# Optimization of Go-Kart Design using Finite Element Approach

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**Abstract:** The aim is to reduce the complexity in overall design of a go- Kart. Effort is to make it simple and light in weight without any premature failure and downfall in performance. Since the efficiency of vehicles mainly depends upon optimum design of its various elements. Finite element analysis (FEM) method was used to create, evaluate, and to achieve the optimal go-kart design. The optimum designs of its various elements like chassis and steering mechanism help the beginners to achieve their dream of making and competing in racing.

**KEYWORDS:** Go-kart design, Elements, FEA, Optimal Design.

**Introduction**: A Go-Kart is a single seater four wheels, high powered and very small racing vehicle. Initially in 1956s the motor based racing go- Kart was developed in USA and California by Art- lngels[1]. In 1959 Mc Colloch was the 1st company to produce engine for go Karts [2]. Immediately, karting rapidly advancement to other developing countries and presently has a massive following in Europe [3]. Normally the speed ranges from 45 Km per hour to 65 Km per hour [4].

**Literature Review**: Presently in a Go Kart spark is mainly obtained by coil ignition system also called battery ignition system, because of low cost and better sparking even at low speed. But before 1920S a magneto ignition system was commonly used [5]. Steering system provides directional control of the vehicle to the driver so that he is able to turn the vehicle in the required direction by changing the front wheel of the vehicle [6, 7].

## A. VEHICLE DESIGN

Designing is very essential to convert the less useful material to more useful form because without designing of components production work become complicated. In nut shell, the designing of product means preparation of drawing, specification and developed work related to the product to be manufactured [8].The designing of any GO Kart parts is a more risky work for every designer because of best design requires high/deep thinking, and very precise calculation.[4]. In Go-Kart the vehicle design section is mainly divided into two major groups.

° Design objectives and considerations.

° Design calculations, analysis and testing.

## B. CHASSIS DESIGN

Chassis is the major machine portion having all the parts required for efficient running and operation of the Go Kart vehicle. The portion of the Go Kart without body is known as chassis [9]. Chassis comprises following main units like frame, breaks, power unit, electrical system, steering system, suspension system, front & rear

axle etc [10]. A good chassis design was to keep driver safe from impulsive forces and atmospheric temperatures. The material used for chassis design and its joint is made up of mild steel [4]. During the design of chassis AISI-1018 material is used because of it is easy to join, ability to resist externally applied forces without breaking known as strength, relatively soft and as well as excellent manufacturing ability etc.[11]. The use of high strengthening material in Go Kart is very much essential because the chassis required absorbing as much energy as possible to prevent the deforming at the time of impulsive forces. In addition AISI- 1018 steel material is chooses for the chassis parts because it possesses better structural and mechanical characteristics that help to attain a low weight to strength ratio. This also helps in reduction of weight. The chassis design and bottom view of Go kart chassis is shown in Fig. 1 & 2.
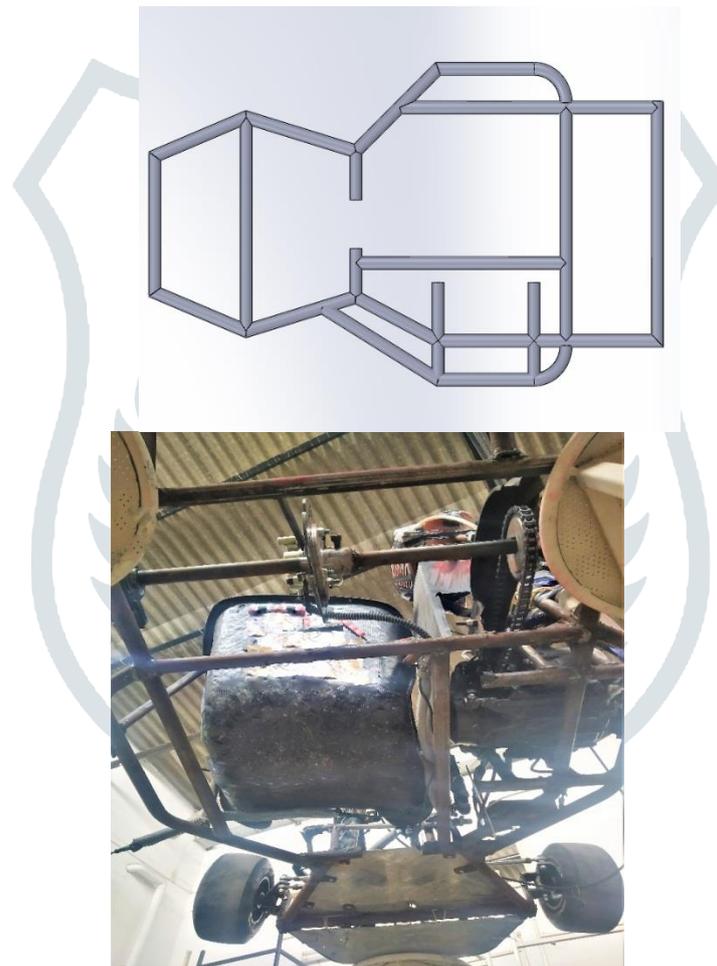
**Fig.1.** Chassis design of Go Kart



*Fig.2.* Bottom view of Go Kart chassis.

**Table II: Chemical composition (%age) of the Chassis material [13].**

| S.No | Material | % age |
|------|----------|-------|
| 1 | Carbon (C) | 0.14 – 0.20 |
| 2 | Manganese (Mn) | 0.60 – 0.90 |
| 3 | Iron (Fe) | 98.81 – 99.26 |

| 4 | Phosphorus (P) | 0.020 |
|---|----------------|-------|
| 5 | Sulphur (S) | 0.040 |

## C. FRONT IMPACT ANALYSIS

According to European new car assessment program (ENCAP), linear velocity under frontal impact condition stands to 64 Km/h. Therefore, using mass moment equation, forces were calculated. Collision time was assumed to be approximately, $\Delta T = 1.01$ seconds. and the gross weight of 140KG.

**P = M × V**

**P = 140 × 17.8**

**P = 2492 kgm/s**

**Now, the frontal impact force we get- F = P × ΔT**

**F = 2492 × 1.10**

**F = 2741 N.** After substituting the above data on the frontal part and by fixing the rear part, the results of the analysis generated by software is shown in Fig. 3.
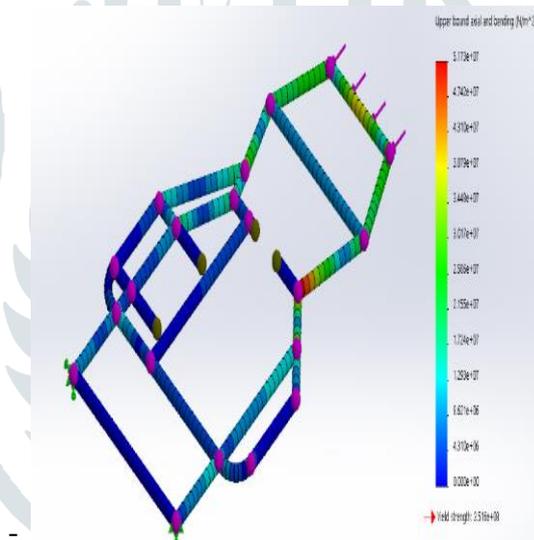


**Fig. 3.** Front side Chassis analysis

## E.  SIDE IMPACT ANALYSIS

According to ENCAP Standard velocity is assumed to be 48 Km/h for side impact analysis. Hence the forces calculated are-

*F = P × ΔT*

*Where, P = M × V*

*P = 140 × 13.3*

*P = 1862 kgm/s*

Now, the side impact force we get $F = 1862 \times 1.10$, $F = 2048 N$.

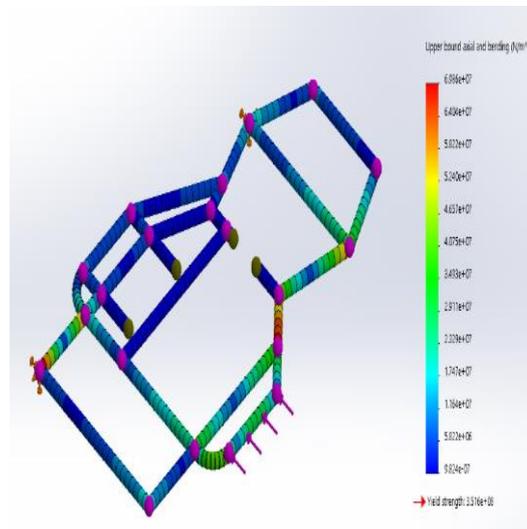Following stresses were simulated in software as shown in Fig. 4.

**Fig.4.** Analysis of sides.

### F. REAR SIDE IMPACT ANALYSIS

According to the ENCAP standards, here the speed is assumed to be 50 Km/h.

Calculations of force are as- $P = M \times V$, $P = 140 \times 13.8$, $P = 1932$ kgm/s

$F = P \times \Delta = 1932 \times 1.10 = 2125$ N.

The analysis results are shown in table 3 and image of rear side chassis analysis is depicted in Fig. 5.

**TABLE III: Technical calculated value of the rear impact force.**

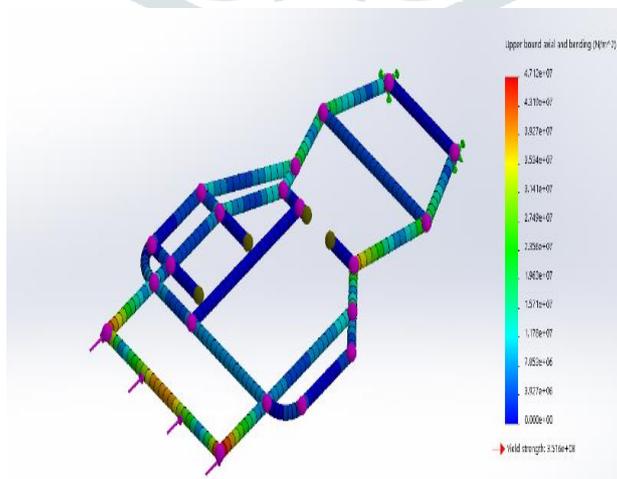| S.No. | Factors | Front | Side | Rear |
|-------|---------|-------|------|------|
| 1 | Impact force | 2741N | 2048N | 2125N |
| 2 | Stress generated | 173.9N | 153.1N | 179N |
| 3 | Overall deformation | 0.50mm | 0.86mm | 0.18mm |
| 4 | Factor of safety (F.O.S.) | 3.09 | 1.99 | 1.53 |



**Fig.5.** Rear side chassis analysis

## STEERING MECHANISM DESIGN

### A. OBJECTIVE

Prime objective of the steering is to provide directional control with minimum effort from driver. Most important objective of steering mechanism is to accomplish steering radius of 3.5m or less in order to maintain 100% Ackerman steering for satisfying correct steering conditions [18].



**Fig. 6.** Steering system from driver's point of view.

### B. DESIGN

Due to very less numbers of joints, play is reduced allowing driver to take sharp cuts more efficiently. Pitman arm have set of holes drilled at equal distances by calculations so that tie rods can be adjusted at any time according to need. This system improves the sensitivity of steering by employing a multi-hole pivot plate which permits the positional change of tie rod from one port to the next aligned port. This mechanism provides simplicity and directional control for driver over kart is shown in Fig.7.
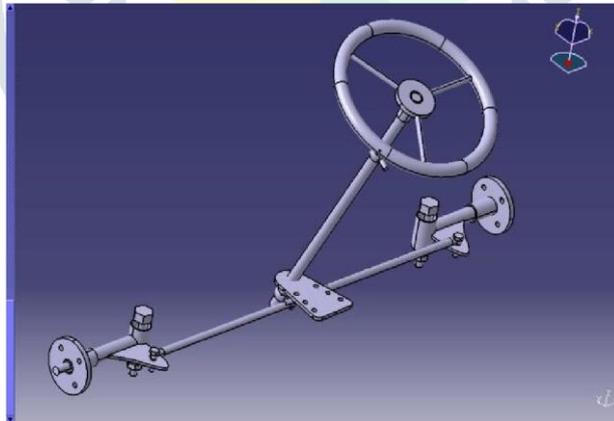


**Fig. 7.** Steering mechanism.

The formulae are used for calculation of steering are:

R = d/2+Lcosec (A/2+B/2)

% Ackerman formula = $\dfrac{A-B}{tan^{-1}(\frac{1}{tan(B)-1})-B}$

Tires exhibit negligible skidding because the inside front wheel carries angle slightly larger than the outside front wheels.

**TABLE V: Go Kart Vehicle steering specifications.**

| S.NO. | Descriptions' | Specification |
|---|---|---|
| 1 | Inner Turning – Angle | 32° |
| 2 | Outer Turning -Angle | 38 ° |
| 3 | Turning Radius | 1.6 m |
| 4 | Caster Angle | 0° |
| 5 | Camber Angle | 0° |
| 6 | Inclination of King Pin | 0° |
| 7 | Length of Tie Rod | 10 inches |
| 8 | Steering wheel diameter | 10 inches |

**Conclusion:** The process of attaining optimal design of the Go-Kart helps to identify the strengths and focus areas of the build quality and design [20]. Chassis design and steering systems have been optimized.

| S.No | Vehicle make model | Values | Vehicle make model | Values |
|---|---|---|---|---|
| 1 | Wheel base | 40 inches | Engine and transmission | 125 cc, 11BHP, 8000rpm |
| 2 | Wheel track | Front=39 Back=40 | Max. engine torque | 11n-m @ 5000 rpm |
| 3 | Overall length | 58 inches | Max. speed | 80 km/hr |
| 4 | Overall width | 46 inches | Gear ratio (at rear axle) | 1:2 |
| 5 | Ground Clearance | Front=2in. Back=2.5 | Fuel Consumption | 30-40 kmpl |
| 6 | Overall weight | 140 kg | Steering | Ackermann (pivot plate) 1:1 |
| 7 | Material | Aisi-1018 | Turning radius | 1.6 m |
| 8 | Tire size | 10 - 0.875 | Brake | Disc brake |

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