Designing and Building Go-Karts As An Engineering Student Project

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ABSTRACT: This paper describes a semester project carried out by automotive students within the Faculty of Mechanical Engineering at Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) to fulfil the requirement of the Vehicle Dynamics module coursework. The students were required to design and develop their own rally go-kart. This allowed them to apply theoretical knowledge that they have acquired into practical work with their own creativity when designing chassis, suspension system, braking system and steering system. The project essentially had three main parts. Initial study concentrated on the design and analysis of the go-kart using a modern computer aided engineering software, CATIA. The second part of the project is the stage of building the go-kart. Lastly, the final stage was when the go-karts had to compete on a racing track. The evaluation of the project was based on the design and analysis of the go-kart using CAD and FEA packages, building process, technical report and also performance during the racing events. The finite element analysis phase of this project is presented here although this is well established in both education and industry. Also described in this paper is the engineering and manufacturing task as well as costing for this project.

INTRODUCTION

Vehicle dynamics in its broadest sense encompasses all form of conveyance including ships, car, train and airplane. In general, the characteristics of vehicle dynamics may be described in terms of its performance, handling and simulation. Therefore the theory of vehicle dynamics is concerned with the study of performance, handling behaviour and ride relationship with the design of vehicle. The student project described in this paper originated after discussion between the academic staff members in the Automotive Engineering Department, Faculty of Mechanical Engineering in KUTKM. Teaching and learning approach in KUTKM are based on the application and hands-on approach. By doing this project, the author feels that students are allowed to design and build their own rally go-kart with the knowledge that they received during the lecture and tutorial sessions with deep understanding in the fundamental dynamics of racing car.

PROJECT OVERVIEW

This project is one way of discussing the fundamental approach towards vehicle dynamics modelling, vehicle response to various driver input, road loads, mechanics of tyre, relation between ride and handling, steering system as well as wheel and suspension system. Similar to other module term project, student might face different kind of problem that came from many different aspects involving technical issues, conceptual design and prototype testing. The main objectives of this project are:

- To expose students to turn the theories they have learnt in the vehicle dynamics class into practice.
- To practice their components designing skill to build the go-kart system.
- To harness management skill in planning and running the project.
- To fulfil practical requirements of the vehicle dynamics course and contribute 30% of total assessment marks.
- To have fun by testing the performance of the go-karts through a racing competition.

The main task for the student is to correctly modelling the conceptual design of their go-kart. A good design will give a good stability during racing tournament. The used of high end CAD software CATIA helps the student to produce good graphical drawing. Finite element modelling is carried out to look at higher stress concentration of the go-kart component. The selection of material to build the car is another important criteria before the production gets started.

SCOPE OF THE PROJECT

The focus of the project was to identity and highlights all the system related to vehicle dynamics performance. Therefore, the design of steering system, braking system and suspension system is the main criteria for evaluation besides the performance during the racing tournament. Problems were also faced on whether the go-kart they were going to produced was the same as real go-karts. Of the 6 groups of students participated, only one resembles the common go-kart. Others are somewhat different in many aspects. Some cited lack of tools in the workshop here as reasons for not being able to resemble the common go-kart more closely. Furthermore the material that they were using was also different than the materials in real go-karts.

Most of the designs by the students focused on the chassis. There was little covering that could be deemed as the body of the kart. However, this might be due to more emphasis on the passenger comfort and handling of the kart that were given as these are covered in the theoretical part of the vehicle dynamics course.

DESIGN, ANALYSIS AND FABRICATE THE GO-KART

As mentioned earlier, the students were to finally build their go-karts. However, they first have to plan their design by using CAD software and predict the strength and behaviour of the components and assembly by using CAE package. Lastly, when all these were done, these inventions went through a racing competition that also serves to gauge the dynamics of the vehicles they designed and built.

Design Stage

For team Sky-RC [3], a motorcycle damper and spring were used as the suspension system. For front suspension, a motorcycle suspension concept was chosen as it is easy to assemble. This suspension is connected perpendicular to the rod in each side. When the absorber received the load be it large or small, it can deform to a certain degree to minimize vibration. This assembly is also good since the suspension is located perpendicular to the road surface and thus it can absorb large force or any vibration from tyre.

A rally go-kart also used a motorcycle damper and spring as the suspension system. Ease of assembly prompted the use of motorcycle suspension on the front axle. This suspension is connected to perpendicular to the road for each side. When this absorber received load whether large or small, it could introduce some deflection to minimize vibrations. This is to follow practice in large real vehicles where their absorbers are also perpendicular to the road.

The front and rear axles are 193 cm apart [3]. Here long wheelbase is used in order to achieve a more comfortable ride for the driver. Here the front axle is fixed to the arm and absorbers, whereas the rear axle is adjustable to suit the driver. In a real car, the adjustment for comfort is mostly done via electronics control system.

The direction of the vehicle motion is controlled by the front wheel by the Ackerman Steering system [4]. This standard mechanical steering use a series of links such as rack and pinion and arms to ensure both front wheels turn in the same direction synchronously.

However, in team Pro-Karting design [4], sprocket and chain were used to transfer the rotation from the steering wheel to the rack and pinion. Gear train was also used to increase the rotation from the input steering wheel to the output pinion gear.

The suspension is the most important system of the vehicle to ensure vehicle stability and reducing vibration due to ride. When vehicles take a turning or cornering, suspension also take part to divide a load or called as weight distribution. Suspension system can perform a comfortable riding to drivers. Nowadays many suspensions are produced to give safety features to users.

The brake system was difficult to design. To ensure that the braking system is perfect and working, a motorcycle disc brake was used and located at the rear shaft, which was the drive shaft. This disc was place normal to the shaft with their center lines coincide with each other to prevent bending due to disk rotation. Actually, the disc was bolted to a steel plate that was welded to the rear shaft. So, when the disc stops rotating, the drive shaft would too.

The steering system is another important subsystem to the go-kart. The system used here is the rack and pinion, which is similar to what real cars have. This kind of system is known to have steering rotation ratio and a long lifetime. Basically, the steering wheel was connected to the rack and pinion through a shaft and a coupling. During this project, a problem with this type of steering surfaced that required some adjustment to the rotation of the left and right wheels.

Finite Element Analysis Stage

Finite element analysis was also done on the computer models of the go-kart components. This is to predict the effect of lad on the chassis. Modal analysis ten helps the study of the components vibration and squeal noise. North in 1948 described brake squeal noise by modelling an elastic rubbing system that creates a negative slope.

Stress analysis was also done using FEA package to investigate how the design would react to expected loads like forces and moments. The results of some of the most important parts of the go-karts are shown below.

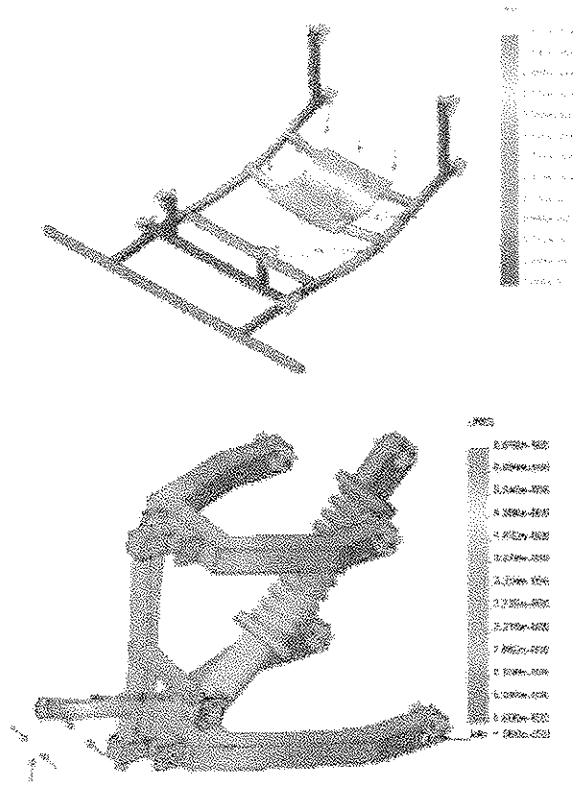


Figure 1. Finite element analysis of the chassis and suspension arm [3,4].

Fabricating The Design

The last part in the design was the fabrication of the go-karts. The chassis is mostly done by utilizing hollow steel bars. This stock can withstand heavy load despite being relatively inexpensive. In fact, we found it easier to shape and weld or join using this stock rather than using hollow rod.

The fabrication part took place at our own facilities. By then, the students were already exposed to the use of manufacturing processes and workshop practices like welding, cutting, bending, bolting, assembling and the likes. Their activities were mainly done in the afternoon after lecture sessions and on weekends under the supervision of staff here. Actually, they finished the design work from scratch to assembling the complete system in six weeks. A total of 6 models managed to be constructed.

The parts that they used were either used or borrowed temporarily like in the case of the engines. The engine capacity ranged from 90 cc to 125 cc, which came from bush cutters and small motorcycles. Modifications were made like to attach stick

shift for the engine transmission system. In most of the design, sprocket and chain system were used to transfer power from the engine to the rear wheels. Disc brakes were also the common feature in the models.

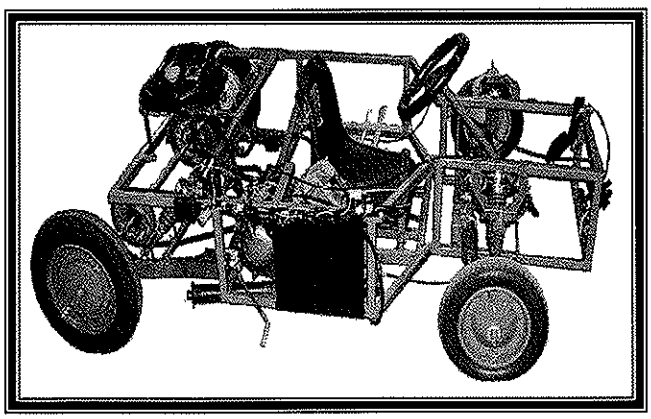
This project was not cheap for any of the teams that took part. They roughly spend between RM 400 (USD 105) to RM 900 (USD 236) for their models. In the end all this contribute to a maximum of 30% marks that is allocated for their coursework project. Below is shown the budget undertaken by one of the team in Table 1 [5].

Table 1. Partial expenditure list

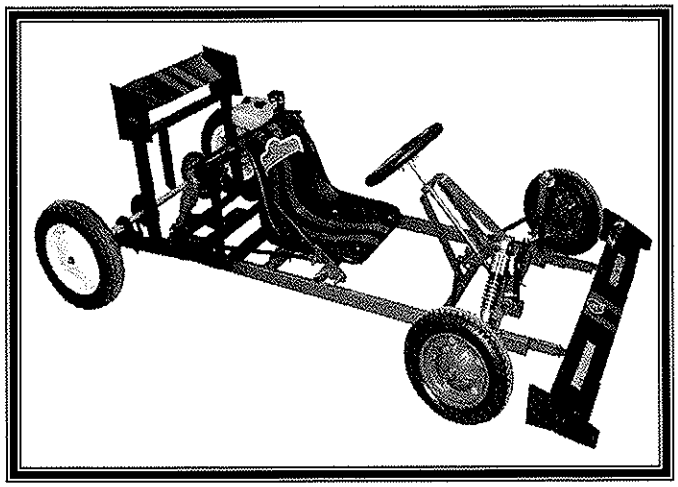
No.	Material	Quantity	Prices
1	Tyres	4	RM 100
2	Aluminium Plates	4m & Above	RM 40
3	Absorber	4	RM 120
4	Disc Brake	1	RM 150
5	Bottles of Spray	3	RM 15
6	Screw and Nut	1 Packet	RM 10
7	Seat	1	RM 15
8	Hollow Rod (25 mm x 25 mm)	3 m	RM 20
9	Hollow Bar (diameter 25 mm)	6 m	RM 30
	Total		RM 500

RACING EVENTS

The racing events last for 12 round after the manoeuvrability test. The performance and toughness of the go-kart before and after race was part of the evaluation criteria. Six of the academic staff has been appointed as the jury for the events.



(a)



(b)

Figure 2. Two of the Go-kart that participated in the racing with (a)125 cc engine and (b)110 cc engine [3,4].

CONCLUSION

The project managed to accomplish what it was aimed for. Students were exposed to relate to the theories they have learnt in the vehicle dynamics class into practice. They also succeeded in harnessing management skill in which they had to plan and then executed the project to get the best design and finished go-karts. In the end, the student all had fun by testing the performance of the go-karts through a racing competition. Here, not just the outlook of it but also how they perform on the road determines good overall design.

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