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Design of Formula Student Vehicle

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Design of Formula Student Vehicle: *Formula Student (FS) is the proven educational motorsport competition in the world.*

Universities around the world are included in this challenge to design and build a single-seated racing car to compete in static and dynamic disciplines that demonstrate their knowledge and test the performance of the car. Participation taken over 600 teams from around the world.

Key words: *Design, Formula Student, Design of Vehicles, Car design*

INTRODUCTION

Formula Student (FS) is the proven educational motorsport competition in the world. It is run by the Institution of Mechanical Engineers and uses the same rules as the original Formula SAE with supplementary regulations. Backed by the industry and senior engineers as Ross Brawn, the competition aims to inspire and develop enterprising and innovative young engineers. Universities around the world are included in the challenge to design and build a single-seater racing car to compete in static and dynamic disciplines that demonstrate their knowledge and test the performance of the car.

Fig.1 Formula Student Vehicle - construction and final result

SUMMARY

Universities around the world are taking part in this challenge to design and build a single-seater racing car to compete in static and dynamic disciplines that demonstrate their knowledge and test the performance of the car. Each and every participant must learn along the way and employ old and new, practical and theoretical, technical knowledge for a successful working and as easy as possible to produce design. However, formula student is not only an engineering competition, as it includes strict deadlines and usually 20+ members in each team that need to be organized and work as a single machine, it proves to be a serious project in a working environment. Thus it requires significant project management skills. More than 600 teams around the world participate in FSAE competitions.

Formula Student is:

- High grade engineering design, highly valued by universities and is usually part of the curriculum.
- The closest intersection point with motorsport engineering for a student during his study.
- Invaluable opportunity to learn and gain practical experience in designing an actual race car.
- Great way for improving project management and problem solving skills for participants.
- Appreciation of real engineering experience in a working environment.

Formula Student is the leading World competition for students who want to gain experience in an innovative racing team.

Fig.2 HFS spaceframe with suspension and engine attached

The mission is to ignite and encourage young engineers to focus on engineering careers. The aim of the competition is to cause students to conceive, design, build, evaluate, present and compete as a team with a small single-seater race car in a series of static and dynamic disciplines. The format of the event is such that it allows an ideal opportunity for students to demonstrate and develop their ability to create complex and integrated product in the refined atmosphere of motorsport competition.

1. *Knowledge Level* - Due to the scratch-built nature of formula cars, the designer must be knowledgeable, or become such, in handling and suspension, chassis, powertrain, direvetrain, electronic systems, aerodynamics and safety design. These major areas of the car design work as an integrated unit and the designer must have an understanding of how changes to one area affect the others. Much of the design work is iterative, meaning re-designing areas based on new changes to another area. After the iterations are completed, the design will be complete and optimized.

2. *Design Challenges:*

• Regulations compliance: there are more than 100 pages of regulations regarding the formula car design for FSAE competitions and additionally each competition branch (FSG or FATA for example) has a few more pages of their own. They serve as the main guideline for the design and the designers must have their final product completely in line with the regulations

• Keep production in mind: A designer could spare a whole lot of frustration for the team, if production, assembly and maintenance are kept in mind in the design phase.

• Weight Distribution: Having a good static weight distribution is important. Typically the front will be lighter in front/rear weight distribution. Left/right weight distribution should be as close to 50/50 as possible unless the car is specifically designed for oval track use.

• Suspension: Maximizing the contact patch of the tires with good suspension geometry is of key importance. Suspension, wheel and tire weights (Unsprung weight) affect the compliance of the suspension, which in turn affects handling, so keeping all these components as light as possible is an advantage. The suspension pickup point locations impact the chassis design.

• Chassis: Maximizing torsional rigidity is important to keep the handling responses consistent. Providing openings to make internal components accessible for maintenance is also important, and quite often at odds with the needs to maximize torsional rigidity. The cockpit opening in a spaceframe often presents the greatest challenge to achieving a high torsional rigidity.

• Powertrain: Weight distribution is heavily impacted by engine position. Intake, Cooling and exhaust need to be considered in relation to chassis design, bodywork and aerodynamics.

• Aerodynamic: Minimizing the drag created by the bodywork frontal area and convergence is important to maximize speed. On non-wing cars, this is an area that has a significant effect on

performance along with the suspension. Where spec engines are used this area takes on even greater significance. Underbody aerodynamics may also be important and will have an effect on overall car balance depending on regulations.

• Safety: Providing a substantial crash/rollover safety cell for the driver is vital as is a racing seat and racing harness. Protection for fuel storage, fire protection, and nose and sidepod crumple zones for impacts.

3. *Design Resources*

In this type of competition it is extremely important that knowledge is passed in the team from one year to another. This accumulated experience is the key for steady improvement each year. Apart from books and university lessons, online forums are good way to acquire information that a designer might need. There are lots of such forums where many teams discuss technical details and problems they encountered. Such a pool of information is too good to miss.

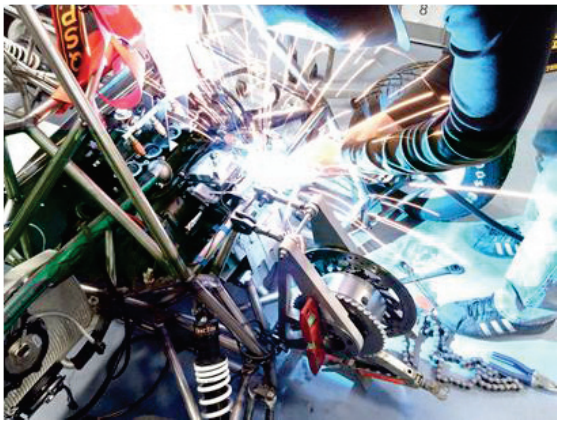

Fig.3 Picture taken during production work on the HFS-01

4. *Construction Challenges* - Due to the precision that is associated with the tuning and performance of formula cars, ensuring the chassis is dimensionally accurate and straight is key. The use of a solid, flat and level build space is important. Jigs are often used in this case to ensure that structural tubing stays in alignment during welding/brazing.

5. Build Effort - Because the car is built from scratch, there will be significant effort in design and construction. There is however, an equally great satisfaction and sense of accomplishment at being one of the few people in the world who have built their own race car from the ground up!

6. *Racing Cost* - Consumable costs are reasonable in relation to other race car types - Tires probably form the single largest consumable expense. Engine rebuilds and crash repairs may be more significant than other race car types, depending on the engine type and frequency they occur.

7. *Business side* – Sponsors have always been critical to motorsport. As such each team's business department must strive to acquire as many as possible to cover costs for consumables, critical components, services (like laser cutting), tools and others. People involved in the business side must also keep close track of the budget allocations and take care of the tricky, usually underestimated, cost report.

8. *Testing* – is critical for achieving good results at the actual race. Since no race car is ready to take a podium directly from the welding table testing is required. The expensive nature of testing dictates that teams must carefully prepare test plans before taking the car to the track. Testing allows for vital suspension and engine maps adjustments. (And of course to see if anything catches fire or simply breaks down while the car is running)

9. *Transportation and Support Equipment* - Obviously each team will need to be well equipped with tools and means of transport for the car. Unavoidable expenses.

10. During the race events, all cars are inspected thoroughly for rule compliance. Teams are then judged in static events, dynamic events, cost report and presentation.

11. ***Static Events:*** include business presentation (max 75 points), cost report (max 100 points), design and documentation of the car (max 150 points). And Technical Inspection (comprising 6 tests): Safety, Chassis, Noise, Tilt, Brake, and Tech (no points).

12. **Dynamic Events:** acceleration (max 75 points), lateral acceleration (skid pad - Figure of 8 - max 50 points), the fastest lap of the track (1 km autocross - max 50 points) and endurance racing (22 km endurance - 300 points and fuel economy - 100 points).

Fig.4 FSG tilt test static event

Formula SAE / Formula Student organised by several FISITA member societies around the world,

Competitions in 2016:

• Formula SAE Australasia (organised by SAE-A) - http://www.saea.com.au/formula-sae-a

• Formula Student Austria (organised by ÖVK) - http://www.fsaustria.at/index.php?id=2&L=1

• Formula SAE Brazil (organised by SAE Brazil) http://www.saebrasil.org.br/eventos/ProgramasEstudantis/site/

• Formula SAE of China (organised by SAE China) - http://www.formulastudent.com.cn/

• Formula Student Germany (organised by VDI-FVT) http://www.formulastudent.de/

• Formula Student Hungary (organised by the Association for Hungarian Automobile Technical Higher Education) http://fshungary.hu/

- Formula Student India, http://www.formulastudent.in/
- Formula SAE Italy & Formula Electric Italy (organised by ATA), http://www.ata.it/content/event-formula-ata/formula-sae-italy-formula-electric-italy-2015
- Formula SAE Japan (organised by JSAE), http://www.jsae.or.jp/formula/en/
- Formula Student Spain (organised by STA), http://www.formulastudent.es/
- Formula Student, United Kingdom (organised by IMechE), http://www.formulastudent.com/
- Formula SAE, United States (organised by SAE Int.) Inc. Formula SAE Lincoln, Formula SAE Electric, Formula SAE Michigan, http://students.sae.org/competitions/formulaseries/
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- Formula SAE Hybrid, http://www.formula-hybrid.org/
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Fig.5 Testing of the HFS-01

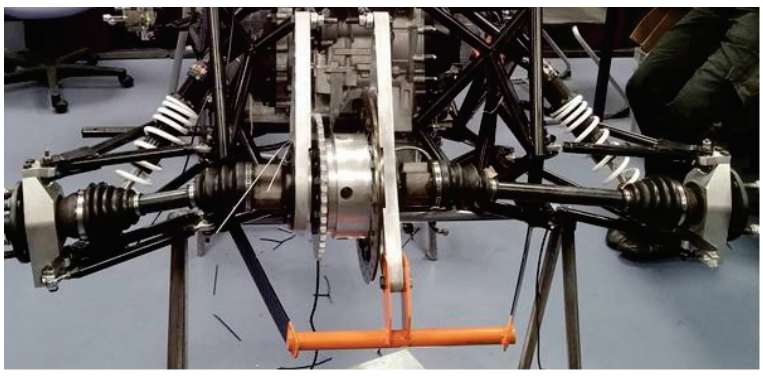

Fig.6 Rear view of the HFS-01 during assembly

CONCLUSION

The idea of the competition each year to form a team and to build a new car. Thus there is continuity between students who passed their knowledge, work together, create valuable links and feel the thrill of battling tight deadlines. They all get the opportunity to get closer to the true emotions of "Formula 1" even during their studies. Or in other words - competition aims to present the interesting side of engineering and ignite the interest of more young people to take on this path. The design of the car is impossible without support from the university and businesses, thus creating this strong bond that is much appreciated worldwide.

Practical tasks can ultimately attract more young people to the engineering profession and thus increase its prestige. Participation in the Formula Student is a "contribution to education."

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