

Designing a Radio-Controlled Car

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1. Abstract

We designed a remote control car from scratch. To complete this task we first had to come together and figure out what kind of car and goals we wanted to pursue. We decided that we wanted to make a buggy style car and chose to focus on acceleration, durability, braking, and cornering speed as our primary goals. Once done with that process, we used the C.A.D. (Computer Aid Design) programs SolidWorks and Inventor to design all the parts needed to make the car. We also used the software to test the parts in terms of their durability and safety factors to see how well the car could function under various kinds of strain and pressure. We then again used the C.A.D. program to assemble the entire car on the computer and review our final product.

2. Introduction

A remote control vehicle is any mobile device that is controlled by a means that does not restrict its motion with an origin external to the device. Cars are among the most common radio-controlled (R/C) models, but these designs can include vehicles such as planes, boats, helicopters, and trains. Radio control was discovered in the late 1800's with the aid of scientists such as Nikola Tesla who tested a remote controlled model boat in 1893. Radio-

controlled items increased development over time during the World War II era. In the 1940's small model cars with nitromethane-powered engines first appeared on the market. However, technology back then was limited such that these cars could only be controlled on a tether, which reduced them to simply spinning in circles. Radio-controlled cars as they are known today, with radio-controlled transmitter units to operate such functions as steering, brake, and throttle, did not appear until the 1960's. After this occurred more developments were made in this field, with the first electrically powered cars emerging in 1974, and the first off-road R/C vehicles becoming available in 1979. By the 1980's, the hobby of using radio-controlled cars experienced a large jump in popularity. During the 1990's more devices including miniaturized equipment became very accessible, and for hobbyists cars got faster. By the 21st century radio control became popular to the point of supplanting other toys, and engines for serious racers improved drastically, particularly for electric and nitro cars.

For this research project the goal was to utilize the more recent developments in radio-controlled cars in order to design an R/C car from scratch with optimal performance in acceleration, cornering speed, and durability. The conditions that we wanted the car to undergo forced us to

salvage car components (such as electrical components, motor, and chassis) from other cars if we were to continue and construct our car. This mixing and matching of parts produced some issues that we had to work around in our part designs. In optimizing performance, we needed to balance acceleration, cornering speed, and durability. These three criteria are best balanced in the design of a buggy style R/C car. For the sake of cornering speed, we chose a two-wheel drive system for our car. To maximize acceleration in the design of the car, we attempted to minimize the weight of the car. To handle durability, we increased the distance from the wheels to the chassis.

3. Background

Remote control model electronics have three basic components. The first component, a transmitter, is important for the control of the model. Transmitters are built to have control sticks, triggers, switches, and dials at the fingertips of the handler for regulation. The second component is the receiver, which is used to receive and process the radio signal from the transmitter before the radio signal is converted and directed to the servos. The third and final component for the electronics is the channels. Channels serve as the conductors of radio signals to the receiver. The amount of servos determines the number of channels the radio must give. Some remote controls also utilize a function called pulse-width modulation, which has the remote control send pulses to the motors of the R/C car in order to tell it what to do. Without any one of these parts the R/C model (car, plane, etc.) would not be able to function correctly, thus each one of these components is essential for the success of

building any type of R/C model. In our model, we also added our own components in order to improve the R/C car. For example, we added a back wheel differential, the reason being to allow for only two-wheel drive. This improves cornering speed because only the back wheels turn around a bend; the front wheels can skid along with the flow of the rear instead of having to turn as well.

4. Engineering Design

The design process began with an examination of previous R/C car models and their design traits. These models all shared, most importantly for our sake, a form of suspension and differentials. We observed that for our purposes certain parts had to be designed slightly differently to accommodate for the buggy-style model we were building. As mentioned previously, the back wheel differential was used to give the car two-wheel drive. For our purposes, having only a back wheel differential also made the car design simpler. Because if we were to have actually printed all our parts they would have been made out of plastic, we had to alter the design of our would be plastic parts to accommodate for certain metal parts that cannot be modified. In many cases we had to sacrifice some structural integrity, but having fewer parts allows for less mass and a greater acceleration, so at the same time we were also helping to achieve a separate goal. To work around structural problems again for the sake of suspension, we lengthened the rear a-arms, which connect the wheels to the fin. When the car hits a bump, the wheels and thus the a-arms will raise. The fin is attached to the horizontal spring, and so when the fin is raised by the a-arms it will tilt and push the springs forward, allowing

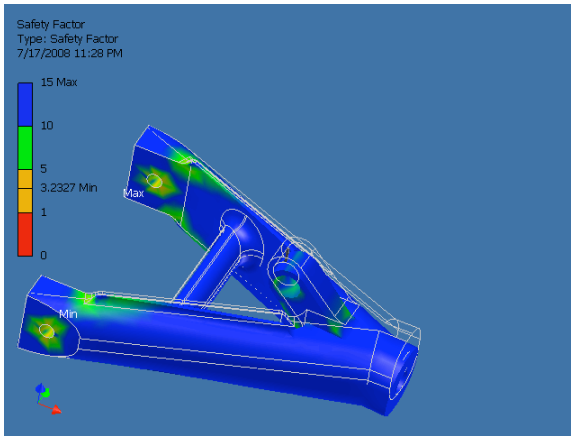
for a suspension system. In the front any shock is absorbed by the basic vertical springs, which ride up and down with the car.

The group collaborated and finalized the design idea to work by pulse-width modulation with digital and analog controls for the remote. Some of the motor ideas also included an electric motor with servos for turn control. Along with all the internal workings, there had to be an external design as well. The outside design is the type of car model such as a basic car or truck. The group decision was to create a buggy car that had the ability to drive off road. The car was also designed to have two-wheel drive. This design's purpose was to increase cornering speed and decrease complexity. The drive was mainly in the rear wheels for power also. These wheels needed a differential to control the speed of the wheels by making them rotate at the same rate. Thus we then had to look at the resources available and the parts we had to create. We were provided with a chassis, the main base of the car, to help model our own design off of. We removed the gas motor parts since they were superfluous in our electric motor design. Thus the chassis for the model also had to be converted to function with electric parts. A new suspension system had to be created as well. The spring placement for the front suspension was designed to be vertical while the rear had horizontal springs for greater A-arm length. These arms are connected to the rear suspension so that any force experienced is transmitted to a fin-like structure in the middle of the arms that turns the springs and absorbs the force. The springs from the previous car were also available but had to be refurbished.

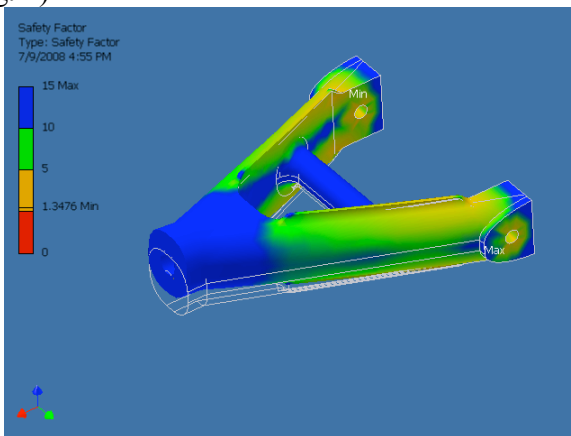
The front and rear wheel suspensions were redesigned on C.A.D. (Computer Aid Design) software along with all the other parts of the model. The 3D drawing program SolidWorks was used for these designs. However, the program Inventor was used for more complicated designs. Such parts that were drawn were the chassis, suspension systems, electric motor mount, gear adapter, servo mounts, steering mounts, speed controller mounts, and battery mounts. Once finalized, these designs were saved and the CAD programs helped to visualize how to assemble the parts into our final product.

5. Results

The best way to test out our parts to make sure our car would run well would be to use the CAD software to evaluate how much stress each part of our car could handle. As such, we ran stress tests for all the crucial components of our design to ensure that our car would be durable under various kinds of pressure. For our purposes, we wanted a minimum safety factor of at least 1.15 for all of our parts. This means that each part ought to be able to withstand an applied force of at least 1.15 times its own weight. Also, while a higher safety factor would be better, a really high safety factor would be unnecessary surplus support, and so we could remove some support in order to make the car simpler and lighter, which coincidentally increases the car's acceleration. The lower A-arm design displayed a minimum safety-factor of 3.2327 (fig. 1). The upper A-arm design received a minimum safety factor of 1.3476 (fig. 2).



(Fig. 1)



(Fig. 2)

6. Discussions

Our parts all ended up with satisfactory safety factors. Thus, we can assume that our car would function sturdily upon being put together in the ABS plastic. Other components of our car, such as the suspension systems and the car's cornering speed and acceleration, could be tested if all the parts were to be printed and assembled. However, we can theoretically assume based on our designing strategies that these parts would all work fairly well.

7. Related Work

Relative examples of our project include the performance of R/C cars on the market today. The latest technology provides vehicles with components such as brushless motors, which are electrically powered for a

clean motor with greater power. More advanced R/C cars also have gear transmissions, the greatest of which are made of entirely metal to handle the heat generated by electric motors. This is obviously in contrast to the parts on our R/C car, which almost all would have had to have been made out of plastic. For our suspension we changed the design of the spring system, but newer cars on the market simply fill their shocks with silicone oil to maximize shock absorption. Instead of focusing on acceleration, cornering speed, and durability specifically as we did, modern R/C car manufacturers are mostly aiming to improve the top speeds of their cars, seeing as high speeds have become the next big thing among R/C car enthusiasts.

8. Future Work

In the future we would focus on taking the design we created and actually making it into a real R/C car model. With the designs of the parts we made in the C.A.D. programs we could now physically make them as real components of a working R/C car. This could be done using a stereolithograph, which is a rapid prototyping machine that creates 3D models by printing out parts made of ABS plastic. From there we could construct our car using the parts we printed and test out the functionality of our design in terms of our goals for maximum acceleration, cornering speed, and durability. We could run tests by timing how long it would take for the car to travel a certain distance having started from rest or having gone around a curve. To check the durability and suspension systems of our car we could check the car's performance on various mildly rough terrains such as grass, gravel, dirt, small bumps, and inclines.

More time would allow for being able to redesign some of our R/C car components on the CAD software and compare different designs by putting them through stress tests to see which one would function best. With more time we could have also added some aesthetically pleasing elements to our car to make our car more unique and reflect our own designing style.

9. Conclusion

We attempted to see how well we could design an R/C car that performed well in our previously chosen categories. There were basic deductions that were derived from the project designs. The stress tests evaluated the conditions of our models and provided results that were later analyzed. Based on these documents we concluded that the components were satisfactory and compatible with the overall R/C car model. We also sent parts to be printed and with more time could have verified our conclusions with the physical car itself.

10. Acknowledgements

First of all, we would like to thank Dean Brown, Blase Ur, and The Governor's School Technology to enjoy all that this program has to offer. We would also like to thank Prudential, Morgan Stanley, Rutgers University, The John and Margaret Post Foundation, and John and Laura Overdeck for sponsoring this program so that we all can have enjoyable experiences as young engineers. We would like to thank Daniel Cobar for helping us put this project together. He worked with us non-stop for hours at a time. We would like to thank him for taking time out of his schedule in order to stay over a number of nights to help us with Solid Works and teaching us more about

remote control cars along the way. We would also like to thank Daniel Hogan for guiding us with our research paper and presentation. Without him we would have been lost on how to transfer our thoughts, works, and ideas on paper.