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Sunrayce 97 - A New Learning Experience for the Engineering Technology Students at Middle Tennessee State University

B. S. Sridhara
Middle Tennessee State University (MTSU)

Abstract

The US Department of Energy (DOE) organizes a solar car race called Sunrayce, once in every two years. This race is open for all colleges and universities on the North American continent. As faculty advisor for the undergraduate team at Middle Tennessee State University, I submitted a proposal in the Spring of 1996. We were selected as one of the top 30 teams to compete in Sunrayce 97. The solar car project gave our students a unique learning experience in areas such as Engineering Mechanics, Machine Design and composite fabrication. It also provided an opportunity to apply their theoretical knowledge to practical situations, gain hands-on experience, and at the same time, get credit for their work. The project has been a great success and we are looking forward to competing in the race in June, 97.

Introduction

Middle Tennessee State University (MTSU) is located in Murfreesboro, about 30 miles to the south of Nashville. MTSU, which was founded in 1911, is the fastest growing university in the state of Tennessee. Currently, we have an enrollment of approximately 18,000 students and 700 full-time faculty members. The university has five colleges; Basic and Applied Sciences, Business, Education, Liberal Arts, and Mass Communication. Engineering Technology and Industrial Studies is one of the 10 Departments under the college of Basic and Applied Sciences. We offer Engineering Technology, Industrial Technology and Pre-engineering programs. There are about 600 undergraduate students in the department, of which 200 students are majors in Computer, Design, Electro-Mechanical, and Manufacturing Engineering Technology areas.

Sunrayce - The Solar Car Race

The objectives of Sunrayce are to stimulate interest in technical education and careers among students, and to promote energy efficiency and the use of renewable sources of energy. The race is nationally sponsored by organizations such as GM, DOE, and EDS. We built our first solar car, the Solaraider and competed in the Sunrayce 95 qualifier in June, 1995. In January of 1996, I submitted a proposal on behalf of MTSU to compete in Sunrayce 97.[1] In the proposal, I discussed, deriving from our Sunrayce 95 experience, different aspects of the project including Design and Engineering (driver safety, design and analysis, and material selection).[2] Topics such as Organization and

Project Planning, Curriculum Integration, Fund Raising and Team Support, Vehicle Testing and Driver Training, and Logistics were also discussed in the proposal. I explained how we plan to meet all of the specifications listed in the Sunrayce '97 Regulations.[3] Proposals submitted by different universities were evaluated and scored by Sunrayce officials. We were selected as one of the top 30 teams to receive an award of $2000. Currently, 60 teams have registered to compete in Sunrayce 97. The list includes MIT, Yale, Texas A&M, Stanford, University of Michigan, and several universities from Canada. We are building our second solar car, the Solaraider II. Many undergraduate students, the Engineering Technology and Industrial Studies Chair, the Dean of the College of Basic and Applied Sciences, the Public Relations, the Development and the Foundation, at MTSU are involved in the project in different capacities.

Sunrayce 97 - The Learning Experience

Our solar car team has fifteen active undergraduate students. It has been divided into subgroups to work in different areas of the project such as fund-raising, publicity, design and analysis, fabrication and testing, and electricity and electronics. As faculty advisor, I am helping the team members at every stage of the project. We have another faculty advisor who takes care of the electrical and electronics areas. We meet once or twice a week and discuss all relevant aspects. Each member reports his/her progress to the team. We have completed the design of the car, fabricated some components, and plan to conduct road tests in March of 1997.

In Indianapolis, our first solar car did not pass the dynamic performance test during the Sunrayce 95 qualifier and scrutineering. We had to withdraw from the competition as the rear axle of the Solaraider failed after three laps (5 miles). Overweight was one of the main reasons for our failure. The car weighed 1100 lb while the estimated weight was 600-700 lb. In 6-8 months time, we designed and built it and therefore, did not have sufficient time before the race to test and correct the problems. The contributing factors for the additional weight of the car were; a) use of fiber glass and steel for the main frame, array and bulkheads, b) inadequate vacuum bagging to remove excess resin during the composite fabrication of these components.

Now our students have a good understanding of the practical significance of strength-to-weight ratio. They have designed a strong main frame and fabricated it using grade 6061-T6 aluminum tubing (FIG. 1). The frame has a double roll cage built as an integral part and weighs 98 lb. This unit has been successfully tested for its impact strength. The team can relate to material selection and manufacturing processes that they have learned in our Engineering Technology courses. The front and rear suspension units have been designed and all components are made of aluminum with the exception of the axles which are machined out of AISI grade 4130 steel. The team decided to fabricate the shell and array using carbon fiber to make the car light and strong. In this connection, two members are attending the composite fabrication course offered on campus to learn different aspects of the technique.

The rear axle of our first solar car broke as fillets were not provided at the appropriate locations and it was not heat treated. Our students have designed new axles with proper fillets and in the process have understood the effects of stress concentration and stress relieving related to machine elements. They have used a large safety factor in the design and hence the diameter of the axle of the new car is larger than that of the old car for the same material. Currently, they are discussing with professionals at a metallurgical company in Murfreesboro the heat treatment methods for the wheel axles.

Our students understand that the shape of the car body plays an important role in the performance. The body for the new car has been designed on a computer using solid modeling techniques. Two different designs were sent to EDS for aerodynamic analysis. From the results, the team members have learned the significance of drag, lift and pressure coefficients. Presently, they are improving the body design to minimize the losses. An aerodynamic analysis image for one body design is shown in FIG. 2.

The team decided to fabricate the carbon fiber composite array and shell using a styrofoam mold. As the overall dimensions of the car are 19'x6.5'x5', it was decided to build the mold out of 35 pieces of styrofoam milled on a CNC machine using our CADD files. In this connection, our students are working with a company in Pennsylvania and learning about computer-integrating manufacturing methods.

Driver safety and structural stability are two major aspects of the projects.[4,5] Two team members have performed chassis impact safety analysis for the Solaraider II.[6] They have learned how to use the energy method and apply their knowledge of Statics, Dynamics and Strength of Materials in the analysis. One member is working on the analysis of the front suspension axle and control arms.

Conclusions

Sunrayce 97 has provided a good learning experience for our students here at MTSU. This project has promoted the team work concept among the members which will be an asset when they start working in the industry. Curriculum integration is one of the requirements of the Sunrayce activities. Our solar car team members have received credit for their work on the solar car in Engineering Technology courses such as Statics, Dynamics, Strength of Materials, Computer-Aided Design/Drafting, Shop Problems, and Senior Problems in Engineering. As a result, the learning process is not only fun but also meaningful. Details of our curriculum integration with Sunrayce 97 are discussed in an article that is preparation. However, similar information regarding Sunrayce 95 can be found in Ref. 7. Our students participated in fund raising activities; worked with MTSU personnel and alumni and members of local industry. During this process, they earned good communications skills. The team members visited some of the local industry to discuss with the engineers and managers the Solaraider project. Issues such as donation of cash, gift-in-kind, and technical services, and the availability of their facilities for our project were also discussed. During the visits, the students got an opportunity to observe and learn about the new methods in production, planning and manufacturing. Our solar car team members also had an opportunity to attend the Sunrayce 97 workshop in Indianapolis and learn more about the solar car project from those teams which competed successfully in the previous three races. In summary, Sunrayce 97 has provided a new and well-rounded learning experience for our Engineering Technology students at MTSU.

Acknowledgment

I would like to thank each and every one responsible for the success of MTSU's solar car project.

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B. S. SRIDHARA

Dr. B. S. Sridhara is an associate professor in the Engineering Technology and Industrial Studies Department at Middle Tennessee State University. He received B.S.M.E. and M.S.M.E. degrees from Bangalore University and Indian Institute of Science, Bangalore, India. He received his M.S.M.E. and Ph. D. degrees from Stevens Institute of Technology, Hoboken, New Jersey, and Auburn University, Alabama. Dr. Sridhara has written several reviewed articles in the areas of Acoustics, Vibrations and finite element methods. He is a member of ASME and ASEE. He is faculty advisor for the Sunrayce team at MTSU.

FIG 1. Aluminum main frame and built-in double roll cage for MTSU's solar car, the Solaraider II.

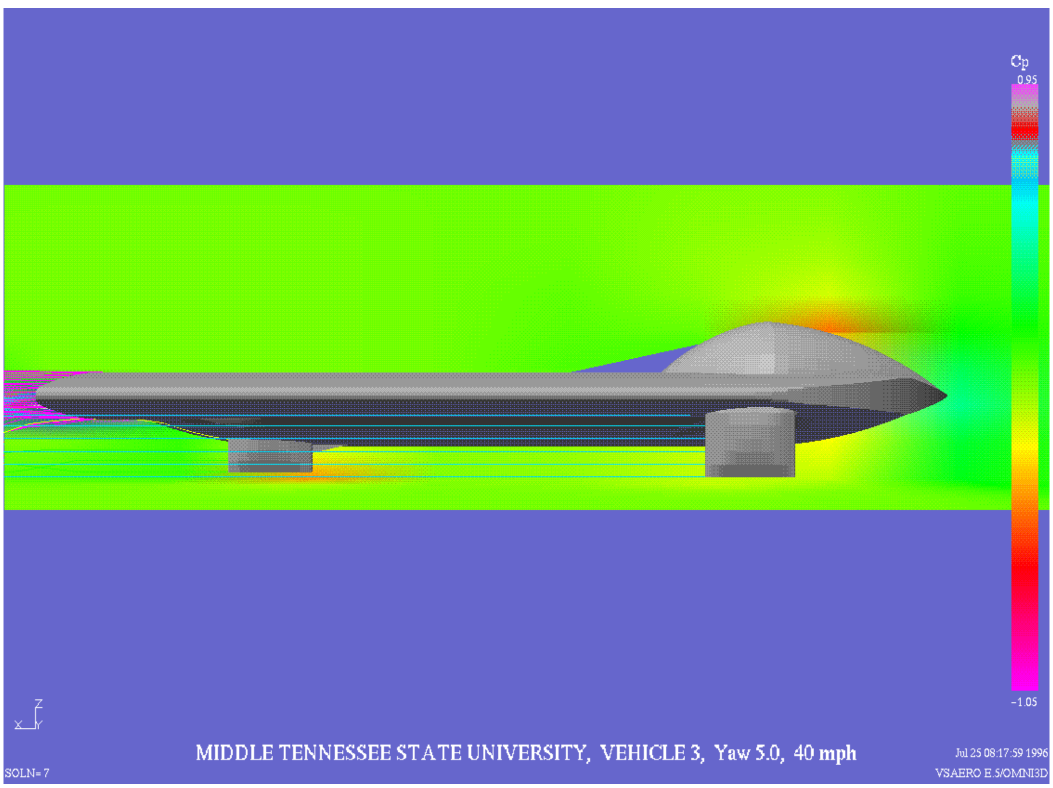

FIG 2. Aerodynamic analysis for the Solaraider II body. The computer model was generated by the MTSU's solar car team and the analysis was performed by EDS.