Scientific Research and Essay Vol. 4 (5) pp. 361-366, May, 2009
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2009 Academic Journals

Review

Design and fabrication of a student competition based racing car

A. A. Faieza*, S. M. Sapuan, M. K. A. Ariffin, B. T. H. T. Baharudin and E. E. Supeni

Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

Accepted 6 May, 2009

Design, fabrication and testing of a student competition based racing car are presented in this paper. The competition will encourage students to compete and demonstrate their practical abilities to develop a mini race car. The design guideline is based on the specifications set by the organizer, Universiti Teknikal Malaysia (UTeM) Formula Varsity Car, 2008. Design of the car was carried out using CATIA solid modelling system. The car was fabricated in one of the laboratory in mechanical and manufacturing engineering, Universiti Putra Malaysia. The car has been tested for its performance. Two types of test were conducted which were Static Test and Track Test.

Keywords: Conceptual design, racing car, static test.

INTRODUCTION

Student competition based on the product they designed and fabricated is a good activity carried out by university students. One such example is Collegiate Design Series (CDS) where in these events the design competitions are organized to encourage engineering students to gain experience in the design, manufacture and testing of vehicles. These competitions such as like Formula SAE, Aero Design® and Baha SAE® (SAE FOUNDATION, 2008) have inculcated the students' experience in design and manufacture of vehicles. In Malaysia, to organize events such as Formula SAE, UTeM has taken steps to organize the race at national level. The concept of this event also came from SAE championship held in the UK, America and Canada. The competition was initiated by Universiti Teknikal Malaysia (UTeM), Durian Tunggal, Melaka, Malaysia called Formula Varsity UTeM 2008. The objectives of such event are to expose student to practical work, to give students to apply theories into practices, to develop new talent of students in automotive industry and to inculcate the cooperation among college students (FaMESA, 2008).

There is not much research about go-kart design. Most of the research is about the safety and injury. Streff and Geller (Streff and Geller, 1988) examined parameters under which risk compensation in driving can occur following the use of safety belts. Risk compensation theories hypothesize that if individuals use safety belts, they will drive in a more risky manner than if they do not use safety belts due to an increased perception of safety. They suggested that the occurrence of risk compensation is dependent upon individuals being able to compare the sensations using a safety belt with those of not using a safety belt. It was reported that the victim characteristics associated with go-kart related injuries for 1990 through 1999 was about 12,600 children less than 15 years old were treated in hospital emergency rooms for injuries associated with go-karts in 1999. About 75% of these injuries were to the go-kart operator; most of the operators were males, 8 years old or older. Collision with a stationary object or a moving vehicle, loss of stability, or falling from the go-kart comprised 6,200 injuries during this 5-month period. There were 113 go-kart-related deaths to children fewer than 15 years old reported (Adler, 2000).

In order to increase more safety, the integration of vehicle chassis control system is considered. Individual control systems were first developed, and then their performances were compared with that of the integrated system. The simulation results indicate that the integrated chassis control scheme utilizing the steering and suspen-

*Corresponding author. E-mail: faieza@eng.upm.edu.my.

sion controllers has proven to be more effective in attaining the desired performance that would not be attained individually (Biancolini et al., 2006). The design of a novel chassis solution for a land speed record stream-liner, the Buckeye Bullet 2, which represents an evolution of the vehicle that recently set various records in the electric vehicle classes. The reference chassis design of the Buckeye Bullet consists of a steel space frame structure, for which alternative candidate solutions are investigated. These include several combinations of aluminium honeycomb sandwich panels and carbon fibre composite skins and a composite monocoque structure. A high-speed streamliner requires a chassis that is stiff in both torsion and bending, especially in transversal direction, in order to avoid undesired vibrations that can compromise vehicle handling. Thus, the various solutions are compared on the basis of mass, stiffness and eigenfrequencies (Biancolini et al., 2006).

Furthermore, researchers are going to obtain the best aerodynamic penetration, the chassis is integrated with an external shell that replaces the side pods and the front noses of traditional go kart. The aerodynamic study was focalized on finding the best "cx" and the pressure loads, variable with speed, on the chassis. The system was first modelled in parametric C.A.D. software and then transferred to F.E.M. software to select a material that guarantees enough strength and stiffness margin for the structure loaded with the maximum pressure loads. To meet such requirements a carbon composite material monocoque solution was adopted (Manieri and Urbinati, 2007).

Katz et al. (2004) examined the available liftoff data on a variety of race cars. This data indicates that prototype race cars have a higher lift slope than open-wheel race cars due to their larger underbody area. In the second part of this study a quarter-scale model of an Indy car was tested to generate similar data on an open-wheel race car. Both the previous and current data indicate that race cars under normal racing conditions have sufficient front downforce to eliminate the possibility of liftoff. Only when some sort of collision or other contact lifts the vehicle front by several degrees can the aero-dynamic lift overcome the weight of the car and result in an unstable pitch up. The available data suggests that by using less ground-effect dependent front downforce devices, the risk of vehicle liftoff is reduced. In the case of open-wheel race cars, some sort of peripheral bumper limiting wheel entanglement could significantly reduce the chain of events leading to vehicle liftoff.

Charles et al. (2002) describe the use of multidisciplinary design optimization to resolve system-level tradeoffs during race car design. Their implementation involves three design variables: weight distribution, aerodynamic downforce distribution, and roll stiffness distribution. Manufacturing of the go-kart with composite materials and decreasing the production time make some research to fabricate racing go-kart to demonstrate the advantages of UV technology for composites. The go-kart project was a was a follow-up to a previous demonstration effort, dubed "Team UV," in which a full-scale fibre-glass-bodied race car was built with UV-curing technology (Black, 2004).

Liang et al. (2007) conducted a study to design and manufacture an optimum go-kart frame. They stated that building a good kart frame is very important in go-kart design. They did details analysis in torsional stiffness of the go-kart frame by using non-linear, explicit dynamic code LS-DYNA 3D. Two design concepts were investigated to improve the torsional stiffness of the kart frame. The first one was the arrangement of extra members at suitable positions on the frame and the second one was to increase the width between two king-pins. The torsional stiffness of each frame type was determined and compared with each other. The result shows that the torsional stiffness of the frames with larger kingpin width is better than those with extra members.

SPECIFICATIONS AND DESCRIPTION OF THE CAR

Prior design concepts were developed, it is important to come up with a Product Design Specifications (PDS). Based on the Formula Varsity Specifications provided by the organizer, the following PDS is developed for the formula varsity car (FVC) and an example of part of the PDS is shown in Table 1.

For making a car the following subsystems such as chassis subsystem, front and rear suspension sub-system, anti-roll bar subsystem, steering subsystem, wheel and tyre subsystem, brake subsystem and power train subsystem should be designed and fabricated. The chassis subsystem comprises a single body that defines the location of all the components that are non-rotating and fixed relative to the vehicle coordinate system. The front suspension subsystem is to control the motion of front wheel relative to the chassis. Anti-roll bar (ARB) subsystem is to avoid rolling of the chassis. The steering subsystem is to connect the driver’s input to the orienttation of the front wheels through the front suspension subsystem. The wheel and tyre subsystem comprises a left and right pair of body parts for each wheel and tyre assembly. The brake subsystem provides a driver control in the form of torque opposing the spin of the wheels. The engine and transmission included within the power train subsystem.

CONCEPTUAL DESIGN

Conceptual design is an essential step in product development process (Sapuan, 1999). The main concept for this car is to have a car that can be mass produced with short lead time and with relatively low cost. For this task, the design and manufacture of the race car was based on low cost production and easy to manufacture concept. The main idea behind this concept is that the design and fabrication can be replicated with ease. This was made possible due to the minimal fabrication needed in producing the car and with minimal use of components.

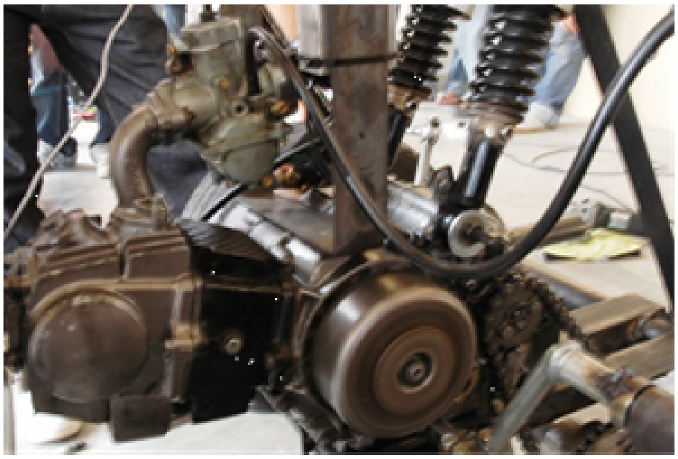

Figure 1. Standard 115cc motorcycle engine salvaged from scrapped yard.

Figure 2. Engine shock absorber from typical motorcycle suspension system.

Another factor that contributes to the short lead time fabrication is by using readily available automotive components. This method does not only reduce to production time significantly, but it also substantially reduces the production cost, which is in line with the overall concept. Another factor within the design exercise is to use salvaged car components. The reuse of abundantly available scrapped components is also in line with the overall conceptual design. For example, all the car wheels were taken from a standard 13 inch car wheel whilst the engine suspension mounting was adopted from the standard motorcycle rear suspension. The major saving was achieved by using the standard 115cc motorcycle engine, which was mass produced and are abundantly available in scrap yard (Figure 1).

DESIGN CHALLENGES

Due to limited time, certain aspect of the design had to be altered and simplified in order to meet the deadline. One of this alteration involved doing away with the suspension system on the front and the rear wheel of the car. One may think that this will cause a significant problem in car handling on race track. However, based on the specification of the track, the uneven surfaces are minimal, hence can be absorbed by the tyre. Nevertheless, the designers were facing another problem due to lack of vibration absorption in the car. The major vibration of the car is now generated from the engine and this proved to be greater than the vibration caused by the road surface condition.

A quick redesign of the engine mounting was deployed and in the end, two standard size motorcycle shock absorbers were used as additional engine mountings as shown in Figure 2. This had enable the engine to be securely fasted to the engine chassis but in the same time allowing greater movement and flexibility of the engine, thus greatly reducing and isolating the vibration source away from the chassis. From the visual inspection, there were hardly any noticeable changes on the car when the engine was running idle and when it was revved up. Further test was carried put and from the feedback gathered of the driver, the driver stated that the vibration that was felt on the drivers body and steering wheel was reduced by half (50%) as compared to previous engine mounting setting.

DETAIL DESIGN

Figures 3 - 5 shows the assembly drawing of formula varsity developed using solid modelling system, CATIA. Rendered model of the car design including the engine.

FABRICATION

Figure 6 shows the fabrication process of Formula Varity Car carried at the Manufacturing Laboratory, Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia.

After the fabrication was completed the car was tested and Figures 7 and 8 show the UVC ready for race. Two types of tests were carried out. The first was Static Test: covers technical aspects and the second test was an On-track Test, where the driver needs to complete 30 laps with 600 m of each lap.

However, the body work of UPM VFC was not installed due to time constraints. A design of body part was carried out and Figure 9 shows design of body of VFC carried out using solid modelling software CATIA.

Conclusions

Design and fabrication of racing car were reported in this paper. From this exercise, engineering and industrial design students have learned design, fabrication and testing of real automobile. The competition activity gives

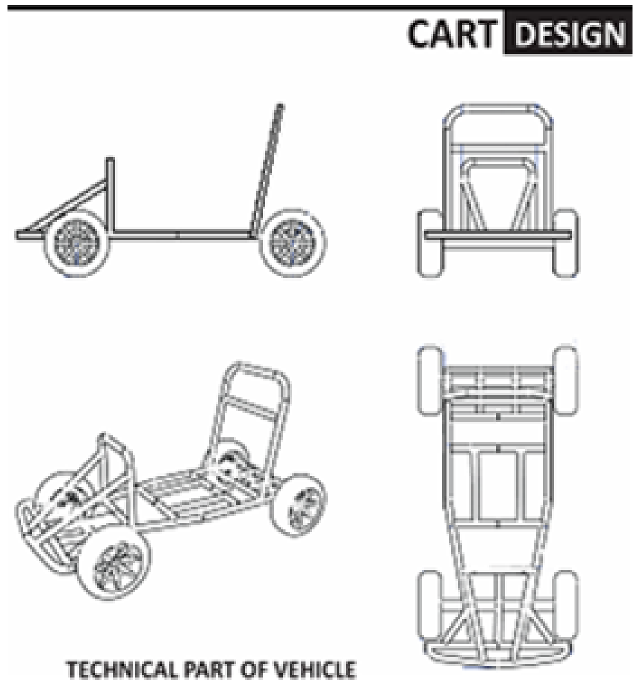

Figure 3. Some basic dimension of the chassis, following the design requirement set.

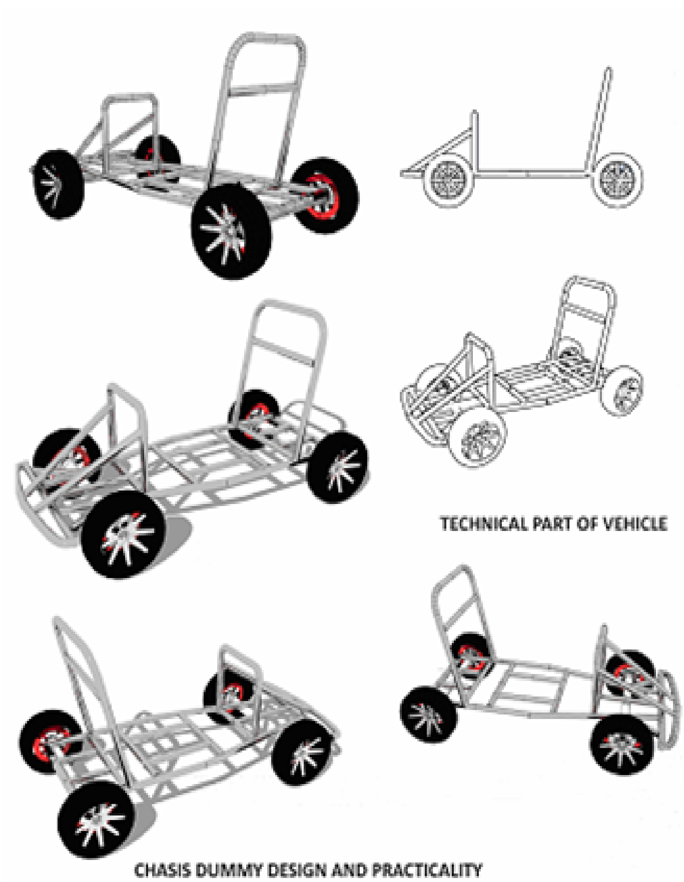

Figure 4. 3D model of the design.

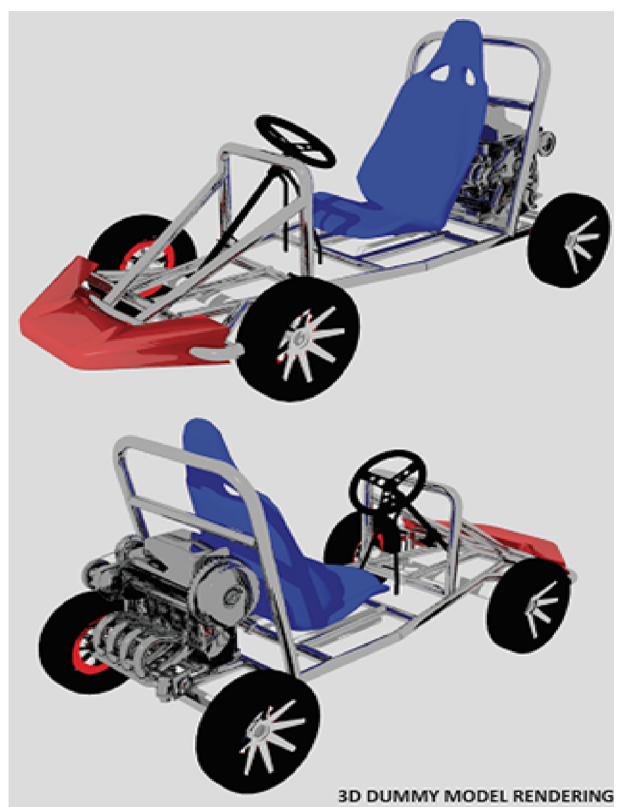

Figure 5. Dimension rendered model of the car design including the engine.

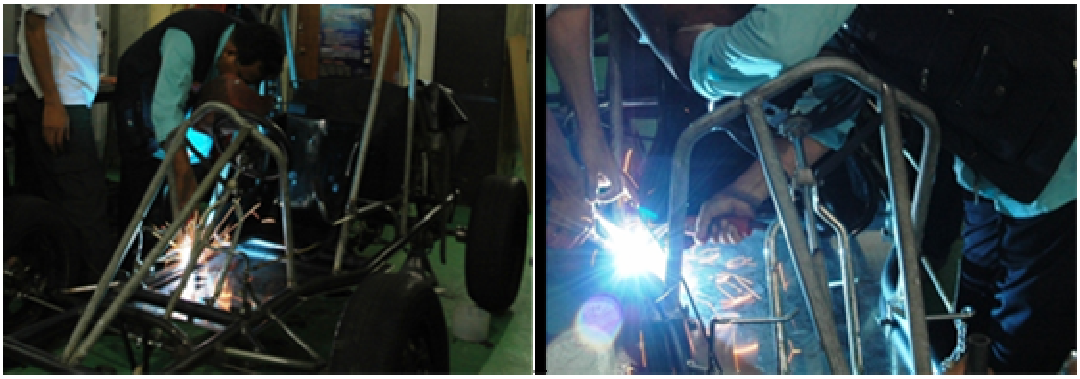

Figure 6. Fabrication of FVC chassis.

Figure 7. Static test of the race car.

Figure 8. Track test and time trial.

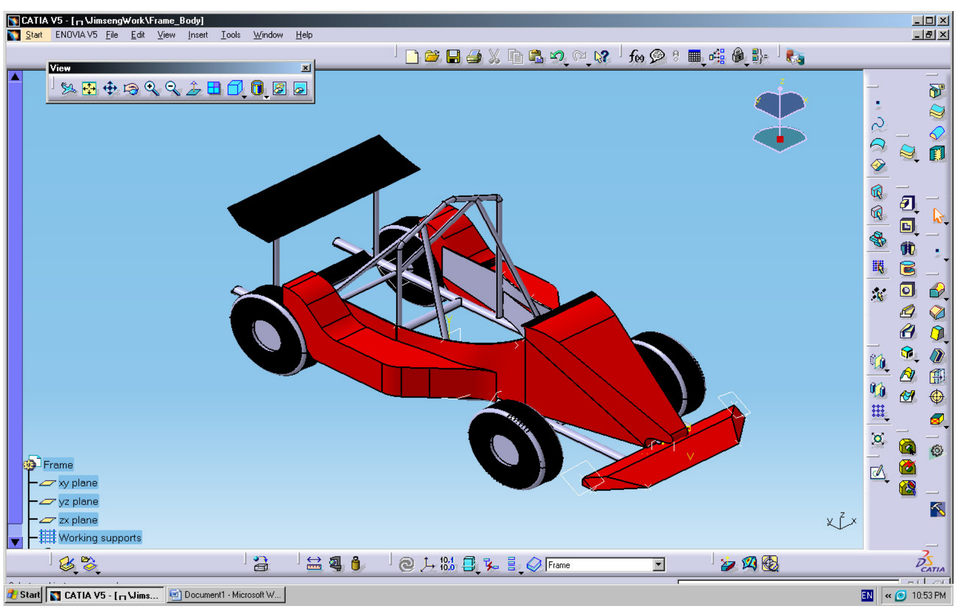

Figure 9. Solid modelling system of car body.

student the opportunity to apply theories they have learnt, as well as exposure to practise work and challenges. The use of solid modelling system has helped designer to perform higher quality design. Students have also experienced real situation and challenge from design stage until fabrication of a real car. Finally the car was tested on-track to evaluate its capability and endurance, and the results were monitored for further improvement.

ACKNOWLEDGEMENTS

The authors wish to thank the management of Faculty of Engineering, Universiti Putra Malaysia (UPM) for allocating some fund for this project, students and technical staff of Department of Mechanical and Manufacturing Engineering, UPM for their participation and contribution.

REFERENCES

Adler P (2000). Go-kart related injuries and death to children,Consumer Product Safety Commission 48.
Biancolini ME, Renzi F, Cantemir CG, Rizzoni G (2006). “Multibody-FEM analysis of a Land Speed Record suspension” – Fisita World Automotive Congress, Yokohama.
Black S (2004). Technologies for UV curing of composite laminates demonstrated. Composites Technology, Gardner Publications, Inc.
Charles DM, Timothy WS, Kurt H, Kemper L (2002). Application of multidisciplinary design optimization to racecar design and analysis Symposium on Multidisiplinary Analysis and Optimization.Atlanta Georgia. pp. 1-7.
FaMESA (2008). Persatuan Pelajar Kejuruteraan Mekanikal (FaMESA), Universiti Teknikal Malaysia Melaka, Malaysia, Brochure.
Katz J, Sluder R, Garcia G (2004). "Aerodynamics of Race Car Liftoff." SAE.
Liang CC, Yu CH, Wu CC (2007). A study on torsional stiffness of the competition go-kart frame, WIT Transactions on the Built Environment. 91: 189-198.
Manieri G, Urbinati M (2007). "Design of a land speed record Go-kart ", 2008, http://www.fisita.com/students/congress/sc06papers/F2006sc16.pdf.
SAE FOUNDATION (2008). SAE FOUNDATION for Science and Technology Education, www.saefoundation.org.
Sapuan SM (1999). Reka Bentuk Kejuruteraan, Era Ilmu Sdn. Bhd., Kuala Lumpur.
Streff FM, Geller ES (1988). An experimental test of risk compensation: between-subject versus within-subject analyses. Accident Analysis and Prevention. 20: 277-287.