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Design and Fabrication of Race Spec Go-Kart

Simranjeet Singh, Aniket Badgujar, Pushparaj Patil, Gaurang Kadam
[1,2]*(Automobile, Rajendra Mane College Of Engineering And Technology, India)*
[3]*(Mechanical, Rajendra Mane College Of Engineering And Technology, India)*

ABSTRACT : *A go kart is a small four wheeled vehicle basically used of traditional kart racing and amusement purpose. We designed and fabricated a go kart for participation at the national go kart championship. The design includes applications of extensive engineering analysis, teamwork, project management, and development of conceptual ideas. These ideas have been then converted into viable concepts ready for fabrication. The main objective of the design is to make a car that is durable as well as reliable and will last through the endurance using parts that are cost effective and easily available in India. The kart has been designed using sound design principles. The principle of triangulation has been extensively used to make sure that the chassis is extremely rigid and provides a safe cocoon for the driver in case of an accident. The vehicle has been designed in such a way that the reliability is not compromised in the pursuit of speed. The wheel and suspension geometry have been designed taking into account the track layout and prevailing conditions.*

Keywords: *Analysis, Teamwork, Durable, Reliable, Sound design principles, Triangulation*

I. INTRODUCTION

ISIE- Indian Karting Raceis a collegiate competition organized by imperial society of innovative engineers. The assigned task is to design and build a go kart vehicle to compete in the events held in the go kart tracks at national levels. During the design evaluation, the vehicle functionality and performance will be evaluated with respect to acceleration, traction, maneuverability, and endurance. Each team is challenged to weigh the many positive and negative aspects that emerged throughout the design process to arrive at cohesive solutions. We decided to focus on the endurance event because of its high point value. This has led to an increased attention on the drive with reliable designs for suspension, brakes, and Steering. During the construction of the previous vehicle some conceptual shortcomings that led to re-design throughout the fabrication process, have also been revealed. As weight is critical in a vehicle powered by a smof all engine, a balance must be found between the strength and weight of the design. To best optimize this balance the use of solid modeling and finite element analysis (FEA) software is extremely useful in addition to conventional analysis. The Following report outlines the design and analysis of the vehicle's frame design.

II. DESIGN CONSIDERATION OF VEHICLE

- Easy operation.
- Lightweight and compact.
- High reliability.
- Good serviceability.
- Low cost.
- Ease of manufacturing.
- Optimum Braking
- Effortless Steering
- Aesthetically Pleasing

III. MATERIAL SELECTION

Steel is a ubiquitous material choice for in mass produced chassis, custom auto racing roll cages, and other car frames because of its high strength, low cost, and high weld ability. Design considerations aside, the driving factor behind chassis material selection were the sae competition vehicle regulations. The steel chassis also has many other benefits including lower cost, higher safety factors, better manufacturability and increased reliability. After the base material had been selected, the team then had to choose which alloy would best suit the vehicle requirements. The sae rule book uses aisi 1018 steel properties as a base for many of their required strength and stiffness equivalencies, so this alloy was considered first.1018 is a very common alloy that is cheap and readily available in multiple geometries and wall thicknesses. The minimum amount of carbon content as mentioned in the bajaj sae rule book is 0.18%.however, because of its low carbon content and lack of other alloying elements, 1018 did not have the superior *hardenability* that other iron alloys like *4130 and 4140 possess*. aisi 4130 had all of the same alloying elements as aisi 4140, but a slightly lower carbon content of 0.30% provides for good *weld ability* as well as decent hardenability. But, considering the availability of both the materials and its cost, it was con cluded that aisi 1018 steel is easily available in the local market and is cheaper in terms of cost.

IV. CHASSIS

For the construction modifications of the frame, close attention was paid to the orientation of the members. the original design called for engine mounting members to be directly behind the driver and extending backwards towards the rear bumper. it was observed that during a rear end impact, these members could potentially harm the driver. these members were modified so that the force during such an impact would be directed to the outer edge of the roll hoop. similar logic was used throughout the design and construction of the frame to ensure driver safety.the frame has undergone major modifications in order to implement the various subsystems. brackets have been added in order to provide attachment points for the suspension arms and coil-over shocks. bracing members are also added in some locations to support the additional loads of the suspension. frame gussets have been also added in strategic locations in order to brace weak members or members that will experience high loading. Front and rear bumpers are added as per the rules in order to protect the vehicle in the event of a front or rear impact

4.1. Modeled Pictures Of The Frame:

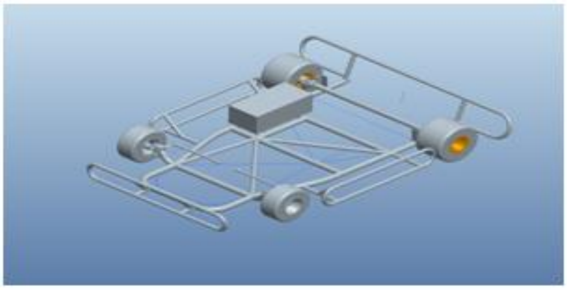

Fig 4.1.1: Chassis

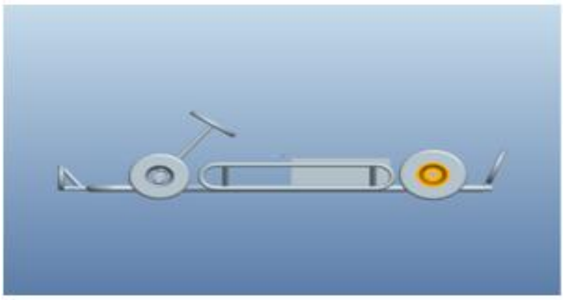

Fig 4.1.2: side view of chassis

4.2. Loading Analysis:

To properly estimate the loading on the vehicle during accidents, an analysis of the impact loading is essential. to model the impact force, deceleration of the vehicle after impact has to be found. research has found that the human body will pass out at loads higher than 9 times the force of gravity or 9 g's. for utmost safety of the driver a value of 10 g's was set as the goal point for an extreme worst case collision. it is assumed this worst case would only take place when the vehicle runs into a stationary object. in baja competition a side impact accident usually occurs from the automotive industry safety tests, impact force in a side impact is assumed to be half of that of a head on collision with a fixed object (equivalent to a deceleration of 5 g's). damping effects of the shock absorbers are also assumed to be 5 g's. Although this value is an overestimation it allows the ability to account for failure of a shock absorber. the impact on the roll cage in a roll over is the next most often accident that would occur this is a secondary impact & deceleration of approximately 2.5 g's is assumed.

4.3. Front Impact

In this case a deceleration of 8 G's was the assumed loading. This is equivalent to a 13600Nload on the vehicle.

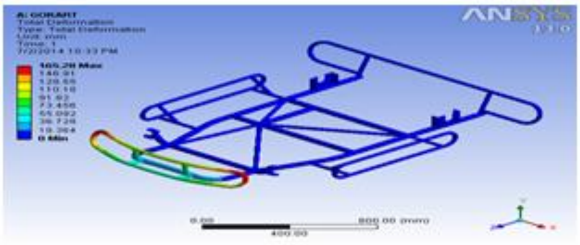

Fig 3: front impact

Above figures indicate large stresses due to the impact, although there is deformation & at some places there is failure, the design is safe as there can be no damage to driver as the forces assumed are very large than actually encountered.

4.4. Side Impact:

In this analysis the side impact is estimated with a 5 g load equivalent to a loading force of 8500N.

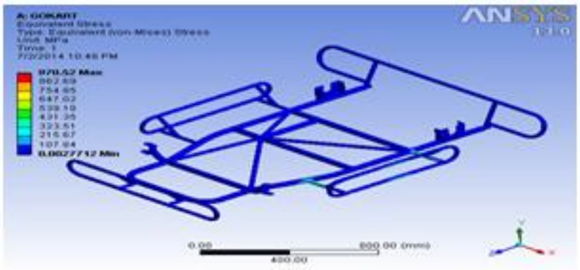

Fig 4: side impact

The analysis indicates a safe design during the most likely accident of the side impact. Although some areas in the chassis are prone to high stresses and can result in failure, suited bracing members would be added to relieve localized stresses.

4.5 Rear Impact:

In this analysis the side impact is estimated with a 4g load equivalent to a loading force of 6800N.

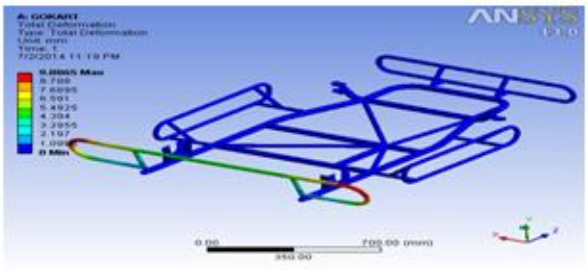

Fig 5: Rear impact

The analysis shows that the chassis is safe in case of rear

V. FABRICATION PROCESSES / MACHINING PROCESSES

Lathe work, cutting, sanding, knurling, drilling, milling, shaping, hobbing – for gears, broaching, grinding, sandering, honing, polishing, finishing, welding.

VI. HEAT TREATMENTS CONSIDERED

Stress relieving - to normalize localized heat affected zones from welding. Heat And Air Quench - to improve mechanical properties & also to increase the yield strength. Temper- to increase toughness and decrease brittleness

VII. BILL OF MATERIALS (BOM)

Considerations –

- Standard parts vs. imported parts vs. fabricated parts
- Modifications to be done to old parts from previous vehicles
- Materials required for new fabricated parts and also the machining process
- Purpose or functionality of the part
- Costs

The bom for the entire vehicle is nearing completion. Parts to be fabricated have been decided upon. Most parts have been freeze. Alternatives are also being worked upon, if main parts not available. The new vehicle shall utilize old components from the previous vehicle for extensive testing and developing a better and cheaper solution.

VIII. STEERING SYSTEM

The steering of the go kart is very sensitive because of lack of differential. In order to turn one of the wheels need to skid over the track surface. In order to achieve this use disc and link mechanism. Our ste0ering geometry has a linear tie rod travel of 65mm for the inside tyre and 58mm for the outside tyre and also gives 71 degree lock to lock turn of steering wheel which is very suitable for the race track as it allows quick turns with a small input and being more precise at the same time. We also attain a perspective turning radius of 2meter.
According to the Ackermann geometry the front tyres will rotate about the mean point as a result the entire force will act on the outer front tyre on a corner. Thus the cornering traction will be primarily governed by the outer tyre.

Table 1: Perfect Ackerman Vs Kart Geometry

PERFECT AKERMAN	KART GEOMETRY
$□_i$= 37.99° □38°	**$□_i$= 38.04° □38°**
$□_o$ = 27.77° □ 28°	**$□_o$ = 31.6° □ 32°**
□ =14.34° □14°	**□ =0(non parallel steering achieved by disc and link mechanism)**
Difference in turn angle for outer tyre: **4°**	

With our steering geometry the outer tyre will turn 4 degrees tighter than it would in case of perfect angle. This will make the inner tyre to scrub, and due to this friction, the entire kart will tend to pivot around it. As the corner is primarily governed by the turn of outer tyre we will be able to achieve over steer and attain higher cornering ability the disk and link mechanism has been chosen because it is cheap, has very low weight and is easy to fabricate.

5.1. Steering Component Analysis:

The stress analysis of front knucle:

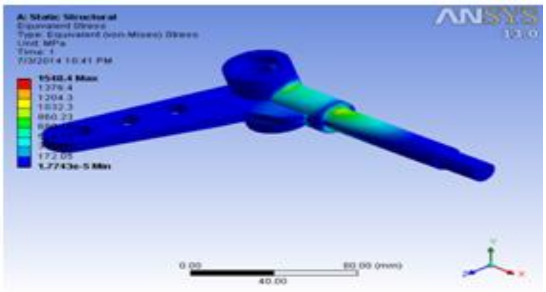

Fig 5.1.1

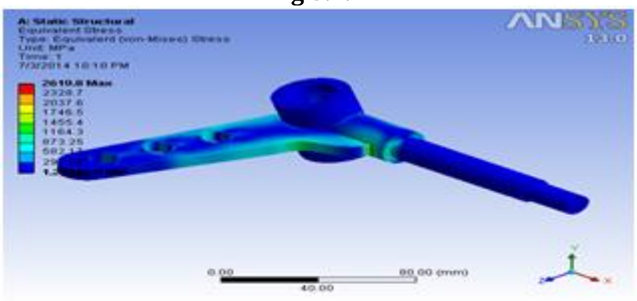

Fig 5.1.2

The deflection diagram:

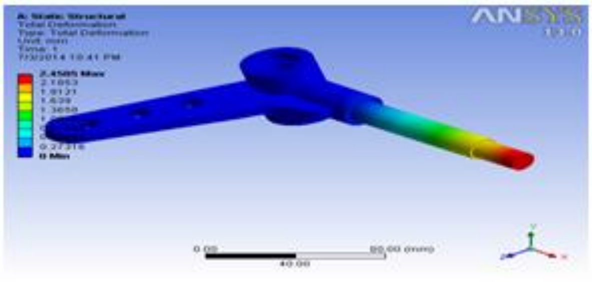

Fig 5.1.3

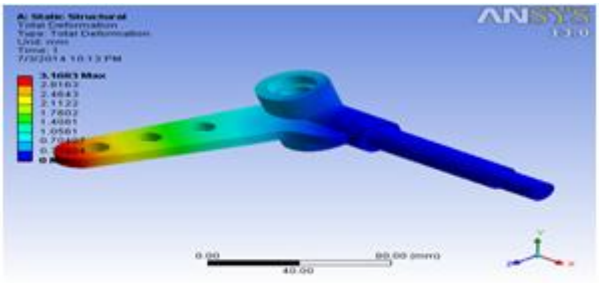

Fig 5.1.4

IX. BRAKING

Obtaining the most efficient inhibition of motion is the basic approach behind selection of proper braking system. The brakes are supposed to perform flawlessly by successfully locking the wheels and putting the vehicle in motion at rest. This is to be done at a certain speed rate without any occurrence of failure. Designing the braking system is based on various parameters of deceleration.

9.1 Selection of Braking System

Braking system could have been optionalised between disc brakes and drum brakes.Disc brakes will be incorporated at the rear axle shaft of the go-kart. The advantages and the reason of selection of disc brakes over conventional drum brakes were simple. Disc brake assembly proves to be lighter in weight. They're more reliable. They provide consistent and stable output, also in every weather conditions. The performance is better and quick at higher speeds. The disc brakes result in lesser wear. Their advantage as thermally observed is higher heat dissipation at all temperatures due to proper and sufficient contact of the disc and air. Working force required is also at its minimum. Considering overall ergonomic parameters and driver comfort ability, the brake pedal is mounted at the foot of the driver, thus resulting into complex fabrication and favouring design simplicity. The pedal ratio of 3.8:1 is taken in account for the brake pedal. The braking/stopping distance also calculated as 4m for a speed of 40km/hr. It is to make sure that the kart stops 1.5 times the length of the vehicle at 80km/hr. For safety purpose appropriate hydraulic circuits and lines are provided.

Table 2: Disc Brake specifications

	Specification
Rear Disc	OD 200mm
Master Cylinder	Dia. 17.5mm

Rear Left Calliper piston Diameter	Dia.- 16mm	TVS Apache RTR 180
Brake Pedal Lever ratio	5:1	Custom
Stopping distance	2.84m	-

Parameter	Front
Area of caliper	0.0004021 m²
Pressure to caliper:-	4175000 Pa
clamping force	1678 N
$F_{friction} = F_{cal} \times \mu_{bp}$	5341 N
R_{tire}-effective rolling radius of tire	0.27
$T_r = F_{friction} \times R_{eff}$	467.3 Nm
$F_{tire} = T_{tire}/R_{tire}$	1729 N

X. DESIGN PARAMETERS OF VEHICLE

Table 3: Design parameters

Chassis	Full tubular roll cage structure	
Steering	Disk & link mechanism	
Engine & Gearbox	125 cc, 8.2 Hp, Air Cooled Engine	Mahindra Rodeo
Brakes	Hydraulic disc brakes (TVS Apache)	Front & Rear
Wheels & Tyres	10*4.5*5	Front
	11*7.1*5	Rear
Weight	120 kgs	Approx.
Length	73 inches	
Width	50 inches	
Height	Inches	
Track Width	46 inches	Front
	56 inches	Rear
Wheel Base	44 inches	
Ground Clearance	1.90 inches	

XI. CONCLUSION

The design and construction for the 2013 national go kart championship has become more challenging due to the increased participation and also participation of foreign competitors. The challenge and aim for this year is to reduce the chance of failures & some innovative ideas.Many aspects of the fabrication will require much more time and attention to them have already been anticipated. a project of this magnitude requires excessive man hours and continues to extend far beyond the requirements. The team has started well in advance in order to give more stress on practical testing, the team is confident with the work that has been completed so far and is sure that they will successfully complete & compete in the competition. Although the road to the numerouno position is very long and bumpy, the team feels confident that it will continue to make its mark.

ACKNOWLEDGMENTS

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