2.810 Manufacturing Processes and Systems

Project Report: Design and Fabrication of Radio Controlled Cars

Group D: Team Members

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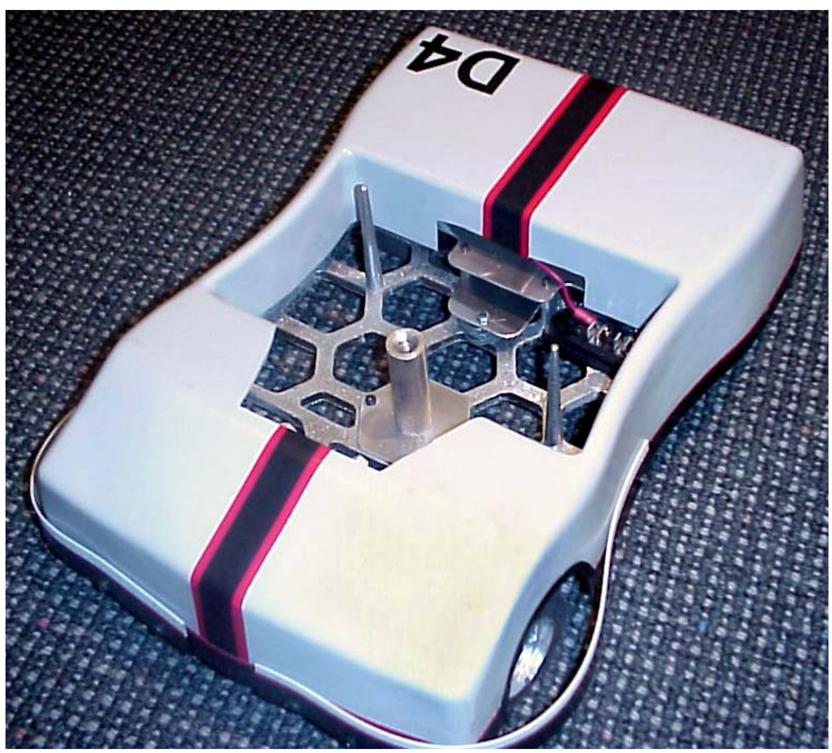
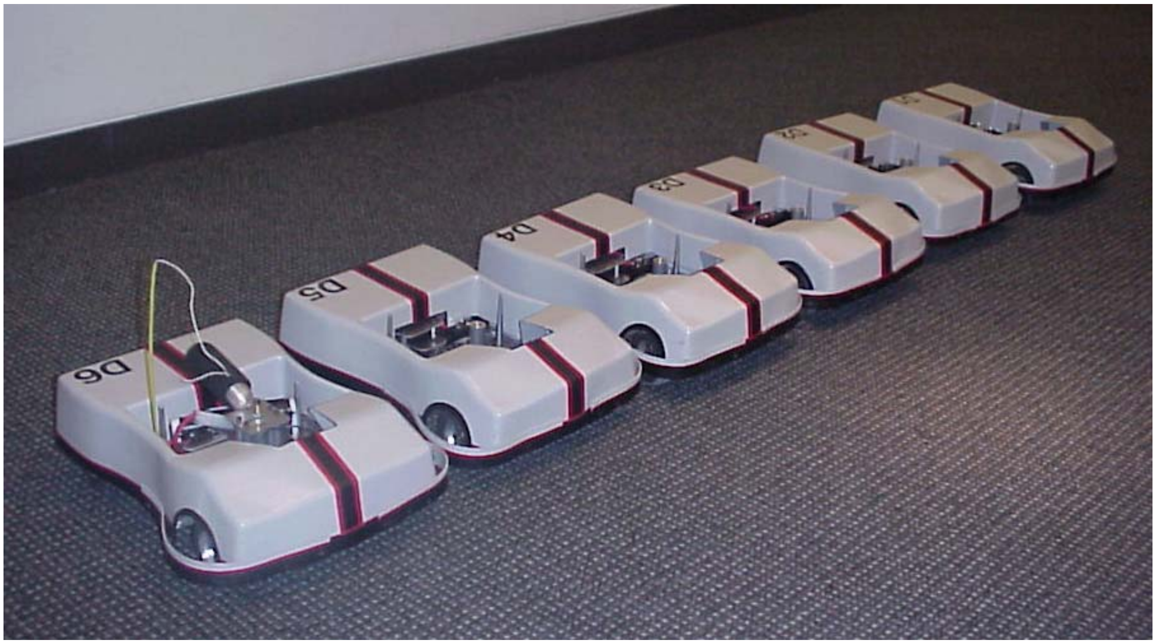
The 'Cah'



Our Fleet of 'Cahs'



Group Strategy and Functioning of the Team

After a series of meetings early in the semester, the group determined the key components and subassemblies involved in the design and fabrication of the car. These items were:

- Car Chassis
- Rear Suspension
- Front Suspension
- Steering Mechanism and Interface
- Interface Plate and Electronics
- Car Shell and Mold

The group met once a week for the first 4-5 weeks after the team had formed, two to three times every week during the following month, and almost every working day during the last six weeks.

During the initial phase of the project, the focus of the meetings was on the design and manufacturing issues related to each of the above subassemblies. These meetings involved intense brainstorming sessions, which generated many ideas on any given component/subassembly. In the following meetings, all team-members would present prototypes of their respective ideas and the entire team would critically evaluate each prototype. Based on this evaluation, the team selected the one or two most-promising designs. The second design was retained as a backup in case the original was unsuccessful on actual implementation.

After these initial sessions on each of the design areas, usually one or two persons in the team would take the lead in that particular area and would spearhead the detailed design of the component/subassembly in concern. At every stage in the process of detailed design, the entire team would scrutinize the design so that the final component/subassembly embodied ideas and suggestions from the entire team. This strategy worked very well. Each person in the team led a certain design area and the others provided their inputs. Therefore, there was no single leader for the entire project; each member assumed leadership in a specific area. By running the group this way, each individual contributed significantly while maintaining a sense of responsibility for the project as a whole.

While all the component/subassembly designs were underway, certain members of the team started the process of integrating these into an overall prototype of the car. This step provided further insights and led to modifications in the individual component/sub-assembly designs, which made the design more suitable for assembly. Once the final prototype was ready, it was thoroughly evaluated for the final design objective: performance of the cars on the racetrack. Satisfied with the final prototype, the team proceeded with the task of manufacturing and assembling multiple cars. This task was shared evenly by the entire team.

Task Distribution in the team:

DESIGN ISSUE	TASK	MEMBERS
Car Chassis	Design/Prototype	Jeff
	Manufacturing	Jeff, Pat, Shorya, Hyun
Rear Suspension	Design/Prototype	Raul, Shorya
	Manufacturing	Pat, Shorya, James, Hyun
Front Suspension	Design/Prototype	Raul, Shorya
	Manufacturing	Raul, James, Pat, Hyun, Shorya
Steering Mechanism and Interface	Design/Prototype	Raul, Jeff
	Manufacturing	Raul, Pat, Hyun
Interface Plate and Mechanism	Design/Prototype	All
	Manufacturing	Jeff, Raul, Pat
Electronics	Design	All
	Manufacturing	Hyun, Jeff, James
Car shell and mold	Design/Prototype	Jeff
	Manufacturing	Jeff, Raul, Hyun, James
Wheel hubs	Manufacturing	Shorya, Jeff, Pat, James
Cutting, Shaping, and Gluing of tires	Manufacturing	Shorya, James, Jeff

Estimate of the total group time spent on this project

	Man Hours
Meetings (20%)	150
Design and Prototyping (18.7%)	
Brainstorming	60
Machine shop time	80
CAD/CAM (9.3%)	70
Manufacturing (23.3%)	
Conventional Machining	105
CNC Machining	20
Water-jet	40
Injection Molding	5
Thermoforming	5
Assembly (20%)	150
Miscellaneous (8.7%)	
Assembly of car-kit	20
Procurement of material	15
Driving Practice	30
Total Time	**750**

Time Estimate for Pit-stops

2.25 seconds

Key Design and Manufacturing Issues

Chassis Design

The critical issue regarding the chassis involved the choice between a sheet metal design and a cast design. As the team wanted a strong and robust chassis, the team elected to go with a cast design. Also, knowing that we would be working with sheet metal for other parts of our car, we wanted to experience an additional process.

The casting design addressed the following concerns:

- Honeycomb design with uniform thickness helped to avoid hot spots and shrinkage cavities.
- Sharp corners were avoided to prevent cracking and tearing during cooling.
- Large, flat sections were avoided to prevent warping.
- Casting pattern was machined slightly larger to take shrinkage into account.
- Casting pattern was machined with the appropriate draft angle.
- Rear fender and one locating post were included into the casting design.

Please see drawing on page 9.

References:

Casting Handout from September 27, 2000.

Kalpakjian, Serope. Manufacturing Engineering and Technology. 3rd edition. pg 334-340

Lessons learned:

Due to the difficulty in predicting shrinkage, tolerances on the actual part differed from prototypes made with the water-jet. Also, material properties of cast aluminum were different from sheet aluminum used in prototypes. These slight variations resulted in some redesign after receiving our cast chassis.

Car Suspension

The key question that arose in this case was whether to have a car suspension or not. Since the car had to negotiate bumps and uneven surfaces, it was decided at a very early stage that the car should be fully suspended, i.e. a front as well as rear suspension was required. The suspension system would certainly make the design relatively more complicated and require more parts, but the car performance could not be compromised.

Rear suspension

Once it was decided that a rear suspension was necessary, the key decision was whether to implement a conventional spring-damper design or to explore a leaf-spring based suspension design. While the conventional spring-damper design would require considerable machining and assembly of many parts, an appropriate use of leaf springs could meet all the suspension requirements despite a simple design. The design concerns were:

- To minimize number of parts and keep the design very simple
- To ensure a static ground clearance of 1”.
- To make the suspension system ‘tunable’ i.e. be able to change the suspension stiffness at later stage if necessary.

The final rear suspension design uses two leaf-springs that can be easily assembled to the motor mount and provide vertical as well as roll compliance. The stiffness of the suspension can be varied by using stacks of leaf-springs.

Please see drawings on pages 10-12.

Front suspension and steering mechanism

The rear suspension design could not be replicated for the front because of space constraints. Other leaf spring designs failed to meet the necessary requirements that arose due to the turning of the front wheels. A much simpler coil spring design was finally implemented. The major challenges foreseen while designing the front suspension and steering mechanism were:

- To keep both the suspension system and steering linkage high enough to clear the 1” bumps.
- To have a simple design without expensive shock-absorbers or difficult to manufacture four-bar linkages.

Our final design coupled the steering linkage to the bracket that held the front wheels. This was done to impart stability to the steering assembly. The bracket that held the front wheels was mounted above the chassis and was designed to slide vertically on a block and two posts, all connected to the chassis. This also protected the steering and suspension system from potential damage when the car 'bottomed out' on bumps. The steering interface was a simple Y-shaped design that would self-align the wheels when the electronics plate was being mounted.
Please see drawings on pages 13-18.

Interface Plate Design and Electronics

There were several design goals necessary for a successful electronics plate: an accurate method of aligning and attaching the plate to the chassis, a comfortable handle, and the packaging and attachment of the electronics. The attachment mechanism consists of a key-chain style quick release button, which snaps into a turned receptacle on the chassis. By pushing the button, two small balls slide into the button body, allowing easy placement and removal of the plate. The alignment of the plate is achieved by aligning two tapered holes on two tapered pins and lowering the unit until the button locks. For comfort and ease of use, a turned aluminum handle covered with soft foam was used as the handle. The handle was positioned to reduce the distance to the button and the force necessary to depress the button. To package the electronics on the plate, small sheet metal clasps were bent around the pieces and bolted to the plate. The power transmission occurred across two copper pieces fixed to a Delrin block on the plate. These copper pieces mesh with switch block contacts, which were purchased in pairs, cut to size, and fixed to an additional Delrin plate on the chassis.
Please see drawings on pages 19-24.

Car Shell

Not wanting to constrain our chassis design by the existing shell options, we chose to machine our own car mold for thermoforming. Our main requirements were those of functionality, although every attempt was made to make an aesthetically pleasing shell.

The shell fits snugly over our chassis, and provides a cavity to help guide the interchange unit into place. The mold design addressed the following concerns:

- Mold pattern was machined slightly larger to take shrinkage into account.
- Draft angles were incorporated into the design to allow for easy removal of the thermoformed piece from the mold.
- Stiffening details on the side walls were added to make the final thermoform more rigid.
- Sharp corner radii and undercuts were avoided.

Please see drawing on page 25.

References:

Thermoform handout from October16, 2000.

Lessons learned:

As with the casting, shrinkage of the thermoform is difficult to predict. However, we were able to fit our shell quite nicely to our chassis. A great deal of fine adjustment was required to perfect the thermoforming process. Heating temperature, heating time, hold time, cooling time, and other parameters of the heating and molding process all had to be adjusted to get the desired thermoform result. Post processing of the thermoform, primarily trimming, also required a fair amount of time and effort.