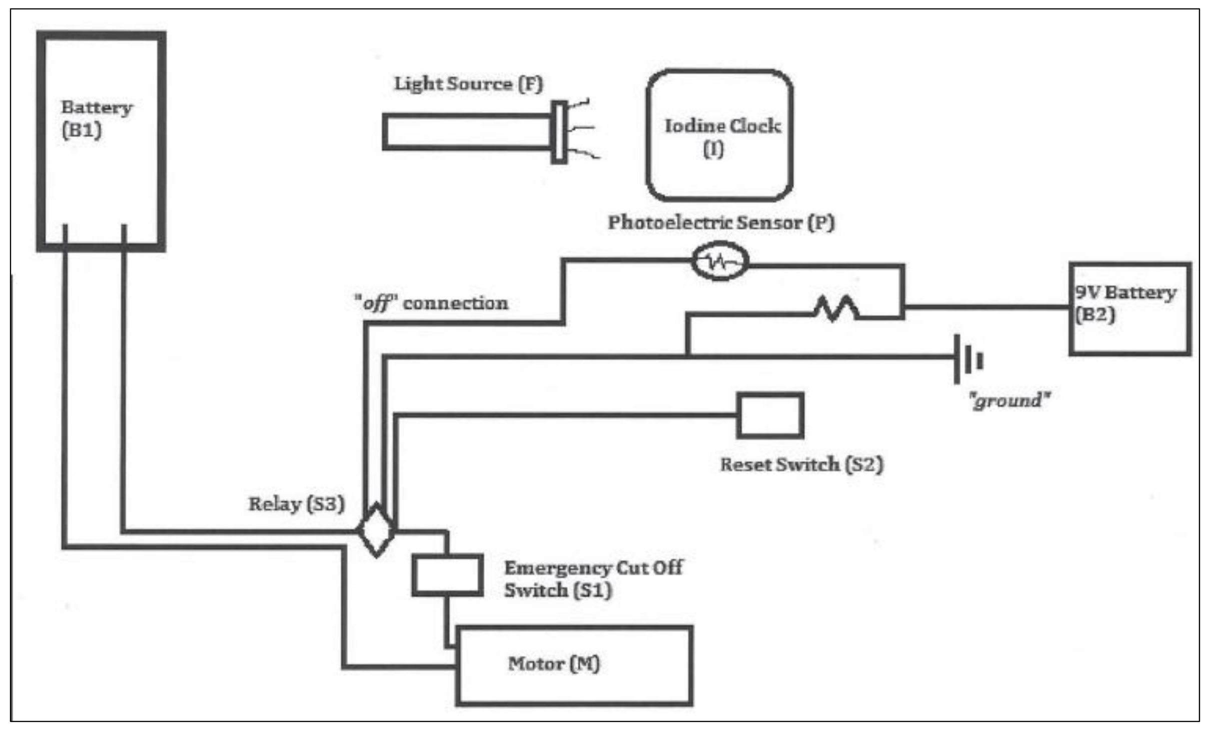
SWAGGON
Clemson University ChemE Car Team

Process Overview

Our car's power source is a student-made battery. The power is generated from a chemical reaction between zinc, manganese oxide, silver oxide, and potassium iodide. The car's stopping mechanism is an iodine clock. A light sensor placed next to the iodine solution will increase resistance in the circuit when the solution has darkened enough such that the sensor no longer senses light. The increase in resistance will interrupt the supply of energy to the motor, stopping the car. An illustration of our circuitry is shown below.



Safety and Environmental

Safety in Design

- Protective coating on sharp metal edges
- Protective containment around the battery, iodine clock, and wiring
- Proper mounting of the battery cells and iodine clock to prevent cargo jettisoning
- Inherent lack of any pressure or temperature hazards in design
- Emergency shut down procedure

Safety in Chemical Handling

- Proper PPE is to be worn at all times including long pants, closed-toe shoes, splash goggles, chemical gloves, and a lab coat.
- Respirator to be worn when handling powders
- Appropriate labeling of all chemical containers, and proper MSDS on hand for materials used
- Chemicals with NFPA toxicity of 2 or greater or NFPA reactivity of 2 or 3 are doubly contained
- Spill tray to prevent spillage of chemicals in prepping the iodine clock
- Chemicals shipped directly to competition institution

Environmental Features

- Proper disposal methods for all chemicals involved in the car (chemicals going into the battery and the iodine clock) as directed by the competition institution to ensure no toxic, reactive, or otherwise harmful chemicals are released into the environment
- No emissions are produced by the car, so no contribution to gaseous atmospheric pollution
- The team recycled some scrap metal and materials from a previous car to be utilized in this one, thus decreasing the environmental footprint of our vehicle

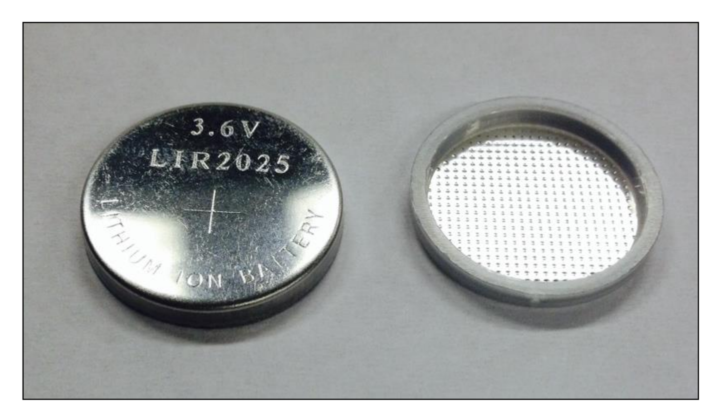
Power Source

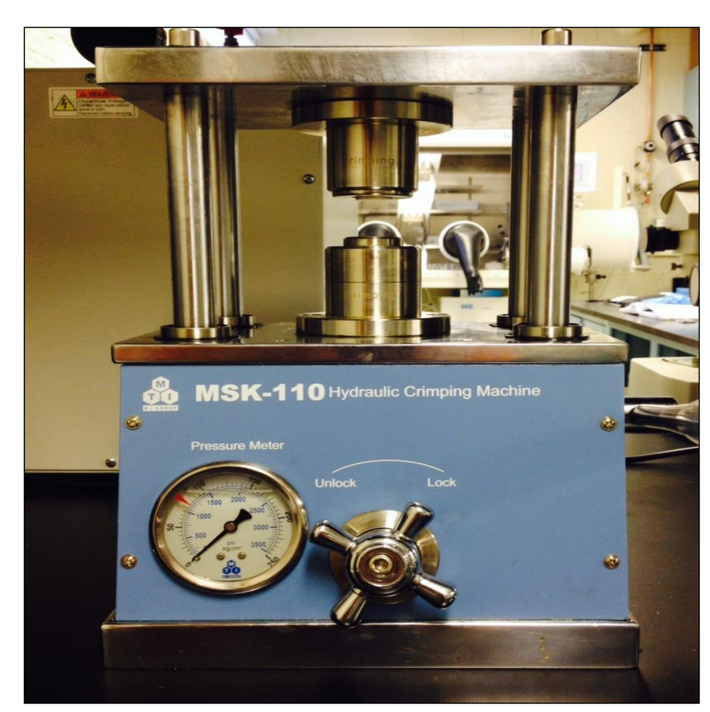
The power source for the car will be what is known as a "silver oxide" battery. The silver oxide battery is a high energy density cell design which involves a zinc anode and silver oxide cathode. This battery chemistry is present in some products on the market currently, and has an average energy density second only to lithium-ion technology. Our design is slightly modified from this standard, as it also includes manganese dioxide at the cathode to help generate electrical potential in the cell. Potassium hydroxide, an alkaline solution, is also used as the electrolyte for ionic transfer within the battery. The chemical equations are as follows:

$$\begin{aligned} Anode&: \ Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^- \\ Cathode&: \ 2MnO_2(s) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq) \\ & \quad Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2Ag(s) + 2OH^-(aq) \end{aligned}$$

The Swaggon's power source design is unique in that it does not implement a single cell, but instead multiple cells with variable arrangement patterns. Each individual battery is created as what is commonly referred to as a "button" or "disc" battery. These small cells are filled with the anodic and cathodic materials, along with the electrolyte and conductive separator, and then pressed into a single unit. Each cell averages about 1.5V, and are stackable to achieve a higher potential. Two stacks of these cells can then be connected in different ways to alter the power sent to the car's motor.

The enclosure of the electrochemical cell components within the discs contributes to the overall safety of this design. Safety in the powering of the vehicle was a major concern for the car design, and so the button cells offer an easy solution to containing potentially hazardous chemicals into a safe and compact setup. Furthermore, the cells are stacked into secondary containment vessels in the car to ensure safety. The high energy density of the silver-zinc-manganese chemistry also facilitates the small footprint of the cells, and streamlines the overall performance of the powertrain.

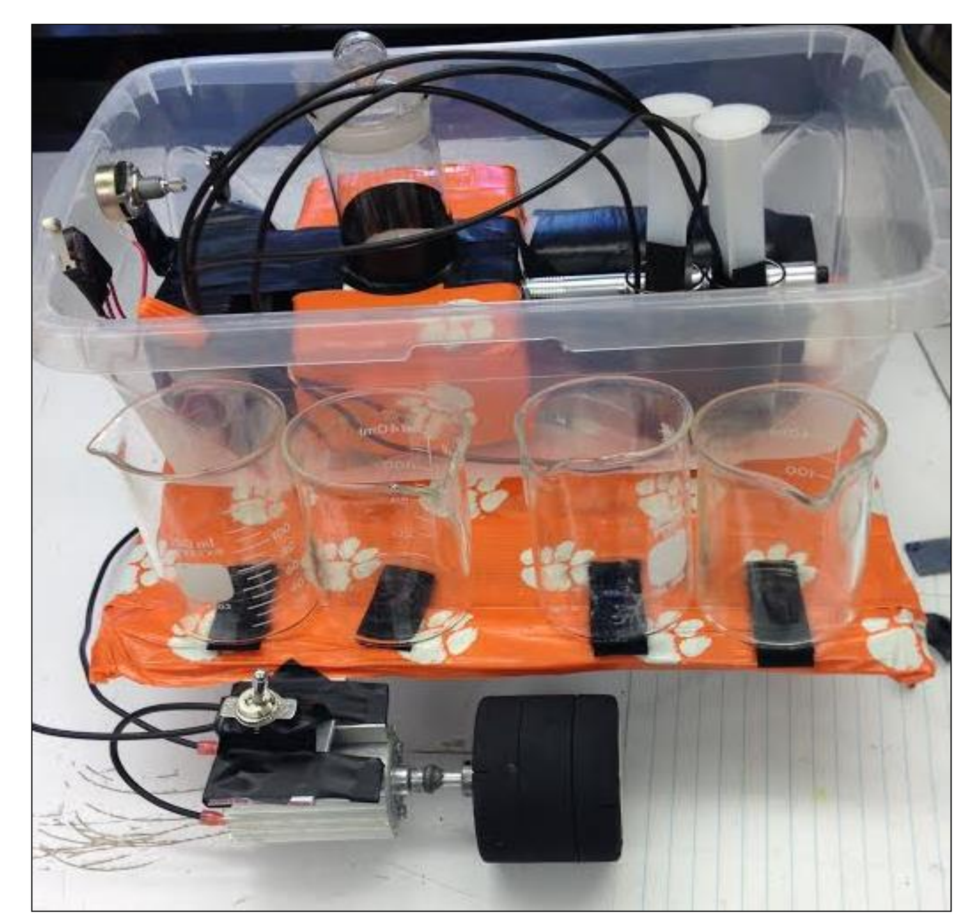




Stopping Mechanism

The stopping mechanism for the car is controlled by an "iodine clock" reaction. Aqueous potassium iodide reacts with aqueous ammonium persulfate, sodium thiosulfate, and starch to darken a solution after a certain period of time. The required time for the color change depends on the proportions of reagents used, and these amounts are determined through calibration of the reaction in conjunction with data on our vehicle speed. Sodium thiosulfate slows down the color change by reacting with the iodine, so it is varied in the Swaggon to change the iodine clock time, where the volume is ascertained from the calibration data. Ammonium sulfate preserves the ionic strength of the solution. A photoresistor detects when the solution becomes dark enough, which trips a relay connecting the motor to the battery thereby stopping the car. Sodium thiosulfate will be the limiting reactant. The stopping mechanism is controlled by the following reactions:

$$\begin{aligned} Generation&: \ 2I^- + S_2O_8{}^{2-} \rightarrow I_2 + 2SO_4{}^{2-} \\ Consumption&: \ I_2 + 2SO_4{}^{2-} \rightarrow 2I^- + S_2O_8{}^{2-} \\ Darkening&: \ I_2 + Starch \rightarrow Dark\ Solution \end{aligned}$$



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