Design to Competition: SAE Energy-Efficient Vehicle

John G. Nee
Central Michigan University

A high-interest design and manufacturing problem that students developed multiple solutions for in advanced CAD classes dealt with a very timely topic--energy-efficient single-occupant vehicle design. The goal for the courses was to design and eventually produce a vehicle that would successfully compete. The students, after considerable research and discussion, decided to propose some solutions consistent with the rules and guidelines of the Society of Automotive Engineers (SAE) Super Mileage Vehicles competition, one of a number of automotive design competitions that the SAE sponsors.[4] Briggs and Stratton engines are used and supplied to fee paid entrants ($ 100).

For the Super Mileage Vehicles competition, students determined that their design should minimize aerodynamic drag in a vehicle that was comfortable to drive and control. Reduction of mass and design of a high-efficiency drive system were required. The design had to meet general SAE safety requirements, which include specifications on several items:

- Kill switch
- Helmets and clothing
- Brake system
- Exhaust system
- Exitability
- Alcohol
- Body shell
- Guards and shields
- Fuel and lube systems
- Fire extinguisher
- Fire wall
- Visibility
- Suspension system
- Electrical controls

Brainstorming Solutions

With these guidelines, and other specifications from SAE, students started an analysis of the problem. They generated a series of questions, which, when answered, served as the basis for a variety of design solutions. Some of the questions the class raised were:

- What positions will the driver assume?
- What human dimensions will the design require?
- How will the driver control and drive the vehicle?
- What braking system will be used?
- What ventilation is required?
- What speed is to be maintained?
- What is the cost of the vehicle?
- What suspensions system will be used?
- What are the critical dimensions?
- Should seating be adjustable?

- What materials are appropriate?
- What are the weight considerations?
- What standard parts are available?

Most of the students had never had to face the issue of solving an open ended problem with no one single answer. At first they were uncomfortable with the situation and were troubled that the answers were not to be found on instructor provided handouts. Constant sharing and coaching reduced the tension.

Data Gathering / Research / CAD Modeling

These questions generated an even larger and more detailed series of design concerns. Students used brainstorming to develop an extensive list of alternatives and criteria for exploration. At this point, there were no criticisms of any proposed idea. Teams of 2-3 students started to review related literatures. Students then started to contact a large number of vendors of materials and standard components which could help in determining the final design of the vehicle.

Responses from vendors were excellent. Asking only that they receive final design illustrations, many vendors supplied not only technical literature but also components for the students to use for experimentation during the initial design stage. The help that vendors supplied gave students even greater interest in the problem--someone other than their professor was providing input and asking to review the result of their design efforts. The professor found the outside input/influence very helpful--at times the students were briefing the professor.

Students used the team approach to problem solving with good success. The teams worked independently on a number of common design problems. The teams would regularly make presentations to the total class to defend and refine their problem solutions. There was considerable debate as to which team had the best solution to any given design problem. The course professor was a constant source of information as to sources and contacts, but did not attempt to limit or direct the design outcomes.

Design standards obtained from major auto manufacturers, as well as technical data from vendors of bicycle, plastic, structural, and mechanical components, served to maintain student interest. Field trips to auto manufacturing facilities added relevance to the design teams' activities. A bus load of students also attended the annual SAE Congress in Detroit, MI. Technicians and engineers in real industrial settings reviewed and provided input to answering many of the questions the students had during the field trips.

One of the most interesting problems students grappled with was the human factor in developing a physiologically satisfactory design.[3] This was a point of great interest because many of the other problems dealt with machines, stress-strain relationships, kinematics, materials, processes, fits, and so on. Students had not been exposed to in depth study to human factors until taking the course. They were often observed arranging prototyping situations and measuring body position results. CAE/CAD software (SDRC I-DEAS) allowed students to simulate driver positions, clearances, and volumes via solid modeling.[1,2]

After completing the preliminary design problem analysis, the students started developing CAD-based true solid models. These models provided the database for finite element analysis and modeling used for stress-strain analysis, creation of cross-section body used in body skin-group development, and preparation for production work drawings.

A major challenge faced by the students (and the professor) was the fund raising required. Students were guided through the steps of developing a fund raising proposal. Over $ 1200 was raised by using the proposal--$600 came from the university president! A third class followed the two (2) CAD-focused semesters. During the third class the focus was on component selecting vehicle manufacturing, construction, and assembly

Evaluating the Experience

As the activities were reviewed to evaluate course outcomes, it was found that students from each class gained a number of benefits from work on this design problem. They maintained a very high degree of interest throughout the classes and met or exceeded course objectives with regard to applying technical content. The students moved past the point of simply producing CAD models drawing--they created an unique object! Students spent considerable time, an estimated 1,200 hours, outside the traditional classroom setting. Over 60 students were involved in the total process over a period of three semesters. Finally, the students were able to use and develop problem solving and decision-making abilities in a very enjoyable educational experience.

The competition held its rewards as well. The vehicle the class produced reached a mileage rate of 327.05 miles per gallon, placing seventh in a field of 27 entries. The students received a cash reward and the satisfaction of bettering entries from some much larger schools. Presently, students are redesigning the steering and suspension systems. Oxygen sensors, electronic monitoring systems, cooling, and automated starting devices have been added. They are revising the engine, to include fuel injection and improved head flow, with the goal of doubling the mileage capabilities.

References

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Biographical Information

Currently a professor in the Department of Industrial and Engineering Technology at Central Michigan University, JOHN N. NEE earned his doctorate from the University of Minnesota. His teaching experience includes 31 years at the community college, technical institute, and university levels. Nee has had articles published in more than 100 publications; he has also published four textbooks and numerous book chapters in engineering technology.

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