P09221: Innovative Composite Parts for a Formula SAE Racecar

Presented by:
David Holland

Project Status

- Mission Statement:
  - To build easily manufactured, light weight, stiff, high performance composite components for the R•I•T Formula SAE racecar.
- Primary Market:
  - R•I•T Formula SAE Team
- Secondary Market:
  - Weekend Autocrossers
- Stakeholders:
  - R•I•T FSAE Team
  - Dr. Alan Nye
- Start Date/End Date:
  - 2008-2/2008-3

Customer Interviews and Goals

- Customers Interviewed: FSAE Team Chief Engineer, FSAE Project Manager, FSAE Driver, and Weekend Autocrosser
  - Space frame from 2 years ago: 74lbs, ~900lb*ft/degree torsional stiffness
  - Space frame from 1 year ago: 65lbs, ~600lb*ft/deg
  - Would like to decrease weight and increase stiffness.
    - Munich's tub: ~4500lb*ft/degree
    - Goal for first chassis: 50lbs, 2000-2500 lb*ft/degree
  - Would like tighter manufacturing tolerances and decreased cycle time
  - Would prefer partial monocoque with steel rear end to simplify manufacturing
  - Teams at competition claim ~25lbs downforce @ 30mph with undertray
  - Undertray is very low risk – weight is sprung, primarily rearward, and below CG of car

Manufacturing Terms/Concepts

Plug

Mold Exterior

Mold Interior

Concepts

Above: Partial Monocoque and Composite Undertray
(TU Graz)

Above: Partial Monocoque Roll Hoop Mounting
(ETS)

Above: Composite Front Wing
(UMR S&T)

Above: Full Monocoque
(RMIT)

Above: Diffuser Tunnels
(TU Graz)

Staffing Requirements

- 5 Mechanical Engineers:
  - Manufacturing and testing of composite coupons
  - Design, analyze, manufacture, and test carbon monocoque
  - Design and manufacture jigs and molds for carbon monocoque
  - Source carbon prepreg, autoclave, tooling board, aluminum, etc..
  - Full aerodynamic evaluation and validation of aerodynamic package (including racecar geometry, ducts, etc...)

- 1 Electrical Engineer
  - Design amplifier and wiring harness for strain gage data acquisition
  - Ensure EMI isolation with new CDI (capacitive discharge ignition) box location

- Faculty Advisor: Dr. Alan Nye

Preliminary Work Breakdown

Name	Discipline	Responsibilities
David Holland	ME	Project Manager. Manage interface between individual team assignments (i.e. chassis design, manufacture, undertray mounting, etc..). Also responsible for structural composite analyses.
Theodore Kusnierz	ME	Impact attenuator design. Also responsible for validation of undertray flow simulations and chassis fabrication/assembly.
Anthony Salvo	ME	Flow simulation and validation of aero package. Flow models should be comprehensive, including entire car and any radiator ducting.
Ryan Baldi	ME	Work with chassis designer to create manufacturing plans and jigs. Also responsible for composite coupon testing and total chassis testing.
Charles Thomas	ME	Carbon monocoque designer. Responsible for overall chassis shape, packaging, and suspension/roll hoop integration.
TBA	EE	Design amplifier and wiring harness for embedded strain gage data acquisition. Work with chassis designer to determine packaging requirements of wiring harnesses and ensure EMI isolation from the CDI (capacitive discharge ignition) box.

Plan for Weeks 1-3

	Week 1	Week 2	Week 3
David Holland	Begin research of analysis methods for large scale composite structures. List and rank possible failure modes of chassis. Create test geometry and analyze to ensure functionality of method.	Obtain material properties from test personnel. Obtain rough chassis geometry and begin first iteration of analysis. Compare results with previous chassis, recommend changes to Charles Thomas.	Continue analysis iterations. Work closely with Charles Thomas to optimize stiffness and weight without compromising packaging efficiency.
Theodore Kusnierz	Research FSAE rules on structural equivalence. Begin planning of tests for structural equivalency.	Work with Ryan Baldi to test and process data for composite coupons. Determine testing and validation procedure for aero package.	Present aero test plan to the team. Make revisions. Begin test plan for monocoque. Begin design work on impact attenuator and other rules compliance structures.
Anthony Salvo	Analyze flat plate undertray model without car geometry. Iterate.	Continue diffuser iterations. Optimize downforce and center of pressure location.	Add racecar geometry, continue diffuser iterations. Begin manufacturing plan with composites personnel.
Ryan Baldi	Research composite coupon testing. Contact Dr. Gupta regarding lab time. Discuss materials/orientations with chassis designer. Source test fabric.	Fabricate coupons. Test coupons in mechanics lab. Obtain raw data and work with Ted Kusnierz on data processing.	Work with Charles to determine chassis size. Begin sourcing of materials for manufacturing. Begin jig design.
Charles Thomas	Begin material selection, fiber orientation selection, and design of chassis geometry. Finalize suspension point location.	Finish first iteration of chassis geometry. Work with David Holland to optimize stiffness.	Continue chassis iterations. Study packaging clearances to ensure no interferences will occur.
TBA	Source strain gages. Research operation of CDI box and DAQ.	Determine spacing/shielding required for CDI box, DAQ, and any other electrical equipment. Plan wiring schemes. Work with Charles Thomas to package these components.	Set up amplifier, strain gages, and DAQ. Test vibration sensitivity.

Required Resources

- R•I•T Machine Shop
- R•I•T Faculty
- R•I•T Formula SAE Team
- Oven/Autoclave
- Production Materials
    - Carbon, Fiberglass, Bond-O, Aluminum, etc...
- Engineering Tools
    - Data Analysis Software (e.g. Excel, MATLAB, etc...)
    - Solid Modeling Software (e.g. Pro Engineer, Solidworks, etc...)
    - Finite Elements Package (e.g. ANSYS, Pro Mechanica, etc...)
    - Fluids Analysis Software (e.g. Fluent, CFDesign, etc...)

Approximate Cost: $6000-$8000
Cost estimate includes: Materials for Jigs (Alum, Steel), Plugs & Molds (Alum, Tooling Board, Bondo, Carbon, Glass, etc..), and Final Parts (Carbon)

Issues and Risks

Issues and Risks					
Description of Risk	**Possible Consequences**	**Probability of Risk**	**Severity of Risk**	**Overall Risk**	**Contingency Plan**
Can not obtain sponsorship for prepreg carbon	Manufacturing is delayed, project budget increases.	High	Low	Low	Purchase materials
Can not obtain sponsorship for aluminum or tooling board	Manufacturing is delayed, project budget increases.	High	Low	Low	Purchase materials
Plug is destroyed in mold making process	Can not remake molds if necessary, project timeline shifts if new plugs are needed	Low	High	Medium	1.) Repair plug with fiberglass/bondo 2.) Remake plug from existing molds
Mold is destroyed in part making process	Can not remake part if necessary, project timeline shifts if new molds are needed	Low	High	Medium	Remake molds from plugs
Can not find EE student	Incomplete or non-functional wiring harness, data acquisition system. EMI interference between CDI box and DAQ.	Low	High	Low	ME's will have to perform tasks of the EE.
Chassis not complete in time for testing	Aero package will not be tested on composite chassis	High	Medium	High	Aero package can be tested on old racecar.

Intellectual Property Considerations

All work to be completed by students in this track is expected to be limited to the R•I•T Community (including students, faculty, and staff) and design judges of Formula SAE competitions. Due to the competitive nature of the Formula SAE program; designs, documents, drawings, etc., shall not be made available to anyone other than the abovementioned.

Team Values and Norms

- Punctual:
  - Team members must be prompt to all team meetings and/or working sessions. Proper notification must be given in the event of an absence. Team member must not consistently allow other commitments to impede on teamwork.
- Professional and Ethical:
  - Team members must never plagiarize, falsify data, ignore engineering responsibilities, or display conduct that is not inline with R•I•T's Ethics and Compliance policies.
- Quality Work:
  - Team member tasks must thoroughly documented. Documents must be clear, accurate, neat, and easy to follow. Work must be peer or faculty reviewed.
- Committed:
  - Team member must not allow personal commitments to impede teamwork. Team member must carry a fair share of work relative to the rest of the team.