MODEL AND MATERIAL ANALYSIS OF GOKART CHASSIS

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Abstract:
The present study of this paper is to select the best material for manufacturing the Go-Kart. To meet this designing of go-kart chassis done by using CAD software CATIA tool and simulate with ANSYS work-bench. To select the best material, strength to weight ratio plays major role on it. Steel is considering to existing material another two materials Aluminum-6061, Kevlar selected. The main reason behind choosing Aluminum-6061, Kevlar materials is two materials are having less density and high yield limit values, and this factor can increase the strength/weight ratio compare to existing material steel. In this project material selection is one of the main design decisions that greatly increase the safety, reliability and performance. The material selection is choosen after my extensive research with various parameters like strength, weight and cost. We are comparing Aluminum-6061 and Kevlar materials with mild steel. In this process boundary conditions applied on each material and calculated results like deformation, stress, strain, safety factor, natural frequency values, by knowing all these results, concluded with optimum material.

Keywords: Chassis, Go-Kart, Aluminum-6061, Kevlar, Natural Frequency.

1. INTRODUCTION
Go-kart is a four wheeled vehicle; mostly it is used for racing purpose. Go-kart is a light weighted vehicle and it is easy to operate. Go-karts does not have suspension due to ground clearance is very small as compare to other vehicles. Mostly Go-Karts are used for racings. These Go-Karts are very low in cost and relatively safe way to introduce drivers, the main parts of Go-Kart are chassis, Engine and transmission, Steering, Breaking system, Wheels In our project the main focus is chassis and it consists of a body frame made up of pipes of various cross sections that are welded together which supports all the components, the chassis should be rigid from all the bending and torsion stress.

2. MATERIALS, MODELING AND METHODOLOGY
2.1 Materials:
The materials used for our chassis are aluminum-6061 and Kevlar are taken as two materials and steel as existed material. After comparing all materials, choose these three materials because of their good properties which is suitable for Go-Kart.
Table 1: Materials and their properties

| Material  | Steel  | Al-6061 | Kevlar |
|-----------|--------|---------|--------|
| Yield strength  | 250MPa | 276MPa | 650MPa |
| Young’s modulus  | 2.0*10⁸MPa | 0.689*10⁸MPa | 0.83*10⁸MPa |
| Poissions ratio | 0.29 | 0.33 | 0.29 |
| density      | 7850 Kg/m³ | 2700 Kg/m³ | 1440 kg/m³ |

2.2 MODELING:

We prepared the model by considering all the aspects and requirements. Model the GO-Kart Chassis in CAD software and then analyze it in ANSYS software. Analysis mainly depends upon the safety, comfort, cost, strength, weight, vibrations, stress, strain and deformations.

Table 2: Chassis dimensions

| Gokart parameters | values |
|-------------------|--------|
| Vehicle Length    | 50 inch (1270mm) |
| Vehicle wheel base | 28 inch (711.2mm) |
| Vehicle width     | 20 inch (508mm) |
| Tube dimension    | 1 inch (25.4mm) |
| Pipe thickness    | 2 mm    |

2.3 METHODOLOGY:

The following Steps used in methodology:
- Model the GO-Kart using CATIA software tool
- Analysis with aluminum 6061, kelvar and steel materials by using ANSYS workbench
- Checking stress, strain, deformation, Natural frequencies
- Estimate the approximate weight and cost by comparing with three materials.

2.3.1 Model of chassis:

The modeling of the chassis is done in CATIA software, designed according to the requirements. Then the design is imported into the ANSYS for further analysis.

Figure 1. Model of the chassis
2.3.2 Meshing of chassis model:

The meshing is the most important tool for analysis and one can expect drastic changes when the results of mesh are obtained. The chassis is divided into finite pieces so that each element is analyzed very extremely.

![Mesh model of Chassis](image)

**Figure 2: Mesh model of Chassis**

2.3.3 Analysis parameters:

In this analysis we have to consider the vehicle which is running in real life. For that condition we have tested our chassis to verify whether the chassis is safe to sustain that condition. The value of force to be applied on the frame for this test could be obtained by one of the following methods.

**Impulse Method:** As we know that force \( F \) multiplied by time of collision \( t \) is impulse and is equal to change in momentum of the body.

\[
I.e.\text{ Mathematically, } F \cdot t = m \cdot (v - u)
\]

Where \( m \) is mass of the vehicle i.e. taken to be approximately 30 kg, \( u \) is the maximum velocity of the vehicle which we take as 60 kmph, and \( v \) is final velocity i.e. 0 kmph in critical condition. Here the unknown parameter is the collision time \( t \), which is obtained by prototype testing.

**G-Force Method:** This is widely used method when prototype testing is not a feasible solution, in which the force applied is calculated in F-force. Force is mass of the vehicle \( m \) multiplied with \( a \) (acceleration due to gravity)

Mathematically, \( F = m \cdot a = 30 \cdot 9.81 = 294.3 \text{ N} \) (5)

| Table3: forces the applied forces in different collisions |
|---------------------------------------------------------|
| Front impact | 4 G = 1177.2N |
| Rear impact | 3 G = 882.9N |
| Side impact | 2 G = 588.78 N |
| Roll-over | 1.5 G = 441.45 N |

2.3.4 Boundary conditions:

According to above mentioned calculations here maximum applied force could be 1.2KN approximately in any direction. So that here checking our object maximum impact force bearing
capacity, here safety factor is consider to be measurement, and it should maintain minimum 1.5 to apply that load.

![Figure 3: Boundary conditions][1]

Force $\Rightarrow 3.8\text{KN}$

After completion of boundary conditions here we have to check results by solving. Just click on solve option and select results like deformation, strain, stress and safety factor values for the object.

**2.3.5 Post processing:**

![Figure 4: Total deformation of steel][2]

![Figure 5: Von-Mises stress of steel][3]

![Figure 6: Total Strain of steel][4]

![Figure 7: Safety factor of steel][5]

![Figure 8: Total deformation of Al-6061][6]

![Figure 9: Von-Mises stress of AL-6061][7]
Figure 10: Total strain of Al-6061
Figure 11: Safety factor of Al-6061
Figure 12: Total deformation of Kevlar
Figure 13: Von-Mises stress of Kevlar
Figure 14: Total strain of Kevlar
Figure 15: Safety factor of Kevlar

Table 4: Comparison of Deformation, stress, strain and safety factor

|                | Steel     | Al-6061   | Kevlar   |
|----------------|-----------|-----------|----------|
| Deformation (mm) | 0.82664   | 2.3979    | 1.992    |
| Stress (Mpa)    | 163.29    | 161.47    | 163.87   |
| Strain          | 0.00083895| 0.0024048 | 0.0020305|
| Safety factor   | 1.531     | 1.7093    | 3.9667   |
Modal analysis

Steel:

Figure 16: Mode 1 Deformation

Figure 17: Mode 2 Deformation

Figure 18: Mode 3 Deformation

Figure 19: Mode 4 Deformation

Aluminum-6061:

Figure 20: Mode 5 Deformation

Figure 21: Mode 6 Deformation

Figure 22: Mode 1 Deformation

Figure 23: Mode 2 Deformation
Figure 24: Mode 3 Deformation

Figure 25: Mode 4 Deformation

Figure 26: Mode 5 Deformation

Figure 27: Mode 6 Deformation

Kevlar:

Figure 28: Mode 1 Deformation

Figure 29: Mode 2 Deformation

Figure 30: Mode 3 Deformation

Figure 31: Mode 4 Deformation
Table 5: Comparison of Frequency in different modes

| Mode       | Steel     | Al-6061  | Kevlar  |
|------------|-----------|----------|---------|
| Mode1 (Hz) | 31.855    | 32.363   | 32.645  |
| Mode2 (Hz) | 35.289    | 35.856   | 36.162  |
| Mode3 (Hz) | 48.589    | 49.383   | 49.787  |
| Mode4 (Hz) | 76.849    | 78.101   | 78.745  |
| Mode5 (Hz) | 77.146    | 82.037   | 82.748  |
| Mode6 (Hz) | 81.097    | 93.475   | 95.384  |

**Weight and cost (approximate) estimation:**

**Steel:**
- Steel chassis gross weight: 28.21 kg
- Cost of material 80/kg (approx.)
- Total cost for chassis = 28.21*80 = 2256.8 RS

**Al-6061:**
- Al-6061 chassis gross weight: 9.9904 kg
- Cost of material 280/kg (approx.)
- Total cost for chassis = 9.9904*280 = 2797.312 RS

**Kevlar:**
- Kevlar chassis gross weight: 4.23 kg
- Cost of material 4501/kg
- Total cost for chassis = 4.23*4501 = 19039.21 RS

**CONCLUSION:**

In this thesis go-kart frame designed by using cad tool CATIA tool and analyzed with the help of ANSYS workbench and in this case 3.8KN load applied as impact force, and the existing material steel can bear up to this load only, to improve the strength and also to improve the efficiency of the object by reducing total gross weight here 3 materials were chosen and analyzed with same boundary conditions.

From the results of static analysis each material has good safety factor values and all materials can withstand 3.8KN impact force, among all strength wise Kevlar c has taken 1st place, al-6061 has
2nd position, steel material have been occupied 3rd position respectively. In real time there are so many factors to be consider to select a new material, by knowing only static analysis results it is not possible to choose one good material for our object, to get more clear knowledge on each material here dynamic load boundary conditions also applied by using model analysis and calculated natural frequency results

From natural frequency values all materials have higher range frequency values than existing material and it means these all materials are good at vibrational conditions also, among all Kevlar is having good static and dynamic boundary conditions.

To get more accurate knowledge on material here cost estimation has been made approximately, and these cost estimations were give final results, from the weight and cost estimation it is clearly shown Kevlar increases 10 times material cost nearly compare to al-6061 and steel materials, previously Kevlar material is used for Ferrari F40 chassis, but in India this material wont suitable for our environment and economic conditions even though it has good strength to weight ratio values, among all steel is cheapest material but while using al-6061 there is no much difference in cost compare to steel, and al-6061 has less density and it can decrease the total weight up to 33%, weight is reduced means indirectly fuel cost is also reduced.

Finally here project can be concluded with al-6061 material due to low weight and high strength among all materials and this material can increase the overall performance of the object and reduce the maintenance cost compare to steel.

References:

[1] Alpesh V. Mehta, Nikunj Padhiar, Jaydip Mendapara, 2011 “Design and Analysis of Hybrid Go-kart” IJAET/vol II / Issue I/277-288.
[2] Lim Wai Tuck, 2007 “Design and Fabrication of ump Go-kart Chassis” University of Malaysia Pahang nov, http://umpir.ump.edu.my/id/eprint/2276.
[3] Kiral Lal, Abhishek O S, 2016, “Design, Analysis and Fabrication of go-kart” International Journal of Scientific & Engineering Research, Volume 7, Issue 4, 429 ISSN 2229-5518.
[4] Pattanshett SV, 2016, “Design and analysis of GO-KART chassis”, International journal of Mechanical and Industrial Technology, 4 (1) 150-164.
[5] Chow H Y, 2016,“Go-Kart’s design and construction based on theoretical and experimental findings”, University of Malaysia, 2016.
[6] Michell S, Rajagopal K, Muthy V S S, Harikrishna V, 2017, “Design of a go kart vehicle”, International journal of science, engineering and technology research 6 (3).
[7] Hajare K, Shet Y, Khot A, 2016, “Design and Analysis of a Go-Kart Chassis”, International Journal of engineering technology, management and applied science, 4 (2).
[8] Khan A S, Danish K, Kathola K, Bhonde, G Ghevande, Harshil M, 2017 “Review on design and analysis of structure of go-kart vehicle”, International journal of research in advent technology, Special Issue National Conference 2017, April 9th 2017.
[9] Nath A, Vikram J C, Nongrum L, Marboh P, 2015, “Design and fabrication of a Go Kart, International journal of innovative research in science “, Engineering and technology, 4(9).
[10] Kelkar K, Gawai S, Suryawanshi T, Ubaid S, Kharat R, 2017,“Static Analysis of Go-Kart chassis”, International journal of research in advent technology, Special Issue National Conference 2017.