CHEM-E-CAR DOWNUNDER

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The Chem-E-Car competition has been run for undergraduates by the AIChE for the past three years with finals at the AIChE annual meetings. The idea is for teams of undergraduate students to design and build a small car powered by a chemical reaction. The objective is for the car to travel a certain distance and then stop. The distance to be traveled and the weight to be carried by the car are not announced until the day of the competition. The emphasis is on control of a chemical reaction, with a keen eye on safety and the environmental impact of the design. The winner is the team whose car stops nearest to the required distance. In addition to designing and building the car, each team must make a poster that describes the car's operation and include a safety and environmental assessment.

Having witnessed the enthusiasm of the participating students and spectators at the AIChE Chem-E-Car Competition finals held in Dallas and Los Angeles, I decided to organize a Chem-E-Car competition here in Australia. Early in 2001, I contacted all chemical engineering departments in Australia and New Zealand, sent them copies of the rules (for the AIChE competition), and invited them to join. Six departments responded enthusiastically, and within a couple of months teams of students were working away. The original plan was to have local competitions within each department, with these competitions generating finalists for the grand Australasian final. University work and the difficulty of the Chem-E-Car task took its toll, however. Several teams fell by the wayside, including the team from my department. As time went on, it became clear that the grand final would be a fight between five teams—four from Australia and one from the National University of Singapore, who, upon hearing about the competition, asked if they could take part. The grand final was held on day three of the World Congress of Chemical Engi-

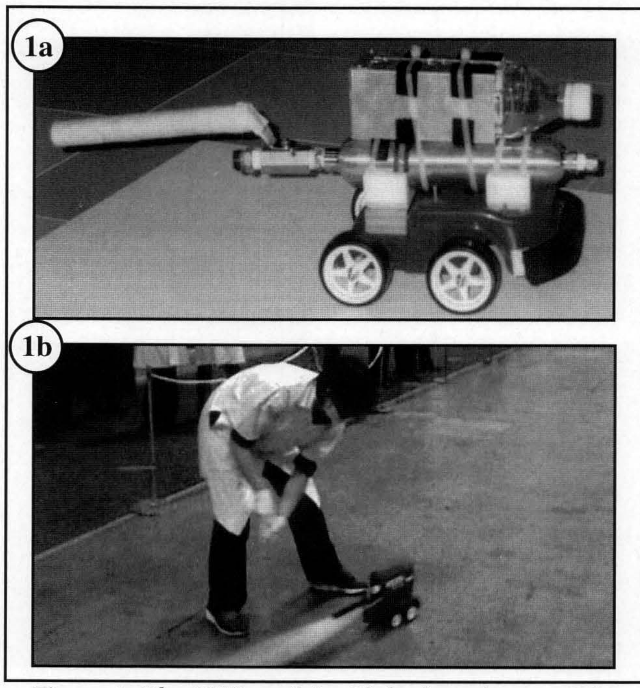

***Figure 1.** The NUS car **(a)** with bodywork removed to reveal the inner detail and **(b)** in motion.*

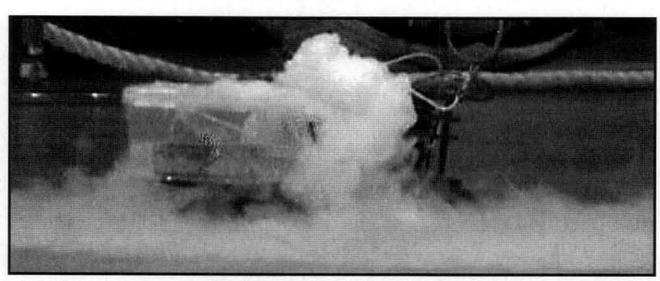

***Figure 2.** The UNSW car drifting through its self-generated mist.*

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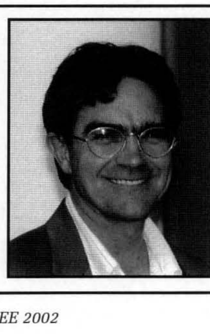

neering at the Melbourne Exhibition Centre in late September.

THE TEAMS AND THE CARS

National University of Singapore (NUS)

The NUS car (Figure 1) used the decomposition of 15% hydrogen peroxide solution with dilute potassium permanganate solution as a catalyst to generate oxygen, which was stored in the stainless steel reactor. Opening the ball valve at the rear of the reactor released the contents in short order, propelling the car along. The car was stopped by friction. The distance traveled was controlled by adjusting the quantities of reactant used and the time for reaction.

During the test runs prior to the competition, this car announced itself with a loud bang and blew away the plastic sheeting that had been specially erected as a splashguard behind the start line. Race helpers hurriedly modified and re-erected the splashguard. The valve on the rear of the reactor was equipped with a lengthened handle. Starting the car involved swinging an oversized pair of laboratory tongs, golf-iron style, to hit the handle and swiftly open the valve. The swipe with the tongs only happened at the precise time, dictated by the reaction countdown.

On its first official competition run, the team member wielding the tongs was either a little too enthusiastic or had poor aim; the result was that the car turned onto its side within a few meters of the start line.

University of New South Wales (UNSW)

The UNSW car, named "Cold Power," was powered by a 1.5-3V electric motor running from an electrochemical cell. The cell used solutions zinc sulfate and copper sulfate with zinc and copper electrodes. The electrodes were made from 1mm sheet, totaling around 200cm^2 for each metal. The distance was controlled using a switch that involved measuring the speed of sublimation of solid carbon. A quantity of solid carbon dioxide was placed in a container on one side of a pulley. On the other side were a number of counterweights such that the solid carbon dioxide container rested on a metal electrode, which completed the circuit. As the solid carbon dioxide vaporized, the weight on that side of the pulley decreased until it was outweighed by the counterweights. Once this occurred, the solid carbon dioxide container lifted off the electrode and cut the power to the motor. The amount of solid carbon dioxide initially placed in the container (anywhere from 20g to 50g) was determined by the distance to be traveled. The UNSW car was interesting to observe as it glided along in a white cloud generated by the subliming carbon dioxide (see Figure 2).

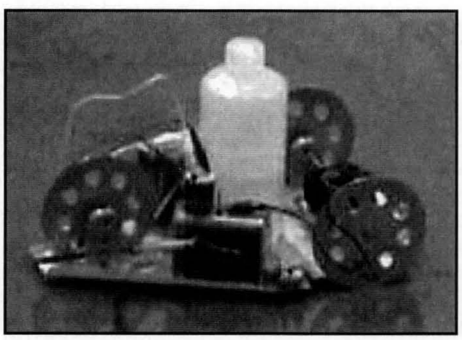

Figure 3. *The Sydney University three-wheeled, two-cell car.*

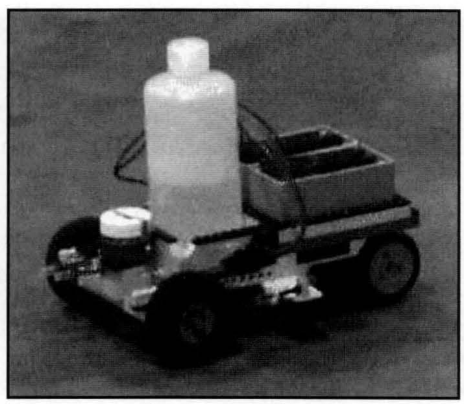

Figure 4. *The Newcastle One team car experiencing terminal technical problems.*

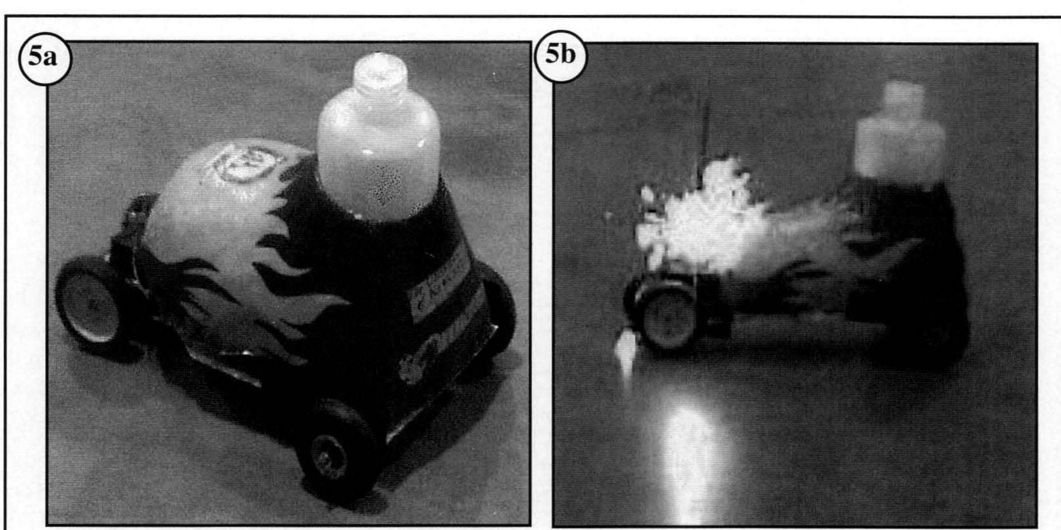

Figure 5. *The Newcastle Two team's car a) running without its sparkler timing device and b) in full sparkling glory.*

Sydney University

The Sydney University car (see Figure 3) was designed and built by a team of first-year engineering students (mechanical and chemical). It was driven by an electric motor powered by an electrochemical cell comprised of 1.8M sulfuric acid and potassium dichromate solution (1g/100ml) with zinc electrodes. This car had three wheels and a low center of gravity. It was able to travel well in a straight line. The inventory of acid was only 5ml, and the cell was enclosed to minimize spillage problems in the event of a crash. The first run of the Sydney team was good, but unfortunately, it started without the required weight.

Newcastle University Team One

The Newcastle Team One car was driven by a small 3.5V 1A motor and powered by a zinc/copper copper sulfate battery, using 1M copper sulfate solution and 1M sulfuric acid. This car made a promising start, getting third closest to the line on its first run. Technical problems (a broken electrical connection to the motor), however, prevented it from leaving the starting line on its second run (see Figure 4).

Newcastle University Team Two

The Newcastle Team Two car (see Figure 5) was driven by a 3V electric motor via a six-speed gearbox. The motor was powered by a battery of four cells each producing 1.45V-two cells in series with another two cells in series. The cell used was an alkaline battery, very similar in chemistry to commercial batteries.

A children's sparkler was used as a timing fuse to stop the car. When the sparkler burned to the end, it melted through a section of solder wire incorporated into the cell wiring and disconnected the power supply from the car motor. The length of the sparkler determined the running time of the car and was decided according to the results of previous trials. Sparklers were found to be remarkably consistent and had a burning rate of around 0.28 cm/s. Extensive safety testing had been carried out on sparklers used indoors to ensure minimum smoking or sparking.

With the sparkler burning away as the car rolled along, it was pleasing to the eye. In practice on home turf, it had managed to consistently stop only a few centimeters from the desired distance. On this day it was the most consistent car and eventually achieved second place.

THE RESULT

Team Newcastle Two won the poster competition with a concise, informative display (see Figure 6). The performance competition winner was the team from the National University of Singapore; after a crash on its first run, their car stopped only 135cm short of the 20m designated distance on its second and final attempt. Team Newcastle Two took second place when their car stopped 180cm after the line. The trophy, a polished Plexiglas CSTR on wheels, was made by the workshop staff at Monash University and is now in the hands of the NUS team.

Reports from faculty involved in supervising the local department competitions suggested that the students benefited greatly from the experience. To get to the start line with a car that was competitive and worked according to the rules, each team had to solve the series of specific engineering problems. Several teams went beyond mere functionality and considered aesthetics. The concentration and enthusiasm of the participants was palpable, and I was privileged to witness it. It is not often that our students engage in something that is fun and also a great learning exercise. The Chem-E-Car Competition was this and more.

The Chem-E-Car Competition will be held again next year with the grand final in Christchurch, New Zealand, at the CHEMECA 2002, the annual conference of chemical engineers in Australia and New Zealand. ❐

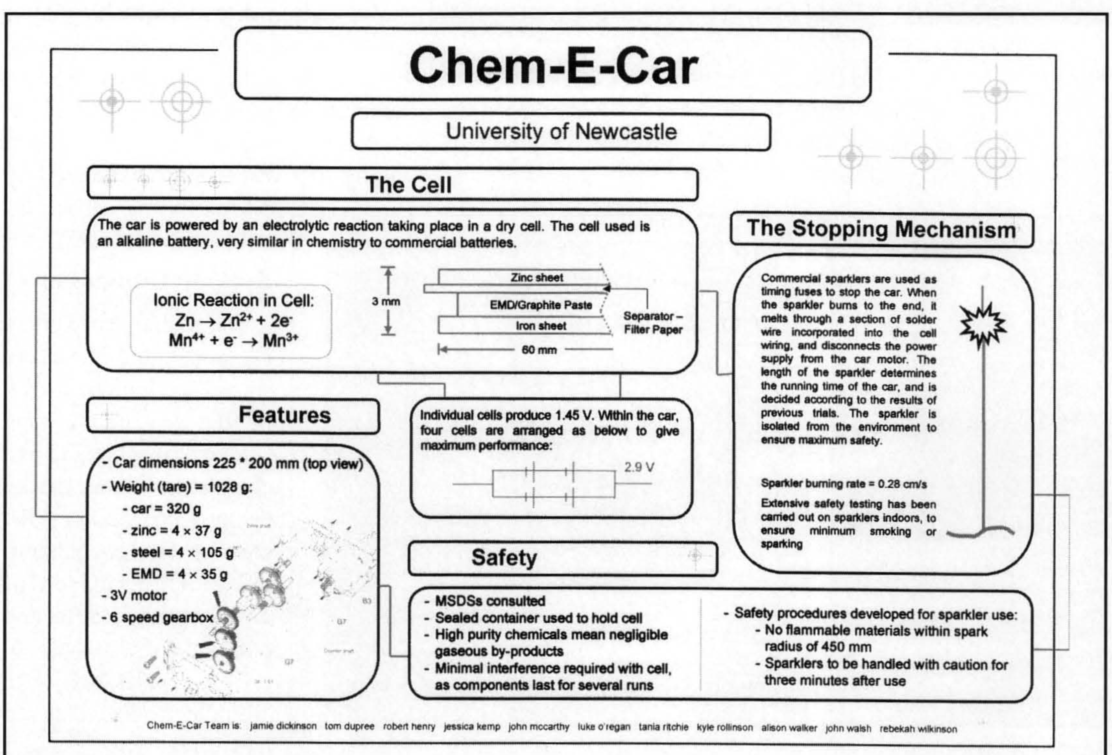

Figure 6. *The winning poster of the Newcastle Two team.*